UNIVERSITI TEKNOLOGI MARA

E-PROCEEDINGS

INTERNATIONAL TINKER INNOVATION & ENTREPRENEURSHIP CHALLENGE

(I-TIEC 2026)

Empowering Innovation & Entrepreneurship for a Sustainable Future

17th April 2026

Faculty of Electrical Engineering
Universiti Teknologi MARA

Johor Branch
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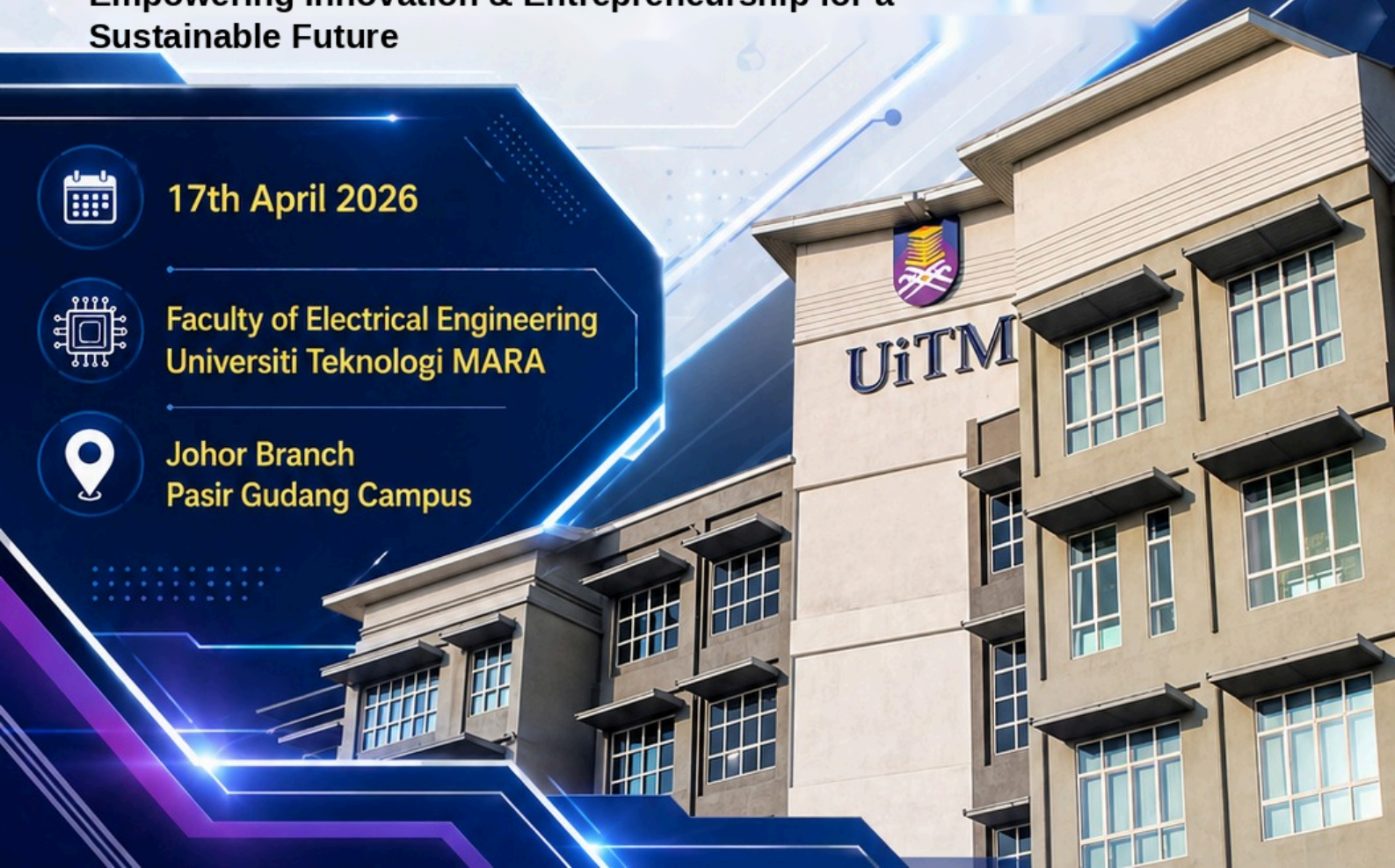

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Editors

Nur Dalila Khirul Ashar

Dr. Rijalul Fahmi Mustapa

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Editors
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Integrating AI-Assisted Web Development to Enhance Html Learning in the OBM255 Course

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ABSTRACT

Diploma in Office Management and Technology students from Faculty of Business and Management enrolled in OBM255 course, Office Software Applications, are required to learn basic HTML to create functional websites. However, many struggle to produce visually appealing and well-structured pages due to limited design experience and reliance on simple tools like Notepad. As a result, website outputs often appear unattractive, inconsistent, or overly simplistic, and some students outsource their assignments, compromising genuine learning. To address these challenges, this innovation introduces an AI-assisted learning approach that supports students in generating high-quality, aesthetically enhanced HTML. Through guided hands-on, students learn to craft effective prompts, understand AI-generated code, and refine website designs with step-by-step support. The integration of an AI-code review workflow and design enhancement modules strengthens both technical understanding and creative confidence. A pilot study conducted in the March 2025 semester evaluated improvements in students' website quality, coding abilities, and grasp of essential web concepts. The initiative also aimed to reduce assignment outsourcing, increase engagement, and better prepare students for digital workplaces where AI-assisted web development is increasingly relevant. Findings from the pilot demonstrated significant progress, with students producing more polished and visually appealing websites compared to previous semesters.

Keywords: AI-Assisted Learning, HTML, Applications, Website, Learning Tools

1. Product Description

This innovative learning tool integrates AI-assisted support into the OBM255 Office Software Applications course to help Diploma in Office Management and Technology students create visually appealing and professional HTML websites. The product combines structured prompt templates, AI-generated HTML code, and guided design enhancement modules to assist students in producing high-quality web pages even with minimal prior design experience. Students interact with ChatGPT for example to generate clean, responsive website layouts and receive step-by-step explanations that strengthen their understanding of coding concepts. The tool also includes an AI-code review feature that helps students identify errors, improve styling, and refine overall design aesthetics. This approach not only enhances creativity but also promotes independent learning and reduces the tendency to outsource assignments. By integrating modern AI tools into the curriculum, this product empowers students to build confidence in their web development skills while preparing them for future digital work environments where AI-supported tasks are increasingly common.

2. AI-assisted tool

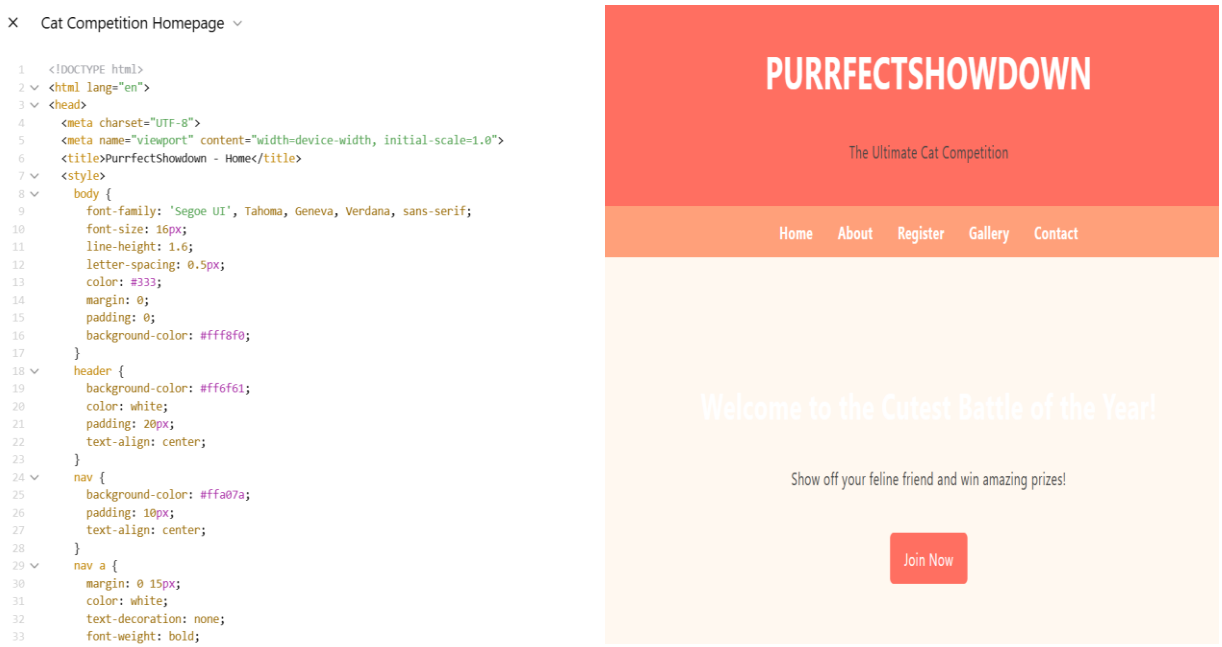

Figure 1. Example of HTML/CSS codes and output generated from AI-Assisted Tools (ChatGPT).

Figure 1 shows an example of HTML and CSS code generated using an AI-assisted tool (ChatGPT) along with the corresponding webpage output. The figure highlights how AI support helped students understand the relationship between source code and webpage rendering, as well as basic web development concepts such as structure, styling, and layout, while reducing the initial cognitive load of manual coding.

Figure 2. A website created by one of the student groups in the class.

Figure 2 shows a website developed by one of the student groups during the course. The website demonstrates students' ability to apply HTML and CSS concepts learned in class and indicates that they were able to produce a functional webpage through collaborative and hands-on learning beyond AI-generated examples.

3. Novelty and uniqueness

This project stands out for its innovative approach in integrating practical web design skills with real-time, interactive learning tools. Unlike traditional HTML teaching methods that rely heavily on static instructions and basic text editors, this initiative introduces a dynamic, visually driven environment that allows students to see immediate results as they code. What makes this project unique is its strong emphasis on aesthetic quality and layout consistency, areas often overlooked in introductory HTML courses. Students are taught not only to write correct code but also to apply fundamental design principles such as alignment, spacing, color harmony, and visual hierarchy. This focus helps them move beyond plain, unstructured outputs and produce pages that look purposeful and polished. By integrating practical coding skills with design-awareness training, the project offers a more holistic learning experience. It equips students with the ability to create functional and attractive web pages even with limited technical backgrounds, setting their work apart from typical beginner-level outputs.

4. Benefit to mankind

This project contributes to society by empowering individuals with essential digital literacy skills, enabling them to participate more effectively in an increasingly technology-driven world. By teaching students to create functional and well-designed web pages, it enhances their employability, supports lifelong learning, and reduces the digital divide. Overall, this initiative supports human development by equipping learners with practical skills that can improve access to information, and foster more connected, informed, and empowered learning communities.

5. Innovation and Entrepreneurial Impact

This project introduces an innovative approach to building digital skills by combining practical HTML training with clear guidance on creating visually appealing and user-friendly websites. This focus on both technical accuracy and design quality equips students with competencies that are highly relevant. The project fosters entrepreneurial potential by enabling learners to create professional web pages that can support small businesses, portfolios, online branding, and service promotion. With these skills, students can offer basic web development services, assist local enterprises in improving their online presence, or develop their own digital initiatives.

6. Potential commercialization

This project has strong commercialization potential as it provides a structured, user-friendly method for teaching basic HTML and guiding beginners to produce visually appealing websites. The approach can be developed into a comprehensive learning package that includes tutorials, design templates, real-time coding tools, and step-by-step guides.

7. Acknowledgment

The authors would like to express our sincere appreciation to all individuals who contributed to the development of this project. Our deepest gratitude goes to the students of OBM255 for their dedication, creativity, and willingness to explore new approaches in learning HTML. Their enthusiasm and participation played a crucial role in shaping the direction and success of this work.

8. Researchers' Biography

Dr. Marlina Muhamad is a Senior Lecturer at UiTM Kedah specializing in information technology. With nearly 12 years of experience, she has actively participated in innovation competitions, served as a jury member, and published her research in WOS-, Scopus-, and ERA-indexed journals.

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BiasGuard: AI-Powered Behavioral Finance Decision Support App

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ABSTRACT
Retail investors often make emotionally investment decisions that influenced by their psychological biases such as Fear of Missing Out (FOMO), overconfidence, loss aversion, and herd mentality. These biases will lead to poor investment decisions and financial outcomes as well as reduced their investment confidence. BiasGuard is an AI-powered application designed to detect psychological biases in real time, provide corrective alerts, and guide users toward rational, and evidence-based decision-making. BiasGuard empowers users to invest smarter and reduce emotional risks by integrating cognitive analytics, behavioral profiling, history and educational modules. The project offers a novel approach by combining financial technology and behavioral psychology. This apps targeting the needs of beginner and young investors through financial literacy programs and the growing retail trading community.

Keywords: Bias, Retail Investor, Decision Making, Investment

1. Product Description
In modern of digital trading platforms, retail investors are increasingly making independent financial decisions. However, these decisions are commonly affected by cognitive and emotional biases that distort their financial decision and judgment. Previous behavioral finance research has confirmed that biases such as herd behaviour, anchoring, and overconfidence lead to irrational decision making in trading market. Current investment apps that available provide data but do not address the psychological aspect of decision-making. BiasGuard Apps addresses gap by offering a tool that helps users identify and understand their biases, enabling more disciplined and rational investment behaviour. Retail investors suffer financial losses not because of lack of information, but due to uncontrolled psychological biases that affect their investment decision-making. There is currently no accessible mobile solution that can detect, alert, and guide investors away from bias-driven decisions in real-time. This leads to emotional trades, panic selling, FOMO purchases, and poor long-term investment outcomes. Therefore, BiasGuard is a mobile application integrating behavioral psychology and AI analytics.

Key features include:

- Bias Detection Engine: Identifies patterns of bias through trading behaviour and user interactions.
- Real-Time Alerts: Provides warnings to user on bias detection.
- Behavioral Profiling System: Personalized "Bias Scorecard" for each user.
- Educational Hub: Offers micro-credential modules related to cognitive biases.
- Dashboard Analytics: Shows bias frequency, decision history, and improvement tracking.

2. Flow Charts

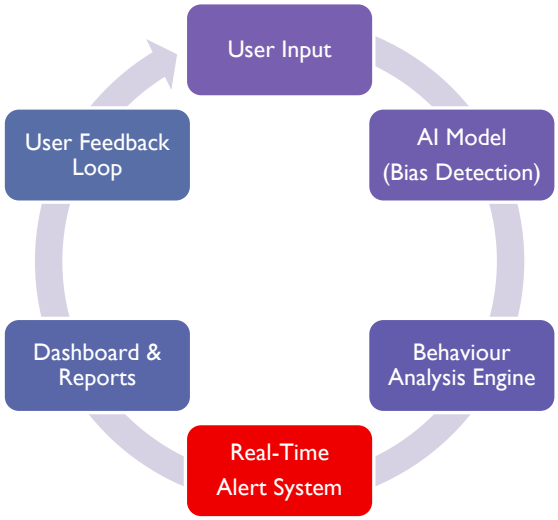

Figure 1. BiasGuard System Architecture Diagram.

The BiasGuard system will be designed to detect investor psychological biases in real time, generate alerts, and continuously improve accuracy through user feedback. The architecture consists of six major components. The system flow in **Figure 1** explained as below:

1. User Input: To collect behavioral data that will be analyzed for potential bias.
2. AI model (Bias Detection Engine): To analyze user input, to assign Bias Probability Score, to detect patterns that associated with overconfidence, loss aversion, FOMO, anchoring and herd mentality.
3. Behavior Analysis Engine: To interprets the AI-generated bias probability and matches behavior with theories, risk level, urgency and determine alerts to triggered.
4. Real- Time Alert: To prevent impulsive decision before they happen, protect users from emotional mistakes.
5. Dashboard & Reports: To empower investors to understand their own psychology and decision-making behavior.
6. User Feedback Loop: after receiving an alert or completing a learning module, the user needs to provide feedback on usefulness, accuracy prediction, and so forth. This feedback will be used to improve bias detection accuracy.

BiasGuard Mockup Interface Designs

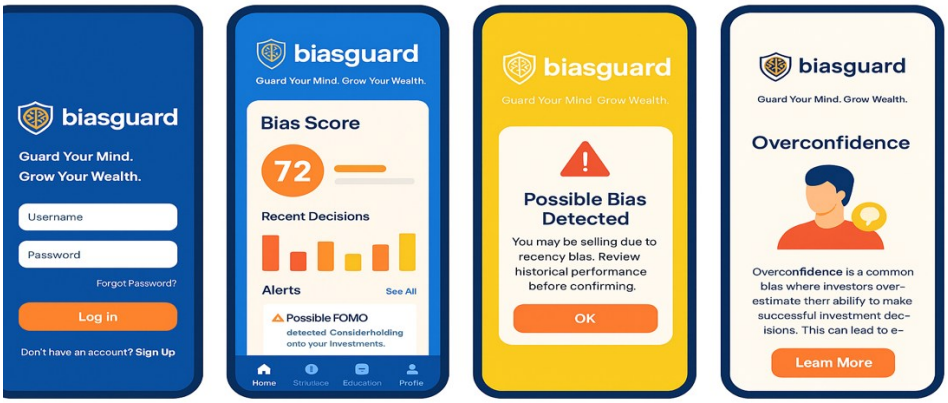

Figure 2. Illustration Prototype BiasGuard Interface Designs.

Figure 2 shows a simple prototype of BiasGuard mobile app interface, explaining how user interact with the system step by step.

- Login screen: User enter username and password.
- Dashboard: this is main screen that shows the user's Bias Score.
- Bias Alert: when the system detects a possible cognitive bias, it sends clear warning to user.
- Education screen: this section explains different type of biases in simple term to help users understand.

3. Novelty and uniqueness

BiasGuard is unique because it:

- Integrates behavioral finance, AI, and real-time emotional monitoring into a single app.
- Detects psychological biases at the moment of decision-making, not after.
- Offers personalized cognitive insights tailored to each investor.
- Includes a bias-free simulation environment for behaviour training.
- Focuses on the mental aspect of investing, a space underserved by existing fintech apps.

This combination of psychology with financial technology and integrated with artificial intelligence (AI) makes BiasGuard is first-of-its-kind solution ideally for new and young retail investors.

4. Benefit to Society

The benefits of this application to improved financial literacy among young and new investors in which this apps may reduce emotional trading losses in their investment decision making. Moreover, it's also enhanced financial confidence for new and young investors since they lack or trading experience as well as increased awareness of personal cognitive patterns that influence their trading behaviors.

This apps also provide wider societal impact by encouraging responsible investing habits, especially among youth and supporting national agendas on financial literacy and digital economy. It's also given the impact in reducing susceptibility to scams, hype-driven speculation and market manipulation that provide more stability in Malaysian investment market. Furthermore, this apps also foster a smarter and financially resilient that encourage and support the financial stability among community.

5. Innovation and Entrepreneurial Impact

This mobile application introduces a new approach to financial and investment decision making using AI-driven behavioral analytics. It bridges the gap between psychology and fintech innovation that has been emerging in this era. BiasGuard apps also contribute to research in behavioral finance and decision sciences through analyzing the pattern of trading behavior among investors. Furthermore, this application encourages innovation in managing emotion and risk management within investment ecosystem hence it may reduce the overreaction sentiment in investment ecosystems. Moreover, this application creates potential for integration into global trading platforms and act as robo-advisors in providing beneficial advice and experience to investors in investment trading.

6. Potential commercialization

BiasGuard has strong market viability that is scalable across Asia and global retail investor markets through:

- Freemium subscription model to provide premium analytics, reports and coaching session.
- Partnership with brokerage firms and investment institutions.
- University adoption for financial education programs.
- Corporate packages for employee financial wellness.
- White-label licensing to robo-advisors and fintech startups.

7. Acknowledgment

We would like to express our deepest gratitude to everyone who contributed to the development of the BiasGuard mobile app prototype. Our sincere appreciation goes to the project advisors, mentors, and experts whose insights greatly to strengthen our concept. We also thank the design and technical team members for their dedication in brainstorming ideas, refining system features, and crafting the user interface with creativity and precision. Special thanks to Universiti Teknologi MARA (UiTM) Melaka and Multimedia University (MMU) for providing continuous support, resources, and encouragement throughout this journey. This prototype is a result of collective effort, collaboration and shared commitment toward innovative fintech solutions.

8. Researchers' Biography

Dr. Faezah Othman is a Senior Lecturer at Universiti Teknologi MARA Kampus Bandaraya Melaka with extensive experience in business management, financial literacy, and innovative pedagogical approaches. Her research interests include financial technologies, behavioral finance, and digital learning strategies. She has contributed to various academic publications, supervised undergraduate and postgraduate research projects, and actively participates in university-industry collaborations.

Dr. Nor Fauziana Ibrahim is a Senior Lecturer at Multimedia University with academic and research expertise in well-being, organisational behaviour, psychology, and intrinsic motivation. Her work explores how psychological factors influence individual performance, workplace culture, and overall mental wellness. She has published in various journals and presented her research at national and international conferences. She is also actively involved in teaching, research supervision, and initiatives related to human behaviour and organisational development.

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Me-a: Transforming Hospitality Education with Game-Based Menu Analysis Learning

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ABSTRACT

Me-A (Menu Analysis) is a pioneering card-based educational tool designed to elevate students' mastery of menu analysis by seamlessly integrating theoretical formulas with applied decision-making. Addressing a persistent challenge in hospitality education and students' difficulty in translating abstract numerical concepts into actionable menu management strategies, Me-A leverages experiential and game-based learning principles. Students engage in calculating, interpreting, and applying key menu engineering metrics, including contribution margin and popularity index, within interactive gameplay. The tool's core features include formula-driven cards, scenario-based menu simulations, and competitive decision-making rounds that emulate authentic foodservice operations. Me-A uniquely balances analytical rigor with immersive engagement, enhancing comprehension, retention, and financial literacy among hospitality students. Beyond the classroom, it fosters industry-ready graduates and exemplifies scalable pedagogical innovation. Its low-cost, modular design ensures adaptability across educational institutions and professional training environments, demonstrating strong commercialization potential.

Keywords: Menu analysis, game-based learning, hospitality education, experiential pedagogy, educational innovation

1. Product Description

The Me-A card game is a pedagogical tool designed to support experiential and game-based learning in hospitality management education. The toolkit comprises formula cards, menu item cards, cost and sales data cards, and decision cards. Students first internalize essential menu analysis formulas and then apply them during gameplay to evaluate menu performance, classify items, and make profit-driven decisions. Each gameplay round presents a realistic menu scenario requiring analytical calculations followed by strategic justification. The game supports both individual and group learning, fostering collaboration, critical reasoning, and discussion. Designed for classrooms, workshops, and training sessions, Me-A aligns with outcome-based education principles while reducing reliance on passive instruction. Its physical card-based format ensures accessibility, portability, and ease of implementation without digital infrastructure.

2. Methods and Results

Figure 1 illustrates the integrated pedagogical framework of the Me-A card game**.** The learning sequence begins with formula learning, enabling students to internalize essential menu-analysis calculations. This stage transitions into applied quantitative analysis, where learners use data-driven menu cards to translate theoretical cost and sales variables into actionable financial insights. Gameplay then advances to strategic decision-making, during which students evaluate performance metrics to classify menu items and develop profit-oriented recommendations under simulated industry constraints. The cycle concludes with a reflective performance review, allowing students to assess outcomes and receive targeted feedback. By integrating experiential and game-based pedagogy, this framework fosters higher-order thinking and collaborative problem-solving, facilitating the effective transfer of theoretical knowledge to complex, real-world hospitality contexts.

Figure 1. Instructional and gameplay flow of the Me-A card game.

3. Novelty and uniqueness

Me-A demonstrates novelty by translating quantitative menu analysis formulas into a tangible, game-based learning experience without compromising academic depth. Unlike traditional spreadsheet-based exercises or lecture-centric instruction, Me-A embeds analytical calculations directly into gameplay mechanics, enabling repeated, contextualized practice. The physical card format enhances peer interaction, discussion, and collaborative
problem-solving, differentiating it from purely digital simulations. Additionally, the modular design allows adaptation across various academic levels and hospitality curricula, enhancing scalability and transferability. This integration of rigor, engagement, and adaptability positions Me-A as a distinctive educational innovation.

4. Benefit to mankind

This game card contributes to societal benefit by strengthening analytical and financial literacy among future hospitality professionals. By promoting active learning and evidence-based decision-

making, the innovation supports the development of graduates capable of managing resources efficiently and sustainably. It also equips educators with an effective pedagogical tool to improve learning outcomes, thereby enhancing the overall quality of hospitality education and workforce preparedness.

5. Innovation and Entrepreneurial Impact

This project fosters innovation by demonstrating how pedagogical challenges can be addressed through product-oriented educational design. It encourages educators and students to adopt creative, solution-driven thinking while integrating learning with practical applications. The project also provides opportunities for entrepreneurial engagement through product development, testing, customization, and dissemination, contributing to an innovation-driven culture within academic institutions and the hospitality education ecosystem.

6. Potential commercialization

It possesses strong commercialization potential as an affordable, reusable, and scalable educational product. Target markets include universities, colleges, hospitality training centers, and professional development programs. The card system can be customized to align with specific curricula, regional menu data, or industry standards. Commercialization strategies may include direct sales, institutional licensing, educator training packages, and curriculum integration partnerships.

7. Acknowledgment

Alhamdulillah, we are thankful for completing this task, which aims to enhance the knowledge and understanding of the student.

8. Researchers' Biography

Dr. Norrina Din is a Senior Lecturer at the Faculty of Hotel and Tourism Management, Universiti Teknologi MARA (UiTM). Dedicated to transforming complex theoretical frameworks into practical, high-impact instructional tools, she specializes in enhancing global hospitality standards through innovative design. Her expertise lies in bridging the gap between academic research and real-world application, fostering pedagogical solutions that prepare the next generation of industry leaders. Through her commitment to Teaching and Learning (T&L) excellence, Dr. Norrina continues to shape the future of international hospitality by utilizing strategic, evidence-based pedagogy to drive student success and industry readiness. Contact at norrina.din@uitm.edu.my

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Noorliza Zainol is a Senior Lecturer in the Department of Food Service Management, School of Hospitality and Tourism, UiTM Penang. She specializes in gastronomy, consumer behavior, food hygiene, academic writing, and cultural studies. Widely published in journals, essays, and newspapers, her research highlights Malaysian heritage food and cultural preservation. As an educator, she mentors students in research, critical thinking, and academic skills, creating creative and culturally rich learning environments. An avid reader and gardening enthusiast, she brings curiosity, patience, and a nurturing spirit to her teaching and research, reflecting her commitment to academic excellence and cultural awareness.

Dr. Mohd Hairi Jalis is a Senior Lecturer in the Department of Culinary Arts and Gastronomy, Faculty of Hotel and Tourism Management, Universiti Teknologi MARA (UiTM). He holds a PhD in Tourism Management. His research and publications focus on local cuisine, destination marketing strategies, culinary education, and tourism policy and planning. Actively engaged in curriculum development and policy-making at both university and national levels, he brings extensive academic leadership to his field. Teaching since 2008, his expertise includes basic culinary skills, Eastern cuisine, Malay culinary heritage, culinary computer systems, and hospitality research methods. He can be contacted at mohdhairijalis@uitm.edu.my

VocabSphere: 130 Essential CEFR B2 Words

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ABSTRACT

VOCABSPHERE is an eBook that consists of 130 essential vocabulary items intended for learners at the B2 level of the Common European Framework of Reference for Languages (CEFR). B2 CEFR learners are intermediate users of English who are able to give clear, detailed descriptions on a wide range of subjects related to their field of interest, expanding and supporting ideas with subsidiary points and relevant examples. However, they often require systematic exposure to high-impact vocabulary to enhance confidence, and effectiveness in daily communication. The vocabulary items in this eBook are carefully selected and organised from A to Z to support structured and focus learning. Each word is presented with clear meanings and contextualised examples to facilitate comprehension and practical use. VOCABSPHERE can be effectively applied in English lessons as a supplementary learning resource and also supports learners in using English confidently in daily communication, academic contexts, and professional settings.

Keywords: CEFR-Based, Vocabulary, ESL Learners, A–Z Vocabulary, Self-Directed Learning

1. Product Description

This product is tailored for L2 learners enrolled in LCC113 course, which covers 130 essential vocabulary items carefully selected to meet the communicative needs of B2 learners in academic, and daily communication. It allows learners to build vocabulary in a structured and manageable way. Each word is presented with a clear definition and contextualised example, enabling learners to understand meaning and apply the vocabulary accurately in real-life communication. The A-Z eBook can be accessed online, making it easily available anytime and anywhere. Additionally, it can be shared by class teachers for classroom use, group learning, or independent practice. Its user-friendly format ensures easy access for learners, supporting both guided instruction and self-directed learning. As a result, VOCABSPHERE serves as an effective supplementary resource for English lessons and a practical language tool for spoken and written production.

2. Diagrams

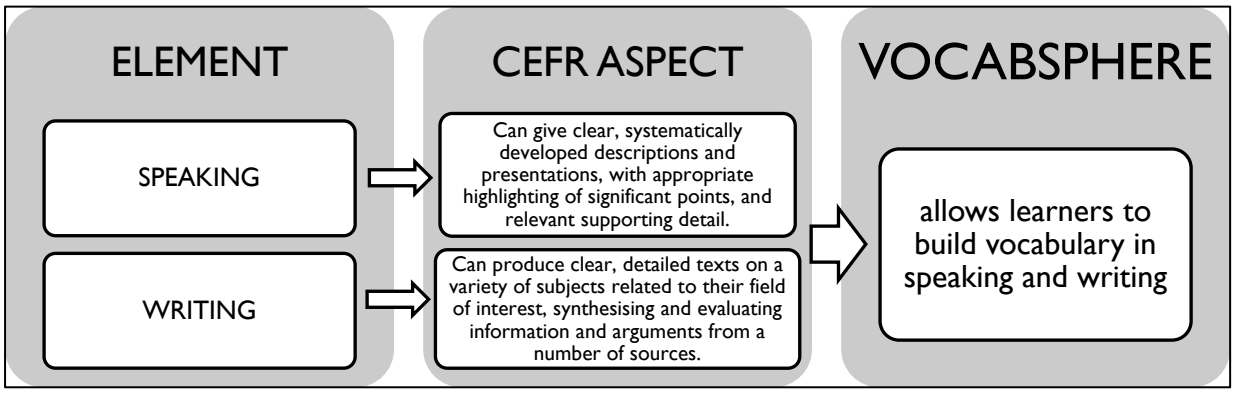

Figure 1. CEFR aspect in speaking and writing.

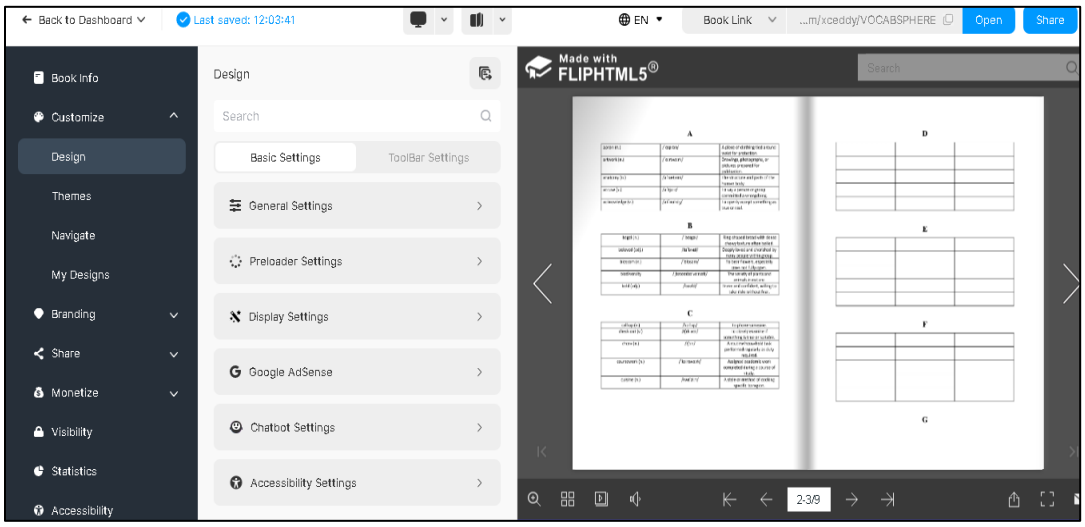

Figure 2. Product Model.

3. Novelty and uniqueness

This project is unique as it offers a compact and user-friendly alternative to traditional printed vocabulary guides. Unlike conventional books, VOCABSPHERE is designed as a digital eBook that can be accessed anytime and anywhere, allowing both students and educators to engage with the content flexibly according to their learning needs. The eBook can be easily integrated into classroom instruction as a supplementary resource for oral and written activities, including discussions, presentations, and writing tasks. Its digital format enables teachers to share the resource effortlessly during class time, promoting active and collaborative learning. The vocabulary items are carefully selected to suit learners at the B2 level of the Common European Framework of Reference for Languages (CEFR). In addition to supporting classroom learning, the words are highly applicable to daily communication, enabling learners to transfer their vocabulary knowledge beyond the classroom context. The structured A–Z organisation, comprising 130 carefully selected vocabulary items, provides an ideal balance between depth and manageability, supporting systematic vocabulary development and enhancing learners' confidence and lexical range.

4. Benefit to mankind

VOCABSPHERE contributes to the advancement of English language learning by providing an accessible and practical vocabulary resource for intermediate learners. By offering 130 essential CEFR B2 vocabulary items in a compact digital format, this eBook supports learners in improving their communication skills, which are essential for academic success, workplace readiness, and social interaction in a globalised world. The eBook promotes inclusive and equitable access to learning. This flexibility benefits learners from diverse backgrounds, including those with limited access to printed resources. Educators also benefit from a ready-to-use supplementary tool that can be easily integrated into classroom activities, reducing preparation time while enhancing lesson effectiveness.

5. Innovation and Entrepreneurial Impact

This product promotes innovation by transforming traditional vocabulary learning into a flexible, digital, and learner-centred resource. The project introduces a systematic A–Z approach with carefully selected CEFR B2 vocabulary, making vocabulary acquisition structured, accessible, and engaging. By leveraging eBook and flipbook technology, it supports modern teaching practices and encourages educators to integrate digital tools into English language instruction. The project also contributes to a culture of entrepreneurship by demonstrating how educational needs can be addressed through accessible digital products. It encourages educators and institutions to explore innovative content development, digital publishing, and alternative learning resources. By bridging pedagogy and technology, VOCABSPHERE fosters creative thinking, problem-solving, and sustainable innovation within the educational community.

6. Potential commercialization

This eBook can be marketed to schools, universities, language centres, and individual learners as a supplementary English learning resource. It can be distributed through online platforms such as institutional websites, learning management systems, or digital marketplaces. Potential commercial models include individual purchases, institutional licensing, or bundled packages with classroom activities and teacher guides. The product may also be expanded into different CEFR levels, interactive versions, or mobile-friendly formats, increasing its market value. With minimal production and distribution costs, VOCABSPHERE offers a sustainable opportunity for educational entrepreneurship.

7. Acknowledgment

The development of VOCABSPHERE would not have been possible without the dedication and collaboration of all team members involved in this project. The authors would like to express their sincere appreciation to the team for their valuable contributions, ideas, and commitment throughout the design and development process. Special thanks are also extended to colleagues and educators who provided constructive feedback and professional insights that helped improve the quality and relevance of this product. Their support and cooperation have been instrumental in bringing this innovation to fruition.

8. Researchers' Biography

Nursuhaila Ibrahim is a Senior Lecturer at UiTM. She completed her Masters in English as Second Language (M.ESL) from Universiti Malaya in 2013. Her areas of expertise include, Teaching English as Second Language (TESL), Speaking Skills and Sociolinguistics. Prior to her service in UiTM, Nursuhaila has served as an English lecturer at an established private university.

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KiND Quest

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ABSTRACT

Traditionally, academic performance has been the primary indicator of educational success. However, the cultivation of *adab,* encompassing respect, manners, and moral values, is equally vital for holistic human development. Many learners today excel intellectually yet display declining ethical conduct, revealing a critical imbalance. This situation underscores the urgent need to reintegrate character formation with scholarly pursuit. To address this challenge, KiND (Kindness in Navigating Decisions) is an educational board game designed to nurture both academic excellence and ethical behaviour. It integrates kindness, empathy, and ethical decision-making into classroom practice through structured modules, reflective exercises, and scenario-based play. The initiative highlights that true educational success lies in producing individuals who balance intellectual achievement with moral integrity, thereby contributing positively to society. It redefines success as the balanced development of mind and character. With adaptability across educational and professional settings, KiND also presents strong commercialisation potential as a scalable, marketable tool for innovative character education.

Keywords: Academic performance, adab, kindness, ethical decision-making, holistic education.

1. Product Description

KiND is an innovative educational initiative designed to nurture good manners and ethical conduct in a relaxed yet impactful way. Unlike conventional academic programs that focus solely on intellectual excellence, KiND emphasises holistic human development by integrating knowledge with values, etiquette, and Islamic principles of morality. The aim is to cultivate individuals who are not only academically competent but also socially responsible, spiritually grounded, and emotionally balanced. Through interactive modules, storytelling, role-play, and practical activities, KiND provides learners with real-life scenarios to practice respect, empathy, and responsibility. It is tailored for students, educators, and parents, making it versatile across different age groups and learning environments. The approach is simple, engaging, and relatable, ensuring that values are absorbed naturally rather than imposed rigidly. KiND stands out as a comprehensive package that combines intellectual growth with character building. It encourages

learners to embody kindness, humility, and discipline in everyday life. By focusing on adab (manners) and akhlak (morality), KiND contributes to the creation of a generation that is well-rounded, compassionate, and capable of contributing positively to society. Ultimately, KiND is more than a program; it is a movement to restore the importance of ethics in education and is a way of life.

2. Pictures and Schematic diagrams

Figure 1. Instructional and gameplay flow of the KiND card game.

Figure 1 illustrates the instructional flow of the *KIND Card Game: Adab and Akhlak*, a values-based learning activity designed to cultivate moral character, social etiquette, and prosocial behaviour through structured play. The process begins with picking a KIND card, each representing a core value such as honesty, respect, or gratitude. Each card then introduces a scenario drawn from everyday life, ensuring relevance to learners' real-world experiences. Participants are encouraged to act it out through role-play, practising appropriate responses that reflect good manners and ethical conduct. The learners reflect and discuss the action, focusing on its consequences, moral implications, and social impact. This reflective dialogue reinforces understanding and internalisation of values. Finally, participants earn points for thoughtful, kind, and respectful responses, adding a motivational element that rewards ethical reasoning and positive behaviour. Overall, the figure presents a cyclical, learner-centred model that integrates cognitive understanding, behavioural practice, and reflective discussion to support character education in an engaging and developmentally appropriate manner.

3. Novelty and uniqueness

The novelty and uniqueness of the KIND Card Game, Adab and Akhlak lie in its integrated, play-based approach to character education that bridges moral theory with lived social practice. Unlike

conventional values education that relies heavily on didactic instruction, this model transforms ethical learning into an experiential and dialogic process. By embedding abstract moral concepts such as respect, honesty, and gratitude within relatable real-life scenarios, the game enables learners to actively construct moral understanding rather than passively receive it. A distinctive feature is the structured progression from value identification to role-play, reflection, and reinforcement. The role-play component uniquely operationalises *adab* and *akhlak* by allowing learners to rehearse ethical responses in realistic contexts, promoting behavioural transfer beyond the classroom. The reflective discussion phase further differentiates the model by encouraging moral reasoning, empathy, and perspective-taking, aligning affective, cognitive, and behavioural domains of learning. Additionally, the use of a point-based reinforcement system introduces motivational gamification without undermining moral intent, balancing intrinsic and extrinsic motivation. Culturally grounded yet pedagogically flexible, the game uniquely integrates moral education, social-emotional learning, and active pedagogy into a cohesive framework, making it adaptable across age groups and educational settings while preserving its ethical depth and practical relevance.

4. Benefit to mankind

KiND benefits humanity by promoting a culture of respect, empathy, and responsibility. In a world increasingly dominated by competitiveness and material achievement, KiND emphasises the significance of compassion and ethical behaviour. Families, schools, and communities benefit from the development of well-rounded students. The program contributes to the reduction of social disputes, the promotion of harmony, and the encouragement of cooperation among people from different backgrounds. Ultimately, KiND creates a generation that prioritises humanity over performance. This has long-term implications for society, such as increased social cohesion, ethical leadership, and ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all (Sustainable Development Goal 4).

5. Innovation and Entrepreneurial Impact

KiND represents an innovative educational card game that integrates academic skill development with moral and character formation within a coherent and practical basis. Unlike conventional approaches that treat values education as peripheral, KiND embeds ethical development as an essential and applied component of contemporary learning. Its entrepreneurial strength lies in its flexibility and modular design, allowing implementation through workshops, digital learning platforms, school-based programs, and community initiatives. This adaptability enables KiND to respond effectively to diverse educational needs and institutional contexts. The package's distinctive value proposition is its grounding in Islamic principles of *adab* and *akhlak*, presented in a manner that is pedagogically relevant and socially engaging. By addressing the growing demand for ethically grounded yet culturally authentic education, KiND fills a clear gap in the global education landscape. Its scalable design supports sustainable growth while preserving educational quality, positioning KiND as an innovative, market-ready educational game card.

6. Potential commercialization

KiND is intentionally designed as an inclusive character development through a game. While it may draw inspiration from moral traditions found in many faiths, its foundation rests on universal human values such as kindness, respect, empathy, and fairness. These shared values reflect a common ethical understanding that all individuals deserve to be treated with dignity and

compassion, regardless of belief, culture, or background. This universality allows KiND to be meaningfully implemented across diverse educational, social, and cultural settings.
In terms of commercialisation, KiND offers multiple scalable avenues, including printed instructional materials, e-learning platforms, mobile applications, and interactive workshops. Strategic collaborations with educational ministries, non-governmental organisations, and private schools can significantly enhance its reach and institutional adoption. Its universal value base also makes KiND suitable for international markets, particularly in regions seeking structured, values-based character education models that are culturally adaptable, inclusive, and socially relevant.

7. Acknowledgment

Alhamdulillah, we acknowledge the contributions of educators, parents, and community leaders who inspired the creation of KiND. Their dedication to nurturing future generations with strong values and ethics has been the foundation of this initiative. Special thanks to all learners who embody KiND in their daily lives, proving that true success lies in knowledge combined with adab and akhlak.

8. Researchers' Biography

Dr Norrina Din is a distinguished Senior Lecturer in Hospitality and Tourism. Her research spans quality of life, consumer behaviour, food safety, gastronomy, and education, consistently bridging theory with real-world application. Dr Norrina is celebrated for driving innovation, fostering cross-cultural learning, and nurturing future-ready graduates equipped for global hospitality and tourism challenges. Her commitment to academic excellence and industry relevance has elevated professional standards internationally. Through her transformative contributions to research, teaching, and community engagement, Dr Norrina exemplifies visionary leadership and continues to shape the advancement of global hospitality and tourism education. Her email is norrina.din@uitm.edu.my.

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Razanawati Nordin is a senior lecturer at UiTM Kedah and a PhD candidate researching verbal communication in autistic children. With 30 years in ESL teaching, she champions inclusive education, community engagement, and created the IMAN Approach for autism intervention. Her work blends language, empathy, and innovation.

MySafeDerma Portal
"Protecting Every Donation, Empowering Every Donor"

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ABSTRACT
MySafeDerma Portal is a national FinTech–LegalTech innovation developed to address critical governance gaps within Malaysia's donation ecosystem. The absence of a single regulatory authority overseeing charitable activities has led to fragmented oversight, limited verification mechanisms, increased donor vulnerability to fraud, and the frequent freezing of legitimate fundraiser accounts by financial institutions. In response, MySafeDerma Portal introduces a centralized, web-based verification system that strengthens transparency, accountability, and public trust. The portal requires activity organizers to formally register their donation activities, while donors can instantly verify the legitimacy of organizers through a simple and user-friendly interface. Functioning as a national verification database, the system enables financial institutions and regulators to cross-verify registered activities and account information. Through secure Application Programming Interface (API) integration, banks can establish preliminary risk profiles for donation-related accounts, thereby reducing unnecessary account freezes and enhancing monitoring efficiency. MySafeDerma Portal delivers significant socio-economic and governance value by preventing donation fraud before it occurs, supporting legitimate organizers, enhancing institutional oversight, and streamlining investigative processes. With a cost-effective, scalable, and easily integrable design, this innovation demonstrates strong potential for national deployment as Malaysia's central donation verification system, fostering a more transparent, secure, and accountable public donation ecosystem.

Keywords: donation safety, donation verification, FinTech innovation, digital governance, fraud prevention

1. Product Description
The MySafeDerma Portal is a national web platform designed to verify the identities of fundraisers, check the legitimacy of registered activities, and monitor transactions related to public fundraising. The portal enables fundraisers to register their activities with complete details, including the fundraising purpose, target amount, bank account information, and other related supporting documents. Donors can also check the legitimacy of fundraisers by searching according to names, phone numbers, or bank account numbers. The portal also serves as a reference database for financial institutions and regulators. Through API integration, MySafeDerma Portal provides a cross-verification mechanism to help banks assess early risks, prevent inappropriate account freezing, and expedite reviews in the event of a complaint.

Regulators can also access a monitoring dashboard that displays charity activities' status, fundraising patterns, and risk indicators. The design of MySafeDerma Portal emphasizes ease of use, transparency, and security. It provides a cost-effective and user-friendly solution that is easy to integrate into Malaysia's digital ecosystem. This product has the potential to become a national standard for donation verification and public fundraising integrity management.

2. Webpages' Screenshots, Schematic Diagram, and Functional Components Table of MySafeDerma Portal

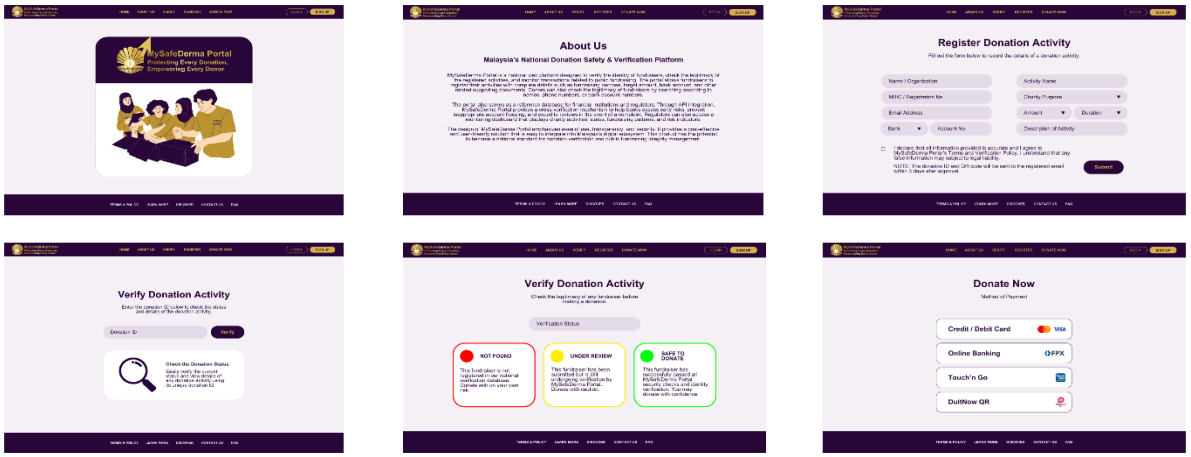

Figure 1. Webpages' Screenshot of MySafeDerma Portal.

Figure 1 demonstrates among others, the main page of MySafeDerma Portal, registration of the fundraisers' activities, verification by the public and, donating safely through the recognised digital payment.

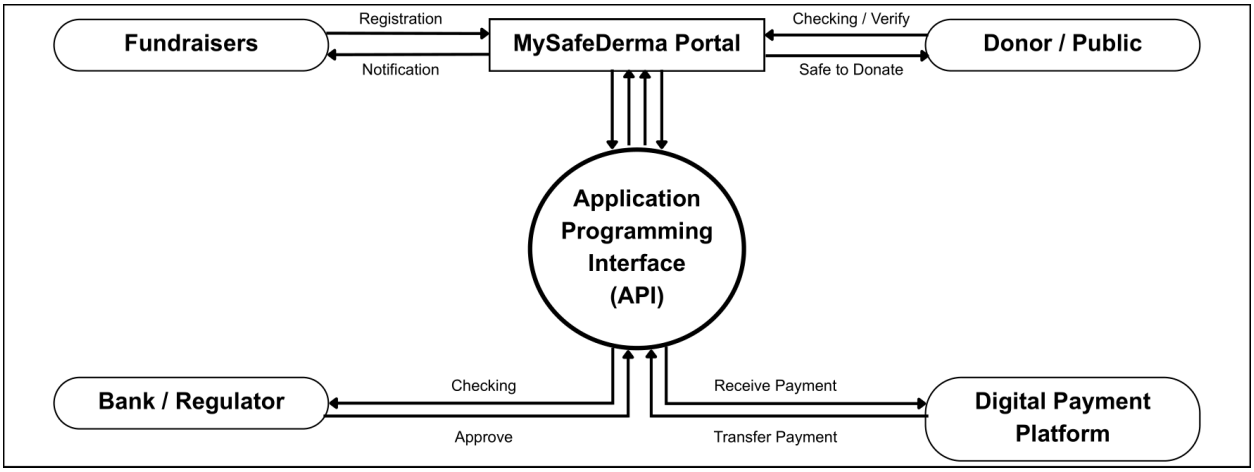

Figure 2. Schematic Diagram.

Figure 2 shows how MySafeDerma Portal functions as a central verification platform connecting donors, fundraisers, banks, and regulators. Fundraisers register their activities in the portal, while donors contribute through existing digital payment platforms. Through API integration, the portal sends real-time verification and alerts to banks and regulators, enabling early fraud detection, preventing unnecessary account freezing, and ensuring transparency. This architecture supports secure, accountable, and scalable nationwide implementation.

Table 1. Functional Components of the MySafeDerma summarizes the key functional modules of the MySafeDerma Portal, showing how donor verification, fundraiser registration, bank notification, and regulatory monitoring are integrated.

Component	Description	Primary Users	Key Features
1. Fundraiser Registration Module	Collect and records fundraiser details such as activities purpose, target amount, and bank account	Fundraiser	Online registration, identify verification, and declaration form
2. Donor Verification System	Allows donors to verify the legitimacy of fundraisers before making donations	Public donors	Account verification check, fraud alert
3. Bank Notification System	Sends automated alerts to banks once a fundraiser account is verified	Bank / Regulator	Account tagging, inflow monitoring, fraud-risk scoring
4. Compliance & Monitoring Engine	Tracks real-time inflow of funds and flags suspicious transactions	Bank / Regulator, MySafeDerma Portal System	Monitoring dashboard, anomaly detection, anti-fraud triggers
5. Governance & Transparency Layer	Ensures transparency and maintain a digital trail for accountability	Fundraiser, Donor, Regulator	Digital records, activities status updates, disclosure reports
6. Centralised Database & Audit Trail	Stores all verified fundraiser data and transaction logs	System / Regulator	Secure database, audit logs, retrieval for investigation
7. User Interface (Web Portal)	Front-end web interface for registration and verification	All users	Simple UI, web-based access, multilingual option

3. Novelty and Uniqueness

MySafeDerma Portal offers a level of innovation that has never been implemented in the Malaysian donation ecosystem. The main uniqueness of this product lies in its concept as the first donation verification platform in Malaysia that combines FinTech, LegalTech, and digital governance elements in a single national portal. Unlike existing donation collection platforms that focus solely on fundraising, MySafeDerma Portal prioritizes security and integrity by providing a cross-referencing system for donor information through API integration with financial institutions and regulators. Among other unique features is the risk monitoring dashboard, which allows regulators to systematically identify unexpected collection patterns, suspicious activities, and verification status. This feature improves the efficiency of fraud investigations and helps banks assess the risk profile of a donation collection activity before taking freezing action. MySafeDerma Portal is also unique in that it offers a safer donor environment, where the public can openly and transparently review the legitimacy of donation collection activities. This approach not only increases public trust but also provides a governance model that can be expanded to the national or regional level.

4. Benefit to Mankind

MySafeDerma Portal directly benefits the community by protecting against fraud in fundraising activities and misuse of public donations. Donors can verify the legitimacy of fundraisers before making a transaction, thus increasing confidence and reducing the risk of fraud. Legitimate fundraisers also get an official platform to register their charitable activities, supporting their fundraising efforts with greater transparency. Moreover, financial institutions get an early reference through verification data, helping them make more informed decisions before freezing accounts. Regulators gain access to a monitoring board that displays risky activities, which will facilitate enforcement actions. Overall, MySafeDerma Portal strengthens the integrity of the donation ecosystem in Malaysia, increases public trust and supports a healthier and more responsible culture of fundraising and giving.

5. Innovation and Entrepreneurial Impact

MySafeDerma Portal is not only a technical innovation, but also a catalyst for the development of a social and digital entrepreneurship ecosystem in Malaysia. By providing a national verification platform, the portal opens up new business opportunities for NGOs, crowdfunding platforms, financial institutions and startups looking to integrate a trusted donation security system. The portal can be commercialized through a subscription model for NGOs, institutional licenses for banks and regulators, and API integration for existing donation platforms. The portal's ability to operate as a national standard system increases its appeal as a high-value product in the market. This innovation also supports Malaysia's aspirations towards digitalizing the social sector through cost-effective, large-scale and easily adaptable technology solutions. As a result, MySafeDerma Portal has the potential to create new job opportunities in the fields of financial technology, digital security and social governance.

6. Potential commercialization

MySafeDerma Portal has a very high and strong commercialization potential through a layered business model that can be directly applied to the country's financial and welfare ecosystem. This platform can be subscribed to by NGOs, humanitarian organizations and crowdfunding platforms

as an official verification system to increase the credibility of their activities. For financial institutions, this portal can be offered through institutional licensing to support the account risk screening process and increase the efficiency of monitoring transactions related to public collections. API integration also provides opportunities for commercial collaboration with technology companies and existing donation applications that want to improve their security features. As a national-scale solution, MySafeDerma Portal also has the potential to be adopted as a standard system by government agencies or regulatory bodies, thus opening up opportunities for long-term contracts and system maintenance. With low development costs, clear market needs and high demand for the security of the charity ecosystem, this product is ready to be widely marketed in Malaysia and the ASEAN region.

7. Acknowledgment

This project is developed as part of an innovation initiative to improve governance and public trust in Malaysia's charity fundraising ecosystem. It is also part of the recommendations to have a single regulator overseeing charity activities in Malaysia, as stated in the PhD research of the project leader. Appreciation is extended to Universiti Teknologi MARA (UiTM), International Islamic University of Malaysia (IIUM), all institutions, advisors, and stakeholders who contributed insights toward the conceptual development of this innovation project.

8. Researchers' Biography

Puan Rozita Othman, the leader for this leading innovation project, is a Senior Lecturer at the Faculty of Law, UiTM Shah Alam, from 2005 and teaches Corporate Law, Trust Law, and Moral and Ethical Issues. She is the Coordinator of the Risk Unit at the Faculty of Law, UiTM Shah Alam. She was an advocate and solicitor at the High Court of Malaya from 1999 to 2004. She graduated with LLB (Hons) and LLM degrees from the University of Malaya, Kuala Lumpur. Currently, she is pursuing her PhD at the International Islamic University Malaysia in the field of charity governance.

Dr. Farizah Mohamed Isa is a Senior Lecturer at UiTM's Faculty of Law with over 20 years of teaching experience in intellectual property, contract, and tort law. She holds an LLB (Hons) from Liverpool John Moores University and completed her LLM and PhD at UiTM. She has taught across diploma to PhD levels and supervised doctoral students. Her leadership roles include Head of the Bachelor of Legal Studies program, Head of Intellectual Property Management at UiLC and RIBU, and Deputy Director at BITCOM. She contributed to drafting UiTM's Intellectual Property and Commercialisation Policies, advancing innovation governance.

Honorary Associate Professor Dr Tunku Intan Mainura Tunku Makmar Nizamuddin is currently co-supervising a PhD student at Law Faculty of UiTM. She Initially joined UiTM in 1998 as a lecturer before her retirement in May 2025. She obtained her PhD (Outer Space Law) from Newcastle University, UK in 2010, her LLM (Public International Law) from Nottingham, UK in 1995 and her LLB (Hons) from Universiti Kebangsaan Malaysia, Malaysia in 1993. In 1994, she was called to the Bar as an Advocate & Solicitor (High Court Malaya). She had represented Malaysia in workshops and conferences on outer space law and policy.

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SafeServe360: Integrated Food Safety Observation & Compliance Rubric

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ABSTRACT

The innovation includes the Premises Observation Rubric for Food Safety Compliance, which is intended to be used in the systematic evaluation of foodservice operations at UiTM Puncak Alam. Accordingly, the rubric was created to address the gap between academic learning and industry implementation and turn the traditional checklists into a practical, measurable, and structured tool. Developed during the Week Without Walls program of experience, it will enable students and operators to perform direct observations in accordance with the Food Act 1983, Food Hygiene Regulation 2009, *Makanan Selamat Tanggungjawab Industri* (MeSTI), and *Bersih dan Selamat* (BeSS) regulations. What is unique about this rubric is that it is rated on quantitative terms, has a wide range of 30 criteria, and serves dual purposes as an academic evaluation instrument and an industry compliance tool. Furthermore, it offers the benefits of being reproducible, clear in pinpointing gaps and versatile across a wide range of foodservice settings. In addition, the socio-economic aspects of the rubric result in higher health protection, consumer confidence, and workforce competence, while the socio-environmental aspects result in sustainable practices in waste management, pest control, and hygiene. As it may be commercialized, the rubric can be developed into a digital compliance application or a consultancy toolkit, with services offered being subscriptions for SMEs and institutional kitchens interested in certification. This innovation is therefore a scalable, effective, and entrepreneurial solution that promotes food safety education, industry standards, and community welfare.

Keywords: Food safety; Observation; Innovation; Compliance; SafeServe

1. Product Description

SafeServe360 is an overall observation rubric and reporting system, which is an innovation to enhance food safety in foodservice operations. It introduces the 30 standardized criteria that encompass the main areas, including facilities, storage, service, ware washing, garbage disposal and pest control. Following this, the assessment of both criteria is conducted with the assistance of the quantitative scoring system, according to which the responses are evaluated as Yes, No, or Not Applicable. This logicality concept guarantees the objectivity of the results and their measurement, as well as being free of any ambiguity, and provides specific data for analysis in order to comply and achieve continuous improvement.

In essence, SafeServe360 is relatively convenient, as it meets the national food safety standards and certification programs, such as MeSTI and BeSS. With the inclusion of these standards in the rubric, the system can ensure that the observations applied are educational and industry specific. The innovation also fosters student participation in the name of experiential learning, namely during the Week Without Walls, when students will gain real-world experience in foodservice and apply their theoretical knowledge to reality. Concurrently, the reporting system will produce a summary and optimization recommendations in addition to compliance, as well as food safety observations are a dynamic innovation tool. In general, SafeServe360 provides the opportunity to identify gaps, propose solutions, and implement changes to close the gap between academic and industry applications and to improve accountability, innovation, and excellence in food safety management.

2. Pictures/Schematic diagrams/Flow Charts/Screenshots/Graphs/Tables, etc.

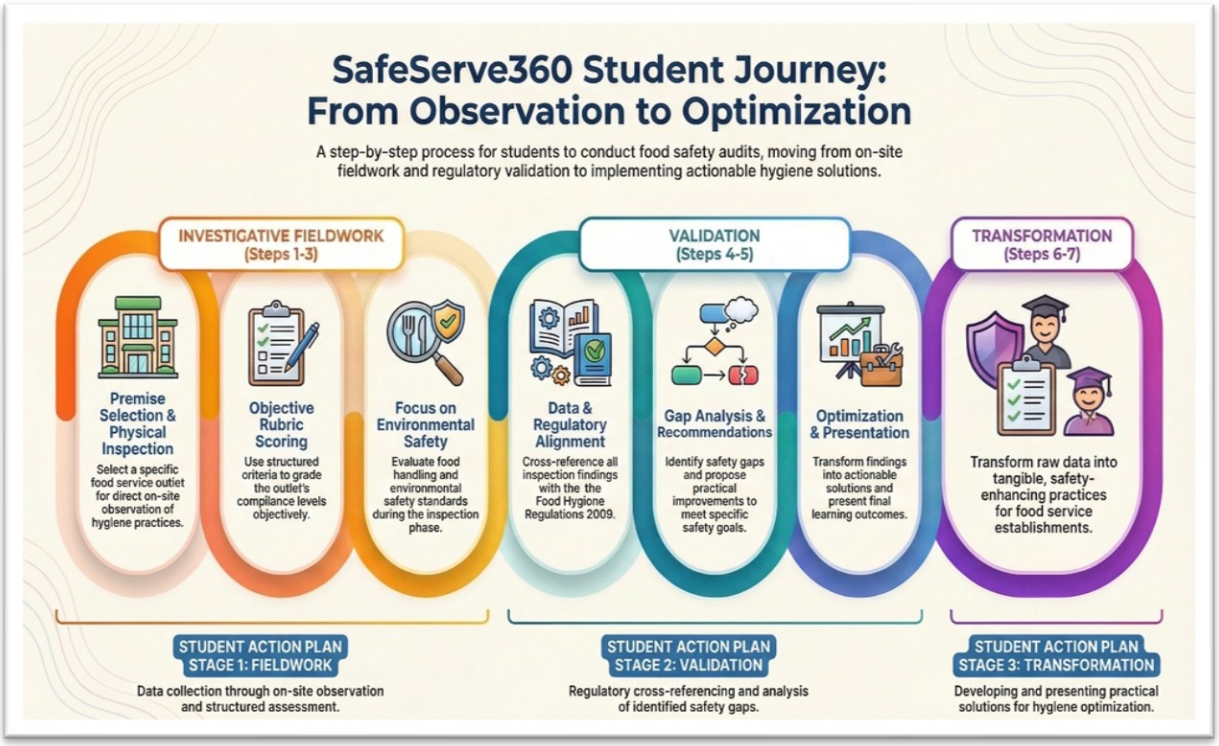

Figure 1. SafeServe360: Integrated Food Safety Observation & Compliance Flow Chart.

Table 1. SafeServe360: Student Perspective Workflow.

Step	Phase	Student Action & Objective
1	**Premise Selection**	**Identify the target:** Select a specific foodservice outlet (cafeteria, kiosk, or stall) located within the UiTM Puncak Alam campus.
2	**Direct Observation**	**Go on-site:** Visit the selected premise to conduct a physical inspection of hygiene practices, food handling, and environmental safety.
3	**Rubric Scoring**	**Evaluate:** Apply the **SafeServe360 structured criteria** to grade the outlet's compliance levels objectively.
4	**Data Compilation**	**Organize:** Convert your raw notes and scores into measurable outcomes (charts, percentages, or compliance ratings).
5	**Regulatory Alignment**	**Verify:** Cross-reference your findings with National Food Safety Standards (e.g., Food Hygiene Regulations 2009) to ensure legal validity.
6	**Summary & Recommendations**	**Analyze:** Identify the gaps between current practices and safety goals, then propose practical improvements.
7	**Optimization Output**	**Transform:** The final stage of the observation process, where raw findings are transformed into actionable solutions to enhance food safety standards.

3. Novelty and uniqueness

SafeServe360 may be regarded as an embodiment of a mix of pedagogy and enforcement and converting the theoretical knowledge of food safety into practice. The Week Without Wall program also exposes students to the real world of foodservice and challenges them in working conditions, enabling them to put what they learn in the classroom into context. Furthermore, this applied learning helps bridge the gap between what is taught in the classroom theory and what is practiced in the industry, whereby the students can view, assess and analyze how the requirements set in regulations can be applied into practice. In addition, it creates a sense of critical thinking and professional responsibility, and an increased regard for the norms of hygiene and safety. In other words, it is an innovation revolving around a system in which subjective observation is substituted with the measurable, repeatable scoring, that is, a system based on rubrics. The standards are all properly outlined and do not violate the national laws regarding food safety, including the Food Act 1983 and the Food Hygiene Regulation 2009. At the same time, it is a sequential process that maintains consistency in assessment, and students can also establish measurable data that will be applied to facilitate learning and operational enhancement. Accordingly, SafeServe360 will be a two-fold application, and it will be utilized as an educational assessment tool by teachers and as a regulatory one by foodservice establishments. Moreover, it allows teachers to assess the abilities of learners, and operators can have their experience of hygiene gaps identification and regulation adherence. Consistent with this, its versatile design enables it to be installed in any foodservice environment, from a campus dining hall to a commercial restaurant, a catering service, or even an institutional kitchen, as an applicable teaching, enforcement, and creativity appliance.

4. Benefit to mankind

SafeServe360 represents a complex ripple that crosscuts the economic, social, health, and welfare of the community. Concerning the protection of overall health, the rubric mitigates the risk of foodborne disease through systematic oversight of hygiene, storage, and service practices. Such organized treatment will ensure that threats of unsafe circumstances or contamination are identified early and addressed to protect consumers. Furthermore, SafeServe360 enables students, within the framework of educational empowerment, to become participants in the process of food safety enforcement. In this way, they can be introduced to the practicalities of compliance implementation in real-world settings through practice in real-life situations, thereby reinforcing their professional competence and preparation to work in the foodservice management field. The availability of clear, actionable feedback to operators is another aspect of the innovation that presents high rates of vendor optimization. Generally, SafeServe360 can be used as an operational excellence tool, as this feedback helps identify areas of strength, highlight areas of weakness, and continually work on them to improve. Lastly, it instills trust in communities by bolstering consumer confidence in college and business food venues by increasing visibility into food safety standards and their consistent enforcement.

5. Innovation and Entrepreneurial Impact

SafeServe360 facilitates innovation by making food safety education an interactive practice that is research-based. As an academic innovation, it serves as a teaching method and a research instrument for pedagogy in food safety. Correspondingly, students will be equipped to implement theoretical knowledge in practice, which will produce quantifiable data that can be examined to assess compliance, make improvements, and conduct scholarly research. Likewise, this twofold position enhances the academic curriculum, but at the same time, food safety research is being developed. As an entrepreneur, there are many commercialization prospects with SafeServe360. The rubric can be presented as a consulting toolkit to Small and Medium Enterprises (SMEs) that apply to the certification of MeSTI or BeSS. It helps businesses comply by offering structured, practical feedback, lowering external audit costs, and simplifying the audit process. This renders innovation a resource that can be of value to the industry players and consultants.

It is also highly probable that the project will have significant digital potential in the future when converted into a mobile application or a cloud-based compliance tracker. Remarkably, these may be provided on subscription terms such that food operators can monitor hygiene operations in real time, generate reports, and maintain them according to the regulatory demands. Subsequently, this digital transformation is shaping the culture of entrepreneurship at the community, institutions, and industry levels by enhancing scalable solutions, new business models, and increasing people's trust in food safety.

6. Potential commercialization

SafeServe360 is capable of offering a simple path to innovation and entrepreneurship since it can be customized in numerous environments. The application of the rubric at the campus level may be a typical compliance audit tool that UiTM food outlets can apply to improve student learning, and the quality of campus dining service may be improved simultaneously. Beyond the world of academia, a rubric can be employed to enhance industry, as restaurants, catering companies and institutional kitchens can use it to perform self-audits. It also requires fewer external audits and

inspections in creating a culture of continuous improvement. On a similar note, the project has immense potential under the influence of digital transformation and the commercialization of a Food Safety Observation App. The operators would be able to track compliance in real-time using analytics dashboards, real-time scoring, and regulatory reporting, and make decisions based on that information. Finally, the SafeServe360 can be developed as a prototype of consultancy where the rubric will be licensed to food safety trainers and auditors, creating business opportunities and improving standards in the sector.

7. Researchers' Biography

Lovelyna Benedict Jipiu is a senior lecturer at the Faculty of Hotel and Tourism Management, Universiti Teknologi MARA (UiTM), Malaysia, with more than 20 years of experience in academia. She completed her PhD in Hotel and Tourism Management (specialized in food safety management) at UiTM Sham Alam, followed by an MSc in Food Science and Nutrition, University of New South Wales, Sydney, Australia. Her academic career is characterized by an outstanding commitment towards research and publication, which she actively pursues, as the first corresponding author in national as well as international periodicals.

Manser Jame Lee is currently pursuing his master's degree in Gastronomy at Universiti Teknologi MARA (UiTM), Puncak Alam. His academic trajectory reflects a progressive engagement with the multidisciplinary study of food, beginning with hotel management, advancing through culinary arts, and culminating in gastronomy. Through this academic lens, he contributes to the growing discourse on gastronomy as an interdisciplinary field, positioning food as a site of knowledge production that bridges professional expertise with cultural and theoretical analysis.

ACE-Cholinergic: A One-Screen Microlearning App to Simplify Cholinergic Pharmacology

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ABSTRACT

Understanding pharmacology is often challenging for medical undergraduates, as many topics are concept-dense, mechanism-heavy, and difficult to integrate within conventional lecture-based teaching. Among these, cholinergic pharmacology represents a foundational yet particularly complex area that requires a clear understanding of mechanisms of action, their effects, and clinical relevance. This complexity, compounded by the breadth of curricular content, frequently results in superficial learning and suboptimal or poor knowledge retention. To address these challenges, we propose *ACE-Cholinergic*, a teaching innovation conceptualized as a handy, hassle-free learning resource to complement lectures and support students' independent learning in cholinergic pharmacology topic. *ACE-Cholinergic* is conceptualized as a progressive web-based microlearning product that delivers concise, topic-focused one-screen learning cards integrating mechanisms of action, pharmacological effects and adverse drug reactions. The design emphasizes low cognitive load, clarity, and ease of access, enabling learners to revisit complex concepts efficiently during brief periods of available time. Embedded short self-check activities promote active recall and allow students to monitor their understanding and identify areas requiring further revision. This innovation aims to enhance student engagement, improve conceptual understanding of complex pharmacological mechanisms, and support better knowledge retention in undergraduate medical education. *ACE-Cholinergic* demonstrates strong potential for scalability and adoption as an educational support product, with opportunities for institutional implementation and future expansion to additional pharmacology topics.

Keywords: Microlearning; Innovation; Pharmacology; Cholinergic; Education

1. Product Description

ACE-Cholinergic is a proposed progressive web-based microlearning product designed to complement traditional lectures in teaching cholinergic pharmacology, a foundational yet highly complex component of undergraduate medical education. While lectures remain essential, the density and breadth of pharmacology content often result in cognitive overload, superficial learning, and suboptimal knowledge retention. *ACE-Cholinergic* is conceptualized as a handy, hassle-free companion resource that reinforces key lecture content and supports independent learning. The platform delivers concise, topic-focused one-screen learning cards integrating mechanisms of action, pharmacological effects, and adverse drug reactions in a clear, visually guided format. Its low-cognitive-load design enables students to revisit complex concepts efficiently during short pockets of free time, such as while waiting for lectures, commuting, or even during breaks. The platform incorporates a lecturer-managed Q&A function, where questions submitted are

addressed by the lecturer in charge of the topic to ensure accurate and curriculum-aligned guidance. At its initial stage, the innovation is personalized for UiTM medical students. It is free to access, requires no downloads, and is optimized for cross-device use. At the time of submission, ACE-Cholinergic remains at the proposal stage, with prototype development and pilot testing planned in subsequent phases prior to wider implementation and scalability to other pharmacology topics.

2. Figures on the Learning Flow and One-screen Learning Card Design on ACE-Cholinergic Microlearning Tool

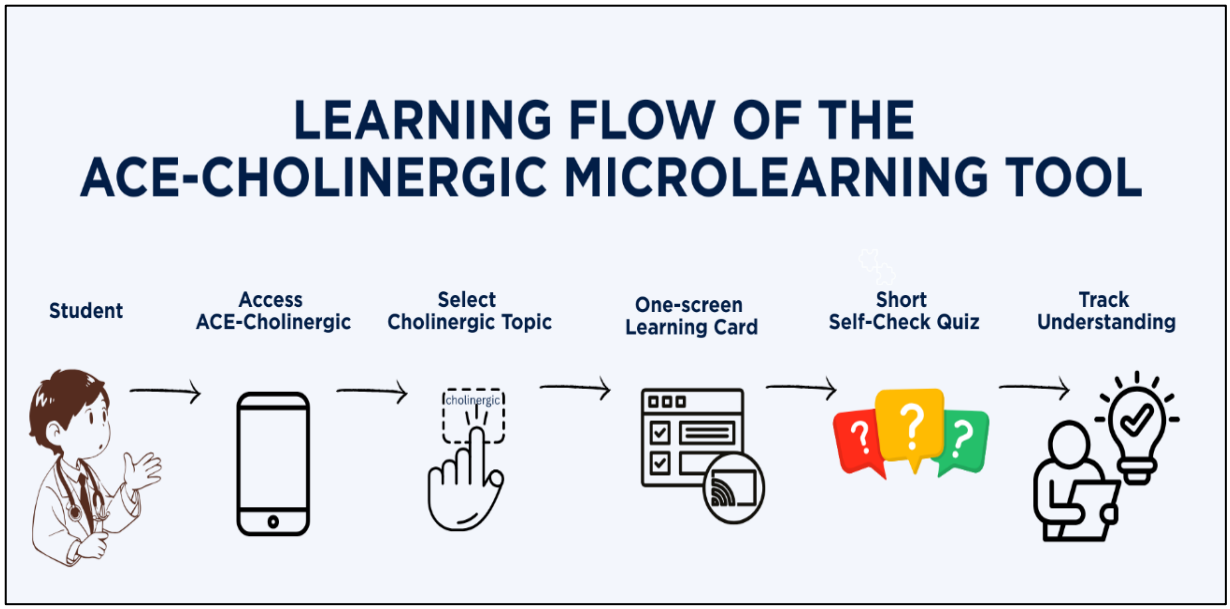

Figure 1. Workflow of Learning in the ACE-Cholinergic Microlearning Tool.

Figure 1 outlines the learning flow of ACE-Cholinergic, beginning with student access to the platform and selection of a cholinergic topic. Learners then engage with a one-screen learning card followed by a short self-check quiz to promote active recall. The final stage allows students to track their understanding and identify topics requiring further revision, supporting efficient, self-directed learning within short periods of available time. **Figure 2** illustrates the one-screen learning card design of *ACE-Cholinergic*. Each card presents concise, high-yield information on a specific cholinergic drug, integrating the mechanism of action, clinical uses, and adverse drug reactions in a visually guided format. Visual elements such as diagrams, videos and icons are used to replace wordy text and enhance knowledge retention. Embedded features include a checklist to track revision progress, a lecturer-managed Q&A button for topic-related queries, and a short self-check quiz to allow learners to assess their understanding after reviewing the content.

Figure 2. One-Screen Pharmacology Learning Card Design for Cholinergic Drugs.

3. Novelty and uniqueness

This microlearning app is distinguished by its *lecturer-managed* and *institution-personalized* design**,** where content and topic-specific Q&A are overseen by the lecturer in charge and tailored to UiTM medical students, ensuring accuracy, relevance, and curriculum alignment. Unlike generic pharmacology apps, the innovation employs an intentional *one-screen microlearning approach* that integrates important pharmacology components within a single, focused interface to reduce cognitive load.

4. Benefit to mankind

This app aligns strongly with *Sustainable Development Goal 4 (SDG 4: Quality Education)* by supporting inclusive, equitable, and effective medical education through accessible digital learning. By strengthening foundational pharmacology knowledge and promoting better knowledge retention, the innovation contributes to the development of competent future healthcare professionals, indirectly supporting *SDG 3 (Good Health and Well-Being)* through safer prescribing and improved patient care. Its free, scalable digital approach has the potential to reduce educational inequities by widening access to high-quality learning support, particularly in settings with limited resources or high academic workload. By fostering self-directed and lifelong learning habits among medical trainees, this app supports sustainable capacity building in healthcare education, with long-term benefits for health systems and society.

5. Innovation and Entrepreneurial Impact

ACE-Cholinergic promotes innovation by translating educational challenges in pharmacology into a digitally scalable microlearning product, reflecting an entrepreneurial approach to educational problem-solving. The project demonstrates how academic domain expertise can be transformed into an edtech-oriented solution with relevance beyond a single course or institution. Its development encourages industry-relevant practices such as user-centered design, modular content architecture, and iterative product development, aligning with current trends in digital learning and health education technologies. At a broader level, *ACE-Cholinergic* contributes to a culture of entrepreneurship by showcasing how teaching innovations can evolve into sustainable, impact-driven educational products that address real-world learning needs in medical education.

6. Potential commercialization

ACE-Cholinergic has strong potential for commercialization as a modular digital learning product within the medical education and edtech markets. Its progressive web-based architecture enables flexible deployment through institutional licensing, subscription-based access, or customized institution-branded solutions for medical schools and training centers.

7. Acknowledgment

I would like to acknowledge the Faculty of Medicine, UiTM, for providing the support and opportunity to expand my teaching and learning ideas and activities in UiTM.

8. Researchers' Biography

Dr Norasikin Ab Azis is a Senior Medical Lecturer in Pharmacology Department at the Faculty of Medicine, Universiti Teknologi MARA (UiTM), Sungai Buloh Campus. Her primary research focus is on the cardiovascular system, and in recent years she has developed a strong interest in medical education. In addition to her ongoing fundamental research, she has received several awards in teaching and learning innovation competitions and has served as a judge in selected innovation competitions.

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Associate Professor Dr. Norhafiza Razali is a pharmacologist specializing in innovative ocular therapies, investigating the neuroprotective and intraocular pressure-lowering effects of resveratrol in glaucoma. She has received multiple awards for her contributions across research, pharmacology education, and mentorship of undergraduate and postgraduate students. An accomplished innovator, she serves as Managing Editor of the Journal of Clinical and Health Sciences and translates scientific discovery into practical solutions, advancing eye health, pharmacological knowledge, and educational excellence.

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HEPLine PMJB: A Digital Transformation Platform for Integrated Student Affairs Management

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ABSTRACT

HEPLine Politeknik METrO Johor Bahru (PMJB) is a digital platform for student affairs management (HEP) that centralizes and automates the functions of Student Affairs Department (HEP). It was purposely created to eliminate inefficiencies and the extensive use of papers in manual processes which led to delays and data discrepancies. The platform is based on ADDIE methodology which means the conversion of physical HEP manual processes to digital ones is systematic and user centric. One of the main features of the platform is a One-Stop Digital Hub that includes functionalities such as application processing in real time, automated PDF document generation and sending email immediately to the applicant. Remarkably, this innovative product was developed at zero cost, making use of existing institutional resources only. The project generates a great socio environmental impact by promoting SDG 12 through its 'paperless' operations, thus significantly lowering paper waste. On the socio-economic side, it raises staff productivity by lessening their clerical work by approximately 60%-70%, thereby giving them more time to focus on students' welfare. Having demonstrated its reliability and based on cost saving measures, HEPLine PMJB has very good commercialization potentials especially among educational institutions which are looking for sustainable and low cost digital transformation solutions.

Keywords: digital transformation, student affairs management, paperless innovation, integrated digital ecosystem, sustainable development goals (SDG)

1. Product Description

The web application HEPLine PMJB serves as an advanced digital solution which changes the way Student Affairs management operates at Politeknik METrO Johor Bahru. The platform functions as a comprehensive digital center through its ability to transform all paper-based manual processes into complete online operations. The transition of these physical HEP manual processes to digital ones is carried out systematically based on the ADDIE methodology, as illustrated in **Figure 1**. The system enables students to submit requests through digital forms such as indemnity forms and leave of absence forms while the system automatically generates PDF documents and sends email alerts. The system also enables centralized data storage which maintains information security and accessibility to students throughout the entire day. The HEPLine PMJB system provides administrative advantages while maintaining environmental sustainability through its paperless operations which support Sustainable Development Goals (SDG) 4, 9, and 12. The system presents an affordable development solution which enables educational institutions to modernize their infrastructure. The platform enables organizations to

decrease their administrative expenses by 60%-70% which creates more opportunities to support student success and personal growth.

2. Method Flow Chart and Making-up Process

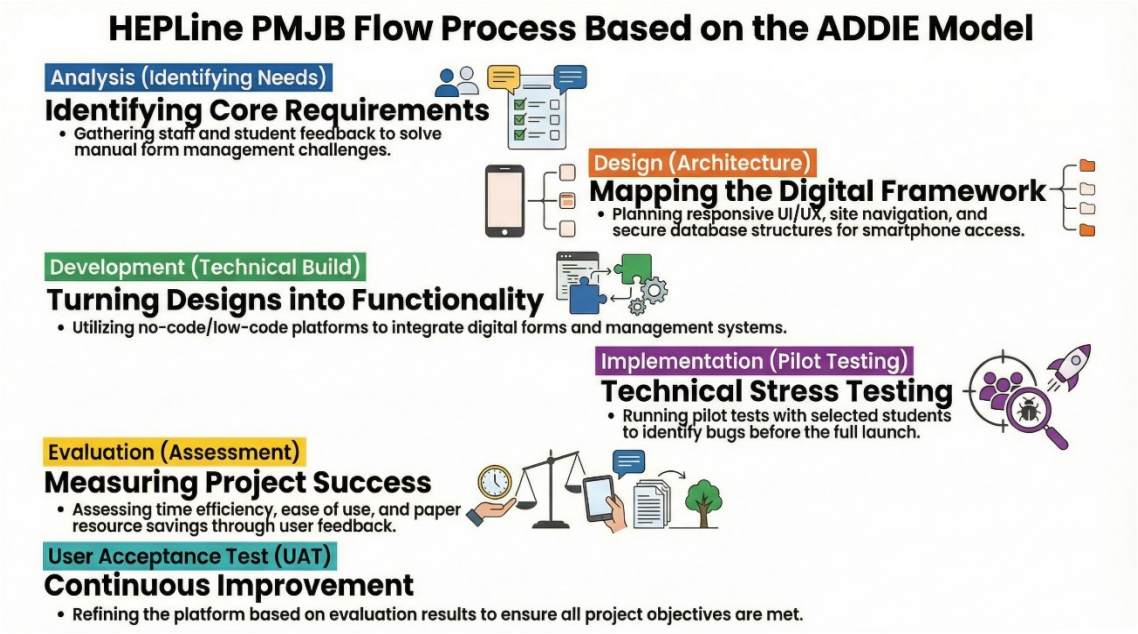

Figure 1. HEPLine PMJB Flow Process Based on the ADDIE Model.

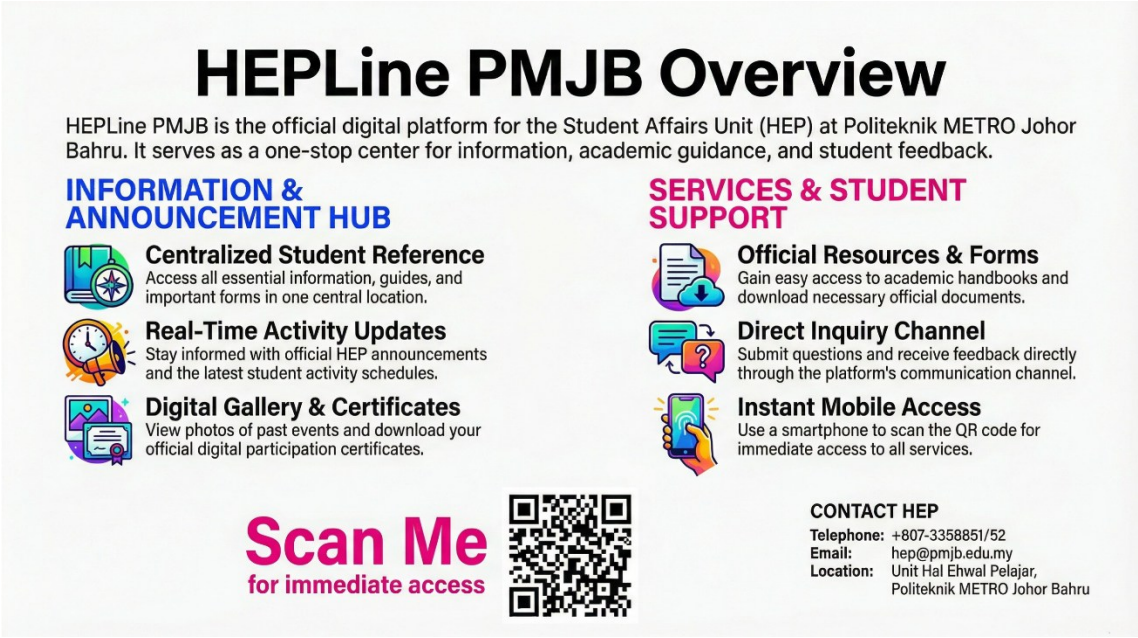

Figure 2. HEPLine PMJB Overview.

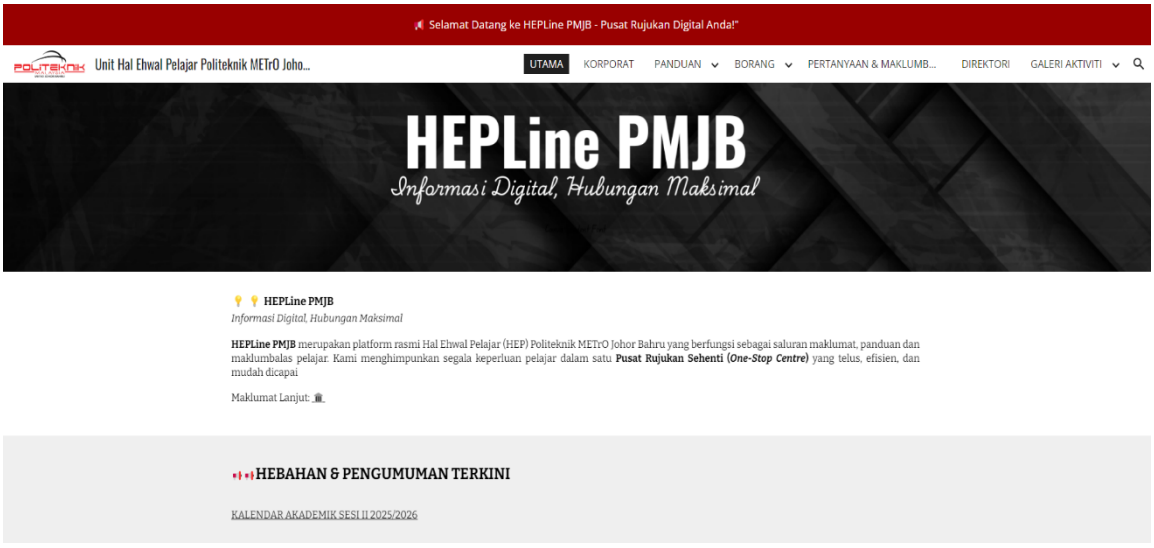

Figure 3. HEPLine PMJB Interface.

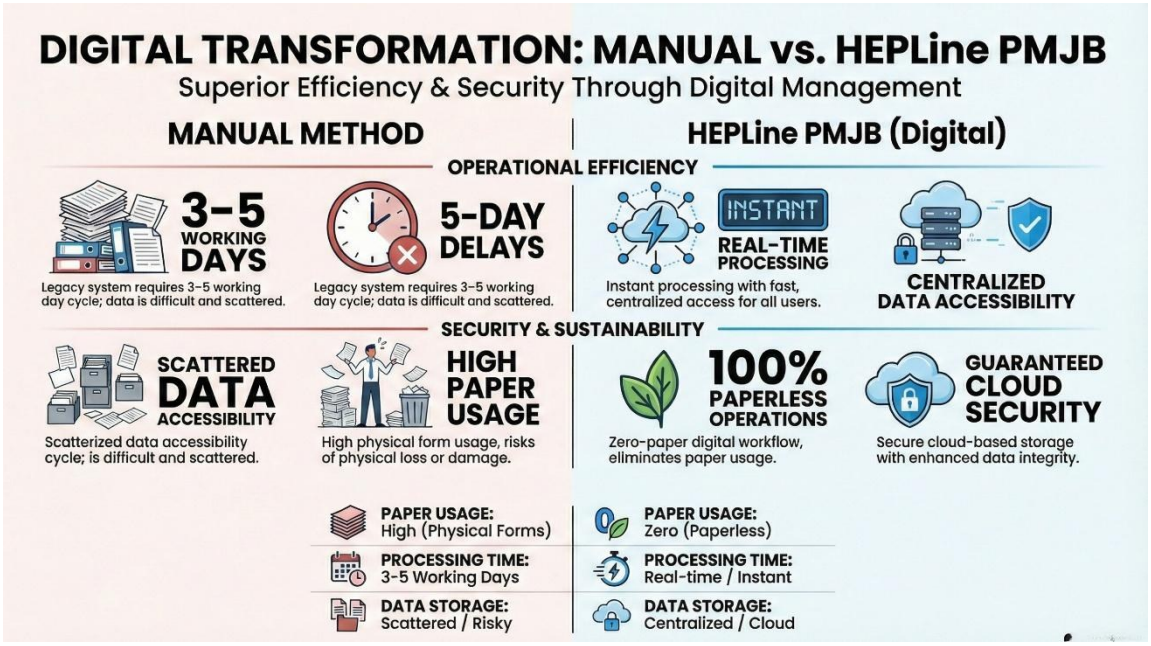

Figure 4. HEPLine PMJB System Transformation.

3. Novelty and Uniqueness

The breakthrough of HEPLine PMJB lies in its transition from a manual, paper-based operation to an entirely digitally integrated system without any cost to the institution. Unlike conventional student affairs processes, the platform acts as a single, centralized One-Stop Digital Hub. The platform serves as a comprehensive digital ecosystem, offering features such as centralized student references, easy access to forms, and a direct inquiry channel which are summarized in **Figure 2**. This overview highlights the platform's role as a one-stop center for all student services. Students can get almost instant access to vital services through its Quick Access functionality, which is a better experience compared to separate, unrelated platforms. The system

can also create real-time PDF files automatically and notify students directly. It prevents unnecessary delays and maintains a smooth flow of processes with visible and clear checkpoints. Referring to , a process requiring 3-5 days previously can now be done instantly through this digital transformation. Moreover, HEPLine PMJB has the Digital E-Certificate system that enables students to download the certificate straightaway, thus, there is no need for hard copy certificates. Furthermore, the platform is a tool for achieving SDG 12 by being a paperless system. The combination of a zero-cost model, real-time automation, and support for multiple SDGs makes HEPLine PMJB very different from simple online form systems.

4. Benefit to Mankind

HEPLine PMJB delivers clear benefits by creating a more efficient and sustainable educational environment. The system boosts institutional productivity by cutting clerical work by about 60%-70%. This automation allows staff to focus more on student welfare and planning instead of routine administrative tasks. The official user interface of the platform, shown in **Figure 3**, provides a transparent and efficient 'One-Stop Centre' for students to access information and official announcements**.** The platform is available 24 hours a day, allowing students to manage official matters without time or location limits. From an environmental standpoint, this innovation supports Sustainable Development Goal (SDG) 12 by using a paperless process, which greatly cuts down on paper use and operating costs. As shown in **Figure 4**, these improvements also raise the quality of education (SDG 4) by offering faster and more transparent service. Additionally, the zero-cost development approach provides a practical model that institutions can adopt around the world to update their systems without financial constraints.

5. Innovation and Entrepreneurial Impact

HEPLine PMJB is a great example of how innovation can be introduced simply by changing manual work to a simple, centralized online system. It illustrates that digital solutions can be created at zero cost if the existing institutional resources are used, thus, not depending on external funding. The idea helps foster an entrepreneurial way of thinking and stimulates institutions to be more resourceful with what they already have. Moreover, the system can be readily implemented by other polytechnics that are interested in a sustainable method of progressing towards digital processes. By cutting down on clerical work by approximately 60%-70%, the staff get more free time to concentrate on significant tasks such as student development and innovation guidance. Moreover, the project advocates the registration of intellectual property (IP), which is a reminder of the critical role of institutional innovations' protection and commercialization.

6. Potential Commercialization

HEPLine PMJB has great potential for commercialization because of its no-cost development model and effective framework. The platform tackles and replaces laborious manual procedures with a real-time One-Stop Digital Hub to solve typical administrative issues in higher education. Email alerts and automatic PDF document creation are two of its primary features, which aid in the development of efficient and standardized workflows. The project is strategically positioned for intellectual property (IP) registration as part of its development phase. The system is a practical and scalable solution for polytechnics and other educational institutions transitioning to digital systems, as it can also reduce clerical work by roughly 60%–70%. The platform provides a

workable paperless management solution without requiring financial investment by supporting effective administration and global sustainability goals.

7. Acknowledgment

Special thanks to the management of Politeknik METrO Johor Bahru for approving this digital initiative. Special appreciation is extended to Director Dr. Supa'at bin Hj. Zakaria @ Jawahir and Deputy Director Hamidah binti Ab Rahman for their administrative support. The team also acknowledges the professional guidance provided by Nurzarimah binti Jamil and Dr. Muhammad Nazri bin Abdul Halim. Finally, thanks are given to the HEP staff and students for their vital participation and feedback during the development phases.

8. Researchers' Biography

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Hjh. Noor Afizah binti Atan is a senior lecturer at Politeknik METrO Johor Bahru and a specialist in Accounting and Islamic Finance. She has more than 20 years of experience and has been polytechnic management lead and innovative digital management system creator. Furthermore, she integrates strategic governance and financial solutions into institutional frameworks. Basically, her knowledge and skills help the institution make new ideas, become more creative, and also implement the SDGs, especially SDG 4, 9, and 12, in the education industry.

Elyn binti Mohd Ridzwan specializes in Shariah, compliant frameworks, innovation, and research methodologies. She has great experience in technical writing and content development thus she can help school and academic documents attain very high quality standards. Besides being a contributor in the research arena, she is a student counselor who deeply cares about the well being and holistic development of students. Her diverse abilities help in facilitating an innovative spirit within the institution, at the same time, she is able to keep all the work done morally and in line with Shariah principles.

Innovating Behaviour, Not Technology: Eco-Can-Bin as a Social Intervention for Sustainable Living

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ABSTRACT

Eco-Can-Bin is a social innovation initiative designed to promote sustainable living by addressing the persistent gap between environmental awareness and actual recycling behaviour. Despite high public awareness, recycling participation remains low due to limited motivation, lack of feedback, and minimal perceived value. Eco-Can-Bin was innovated as a behavioural intervention that applies principles of behavioural nudging, gamification, and positive reinforcement to transform recycling into an engaging and rewarding social experience. Users recycle aluminium cans in exchange for immediate incentives such as e-wallet credits, vouchers, or the option to donate rewards to charitable causes, encouraging both pro-environmental and pro-social behaviour. The main advantage and uniqueness of Eco-Can-Bin lie in its emphasis on changing human behaviour rather than on recycling technology, by embedding social rewards and altruistic choices into the recycling process. The initiative generates positive socio-environmental impact by reducing recyclable waste, strengthening community engagement, and cultivating sustainable habits, while socio-economic benefits are reflected through public participation, charitable contributions, and awareness campaigns conducted in real community settings. Eco-Can-Bin also demonstrates strong commercialization potential through scalable deployment in public spaces, partnerships with CSR programmes, sponsorships, and incentive-based service models.

Keywords: behavioural nudging, social innovation, recycling behaviour, gamification, sustainable living

1. Product Description

Eco-Can-Bin is a human-centred social innovation designed to encourage sustainable behaviour by integrating behavioural science principles with simple digital engagement. The system allows users to recycle aluminium cans and receive immediate rewards, such as e-wallet credits and vouchers, or donate their earned rewards to charitable causes. This approach supports SDG 12 (Responsible Consumption and Production) by promoting recycling practices, waste reduction, and responsible resource management through everyday behaviour. The application of gamification and positive reinforcement addresses behavioural barriers to recycling, fostering long-term habit formation and environmental awareness. By making recycling accessible, inclusive, and engaging for users of all ages and backgrounds, Eco-Can-Bin contributes to SDG 11 (Sustainable Cities and Communities) through enhanced community participation and environmentally responsible urban living.

Furthermore, the project encourages social responsibility and collective action by integrating donation options and community-based awareness campaigns, aligning with SDG 13 (Climate Action) through indirect reductions in waste-related environmental impacts. Eco-Can-Bin functions not merely as a recycling unit but as a social engagement platform that strengthens sustainability culture and supports long-term socio-environmental well-being.

2. Engagement with the Community

Figure 1 illustrates the implementation of the Eco-Can-Bin initiative during the Kiwanis Sentosa Charity Family Day organized in support of the Kiwanis CareHeart Centre. The program served as an awareness and educational platform to introduce the public, particularly families and children, to aluminum and recycling. Through the Eco-Can-Bin system, participants were encouraged to insert used aluminium cans and engage in interactive recycling activities. This approach not only promoted environmental responsibility but also educated the community on the importance of waste segregation and sustainable recycling practices. The activity successfully attracted public participation, demonstrating how interactive recycling initiatives can enhance environmental awareness while supporting community-based charity events.

Figure 1. Eco Can Bin at Kiwanis Sentosa Charity Family Day.

Figure 2 shows the deployment of the Eco-Can-Bin during the Kuru-Kuru Trade With Love event held at Sutera Mall. The program aimed to raise public awareness of sustainable waste management and to educate visitors about the benefits of recycling aluminium cans. Visitors were invited to participate by depositing empty cans into the Eco-Can-Bin and engaging in simple educational activities related to environmental sustainability. By integrating recycling activities into a public event, the initiative effectively reached a wider audience and promoted responsible environmental behaviour. The program highlights the potential of Eco-Can-Bin as an educational tool to foster recycling habits and strengthen community engagement in sustainable waste management practices.

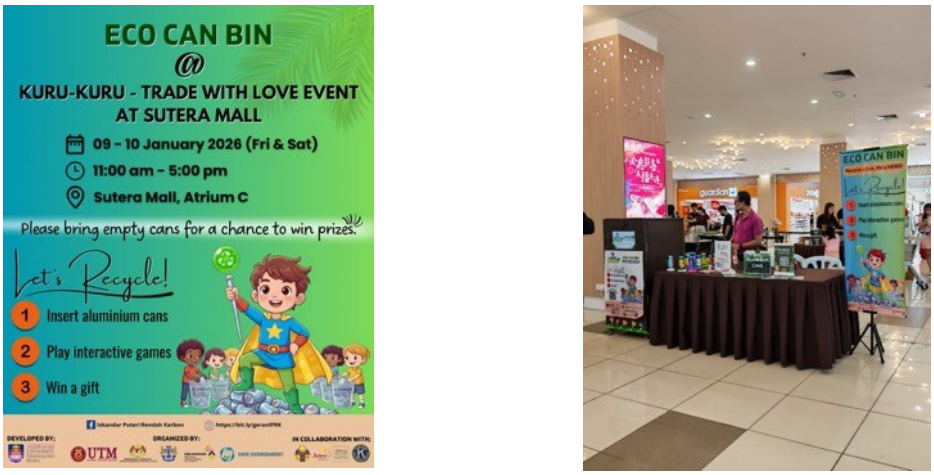

Figure 2. Eco Can Bin at Kuru-Kuru – Trade With Love Event.

3. Novelty and Uniqueness

The novelty of Eco-Can-Bin lies in its emphasis on behaviour innovation rather than technological advancement. While most recycling initiatives focus on improving collection efficiency or sensor technology, Eco-Can-Bin redefines recycling as a social experience driven by behavioural motivation. By applying behavioural nudging, gamification, and social incentives, the system bridges the gap between environmental awareness and consistent recycling action. The inclusion of donation options introduces an altruistic dimension, enabling users to contribute to social causes and reinforcing pro-social values. This dual-reward mechanism distinguishes Eco-Can-Bin from conventional incentive-based recycling systems. Furthermore, Eco-Can-Bin promotes habit formation through repeated positive reinforcement, transforming recycling from an obligation into a voluntary and rewarding behaviour. Its adaptable design enables deployment across diverse community settings, making it a scalable, replicable social intervention model for sustainable living.

4. Benefit to Mankind

Eco-Can-Bin delivers tangible societal benefits by promoting sustained recycling behaviour through real-world community engagement and awareness campaigns. The initiative has been actively implemented through public outreach programmes such as the Eco-Can-Bin @ Kuru-Kuru – Trade with Love Event at Sutera Mall and the Eco-Can-Bin @ Kiwanis Sentosa Charity Family Day, where members of the public were directly exposed to interactive recycling experiences. These campaigns transform environmental awareness into action by allowing participants to recycle aluminium cans, engage in interactive activities, and receive immediate rewards or contribute donations to charitable causes. At the individual level, users develop positive recycling habits and heightened environmental responsibility. At the community level, Eco-Can-Bin strengthens social participation, inclusivity, and collective ownership of sustainability initiatives. By integrating awareness campaigns within real social settings, Eco-Can-Bin effectively bridges the gap between knowledge and practice, contributing to long-term behavioural change and sustainable living.

5. Innovation and Entrepreneurial Impact

Eco-Can-Bin promotes social innovation by demonstrating how behavioural science can be effectively integrated into sustainability initiatives to address real societal challenges. Rather than relying solely on technological advancement, the project introduces an innovative service-based model that redefines recycling as a socially engaging and value-driven activity. By incorporating behavioural nudging, gamification, and reward-based mechanisms, Eco-Can-Bin encourages continuous user participation and fosters a culture of environmental responsibility within communities.From an entrepreneurial perspective, the project creates opportunities for scalable deployment through public–private partnerships, corporate social responsibility (CSR) programmes, and collaborations with local authorities, educational institutions, and commercial centres. Eco-Can-Bin also supports the development of social entrepreneurship by offering potential revenue streams through sponsorships, reward partnerships, advertising spaces, and data-driven engagement services. Furthermore, the initiative provides a practical platform for student innovation, interdisciplinary collaboration, and community-based enterprise development, contributing to a sustainable innovation ecosystem that balances social impact with economic viability.

6. Potential Commercialization

Eco-Can-Bin demonstrates strong commercialization potential through a scalable, service-oriented social innovation model that balances social impact with economic sustainability. The system can be deployed in public spaces such as shopping malls, educational institutions, transportation hubs, and community centres through partnerships with local authorities, corporate organizations, and non-governmental agencies. Revenue generation opportunities include corporate social responsibility (CSR) sponsorships, advertising, and branding spaces on the system interface, rewards, partnerships with retailers and e-wallet providers, and data-driven sustainability reporting services for stakeholders. Additionally, Eco-Can-Bin may be commercialized as a managed service, offering installation, maintenance, community engagement programmes, and behavioural impact analytics. This approach allows organizations to adopt the system without a high upfront investment while achieving measurable environmental and social outcomes. By positioning Eco-Can-Bin as both a sustainability solution and a community engagement platform, the project supports long-term financial viability and broader market adoption across urban and institutional settings.

7. Acknowledgment

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8. Researchers' Biography

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Mohamad Zhafran Hussin is an Associate Professor in the Faculty of Electrical Engineering of the Universiti Teknologi MARA (UiTM), Malaysia. He received his Ph.D in Electrical Engineering from the Universiti Teknologi MARA (UiTM), Malaysia in 2014. His research interest is in Renewable Energy, Energy Efficiency and Electrical Machines.

RescueRecipe: Reduce Waste, Cook Smart

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ABSTRACT

RescueRecipe is a mobile application designed to reduce household food waste by transforming available fridge ingredients into personalized, practical meal suggestions. The application addresses the persistent issue of domestic food wastage, which contributes significantly to environmental degradation, financial loss, and inefficient resource utilization. Leveraging artificial intelligence and computer vision. It allows users to scan raw ingredients or manually input items, after which the system generates tailored recipes based on ingredient availability, dietary preferences, and time constraints. The innovation is anchored in Sustainable Development Goal (SDG) 12 (Responsible Consumption and Production) by promoting mindful food utilization and minimizing avoidable waste. Key features include AI-powered ingredient recognition, smart recipe filtering, ingredient substitution recommendations, and a sustainability impact dashboard that quantifies food saved, money preserved, and carbon footprint reduced. Unlike conventional recipe applications, RescueRecipe prioritizes urgency-based cooking using near-expiry items, thereby addressing real behavioral frictions in meal planning. The socio-economic impact includes reduced household food expenditure, increased nutritional awareness, and strengthened sustainable consumption habits. In terms of commercialization, RescueRecipe offers scalable revenue models through freemium subscriptions, grocery retail partnerships, and data-driven food sustainability insights for policymakers and retailers. Overall, RescueRecipe represents a practical, market-ready digital innovation that merges artificial intelligence with environmental stewardship and everyday convenience.

Keywords: Food Waste Reduction; Sustainable Consumption; Mobile Application; Artificial Intelligence; Smart Meal Planning

1. Product Description

RescueRecipe is a user-centric mobile application that assists individuals in preparing meals using ingredients already available in their refrigerators. While most existing applications are started in developed countries (Hong, et al., 2023), these applications allowed more variety of recipes to suit the local contexts. The application offers two primary input modes: a camera-based ingredient scanning function powered by computer vision, and a manual entry option for greater flexibility. Once ingredients are identified, RescueRecipe generates a ranked list of recipes based on ingredient match percentage, preparation time, dietary preferences (e.g., halal, vegetarian), and nutritional value. The interface adopts a minimalist and action-oriented design, featuring a prominent "Scan Ingredients" button on the home screen, complemented by quick filters such as breakfast, lunch, dinner, healthy, and budget meals. Each recipe card displays essential information including cooking time, difficulty level, and ingredient sufficiency indicators. Users can save

recipes, share meal ideas, and mark dishes as cooked, enabling longitudinal tracking of waste avoidance behavior.A distinctive sustainability dashboard visualizes food saved (in kilograms), estimated money conserved (in RM), and approximate carbon emissions reduced. These metrics provide behavioral reinforcement and tangible evidence of impact. RescueRecipe is designed for accessibility across demographic segments, making sustainable cooking intuitive, measurable, and habit-forming. This app aids in cutting down household food waste, which benefits both environment and economy (Mastorakis, 2024).

2. Flow Chart

Figure 1. Rescue Recipe User Experience Flowchart.

The flowchart depicts an end-to-end, user-centred journey that operationalises responsible consumption through behaviourally informed design. Users begin with App Launch and Onboarding, where preferences (dietary needs, skill level, goals) personalise subsequent recommendations. The Home Dashboard functions as the primary action hub, directing users to input ingredients via camera scan (AI detection) or manual entry. Both pathways converge at Ingredient Confirmation, ensuring data accuracy and enabling expiry prioritization. The system then performs AI-driven recipe generation, ranking options by near-expiry items and ingredient match to nudge waste-reducing choices. Users proceed through Recipe Results to Recipe Details, and into Cooking Mode, which supports execution with stepwise guidance and timers. Post-use, Meal Completion captures feedback and leftover status, which feeds into the Sustainability

Dashboard to visualise impact (food saved, RM saved, CO_2 reduced). Smart Notifications close the loop by prompting timely actions (expiry alerts, suggestions), reinforcing habit formation and returning users to the Home Dashboard for continuous engagement.

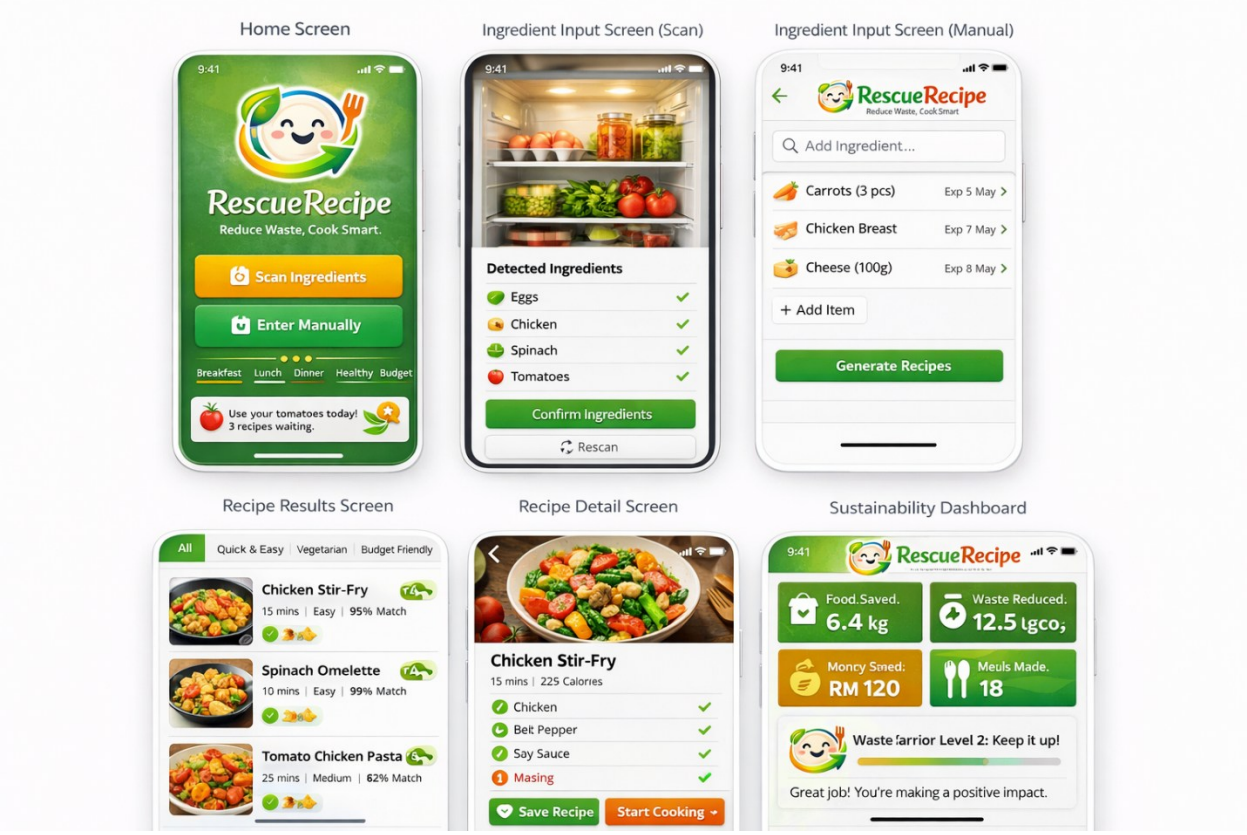

Figure 2. Rescue Recipe Interface Mockup.

The RescueRecipe interface mockup demonstrates a human-centred, sustainability-oriented design that prioritises usability, behavioural nudging, and task efficiency. The visual language adopts a green–orange palette to symbolise environmental responsibility and positive action, while maintaining high contrast for accessibility and quick visual scanning. The RescueRecipe logo is embedded consistently in the header to reinforce brand recall and trust. The **Home Screen** functions as a clear decision hub, presenting primary actions (Scan Ingredients; Enter Manually) with minimal cognitive load and prominent call-to-action buttons. Quick filters (e.g., healthy, budget, quick meals) enable rapid personalisation, supporting time-constrained users. The Ingredient Input screens (scan and manual) emphasise error reduction through confirmation and editability, which enhances perceived control and data accuracy—critical for algorithmic recommendation quality. The Recipe Results and Detail screens employ card-based layouts and visual cues (time, difficulty, match %) to facilitate comparative evaluation and decision-making. Finally, the Sustainability Dashboard translates abstract environmental outcomes into concrete metrics (food saved, RM saved, CO_2 reduced), reinforcing pro-environmental behaviour through immediate feedback and gamified progression.

3. Novelty and uniqueness

RescueRecipe is an AI- enabled food management application aligned with SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action) through its waste-first design approach. Unlike conventional applications that prioritize user preferences, RescueRecipe optimizes meal planning based on ingredient availability and proximity to expiry, directly aiming at reducing food waste. The application delivers real-time expiry notifications which identified as a high-value user feature by supporting timely consumption and minimizing avoidable disposal (Mastorakis, 2024). The integration of computer vision automates ingredient recognition, minimizing manual data entry and lowering adoption barriers. By leveraging AI to optimize resource efficiency, RescueRecipe contributes to reduced food waste-related emissions and promotes sustainable consumption behaviors (Onyeaka et al., 2023; Shah et al., 2025). In a nutshell, a built-in sustainability impact dashboard translates SDG goals into actionable behavioral feedback. Key performance indicators include: (i) percentage reduction in household food waste, (ii) number of meals prepared using near-expiry ingredients, (iii) estimated CO_2-equivalent emissions avoided, and (iv) user compliance with optimal food storage recommendations. Beyond individual benefits, anonymized consumption data enable insights for policymakers and institutions addressing food security andenvironmental sustainability, positioning RescueRecipe as a scalable, dual-impact digital innovation.

4. Benefit to mankind

Food waste remains a critical global challenge, with households accounting for the largest share of wastage. According to the United Nations Environment Programme Food Waste Index Report (2021), 61% of food waste occurs at the household level, compared to 26% in food services and 13% in retail (Xue et al., 2017; UNEP, 2021). These figures highlight the urgent need for household-focused interventions. RescueRecipe brings broad societal benefits by addressing food insecurity, environmental degradation, and increasing household living costs. By enabling efficient ingredient utilization, the application directly reduces avoidable domestic food waste, which represents a substantial proportion of global food loss. This reduction contributes to lower methane emissions from landfills and eases pressure on agricultural production systems. At the household level, RescueRecipe promotes financial savings by encouraging meal preparation using existing food supplies, thereby reducing unnecessary grocery purchases. The integration of nutritional awareness within recipe recommendations further supports healthier dietary choices. At a societal level, RescueRecipe promotes a culture of mindful consumption, mainly among urban populations, who are prone to convenience-driven waste, while reinforcing environmentally responsible behaviors aligned with long-term environmental sustainability.

5. Innovation and Entrepreneurial Impact

RescueRecipe promotes innovation by integrating artificial intelligence, behavioral design, and sustainability analytics into a single consumer-facing platform. The project fosters interdisciplinary collaboration among educators, food technologists, and sustainability advocates, reinforcing an institutional culture of applied digital innovation. Entrepreneurially, RescueRecipe offers a scalable product design accomodating regional and international markets. Its data-driven features enable continuous product iteration based on user behavior analytics and ingredient usage trends. The innovation also opens avenues for student-led startups, hackathon initiatives, and industry partnerships, thereby strengthening the university's entrepreneurial ecosystem.

Additionally, this mobile application bridges academia through commercialized research, which is later translated into market-viable sustainability solutions, Hence, RescueRecipe demonstrates responsible innovation and reinforces the role of higher education institutions as catalysts for socio-economic transformation.

6. Potential commercialization

RescueRecipe possesses strong commercialization potential through multiple revenue streams. A freemium subscription model can provide advanced features such as personalized meal plans, premium recipe libraries, and nutrition tracking. Furthermore, strategic partnerships with grocery retailers, online delivery platforms, and appliance manufacturers offer cross-promotion and affiliate marketing opportunities. Meanwhile, the anonymized consumption data generated by the platform can support institutional licensing agreements with food sustainability agencies, municipal councils, and research organizations. Additionally, branded collaborations with sustainable food producers and kitchenware companies can enhance market penetration. Finally, with minimal infrastructure requirements and cloud-based scalability, RescueRecipe is well-positioned for rapid deployment across Southeast Asia (SEA) and beyond. Its alignment with global sustainability agendas further enhances its attractiveness to impact investors, government innovation funds, and green technology accelerators.

7. Researchers' Biography

Dr Sharifah Nurafizah Syed Annuar is a senior lecturer at Universiti Teknologi MARA (UiTM) Sabah Branch specialising in marketing communications. She is actively involved in sustainable tourism and social impact initiatives through her membership in Responsible Borneo and Social Value Malaysia. An Associate Member of the Academy of Sciences Malaysia and a member of the Sabah Science Council, she contributes to evidence-based regional development. Her work includes collaborations with local authorities and NGOs, and she serves as a Subject Matter Expert for the Sabah Maju Jaya Development Plan, supporting community- and policy-oriented development initiatives.

Franklin Hazley Lai is a Senior Lecturer in the Faculty of Business & Management at Universiti Teknologi MARA (UiTM) Sabah Branch, a position he has held since 2008. He is a Chartered Marketer accredited by the Chartered Institute of Marketing (UK), with academic expertise in Consumer Behavior, Product Management, and Services Marketing. With prior industry experience as a Product Research Manager and in customer service roles, he brings strong practical insight to academia. His expertise supports impactful research consultancy projects, professional training, and industry-focused advisory work.

Dr Cynthia Robert Dawayan is a Senior Lecturer at the Faculty of Business and Management, Universiti Teknologi MARA (UiTM) Sabah Branch, with eighteen years of academic experience. She is a member of the Institute of Marketing Malaysia and is pursuing professional certification in digital marketing. Her work encompasses teaching, research, consultancy, and public engagement, including government-funded community development projects. Her research interests includes tourism and digital marketing, entrepreneurship, and community-based tourism.

Application of Volunteerism and Social Media in Finding Historical Printed Material for Bahagian Arkib Universiti (Baru), Universiti Teknologi Mara (UiTM)

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ABSTRACT

This idea is under Social Sciences: Sustainability & CSR Projects. The objective of this innovation is to help Bahagian Arkib Universiti (BARU) UiTM in finding historical printed material via volunteerism. This objective achieved with the assistance of social media. This innovation come as a problem solving for lack of volunteer to help Bahagian Arkib Universiti and at the same time the usage of social media makes the process of finding the material become effective and efficient. The advantage of this innovation is UiTM members can become a volunteer and with the technology advancement nowadays, especially in social media, it can become a search engine and focused on the collector that want to sell the material. The uniqueness of this innovation is the usage of Facebook Group feature to find the material on various group like *Jual & Beli Buku Terpakai Malaysia*, *Kelab Pengumpul Buku Dan Majalah Antik*, *BUKU2 Lelong* and many more. This innovation give benefit to university as it not only helps to find historical printed material about UiTM easily, but also preserve the sustainability for future generation. As for commercialisation prospect, this idea can be commercialised by Bahagian Arkib Universiti with the involvement of university members and alumni.

Keywords: historical, social media, UiTM, volunteerism

1. Product Description

The problem that this idea address is about the lack of time and manpower (volunteer) to find and locate historical printed material about UiTM on Bahagian Arkib Universiti side. From this problem, there is a risk of losing valuable item to another collector as the item are rarely advertised by the owner or collector, or worst scenario, the item being thrown away or destroyed. Therefore, to introduce the idea of volunteerism and implementation of social media, the process of retrieving the item become effective and efficient.

2. Methods and Results

Figure 1 depicts the process of official hand over of Kemajuan MARA book to Bahagian Arkib Universiti on 7 November 2025. This book was published on Mac 1967 by Majlis Amanah Rakyat (MARA) with 62 pages. This book gives precious information regarding Maktab MARA at that time. At the time this book being published, there are about 600 students taking courses like Institute of Cost and Works Accountants, Chartered Institute of Secretaries, Diploma in Business Studies, Stenography and others. **Figure 2** concentrates on the official hand over of Executive book to Bahagian Arkib Universiti on 24 June 2025. This book, with 104 pages was published on

1973 by Kesatuan Siswa ITM. There are 17 articles published in this book by authors from different background like student leaders, ITM's management and figures from corporate sharing their aspirations, opinions, research and ideas. These writings give better understanding regarding events and issue arise during the time this book being publish. **Figure 3** shows the official hand over of Kampus INTEKMA '81 and Pesta Konvo Sempena Perayaan Jubli Perak ITM 1981 book on 14 October 2025 to Bahagian Arkib Universiti. Kampus INTEKMA '81 writes about stories for ITM Convocation on 26-27 September 1981 while Pesta Konvo Sempena Perayaan Jubli Perak ITM 1981 writes about the Pesta Konvo event, schedule, program and activities on 24-27 September 1981.

Figure 1. Official hand over of Kemajuan MARA book to Bahagian Arkib Universiti.

Figure 2. Official hand over of Executive book to Bahagian Arkib Universiti.

Figure 3. Official hand over of Kampus INTEKMA '81 and Pesta Konvo (1981) book to Bahagian Arkib Universiti.

3. Novelty and uniqueness

This idea differs from existing traditional method as the author promote volunteerism as the pillar of this project. Here, the author volunteer in finding the material using social media instead of depends to Bahagian Arkib Universiti effort. The author does not take over the role and responsibility of Bahagian Arkib Universiti, but, enhance it with smart collaboration. For uniqueness, this innovation introduces the usage of social media as 'search engine' to search and find the potential material. The author utilises Facebook Group feature to find the material about UiTM listed for sale by the owner or collector on various group like *Jual & Beli Buku Terpakai Malaysia*, *Kelab Pengumpul Buku Dan Majalah Antik*, *BUKU2 Lelong* and many more. Another Facebook feature that has been utilise by the author is Facebook Marketplace. The advantages of using these Facebook features are the finding process become easier and faster, and the finding process become efficient as this method focused on the listing from the material owner or collector.

4. Benefit to mankind

As historical printed material like books, magazines and other publication have writing, story, facts and figures, opinion and well-known figure's quotes at that time, people nowadays can have better understanding and clear picture regarding events and issue during the printed material being published. As for Bahagian Arkib Universiti, every writing is important and vital for university's records and sustainability. When there are questions regarding university's history,

this historical printed material provides written facts, details and figures that are relevant to be referred. As for researcher, the information gained from these materials are very helpful in completing their study or research especially about Dewan Latihan RIDA, Maktab MARA, Institut Teknologi MARA and Universiti Teknologi MARA.

5. Innovation and Entrepreneurial Impact

This project promote innovation as the author has to think creatively beyond ordinary to come with the solution. Normally, Bahagian Arkib Universiti will come and collect the historical material when they have confirmed with the owner of the material. As for this innovation, instead Bahagian Arkib Universiti look for the material, the author volunteer to use the social media (Facebook) and access the Facebook Group and Facebook Marketplace to find and buy the historical printed material about UiTM. After that, the material obtained will be hand over officially to Bahagian Arkib Universiti for further action. For entrepreneurial impact, this innovation ignites entrepreneurship spirit by demonstrating creative, proactive, aggressive and collaborative action with Bahagian Arkib Universiti.

6. Potential commercialization

This innovation has a huge commercialisation potential especially on Bahagian Arkib Universiti. Bahagian Arkib Universiti can improve their historical printing material procurement by adding social media as one of the sources of procurement. In addition, they can promote volunteerism and collaborate with university members and alumni to seek potential material nationwide.

7. Acknowledgment

The author would like to acknowledge the support from Penerbit UiTM, Jabatan Penyelidikan & Inovasi UiTM and Bahagian Arkib Universiti. Special thanks to family and friends for encouragement and motivation beyond boundaries.

8. Researchers' Biography

Mohammad Sufian Bin Abdul Manan is a Senior Assistant Registrar at Universiti Teknologi MARA. With over 15 years of experience, he has vast experience as administrator at various departments and area of work like human resource management, student affairs, Malay leadership and thoughts, faculty management and academic affairs. Now serving at Penerbit UiTM, Jabatan Penyelidikan & Inovasi Universiti Teknologi MARA.

Making the Learning and Accounting for Share-Based Payment Transactions Easier Through Sbp: No-Option!

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ABSTRACT

The SBP: No-Option! is an innovative teaching and learning method designed for accounting students taking FAR570 in an accounting course at UiTM to account for Share-Based Payment transaction based on MFRS 2 requirements that does not involve any option to choose the settlement method. Due to complexity and difficulty to understand the Standard, the SBP: No-Option! is the simplification of the accounting treatment of Share-Based Payment in accordance with MFRS 2 aims assist accounting students to grasp comprehensive understandings about the topic. As Share-Based Payment is one of the topics commonly tested in final examination, the SBP: No-Option! offers quick recall, simplicity and inclusivity of the accounting treatment during students' short-revision-time. In addition, the key points included in the SBP: No-Option! are useful for both theoretical and application (calculation) form of questions. By utilizing 3W1H questions, the SBP: No-Option! fosters the culture of innovation in accounting education and facilitates knowledge exchange between educators and students. The SBP: No-Option! could be commercialized to other higher institutions through collaborative teachings or trainings, particularly to those offering accounting programs.

Keywords: Share-Based Payment, cash-settled, equity-settled, accounting

1. Product Description

Accounting course has always become killer subject in accounting program at all level of studies. One of the topics in an accounting course code FAR570 is Share-Based Payment (SBP) under MFRS 2. The topic usually requires the students understand how to account for SBP transaction between an entity with different groups of counterparties i.e. employee or non-employee. Hence, a teaching and learning innovation called the SBP: No-Option! is designed to help the students in their study to master the recognition and measurement of SBP transaction. The SBP: No-Option! provides brief yet resourceful and impactful information with easy-to-remember short forms like GSR (for goods received or services rendered), CS (for cash-settled), ES (for equity-settled), FV (for fair value), IV (for intrinsic value), and EI (for equity instrument). Mastering the SBP: No-Option! requires educators and students to answer 3W1H questions – Who, What, When, and How? **Figure 1** shows the procedure of using the SBP: No-Option! to an SBP transaction based on 3W1H questions.

2. Diagrams

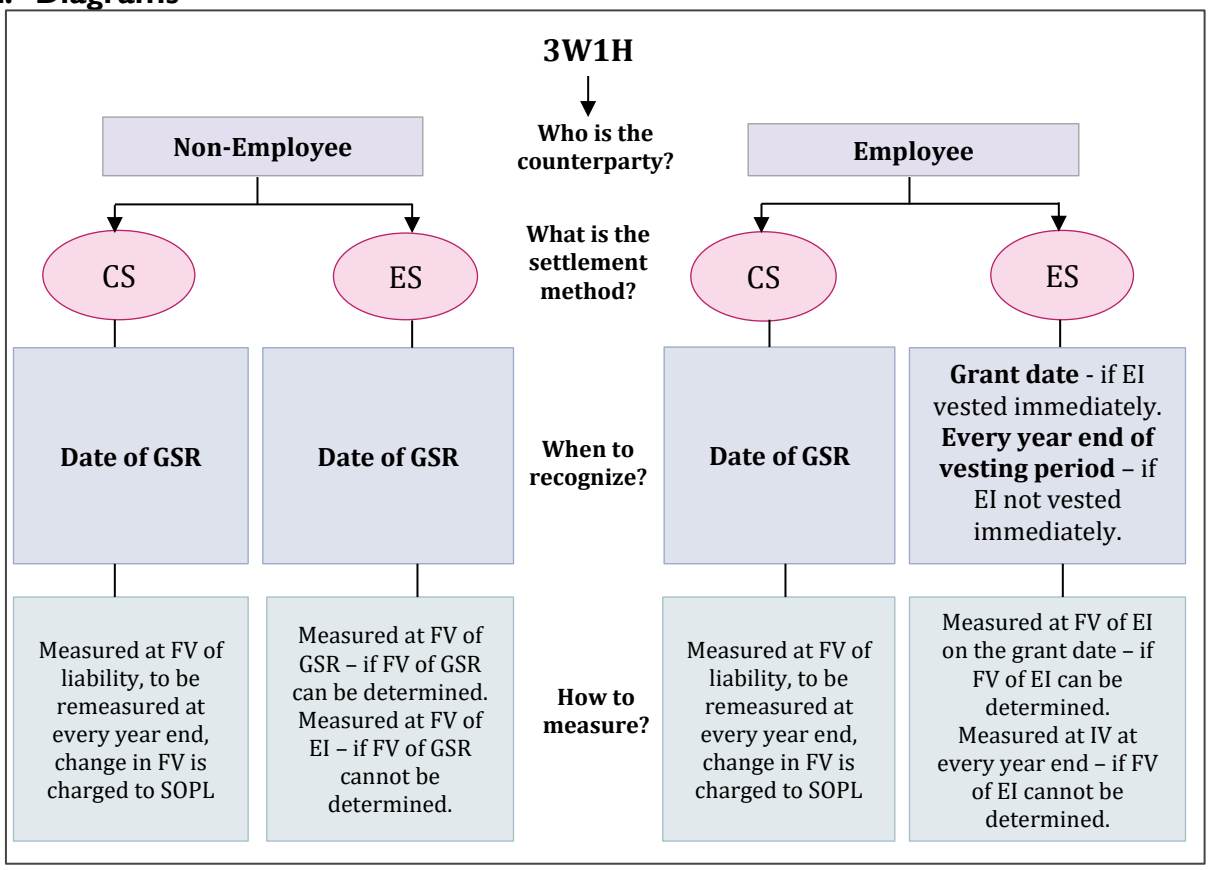

Figure 1. SBP: No-Option! Diagram.

Figure 1 illustrates the SBP: No-Option! with 3W1H questions related to recognition and measurement under MFRS 2. The 3W1H questions must be answered in the following sequence: 1. Who is the counterparty; 2. What is the settlement method; 3. When to recognize the SBP transaction; and, 4. How to measure the SBP transaction. The whole idea of the recognition and measurement of SBP transaction is dependent on the counterparty – employee or non-employee.

3. Novelty and uniqueness

With the aim to illustrate the accounting treatment for SBP transaction in simpler term, this teaching and learning innovation is novel and unique by outlining the core principle in recognizing and measuring SBP transaction using 3W1H questions. The SBP: No-Option! allows not only the students but the educators who are new to the topic to comprehend the central pillar of MFRS 2 with regards to SBP transaction without option. In addition, the use of diagram allows the reader to quickly capture and visualize the accounting treatment for SBP transaction.

4. Benefit to mankind

The SBP: No-Option! offers significant benefits to mankind by making the accounting for SBP transaction under MFRS 2 easier to:

i. Memorize – as the information in the SBP: No-Option! is presented in key-points form, it is easier for lecturers to explain and students to memorize the key idea about

SBP under MFRS 2, particularly for SBP transaction without option to choose method of settlement.

ii. Understand – the SBP: No-Option! offers better understanding as it clearly differentiates the recognition and measurement of SBP transaction between an entity with employees and non-employees.

iii. Write and explain – students would easily write and explain the accounting treatment for SBP transaction by recalling and answering the 3W1H questions in the diagram of SBP: No-Option!

5. Innovation and Entrepreneurial Impact

The SBP: No-Option! promotes innovation in teaching and learning by applying the WH questions (3W1H) to accounting topics in which the WH questions are commonly use in writing academic papers. By answering the 3W1H questions, educators and students would be able to master the requirements of MFRS 2 with regards to recognition and measurement of SBP transaction. The exciting feature of 3W1H embedded in the SBP: No-Option fosters the culture of innovation be encouraging both educators and students to find ways to be more innovative, hence, enriching learning experience. This stimulates the interest in entrepreneurship by engaging in innovative approaches to accounting standard and its requirements.

6. Potential commercialization

Higher education institutions that offer accounting program may incorporate the Share-Based Payment topic in their syllabus. The SBP: No-Option! could be potentially commercialized to these institutions for more innovative approach to learning accounting topic, particularly the Share-Based Payment under MFRS 2. The educators could organize collaborative teachings or trainings to connect to each other and communicate about the SBP: No-Option!. Therefore, this innovation could be included in the teaching or training module as value-added factor to the module.

7. Acknowledgment

We would like to express our gratitude to UiTM Sarawak in general, and Faculty of Accountancy UiTM Sarawak in particular for the continuous supports. Also, special thanks to the members of this innovative teaching method for their significant contributions.

8. Researchers' Biography

Dr. Dayang Hafiza binti Abang Ahmad is a Senior Lecturer at the Faculty of Accountancy, UiTM Sarawak, Samarahan Campus. She earned her PhD in Accountancy in 2021 from Universiti Teknologi MARA (UiTM) Shah Alam and has over 15 years teaching experience. Her areas of expertise include financial accounting and reporting, accountability, disclosure, and index development. Currently, her work focuses on teaching financial accounting and reporting as well as writing academic articles.

Judith Kristian anak Ah Choi is a Lecturer at the Faculty of Accountancy, UiTM Sarawak, Samarahan Campus. She obtained her Master of Science (Accountancy) in 2022 from Universiti Teknologi MARA (UiTM) Shah Alam and has over 10 years of experience in the auditing field and insurance industry. Her areas of expertise include audit, tax, cost and management accounting, and index development. Currently, her work involves academic lecturing focuses on financial audit and cost and management accounting and the publication of academic writing within the field of financial accounting.

FYP Hub Ecosystem: Integrated Digital Management Ecosystem for Diploma in Information Technology

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ABSTRACT
The FYP Hub Ecosystem addresses the critical fragmentation in managing final year projects for Diploma in Information Technology (DIT) students. Traditionally, project management suffered from disorganized documentation, decentralized communication, and manual progress tracking. This innovation solves these issues by integrating a Centralized Resource Hub (Google Sites) with the Integrated Project Management System (IPMS). Uniquely, it digitizes the entire academic workflow from registration to final assessment by ensuring strict compliance with the DFT50114 Guidelines (2022 Edition). The ecosystem features a real-time dashboard for the Unit of Project Coordination and a streamlined submission interface for students. The impact is significant: it enhances operational efficiency, eliminates administrative redundancy for lecturers, and ensures data integrity for Malaysian Qualifications Agency (MQA) accreditation audits. Commercially, the FYP Hub Ecosystem is a scalable "Digital Management Kit" marketable to other TVET institutions, offering a low-cost, high-compliance solution for academic project supervision.

Keywords: Final Year Project, Project Management

1. Product Description
The FYP Hub Ecosystem serves as a comprehensive "One-Stop Centre" tailored specifically for the Unit of Project Coordination by functioning through three core integrated components. The first component, the Centralized Resource Portal, is a web-based interface built on Google Sites that provides immediate access to the Project Implementation Flow, mandatory templates such as Appendices A through E, and official Assessment Rubrics for both Coursework and Final Assessments, ensuring total transparency regarding academic requirements. The second component is the IPMS Integration, a backend tracking engine where students submit their weekly logbooks, project proposals, and technical reports. This system integration also allows supervisors to directly key in assessment marks, effectively automating the grade compilation process. Finally, the Active Monitoring Dashboard acts as a dedicated interface for the Unit of JTMK Project Coordination to monitor the progress of the entire cohort. By actively tracking submission adherence and flagging "at-risk" students, this dashboard ensures that timely interventions can be made in accordance with the official course timeline.

2. Pictures

Figure 1 shows the Project Timeline and Milestones, serving as the central navigation point for current students who registered for the DFT50114 / DFT50194 course.

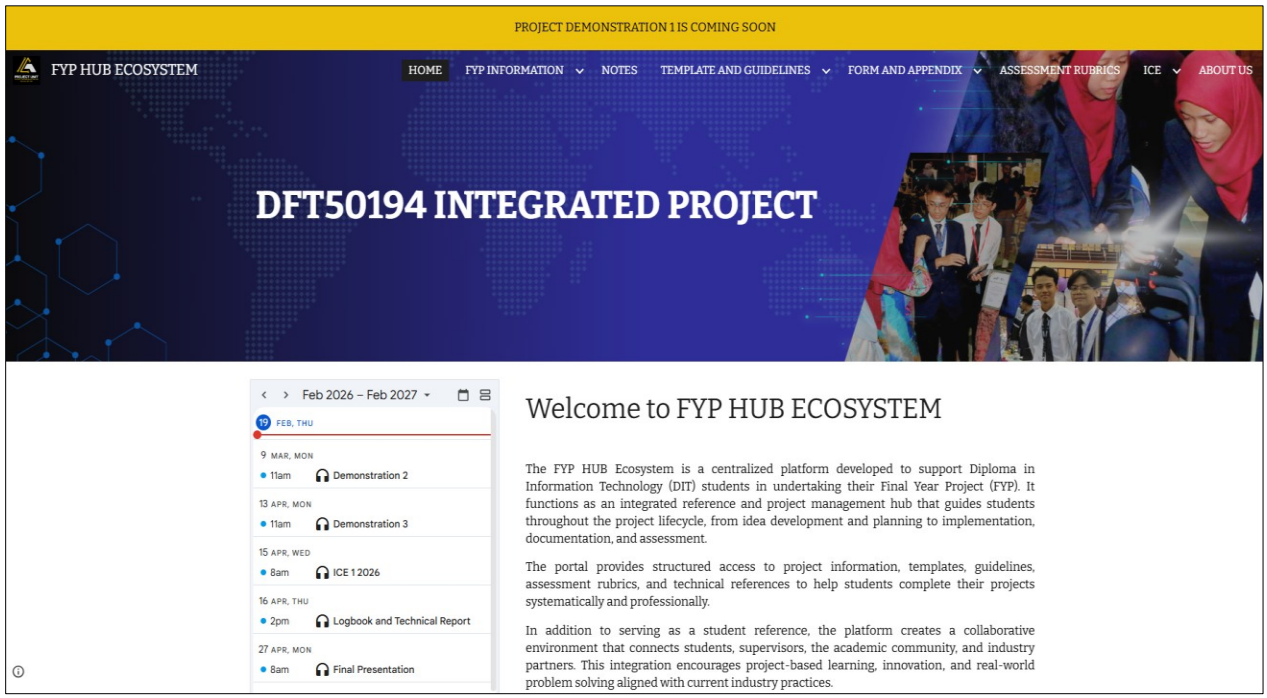

Figure 1. "Home" interface.

Figure 2 shows the "Template and Guidelines" repository, housing critical documents such as the Project Proposal format and Technical Report guidelines.

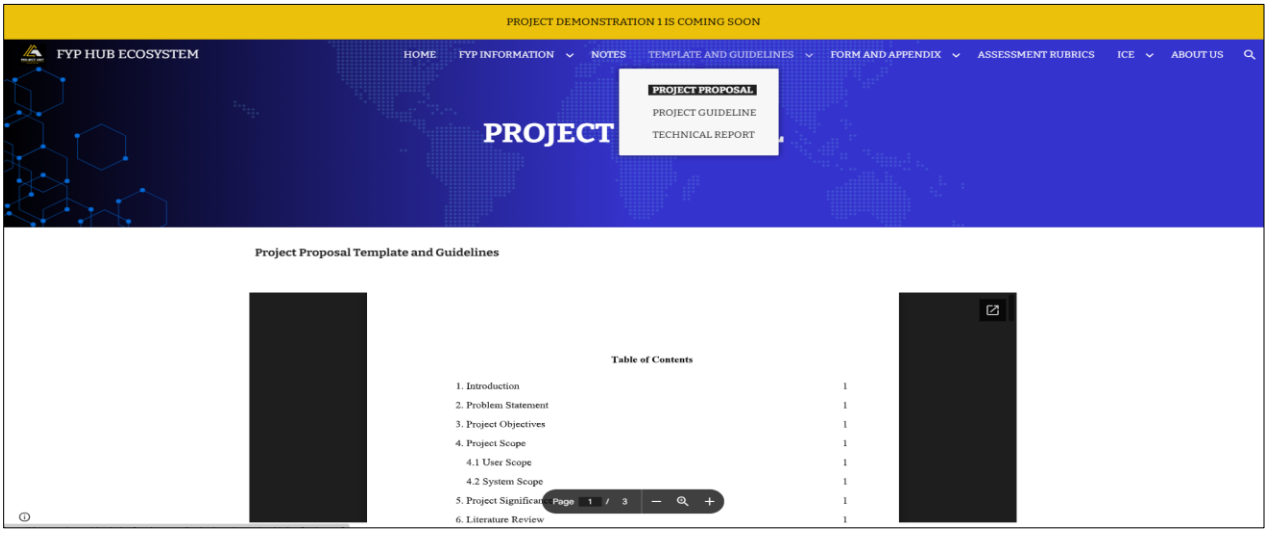

Figure 2. "Template and Guidelines" interface.

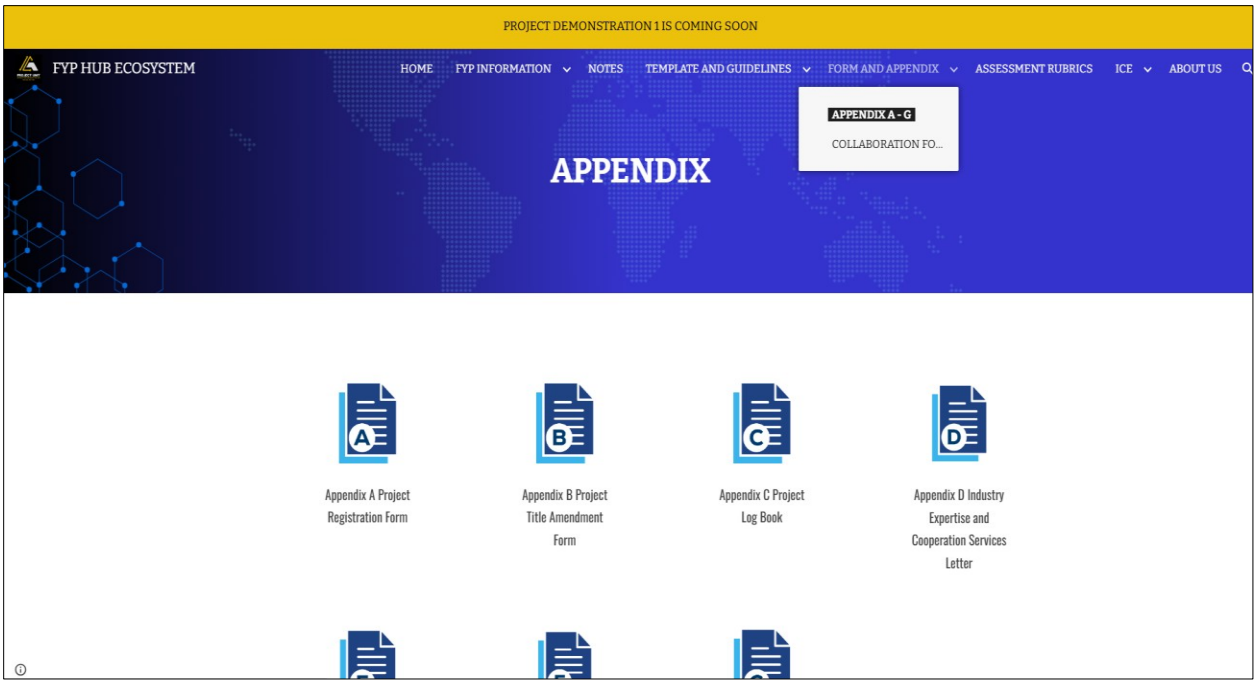

Figure 3. "Form and Appendix" interface.

Figure 3 shows the "Form and Appendix" section, providing downloadable official forms required for compliance.

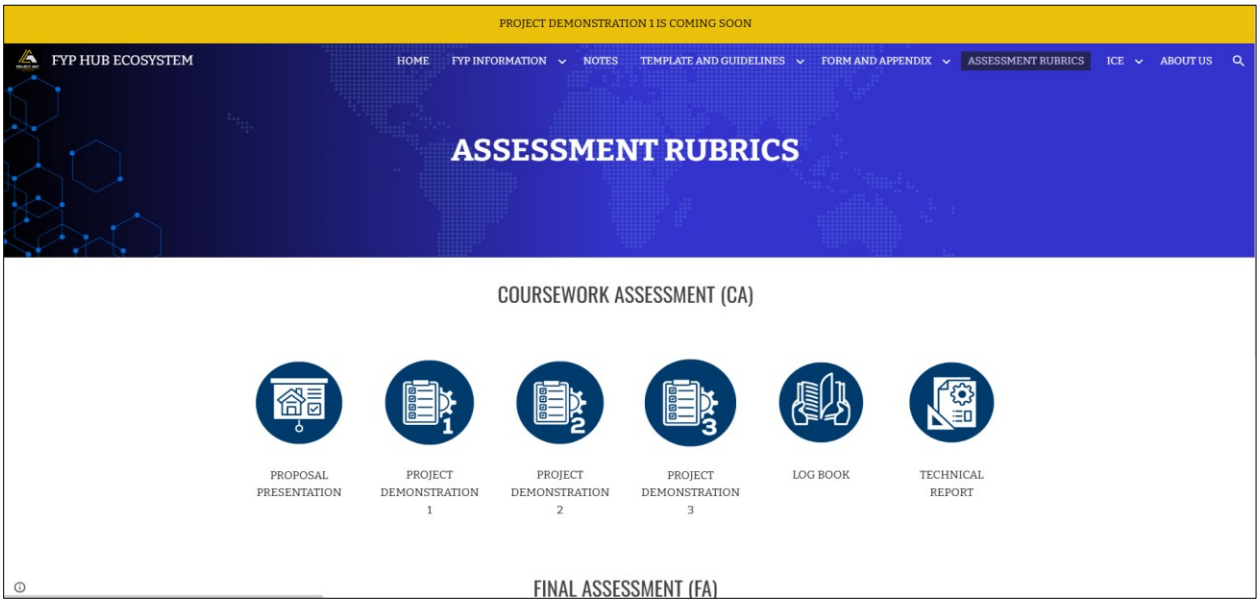

Figure 4. "Assessment Rubrics" interface.

Figure 4 shows the "Assessment Rubrics" display, ensuring transparency in grading criteria for Coursework (CA) and Final Assessment (FA).

Figure 5 shows the IPMS System Integration, illustrating the workflow for student submissions (Logbook/Project Proposal/Technical Report) and supervisor grading.

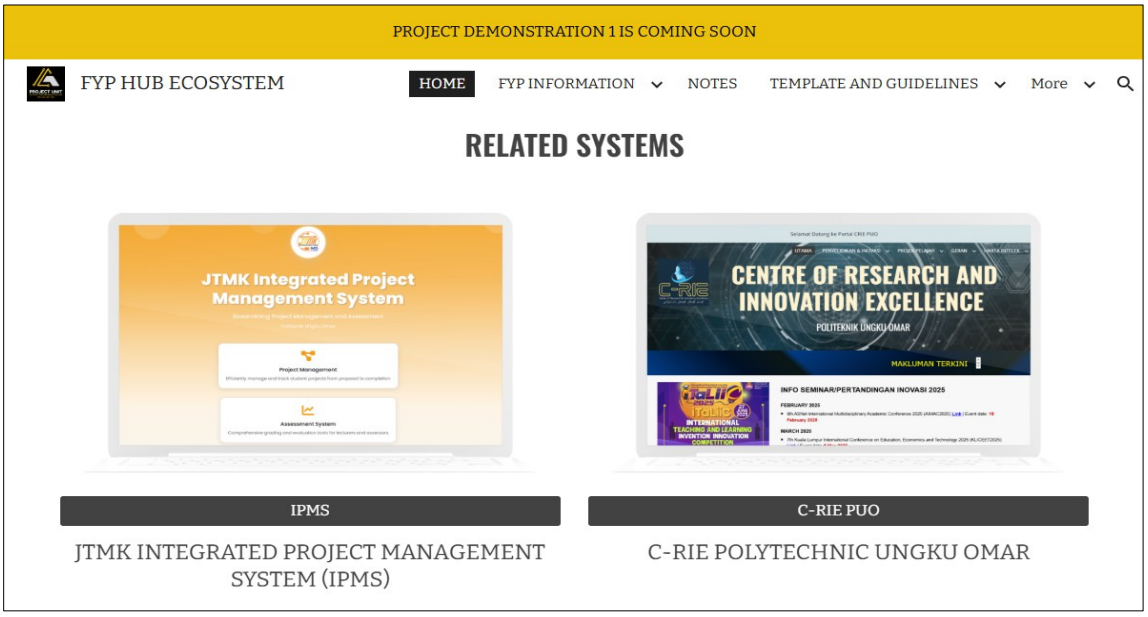

Figure 5. IPMS System Link at "Home" interface.

3. Novelty and uniqueness

The FYP Hub Ecosystem introduces a novel shift from manual, paper-based tracking to a cloud-based automated ecosystem. Unlike generic Learning Management Systems (LMS), this innovation is a curriculum-centric solution. Its novelty lies in the custom integration of the specific DFT50114/DFT50194 Assessment Architecture directly into the digital workflow. While standard tools only accept submissions, this ecosystem guides the user through the specific "Project Life Cycle" by mapping the Project Proposal, Logbook, and Technical Report distinctively to meet Malaysian Qualifications Agency (MQA) requirements. It features a "Compliance-First" design, where the availability of resources mirrors the active academic phase (Planning, Development, or Reporting), a unique feature that ensures students are always aligned with the official guidelines.

4. Benefit to mankind

This innovation delivers substantial benefits to the academic community by addressing the needs of students, supervisors, and the institution in a unified platform. For students, it reduces "deadline anxiety" by providing a transparent roadmap and centralized access to critical templates, which ultimately fosters self-regulated learning and digital discipline. Simultaneously, for supervisors, it eliminates the heavy administrative burden of manual file keeping and grade calculation; the automated tracking allows lecturers to focus their efforts on actual technical mentoring rather than tedious clerical work. Finally, for the institution, the ecosystem supports environmental sustainability by going paperless and ensures strong academic governance. The system effectively acts as a reliable digital repository that simplifies MQA accreditation audits by safely preserving organized evidence of student-supervisor interactions alongside Continuous Quality Improvement (CQI) data.

5. Innovation and Entrepreneurial Impact

The FYP Hub Ecosystem promotes innovation by familiarizing students with professional project management tools and digital workflows, which are essential skills in the IR 4.0 industry. By enforcing a structured "Entrepreneur Mindset" reporting format as required in the Technical Report, the portal encourages students to view their projects not just as academic tasks, but as marketable products. Furthermore, the portal includes a "FYP Title Directory" to showcase high-potential student projects. This feature increases visibility to industry partners and potential investors, directly supporting the commercialization ecosystem within the polytechnic and bridging the gap between academia and industry.

6. Potential commercialization

The FYP Hub Ecosystem has strong commercial potential as a replicable Software as a Service (SaaS) template for educational institutions. The framework can be packaged as a "TVET Project Management Kit" that includes the site architecture, IPMS integration logic, and user manuals. It targets Polytechnics, Community Colleges, and vocational institutions requiring a low-cost, high-impact system to manage student projects without investing in expensive custom software development. Additionally, consultancy services for setting up, customizing, and training faculties on using this digital ecosystem present a viable and scalable revenue stream.

7. Acknowledgment

Thanks to the JTMK, PUO management and JTMK Unit Project for their continuous support and access to technical resources throughout the project. Gratitude is also extended to the lecturers and students who provided valuable feedback during usability testing.

8. Researchers' Biography

Ts. Maizatul Akmam binti Ismail is a lecturer at the Department of Information and Communication Technology (ICT), Politeknik Ungku Omar, Perak. Her research interests are teaching and learning, cybersecurity, information technology, games, and educational technology. She is frequently involved with research presentations, innovation competitions, and publications at the national and international levels. She won various awards in various fields and services, including research and innovation.

Munirah Abdullah is a dedicated ICT Lecturer with extensive experience in teaching and developing curriculum in software engineering, programming, mobile application development, and databases. With over a decade of experience in higher education, she is passionate about equipping students with both strong theoretical foundations and practical technical skills. Her expertise includes Android development, database systems, and web technologies, and she actively integrates modern tools and interactive approaches into her teaching to enhance student learning.

She is involved in academic development and continuously explores innovative methods to improve technology education.

Asliza Binti Yacob is an experienced lecturer at Politeknik Ungku Omar with 19 years of academic service. She focuses on Information Security and Programming, equipping students with both theoretical knowledge and practical technical skills. Throughout her career, she has remained committed to nurturing competent, ethical, and industry-ready graduates while contributing actively to academic development and innovation in teaching and learning.

Waqa Shield

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ABSTRACT

Waqa Shield is a smart shield that is able to give an S.O.S signal to security if the patient is at the stage of aggression. Plus, this shield is used to restrain an aggressive patient, which can reduce his or her injury. Therefore, healthcare workers are also able to reduce their physical injury and psychological issues. On the other hand, this shield produces low impact if the patient's head hit toward shield due to the restraint event because this shield has high hysteresis. Therefore, the workers were able to parry the whole attack from the aggressive patient. Hence, this shield follows the regulations such as the Mental Health Act 2001 (Act 615) and Medical Act 1971) which means the staff does not hesitate to use it when restraining the aggressive patient, and this shield obeys the law. In addition, this shield give positive impact on staff's service and productivity because this shield can save many lives and properties of the clinic and hospital, whether the setting place at the private or government healthcare institute. Hence, this shield is the first restraining shield which had been built in Malaysia. Possibility Waqa shield is an opportunity to commercialize outside Malaysia.

Keywords: Hysteresis, low impact, S.O.S signal, Physical Injury and Psychological Injury.

1. Product Description

Waqa's shield is not an ordinary shield. This shield is a smart protection shield that consists of an S.O.S signal to the security, which can be shown from figure 1 below. In addition, this shield give a lesser harm to the aggressive patient which obey Mental Health Act 2001 (Act 615), Medical Act 1971, and ethics and Penal Code (Act 574). Plus, this shield is also a protection for the healthcare workers from any physical injury and psychological issues. This shield has less impact on the aggressive patients when restraining happens, and it can parry any physical action from these patients without giving them any injury. This is because this shield has high hysteresis due to the material of the shield, which is made of rubber foam. Thus, this foam is attached with wooden board and EPDM material is used as handle and attached to this foam. Therefore, the Waqa shield is made with cheap materials, and it is easy to build. Before the shield is ready to use, the Waqa Shield needs to undergo the simulation and experimental based the methodology's criteria as a standard of the shield quality before it is used by healthcare workers.

2. Methods and Results

Figure 1. Flow Chart apply S.O.S.signal.

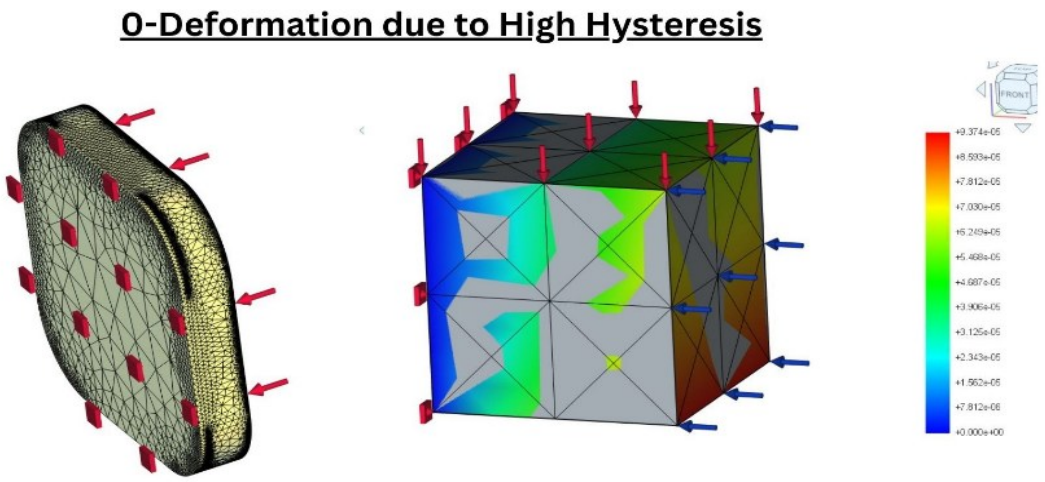

Figure 2. deformation based on simulation Finite Element Analysis(FEA). The blue colour is the effectiveness zero deformation of a foam.

3. Novelty and uniqueness

The unique Waqa shield is used to parry against any patient's attack. This shield has an SOS signal to the security. This system is linked with Google Meet and signals to the specialist and security. The PowerPoint had programmed as an SOS signal for help. Plus, the session between the patient and the healthcare workers was programmed to be muted, but the alarm is ready to stand by when it is activated. This model is safer and had low impact on the patient's head. This is because when the simulation is made. It is proven that the shield has high hysteresis, which can diminish high energy during the impact. That is why it shows 0 deformation at the end of the model. According to Gates and Halladay (2017),it takes 5 to 10 seconds to return to the original form after impact. However, this waqa shield takes 2.97 seconds to gradually change the form into its original state after impact. Therefore, it is safe to parry any aggressive attack. Plus, this model help staffs not to hold patients' hands as a cushion, which can affect the injury toward staffs hand due to impact and biting when a restraining event is happening.

4. Benefit to mankind

Apart from patients and staffs that are getting hurt during restraining events. They would not experience physical injury and more safety. Furthermore, with the waqa shield they were able to handle the patient without any self doubt and by obeying the law according to Mental Health Act 2001 (Act 615), Medical act 1971 and medical ethics and Penal Code (Act 574). That mean the waqa shield help to ease the restraint efforts, not harming the patient and not voluntary causing hurt to the patient.

5. Innovation and Entrepreneurial Impact

Waqa Shield shows a positive impact on health institutions. This model is a smart protection S.O.S signal to the security staff, which they are able to find the incident location easily and save many lives and medical personnel from losing millions of dollars. This shield help staffs to reduce taking medical leaves if there are any incidents occur. Likewise, this shield increases the service and working productivity of the health institute. Plus, the staff do not need to remember the extra restraining technique procedure, which takes a lot of memorization that may affect their job if there in case of emergency happens. Based on Entrepreneur impact, Waqa Shield is the first restraining shield in Malaysia, which gives an opportunity for businesses inside and outside Malaysia, and give opportunity to boost local vendor companies. This shield will be registered as a patent for the sake of intellectual property and profit outcome.

6. Potential commercialization

Therefore, this shield show commercialize potential toward any hospital and clinic whether government or private to the better use for the society.Plus, it is cost effective which take around RM50 to built rather spend million of dollar to make sure the floor is soft to built in order to handle aggressive patient.In addition, this model never been used in Malaysia and other countries.Therefore it is marketable potential for the benefit of the people.

7. Acknowledgment

The authors would like to express gratitude to the one and only god who gave us the wisdom to create a research called Waqa Shield. Waqa means shield in Arabic. Also, thank you to the parents, colleagues, families, and professional health clinical, management, and communities in Labuan for giving us support in our research. Even though this is our first time create this shield for the betterment of humanity.

8. Reference

1. Halladay, J. R., & Gates, K. (n.d.). Sources of Hysteresis in rubber compound. Rubber & Plastics N www.rubbernews.com Ews. https://s3-prod.rubbernews.com/s3fs-public/RN1142784.PDF

9. Researchers' Biography

Mohd Fadzlee bin Junaib is a Registered Nurse in the Psychiatry Department at Hospital Labuan. He graduated from Lincoln International College with a Bachelor of Science in Nursing and holds an Advanced Diploma in Mental Health Nursing.With over 13 years of clinical experience, he has extensive expertise in psychiatric ward management and mental health care. He also serves as a facilitator for Restraint and Breakaway Techniques at Hospital Labuan, contributing to safer and more effective patient handling practices in psychiatric settings.

Dr. Mohamad Yurizal is a Medical officer of pyschiatry department at Hospital Labuan. Graduated from Universiti Sains Malaysia and with over 4 years experience in medical field, he has innovate the grounding technique principle to improve on the effectiveness of it in real world. His work on Ard al Eab- project related to grounding techniques had won gold medal in international research and information science expo 2026, with the expertise he hoped to strive higher in improving medical psychiatry innovation at the top level.

Ag Mohd Syazwie Bin Abd Mutalip is an accomplished Assistant Medical Officer in the Psychiatry Department at Hospital Labuan, with over 12 years of dedicated experience in the clinical field. He holds a Diploma in Medical Assistant from Management & Science University (MSU), an Advanced Diploma in Psychiatric Nursing from Kolej Sains Kesihatan Bersekutu Kuching, and a Bachelor of Medical Health and Sciences (Hons) from Open University Malaysia (OUM).He is recognized for his contributions to psychiatric innovation, specifically in refining grounding technique principles to enhance their efficacy in real-world clinical settings.

Mohd Nabihan Adli is a former engineer which specialize in automotive in terms of mechanical and surface design. He graduated from Curtin University, Western Australia. Thus, he pursued a Master's in Psychology Counselling and graduated in the year of 2021. He has experience in various engineering and psychological fields. Plus, he joined numerous competitions such as Shell Eco-Marathon Asia, Chem-Ecar, and Autonomous hovercraft. Plus, he coached students from Sekolah Rendah Agama Islam Nurul Hidayah Layang-Layangan and succeed bronze medal in the I3DC Competition. Plus, he was rewarded with gold Medal for the Labuan team in the IRISE Competition.

Digitalizing Folktales of Filial Piety

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ABSTRACT
Digitalizing Folktales of Filial Piety is a culturally responsive edtech innovation that transforms selected Nusantara folktales into interactive English as a Second Language (ESL) learning modules. The project was developed to address declining learner engagement in conventional classrooms and the gradual erosion of cultural heritage among digital-native generations. Through structured multimedia integration, combining audio narration, synchronized subtitles, animation, replay functions, and contextual vocabulary scaffolding, the platform enhances comprehension, pronunciation accuracy, and learner autonomy based on multimedia learning principles. Unlike conventional digital storybooks, this solution strategically embeds pedagogical scaffolding within culturally rooted narratives, integrating moral education with language acquisition. Its key advantage lies in merging heritage preservation, structured ESL instruction, and learner-controlled interactivity within a scalable digital ecosystem. Pilot implementation indicates increased motivation, independent learning behavior, and stronger cultural appreciation among learners. Socio-economically, the platform supports sustainable cultural preservation while strengthening digital education access. Commercially, it offers scalable revenue potential through institutional subscriptions, LMS integration, multilingual expansion, and regional adaptation within the growing edtech market.

Keywords: Digital storytelling; ESL learning; Cultural sustainability; Educational innovation; Commercial scalability

1. Product Description
The platform digitizes three iconic folktales such as Si Tenggang, Nakhoda Manis, and Malin Kundang—into interactive multimedia modules accessible via computers, tablets, and smartphones. Core features include audio narration, subtitle synchronization, animation, replay controls, and contextual vocabulary pop-ups. The system architecture integrates cultural content, multimedia enhancement, and pedagogical scaffolding to support differentiated and self-paced ESL learning. By combining moral storytelling with structured language acquisition strategies, the product enhances vocabulary retention, reading fluency, and speaking confidence while preserving intangible heritage in a digital-native format.

2. Digital Storytelling System Architecture

Figure 1 illustrates the structural framework of the digital storytelling system, which integrates cultural content, multimedia elements, and pedagogical scaffolding to enhance ESL learning.

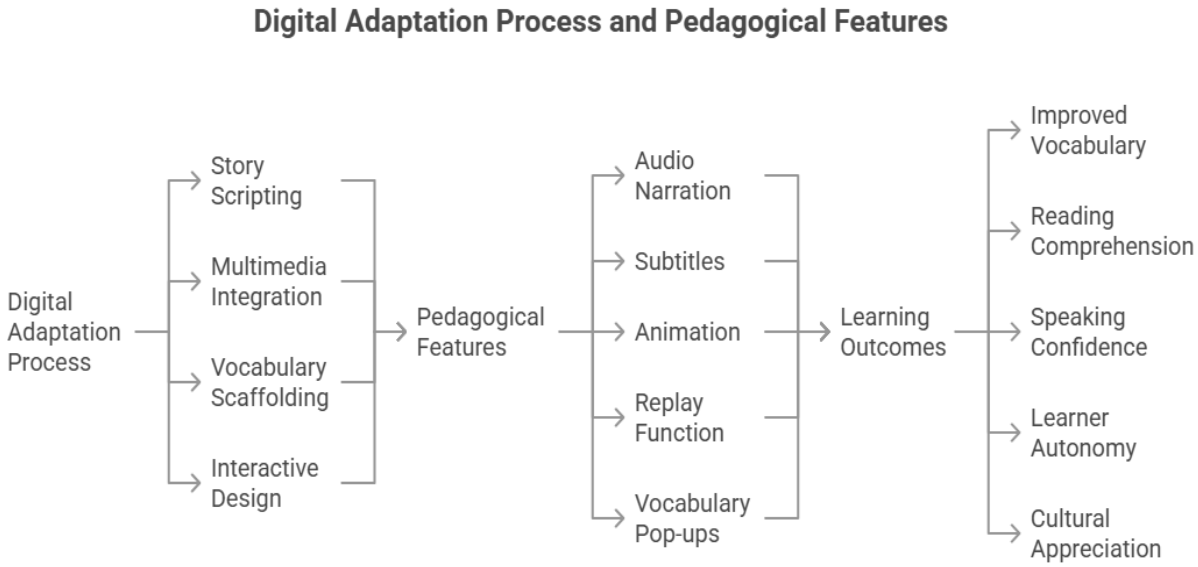

Figure 1. Conceptual framework of the Digitalizing Folktales of Filial Piety platform.

Figure 1 illustrates the conceptual framework of the Digitalizing Folktales of Filial Piety platform, demonstrating how traditional cultural narratives are transformed into an interactive digital learning system. The process begins with the content source, which consists of three selected Nusantara folktales—Si Tenggang, Nakhoda Manis, and Malin Kundang—all of which emphasize the moral value of filial piety. These stories undergo a digital adaptation process, including story scripting, multimedia integration, vocabulary scaffolding, and interactive design. This transformation ensures that the original moral essence is preserved while making the content accessible and engaging for ESL learners. The adapted materials are then delivered through structured pedagogical features such as audio narration, subtitles, animation, replay functions, and vocabulary pop-ups, which support comprehension and differentiated learning. Ultimately, this integrated framework leads to measurable learning outcomes, including improved vocabulary acquisition, enhanced reading comprehension, increased speaking confidence, strengthened learner autonomy, and deeper cultural appreciation. The framework highlights the systematic relationship between cultural preservation, digital innovation, and educational effectiveness.

Figure 2 presents the user interaction flow within the digital book. Learners select a folktale, engage with multimedia storytelling, access vocabulary explanations, and complete reflective activities.

Figure 2. User navigation flow of the digital storytelling platform.

The Story Selection stage represents the learner's initial engagement with the digital storytelling platform. At this stage, students are presented with a choice of three culturally significant folktales—Si Tenggang, Nakhoda Manis, and Malin Kundang, each emphasizing the moral value of filial piety. This feature is intentionally designed to promote learner autonomy by allowing students to select a story based on their interest, familiarity, or curiosity. Providing choice enhances intrinsic motivation and encourages a sense of ownership over the learning process. Additionally, brief story previews or summaries may be included to guide informed selection. By empowering learners to make decisions at the outset, the platform fosters engagement and personal relevance, which are critical factors in sustaining attention and promoting deeper comprehension throughout the subsequent interactive learning stages.

Table 1 presents summarized learner perception scores (Mean values). The data indicate positive learner perceptions, particularly in autonomy and cultural engagement.

Table 1. Summary of Learners' Perceptions.

Dimension	Mean Score
Learner Independence	3.96
Responsibility for Learning	3.92
Motivation Increase	3.80
Vocabulary Learning	3.76
Cultural Appreciation	3.88
Overall Effectiveness	3.68

3. Novelty and uniqueness

The novelty of Digitalizing Folktales of Filial Piety lies in its integration of culturally embedded moral narratives with technology-enhanced ESL pedagogy. Unlike conventional digital storybooks, this product does not merely digitize text; it transforms traditional folktales into interactive multimedia learning experiences grounded in educational theory. The project uniquely combines three dimensions: cultural preservation, language acquisition, and moral education. While many digital ESL platforms emphasize global or Western content, this initiative centers on Nusantara heritage, reinforcing local identity and filial piety values. The inclusion of audio narration, subtitles, vocabulary scaffolding, and replay functions supports differentiated learning and autonomy. Furthermore, the project bridges cultural sustainability and digital transformation by making traditional stories accessible to digital-native learners. Its cross-disciplinary design, merging literature, technology, linguistics, and moral education which distinguishes it from typical ESL materials. This hybrid approach ensures that cultural heritage is not only preserved but revitalized through innovative pedagogical design.

4. Benefit to mankind

This project benefits society by preserving intangible cultural heritage while enhancing language education. By digitalizing folktales that emphasize filial piety, the platform strengthens moral values such as respect, gratitude, and family responsibility among younger generations. Educationally, it promotes learner autonomy, engagement, and vocabulary development through interactive storytelling. Culturally, it prevents traditional narratives from fading in an increasingly digital world. Socially, it reinforces identity and pride in local heritage within multilingual contexts. The platform also supports inclusive education by enabling self-paced learning accessible across devices. Ultimately, the project contributes to both educational advancement and socio-cultural sustainability.

5. Innovation and Entrepreneurial Impact

The project promotes innovation by integrating digital technology with traditional literature to create scalable educational products. It encourages interdisciplinary collaboration between educators, multimedia designers, and cultural scholars. Entrepreneurially, the digital storytelling model fosters edtech innovation within the local community. It can inspire educators to develop culturally contextualized digital learning materials and stimulate creative industry participation in heritage preservation. By transforming folktales into commercially viable digital modules, the project contributes to a culture of educational entrepreneurship. It supports the growth of digital content development industries while aligning with national digitalization and cultural sustainability agendas.

6. Potential commercialization

The product has strong commercialization potential through subscription-based digital modules for schools, language centers, and higher education institutions. It can be licensed as part of ESL curricula or integrated into Learning Management Systems (LMS). Future expansion may include multilingual versions, interactive mobile applications, teacher guides, and premium editions with gamified features. The platform may also collaborate with ministries of education or cultural heritage organizations. Given increasing demand for culturally responsive digital education tools,

the product is well-positioned for both local and regional markets. Its scalable digital format ensures cost-effective distribution and sustainable long-term revenue generation.

7. Acknowledgment

The researchers would like to express sincere appreciation to the students who participated in the implementation and evaluation of the digital storytelling project. Their feedback contributed significantly to the refinement and improvement of the platform. Gratitude is also extended to colleagues and institutional support that made this innovation possible.

8. Researchers' Biography

Sharina Saad is a lecturer at the Academy of Language Studies, Universiti Teknologi MARA (UiTM) Kedah Branch, Malaysia. She specializes in English as a Second Language (ESL) education, with particular interests in learner autonomy, digital pedagogy, and technology-enhanced language learning. Her research focuses on integrating innovative digital platforms such as social media and interactive storytelling into ESL classrooms to enhance student motivation, speaking fluency, and independent learning. She is actively involved in developing culturally responsive teaching materials that combine language acquisition with heritage preservation. Through her academic and research contributions, she advocates for meaningful, learner-centered approaches in contemporary English language education.

Shafilla Subri is a lecturer from the Faculty of Arts and Design with a strong interest in creative education and digital innovation. Her work focuses on integrating visual storytelling, multimedia design, and cultural heritage into English as a Second Language (ESL) learning environments. She is particularly passionate about digital storytelling projects that combine artistic expression with language development and moral values. Through interdisciplinary approaches, she promotes culturally responsive pedagogy and innovative teaching practices. Shafilla actively contributes to initiatives that preserve traditional narratives while adapting them into engaging digital formats suitable for contemporary learners.

Alia Nabella Fateha binti Zolkifli is affiliated with the School of Humanities, Universiti Sains Malaysia. Her academic interests focus on English language studies, cultural narratives, and interdisciplinary approaches to humanities education. She is particularly interested in integrating cultural heritage with contemporary educational practices, including digital storytelling and multimedia-based learning. Her work explores how traditional narratives can be revitalized through innovative platforms to enhance language acquisition and cultural appreciation. Committed to research and community engagement, she aims to contribute to meaningful educational initiatives that bridge language learning, cultural preservation, and digital transformation in modern academic contexts.

Haseena Kutty Abdul Aziz is a lecturer at the Academy of Language Studies, Universiti Teknologi MARA (UiTM) Kedah Branch. She specializes in English as a Second Language (ESL) education, with research interests in language pedagogy, digital learning integration, and student-centered instructional approaches. Her work focuses on enhancing learners' communicative competence, motivation, and academic performance through innovative teaching strategies. She is actively involved in curriculum development and educational research that promotes effective and meaningful language learning experiences. Committed to academic excellence, she contributes to initiatives that integrate technology and interactive methodologies into contemporary ESL classrooms.

Vylthra: The Human Translator App

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ABSTRACT
Vylthra is an emotional AI-based translator designed to bridge the gap between language and emotion in real-time. While conventional translation applications focus strictly on literal, word-for-word outputs, they frequently fail to capture the speaker's tone, intent and subtle cultural meanings. Vylthra solves this by blending advanced language processing with emotion detection, sarcasm understanding and deep cultural context analysis. Specifically targeting travelers navigating new cultures, the app translates dialects into natural language while identifying the true emotional intent, even assigning relevant emojis to clarify the speaker's feelings. Socio-economically, it enhances the tourism sector and global business interactions by minimizing conflicts and building trust. The application operates on a highly scalable freemium business model, offering basic features for free and advanced emotional translations via a premium subscription.

Keywords: Emotional AI, sarcasm detection, real-time translation, cultural interpretation

1. Product Description
Vylthra is a human translator application that functions as an interpreter of tone, emotions, sarcasm, slang and cultural contexts in real-time. Unlike traditional translation applications that focus solely on direct, literal translations, Vylthra fuses advanced language processing with deep emotion detection. The application features a user-friendly interface that translates local languages, starting with the Sarawakian Malay dialect into natural English. For example, instead of a confusing literal translation, Vylthra processes colloquial phrases and outputs the culturally accurate meaning while attaching context-appropriate emojis to visually represent the conveyed emotion. By capturing the underlying feelings and intentions of the speaker rather than just the words spoken, Vylthra makes global communication more empathetic, human and authentic.

2. Screenshots
Figure 1 displays the welcoming front page of the Vylthra Human Translator application. The interface is designed to be user-friendly and inviting, featuring the app's robotic mascot, a greeting message, and a straightforward "GET STARTED" button to initiate the translation process. This clean design ensures that users, particularly travelers, can quickly access the tool without navigating through complex menus.

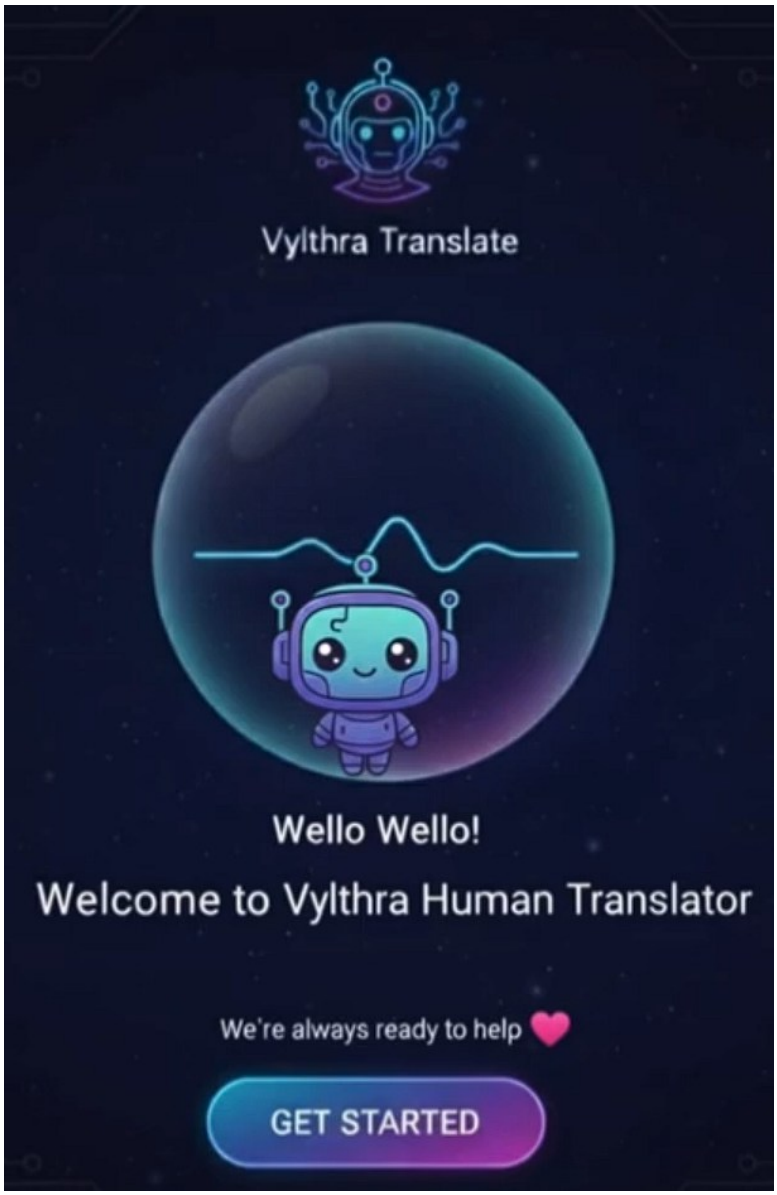


Figure 1. The homepage.

Figure 2 demonstrates Vylthra's core real-time emotional translation capabilities in action. The interface shows an active audio soundwave, indicating that the app is listening to or processing spoken input. In this example, a Sarawakian dialect phrase ("siboh kamboh gilakk kau eh, ingga kali bah") is inputted, and the language parameters are set to translate from Sarawak Dialect to English. Rather than providing a rigid literal translation, the app accurately interprets the slang and cultural context to output the natural English phrase, "Don't be so fussy about it, you made me cringe". Crucially, the app also generates a green, cringing emoji alongside the translation. This visual cue proves the application's unique ability to detect and convey the speaker's true underlying emotion, setting it apart from standard text-based translators.

Figure 2. Example of translation from the Sarawakian Malay dialect to English.

3. Novelty and uniqueness

What sets Vylthra apart is its status as the world's first emotional AI-based translator. It addresses the fundamental flaw of conventional translation apps by focusing on the underlying intent behind spoken words. The novelty lies in the fusion of three advanced features which are emotion-aware AI translation, real-time sarcasm recognition and deep cultural and contextual analysis. While other apps might translate a sarcastic remark literally, which often leads to severe miscommunication, Vylthra recognizes the sarcastic tone and translates it to accurately reflect the speaker's true intent. It goes far beyond the basic translation of words to ensure users grasp the complete emotional and contextual meaning of every conversation, something no other translation app currently provides.

4. Benefit to mankind

Vylthra significantly improves human interaction by making cross-cultural communication clearer and more emotionally accurate. For travelers venturing into new regions, it removes the fear of miscommunication, helping people understand each other with genuine empathy. By avoiding

misunderstandings caused by tone or cultural differences, Vylthra builds trust, particularly in sensitive personal or professional situations. It bridges the gap between language and emotion, fostering a more connected, respectful, and understanding global society.

5. Innovation and Entrepreneurial Impact

Vylthra fosters innovation by introducing emotional intelligence into the artificial intelligence language processing sphere. Entrepreneurially, the project presents a highly scalable software-as-a-service solution driven by a freemium business model. It creates significant avenues for B2B partnerships with tourism agencies, educational institutions, and multinational corporations. By starting locally with Sarawakian dialects and projecting a strategic roadmap toward national and global language integration, the project demonstrates a structured entrepreneurial growth strategy capable of scaling efficiently.

6. Potential commercialization

Vylthra utilizes a scalable freemium model where basic features are free, and advanced emotional and cultural translations are unlocked via a premium subscription at RM20 per month. The primary target audience consists of global travelers. The early phase targets 250 paying users, generating approximately RM5,000 monthly. As the user base expands globally, monthly profits are projected to reach RM72,000, with an average of RM33,000 per month (RM400,000 yearly).

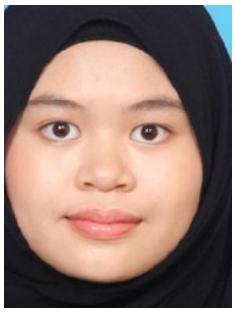
7. Acknowledgment

We would like to express our gratitude to our institution and mentors for their support and guidance in the conceptualization and development of Vylthra.

8. Researchers' Biography

Nurul Izzah is a student from the Faculty of Business Management, Universiti Teknologi MARA (UiTM) Sarawak, Kampus Samarahan. She is currently a 2nd-year Diploma in Office Technology Management student.

Naomi Aren is a student at Universiti Teknologi MARA (UiTM) Sarawak, Kampus Samarahan's Faculty of Business Management. She is presently a second-year student pursuing a diploma in office technology management.



Dayang Liwanie attends Universiti Teknologi MARA (UiTM) Sarawak, Kampus Samarahan's Faculty of Business Management. She is a second-year student pursuing a Diploma in Office Technology Management.

Rudy Ujang is a Lecturer at the Faculty of Business Management, Universiti Teknologi MARA (UiTM) Sarawak, Kampus Samarahan. Specializing in Marketing and Economics, his research focuses on social creativity and innovation. He has a proven track record in innovation competitions, including past success with projects like "Kuruma." His recent scholarly work explores sustainable tourism and consumer behavior, bringing a wealth of academic and entrepreneurial expertise to the development and strategic commercialization of the Vylthra translation application.

GovNova: AI-Powered Shariah Governance and Board Analytics Platform for ASEAN Islamic Finance Sustainability

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ABSTRACT

Governance solution for Shariah-compliant entities, GovNova, is an artificial intelligence solution specifically developed for Shariah-compliant entities in Malaysia and other ASEAN emerging markets. With the global Islamic finance industry exceeding $3.5 trillion, Sharia-compliant entities are struggling to manage Sharia Supervisory Board governance, different regulations in different countries, and ESG reporting in line with Islamic principles. Existing solutions, developed primarily to serve the corporate world in the West, cannot address the specific requirements of Islamic financial entities or the regulatory needs of ASEAN nations. GovNova, therefore, provides the solution by bringing together Shariah governance intelligence, ASEAN regulatory intelligence, and predictive analytics under one unified solution. GovNova allows Sharia-compliant entities, such as Islamic banks, takaful operators, Shariah-compliant funds, and ASEAN emerging market entities, to attain governance excellence while being absolutely true to their religious integrity. Additionally, GovNova is priced at 90% lower than its competitors in the West. This democratises governance excellence in Malaysia, Singapore, Indonesia, and the broader global Islamic finance industry.

Keywords: Shariah Governance, Islamic Finance, ASEAN Compliance, Board Analytics, Emerging Markets

1. Product Description

GovNova is a platform specifically designed to support Shariah governance and board analytics. The platform has been developed to meet the specific needs of Islamic financial institutions and organisations across ASEAN. At the heart of GovNova lies an advanced Shariah Supervisory Board (SSB) management system. The platform has been designed to support all aspects of Shariah governance. This includes tracking SSB members' qualifications according to Bank Negara Malaysia (BNM) regulations to support fatwa applications. Additionally, it includes recording board meetings and supervising implementation. GovNova has also been developed with specific features to support Shariah governance. These include checklists to support AAOIFI (Accounting and Auditing Organization for Islamic Financial Institutions) Governance Standards. The platform also includes an automated system to identify Shariah non-compliance events. The platform directly ingests Islamic finance regulations from key markets. These include Malaysia's Bank Negara Malaysia (BNM), Singapore's Monetary Authority of Singapore (MAS), and the ASEAN multi-jurisdiction framework, which is a set of guidelines for regulatory cooperation among Southeast Asian nations. The platform also includes templates to support general corporate

governance. These include the MCCG (Malaysian Code on Corporate Governance), Singapore's Code of Corporate Governance, and OJK regulations, as well as Shariah governance. The most impressive feature of GovNova is the Progressive Governance Framework. The framework includes a five-step model for supporting organisations. These range from seed-stage Shariah governance to support Islamic fintech to a public listing. Additionally, it includes tools to support proactive Shariah governance. These include AI tools to analyse successful IPOs across ASEAN and the Islamic financial sectors. The tools offer real-time dashboards that make trends in Shariah governance easy to see.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs and etc.

Figure 1. The Innovative Board Analytics Platform and Its Components.

GovNova

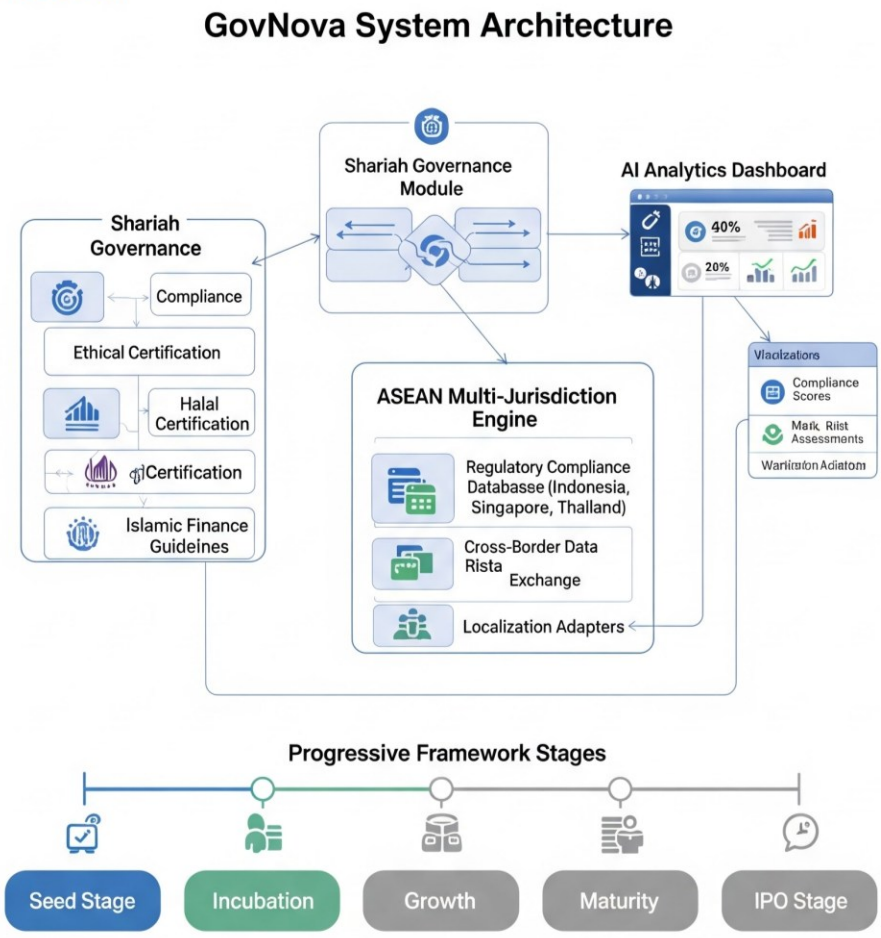

Figure 2. System architecture.

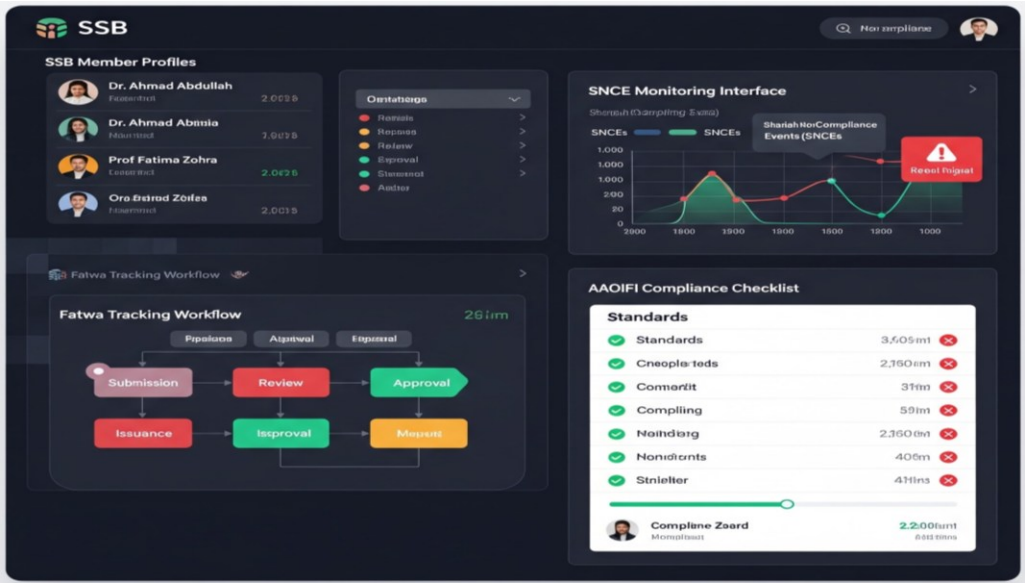

Figure 3. System Architecture and Interface.

3. GovNova stands out for its novelty and uniqueness.

GovNova enters underserved markets and distinguishes itself from competitors like Diligent, BoardEffect, OnBoard, and Nasdaq Boardvantage, which are very Western and corporate-centric and do not consider Shariah at all. GovNova serves as a comprehensive solution for Shariah Supervisory Boards, adhering to the standards set by the Accounting and Auditing Organization for Islamic Financial Institutions (AAOIFI) and Islamic finance regulations. It's not just Shariah-compliant but built around Shariah. This capability is important, as Malaysia has 16 full-fledged Islamic banks, over 30 takaful and Islamic investment bodies, and hundreds of Shariah-compliant companies. Additionally, the ASEAN Regulatory Toolkit built into the system helps Malaysian businesses comply with Bursa Malaysia regulations, Bank Negara Malaysia regulations, MAS regulations, and OJK regulations. On pricing, GovNova outshines its competition, as the monthly fees start at RM199 and go up to RM4,999. This discount translates to 90–95% less expensive than the annual fees of $10,000–$50,000 that the competition charges. With this pricing, professional-grade corporate governance solutions are now within reach of Malaysian SMEs, Indonesian startups, and other ASEAN growth companies. Additionally, the progressive maturity model ensures that companies are taken from the seed stage to IPO-ready, closing the huge gap left by solutions that cater to mature corporations and leaving startups and small companies behind.

4. Benefit to mankind

The vision of GovNova is to make top-tier governance more accessible to all, bringing world-class governance within everybody's reach. In this way, it ensures that small and medium-sized enterprises have an equal opportunity to compete for large investments by keeping the costs of their capabilities low. At its core, GovNova ensures the integrity of Islamic finance through Shariah governance, going beyond the hype to deliver real integrity, real compliance with Islamic law, and real trust in ethical finance among Muslims worldwide. GovNova serves as a protective shield against corporate failures, which can cause economic instability, thereby protecting employment, economies, and vulnerable people in emerging economies from financial crises. GovNova contributes to several of the United Nations Sustainable Development Goals, which are to promote sustainable business growth (SDG 8), reduce inequality through accessible governance platforms (SDG 10), increase accountability (SDG 16), and facilitate cooperation (SDG 17). Moreover, the digital governance platform eliminates barriers to entry, which allows more women directors and younger professionals to join the corporate world.

5. Innovation and Entrepreneurial Impact

GovNova solves the biggest challenges faced by ASEAN entrepreneurs and innovators in the realm of Islamic finance. Today, every venture capitalist scrutinises the governance of a business during the due diligence phase of the funding process. With GovNova, the entrepreneur comes prepared with world-class boardroom management, risk management, and compliance tracking, giving themselves the best chance of securing funding from VCs or other sources. Islamic finance is especially complex because of the twin pressures of technological innovation and the need to stay true to religious principles. The integrated module of GovNova enables Islamic finance innovators to maintain their religious principles while operating at the rapid pace of a startup. Moreover, the Pre-IPO module of GovNova can be used as a preparatory module for listing on the Bursa Malaysia or other exchanges in the region, identifying and remedying governance issues

early on to speed up the time-to-IPO process. With the multi-jurisdictional compliance module of GovNova, ASEAN expansion can happen quickly without the high costs of engaging consultants locally in every country. By building governance in the very early stages of the business, GovNova ensures that accountability, transparency, and decision-making are embedded in the very DNA of the business, setting the stage for long-term success while avoiding the "governance debt" that can plague a business as it scales.

6. Potential commercialization

GovNova is launching with a strong bet on Malaysia, focusing on the country's 650 Islamic finance institutions and 1,500 growth-oriented firms, which present a potential market size of RM15–30 million in annual recurring revenue (ARR). Our SaaS solution is a multi-tier offering, with Shariah Startup at RM199/month targeting Islamic fintechs, Shariah Professional at RM999/month targeting Islamic institutions, and Shariah Enterprise at RM4,999/month targeting large banks and holding companies. The project expects to achieve RM240,000 ARR in Year 1 from 20 customers, with growth accelerating to RM1.2 million ARR in Year 2 from 100 customers. Strategic partnerships with regulators like Bank Negara Malaysia and Securities Commission Malaysia (ASAS), MDEC, and MaGIC to obtain regulatory approval, access to ASAS, and accelerator programmes to fuel startup growth are essential to the project's success. After our ASEAN push with INCEIF/IBF to target Indonesia, Singapore, Brunei, and Thailand, the platform will target global Islamic finance hubs in the Middle East and South Asia. The potential funding sources will be Cradle Fund CIP (RM500K), MDEC digital economy grants, specialised Islamic VCs, and ASEAN-based fintech investors.

7. Acknowledgment

The researchers acknowledge that this innovation is at the conceptual validation stage.

8. Researchers' Biography

Maizatul Akmal Musa is an academic researcher who focuses on corporate governance and administration. Her research interests revolve around enhancing organisational effectiveness by implementing better governance structures and administrative processes, particularly in a Malaysian corporate context. Key research areas include corporate governance mechanisms, the effectiveness of the board, organisational performance, and corporate sustainability practices.

Shahril Eashak Ismail is a researcher in innovation and technology management who works to advance strategic technological development and organisational transformation. Shahril is deeply committed to understanding the intersection of technological innovation and strategic implementation. He investigates complex frameworks for technological adoption, innovation diffusion, and organisational change management, and he gives helpful insights to academics, policymakers, and industry leaders who are attempting to navigate the complex landscape of technological advancement.

Metafiqh: An Immersive Metaverse Experience for Enhancing Understanding of Islamic Economic Jurisprudence

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ABSTRACT
METAFIQH is a metaverse learning framework that is based on digital learning to enhance the understanding of Islamic Economic Jurisprudence (*Fiqh Ekonomi*). The traditional methods of teaching are lecture and heavy text content, and they do not enable students to contextualise the principles of Shariah-based economic principles in the socioeconomics of real-world systems. METAFIQH was created to bridge this gap and transfer such imperatives as the ban of riba and Maqasid al-Shariah to a 3D virtual marketplace and into a 3D interactive simulation. The system is built on the immersive platform (Spatial.io) and presented with the help of a structured video demonstration, allowing learners to work in Shariah-compliant financial situations and see the socio-economic effects of ethical and non-ethical choices. The main advantage is that it unites the ideas of Islamic jurisprudence and the metaverse and substitutes the concept of knowledge transfer with experience. The project helps to promote sustainability, economic and ethical awareness, and digital literacy. It contributes to good financial and overall economic literacy socio-economically. METAFIQH has robust commercialisation potential with institutional licensing, online modular courses, and professional Islamic finance training programs.

Keywords: Islamic Economic Jurisprudence, Metaverse-Based Learning, Experiential Simulation, Maqasid al-Shariah, Shariah-Compliant Financial Education

1. Product Description
METAFIQH is a training program designed to offer post-secondary courses in English Islamic Economics, namely the Pengenalan kepada *Fiqh Ekonomi* (EPPE2423). It is an amalgamation of content in organised jurisprudence and simulations in the interactive metaverse within the architectural platform of Spatial.io. The product will consist of three fundamental components, namely: a conceptual knowledge domain, which will be a digital representation of a Shariah-compliant marketplace; a virtual economic simulation space, which will be a digital manifestation of the digital representation of a Shariah-compliant marketplace; and a reflective assessment interface, which will enable the evaluation of financial decisions in an illuminated manner. The 3D space allows students to decide on economic situations, model contract forms, and preview the socio-economic outcomes that occur, such as the redistribution of wealth and equity consequences. A demonstration video supports the immersive prototype in order to support both formal and informal learning. The system is flexible to be incorporated into learning

management systems and advanced Islamic finance modules. METAFIQH is a digital prototype of immersive Islamic economic education and can be interpreted as a pedagogical device as well.

2. Operational Model and 3D Learning Interface.

The flow of operation in the simulation is provided in **Figure 1**. The cause-and-effect issues of economic decisions and distributive justice outcomes are explained in this flowchart to the learners.

Figure 1. Operational Flow of Simulations.

Figure 2 shows a screenshot of the METAFIQH virtual environment of immersive learning set up on the Spatial.io platform.

Figure 2. Spatial.io Avatar-Based Simulation Environment for Islamic Economic Jurisprudence.

The design of one of the three-dimensional virtual classrooms and exhibition spaces that will be developed in the course is depicted in **Figure 2**, which is the "Pengenalan kepada Ekonomi (EPPE 2423)." Such an environment allows the learners to recognize themselves through some sort of avatars, and they are given the chance to actively engage in a simulation learning environment. The presented panel in the background presents the heading of the course and the general framework of Fiqh Ekonomi. The space composition of visual learning boards enables the students

to move through conceptual boards, systematic exposition, and interpersonal learning materials. The design encourages exploration by oneself and experience, as opposed to observation. The interface allows the students to see how Islamic economic jurisprudence is transformed into a digital learning environment. For instance, students can visually touch upon the course materials, simulate economics, and participate in the discussion. The use of avatars supports the sense of immersion among learners, digital literacy, and interactions in the metaverse environment. This figure proves the existence of the METAFIQH prototype and justifies the viability of immersive Islamic economic learning with the help of the Spatial.io technology.

3. Novelty and uniqueness

METAFIQH is unlike any other in its interdisciplinary approach, combining Islamic jurisprudence with economic theory and immersive metaverse technology. Unlike traditional e-learning platforms that are a static delivery system for content, METAFIQH re-creates Islamic economic jurisprudence into socio-economic simulations. The innovation is the development of regulations (legal-economic precepts), which are turned into real-life digital situations when learners are actively engaged with money-related decision-making processes. The combination of Maqasid al-Shariah as quantifiable simulation results makes the platform a departure from the tools of traditional Islamic studies. Furthermore, the use of Spatial.io creates an immersive three-dimensional learning space as opposed to a two-dimensional learning interface. The ability to integrate jurisprudential principles into an open-ended ecosystem of economics will enable the implementation of an experiential rather than memorization-learning process with the aid of METAFIQH. This interdisciplinary and immersive approach makes the project a breakthrough innovation in the field of Islamic social science education.

4. Benefit to mankind

METAFIQH makes a contribution to society by strengthening ethical financial literacy and promoting responsible economic behavior. In particular, the platform fosters an understanding of elements of justice, redistribution, and sustainability in economic systems by engaging the learners in their personal experiences of Shariah-based economic concepts through simulation environments. This is the innovation that stimulates quality education, as it provides students access to technology and prepares them with skills to include technology in the financial ecosystem. It provokes a questioning attitude and ethical standards for the development of socio-economic welfare in the long run. In short, METAFIQH helps the preparation of socially responsible individuals and communities by promoting sustainable and equitable economic knowledge.

5. Innovation and Entrepreneurial Impact

METAFIQH promotes innovation as a result of its linkage between the discipline of Islamic studies and immersive digital technology. It promotes discussion and interdisciplinary cooperation between economics, Shariah scholarship, and educational technology development. The project promotes a culture of digital experimentation within the institutions of higher learning. Entrepreneurially, METAFIQH launches a model of educational technology at scale with the potential for expansion toward subscription-based immersive learning technologies. It opens up collaboration opportunities with Islamic financial institutions and training providers, as well as ed-tech developers. By reconstructing traditional knowledge systems through immersive innovation, METAFIQH is part of an entrepreneurship-driven transformation in Islamic education.

6. Potential commercialization

METAFIQH holds enormous commercialization potential in terms of institutional licensing to universities that provide Islamic Economics and Finance learning programs. The format is modular and therefore easy to integrate into online courses, business certification, and Shariah-compliance training of professional associations. Other possible sources of income might include entry via subscription and custom-made simulation programs to banks and European joint ventures in Muslim education markets. With the demand for Islamic finance and digital learning not expected to subside in the international arena, there is a lot of commercial promise behind immersive juristic learning tools.

7. Acknowledgment

The authors would like to express their gratitude to the Faculty of Economics and Management, Universiti Kebangsaan Malaysia, for funding this project under Geran Inisiatif Penyelidikan (EP-2023-045). The grant provided the necessary financial support for project development, along with motivation to become more innovative in this area of Islamic economic education. Additionally, the authors wish to thank the students and associates who provided their feedback during the development and testing of the METAFIQH immersive prototype.

8. Researchers' Biography

Dr. Raudha Md. Ramli is a Senior Lecturer at the School of Economics, Faculty of Economics and Management, Universiti Kebangsaan Malaysia (UKM), and currently serves as Coordinator of Quality and Strategy at FEP-UKM. She specializes in Islamic Economics and Finance, with research interests in zakat and waqf, halal economy, Islamic fiscal policy, sustainable development, and natural resource economics. She actively leads and participates in funded research projects and teaches various undergraduate and postgraduate courses in Islamic economics. Her work focuses on promoting ethical, sustainable, and socially responsible economic thinking grounded in Islamic principles.

Dr. Nadiah Mahmad Nasir is a Senior Lecturer and Lead Researcher at the Faculty of Business and Communication, Universiti Malaysia Perlis (UniMAP). She specializes in strategic management, entrepreneurship, and qualitative research methodology. Her research focuses on family business succession, halal tourism, and sustainable rural development. She has led and contributed to nationally and internationally funded research projects, including her current INTERES-funded study on female successors in agro-based family businesses. Her work emphasizes translating research into practical frameworks that support entrepreneurship and sustainable community development.

Qayra 2.0 – Multifunctional Muslim Prayer Attire: A Smart Innovation in Modest Wear Design

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ABSTRACT

The design of Muslim prayer attire is guided by Islamic dress code principles as prescribed in the Qur'an. However, most prayer garments available in the market are designed as conventional two-piece attire with a single function, primarily catering to non-disabled users. Although numerous brands offer prayer attire, limited attention has been given to developing designs specifically tailored for women with disabilities, largely due to the perception of a highly segmented market. Consequently, existing products often fail to meet the functional, fabric, and durability requirements necessary for wheelchair users, particularly those with spinal cord injuries. This study led to the development of Qayra 2.0 multifunctional muslim prayer attire, a smart innovation in modest wear design, an enhanced version of the initial prototype. The research aims to identify and analyze essential design attributes required to produce a multifunctional prayer garment that meets the specific needs of Muslim women with mobility impairments. Emphasis was placed on functionality, aesthetics, and technical performance. Data were collected through observation, surveys, and interviews to obtain reliable user feedback and professional insights. Post-test evaluation conducted at PDK Marwaddah Rembau demonstrated improvements in donning and doffing, versatility, practicality, comfort, and durability. The final design enhances mobility during prayer while promoting inclusive and socially responsive modest wear innovation.

Keywords: Multifunctional, Prayer attire, Disabled women, Modest.

1. Product Description

Qayra 2.0, Multifunctional Muslim Prayer Attire is developed with a new silhouette that enhances both modesty and functional performance for Muslim women with mobility limitations. The redesigned structure supports seated posture, particularly for wheelchair users, while maintaining Shariah-compliant coverage. The garment emphasizes comfort through thermal-regulating properties, optimized movement capacity, and functional adaptability during prayer activities. In terms of usability, the product integrates a 4-in-1 multifunctional design, allowing it to serve as prayer attire, outer modest wear, travel garment, and protective covering. The sizing system is custom-made to ensure accurate body fit, accommodating individual anthropometric measurements and specific mobility conditions. Special consideration is given to body part movement, enabling ease in upper and lower limb positioning without fabric restriction. Constructed from polyester fabric, the attire offers durability, lightweight comfort, and thermal consistency suitable for prolonged wear. Protective elements are incorporated through integrated arm and leg protectors, enhancing coverage and safety. The design also prioritizes ease

of donning and doffing, allowing users to wear and remove the garment independently. Overall, the product demonstrates a balance between aesthetics, technical functionality, protection, and durability in inclusive modest wear innovation.

2. Methods and Results

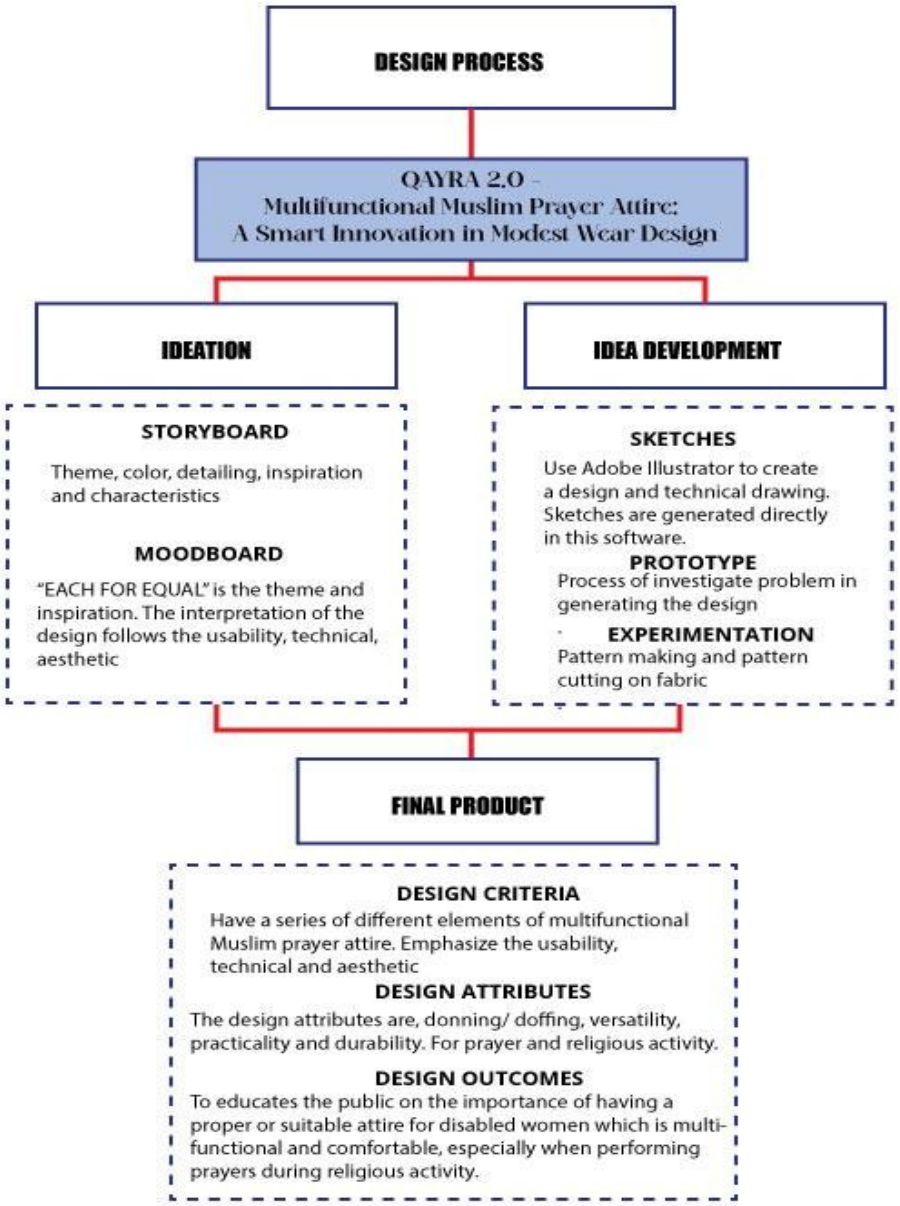

Figure 1. Framework of the design process.

Figure 2. Qayra 2.0, adaptive prayer attire classic cutting.

Table 1. Characteristics of Design.

Qayra 2.0	Description
1. Concept	Multifunctional prayer attire
2. Color	Dusty pink
3. Fabrics	Como crepe and cotton lycra
4. Characteristics	Classic cutting. Round shape. Top can transform into khimar. Additional with welt pocket and detachable bag.
5. Techniques	Elastic in face opening, cord stopper, buckle clip and zipper.

3. Novelty and uniqueness

Qayra 2.0 introduces a novel approach to modest wear by integrating inclusive design principles into Muslim prayer attire specifically tailored for wheelchair users and women with mobility impairments. Unlike conventional two-piece prayer garments available in the market, this innovation incorporates a new silhouette adapted to seated posture, ensuring proper coverage, comfort, and ease of movement. The design uniquely combines functionality, protection, and aesthetics within a single garment. Its 4-in-1 multifunctional concept distinguishes it from existing

products, as it can function as prayer attire, travel wear, protective covering, and modest outer garment. The integration of arm and leg protectors further enhances safety and coverage, which is rarely addressed in mainstream prayer attire design. Additionally, the custom-made sizing system ensures individualized fit based on users' physical conditions, particularly those with spinal cord injuries. The emphasis on thermal comfort, durable polyester fabric, and easy donning and doffing mechanisms reflects user-centered innovation derived from observation and post-test evaluation. This combination of adaptive design, multifunctionality, and inclusive modest fashion positions Qayra 2.0 as a unique contribution to disability-responsive apparel innovation.

4. Benefit to mankind

Qayra 2.0 contributes to social inclusion by empowering Muslim women with disabilities to perform prayers independently, comfortably, and with dignity. The design addresses physical barriers commonly experienced by wheelchair users, particularly in achieving proper coverage and ease of movement during prayer. Beyond its primary users, the multifunctional features also benefit Muslim women travelers seeking practical and portable modest wear. The innovation promotes equal access to religious practices, supports emotional well-being, and enhances self-confidence among persons with disabilities. By advocating inclusive design in modest fashion, the product raises public awareness about the importance of adaptive clothing and encourages greater sensitivity toward the needs of vulnerable communities.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by applying research-driven, user-centered design to address unmet needs in the modest fashion industry. By focusing on adaptive apparel for persons with disabilities, Qayra 2.0 expands the scope of conventional prayer wear into a niche yet socially significant market segment. Within the institutional and community context, the project fosters a culture of inclusive innovation, encouraging students and designers to integrate social responsibility into product development. It demonstrates how empathy-based research can be translated into commercially viable solutions. Entrepreneurially, the innovation opens opportunities for small-scale production, customization services, and collaboration with rehabilitation centers and disability organizations. It positions inclusive modest wear as a potential emerging market within the broader halal and modest fashion industry.

6. Potential commercialization

Qayra 2.0 has strong commercialization potential within the modest fashion and adaptive clothing markets. The product targets Muslim women with mobility impairments, rehabilitation centers, disability associations, and travelers seeking multifunctional modest wear. Commercial strategies may include made-to-order customization, online marketing platforms, and collaboration with community-based rehabilitation centers. The use of durable polyester fabric supports cost-effective production while maintaining quality and thermal comfort. Market expansion can extend to hospitals, physiotherapy centers, and Islamic institutions that support persons with disabilities. With proper branding and intellectual property protection, Qayra 2.0 can be positioned as a pioneering adaptive modest wear brand at national and regional levels.

7. Acknowledgment

The researcher would like to express sincere appreciation to the participants and staff of PDK Marwaddah, Rembau for their cooperation and valuable feedback during the post-test evaluation. Gratitude is also extended to all individuals and institutions who directly and indirectly contributed to the successful development of Qayra 2.0.

8. Researchers' Biography

Fara Azeerin binti A. Karim is a lecturer in the Fashion and Apparel Department at Kolej Komuniti Rembau (Rembau Community College), Malaysia. With over 13 years of teaching experience, she specializes in fashion design, garment construction, and modest wear development. Her academic and professional expertise integrates technical design skills with industry-relevant practices, emphasizing functionality, aesthetics, and innovation. She is actively involved in product development and community-based research, particularly in inclusive and adaptive apparel design. Her work reflects a strong commitment to social innovation, bridging academia and industry to produce practical solutions that address real societal needs, especially for persons with disabilities.

Nurul Syafiqah Binti Md Amin is a lecturer at Raub Community College, Pahang, Malaysia. She has accumulated four years of teaching experience in Visual Arts Education and has been serving as a lecturer in Fashion Design and Clothing at Raub Community College for the past six years. Her research interests focus on fashion and apparel studies, particularly in the areas of fashion technology, fashion design, and fashion marketing. In addition, she is actively engaged in research related to art education and visual arts, especially in the context of teaching innovation and creative learning approaches.

Physics Battle: A Gamification Approach for Teaching Free Body Diagram

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ABSTRACT

Physics Battle: FBD Edition is an educational card game designed to support the learning of free body diagram (FBD), a fundamental topic in introductory university physics. Many students struggle to identify forces and construct correct FBDs due to abstract representation and limited engagement in traditional lecture-based instruction. Therefore, this game transforms practice into an active and interactive learning experience. The game applies a fast-reaction matching mechanism in which players match situation cards with the correct FBD cards using force analysis and color cues, while action cards (*See the Future*, *Break Turn* and *Sharing is "Caring"*) introduce strategy and motivation. The gameplay promotes repeated practice, peer discussion and immediate feedback. A study involving 18 pre-diploma students showed improvement after the intervention. The mean score increased from 12.17 in the pre-test to 12.72 in the post-test (full mark = 13), with more students achieving full marks. The results indicate reduced minor errors and strengthened conceptual understanding. Overall, the findings suggest that the game does not merely introduce the concept but helps refine students' understanding and improve mastery of FBD across the class. The game is portable, low-cost and suitable for learners with limited physics background. It enhances engagement, confidence and collaborative learning, supporting STEM interest in the community. The product also has strong commercialization potential as a teaching aid for schools, colleges, tuition centers and training workshops, and can be expanded to other physics topics.

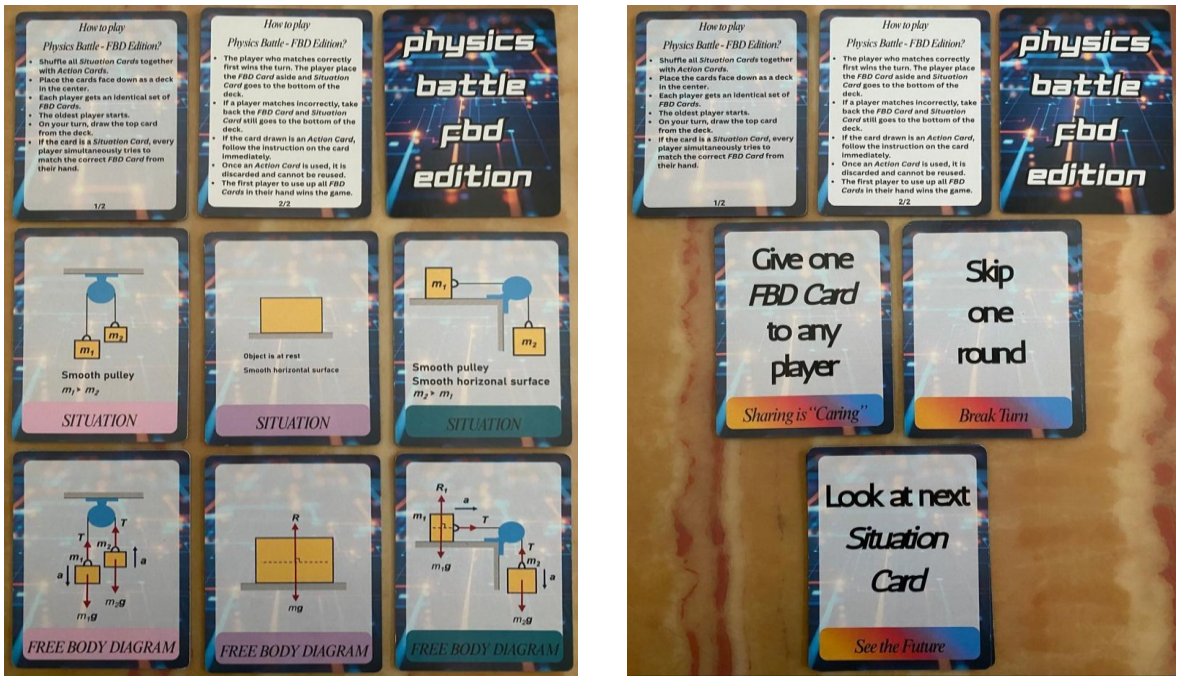
Keywords: Gamification, Free Body Diagram, STEM, Physics, card game

1. Product Description

Physics Battle: FBD Edition is a gamified learning tool that transforms the abstract topic of forces into an engaging hands-on activity. The game consists of 14 situation cards, 14 matching FBD cards, and 3 action cards (*See the Future*, *Break Turn*, and *Sharing is "Caring"*). The cards were designed using Canva with clear visuals and simple layout. The gameplay is inspired by the fast-reaction concept of the Halli Galli card game. A situation card is revealed, and players must quickly identify the correct FBD from the cards in their hand. The fastest player who matches correctly places the card aside, and the first player who finishes all FBD cards wins. The game is designed for 2–4 players, making it suitable for small group learning and classroom activities. Unlike Halli Galli, no bell is used because the task requires thinking and force analysis, not only observation. To support beginners, a color-coding system is included. The correct FBD and its

situation share the same color, allowing even players who have not formally studied FBD to participate while gradually understanding the concept.

2. Methods and Results



(a) (b)

Figure 1. Components of Physics Battle: FBD Edition: (a) situation and FBD cards, (b) action cards.

Figure 1(a) shows the game cards with the card back design and the instruction card *"How to Play Physics Battle: FBD Edition"*, together with sample situation cards and their corresponding FBD cards. The game consists of 14 situation cards and 14 matching FBD cards, and each correct pair shares the same color as a visual cue to support identification and learning. **Figure 1**(b) presents the complete set of action cards (*See the Future*, *Break Turn*, and *Sharing is "Caring"*) along with the instruction card and card back design. These cards introduce strategy and player interaction during gameplay. **Figure 2** illustrates the sequence of play, including situation card matching and the use of action cards. The winner is the first player to finish all the FBD cards in hand. **Table 1** shows that students already had a good basic understanding of FBD concepts, as the mean scores were close to the full mark. The full mark is 13. However, the increase in the post-test mean score indicates improvement after using the FBD card game.

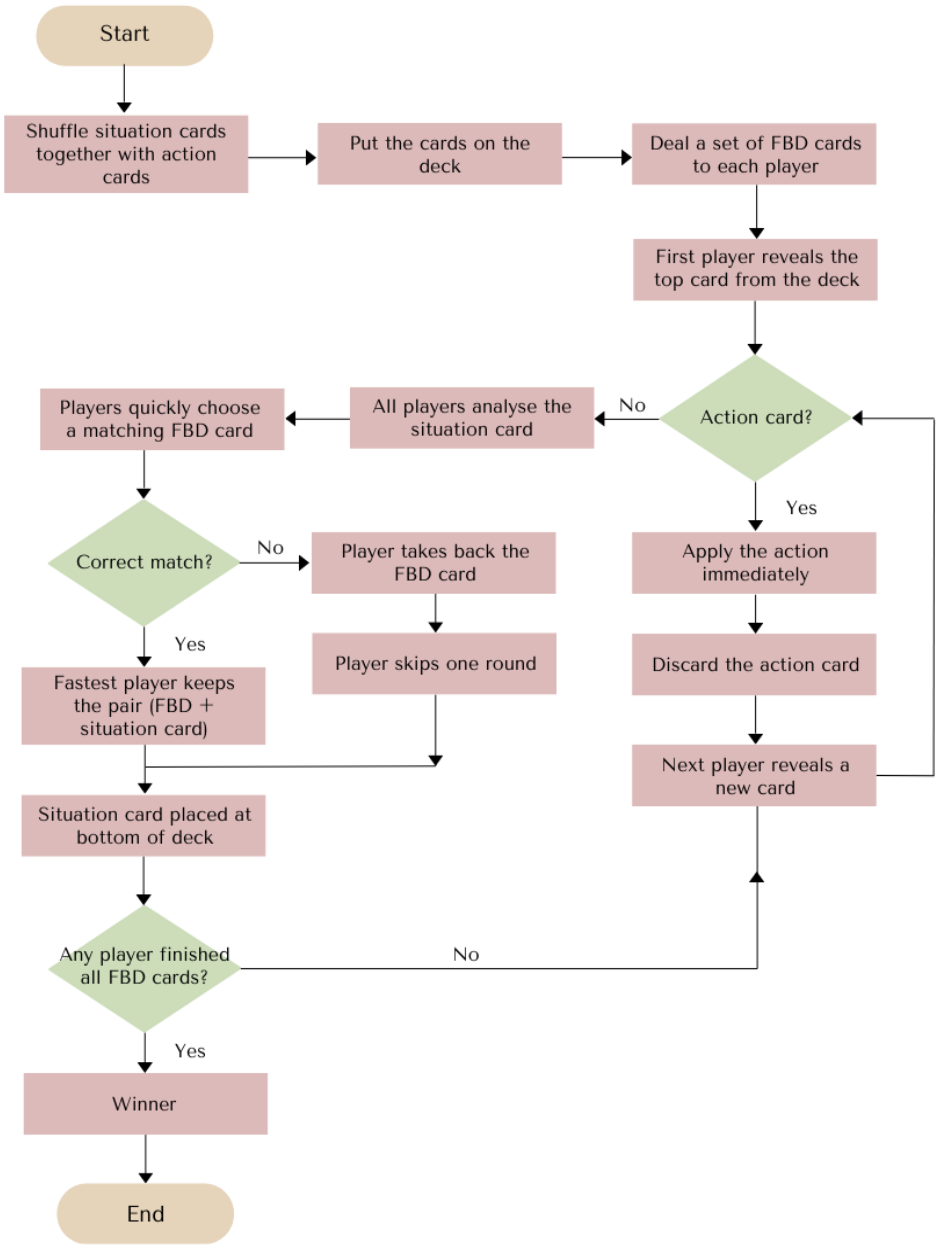


Figure 2. Gameplay flow of *Physics Battle: FBD Edition*.

Table 1. Pre-test and post-test performance comparison.

Score	**Pre-test**	**Post-test**
Minimum	3	8
Maximum	13	13
Mean	12.17	12.72

3. Novelty and uniqueness

Physics Battle: FBD Edition introduces a new approach to learning force analysis by converting a traditional paper-and-pencil university physics topic into a real-time interactive card game. Instead of solving static textbook questions, players must quickly interpret physical situations and identify the correct free body diagram under time pressure. The game combines cognitive reasoning and reaction speed, encouraging immediate application of concepts rather than memorization. A color-coding guidance system is incorporated so that beginners who have never studied FBDs can still participate while gradually associating forces with visual representations. In addition, strategy elements through action cards such as *See the Future*, *Break Turn*, and *Sharing is "Caring"* promote communication, anticipation, and decision-making among players. Inspired by a popular reaction-based card game but redesigned for conceptual learning, the product uniquely integrates gamification, scaffolding, and collaborative learning into a portable teaching aid suitable for both formal and informal learning environments.

4. Benefit to mankind

The innovation supports meaningful physics learning by reducing students' fear and misconceptions about forces, which are foundational concepts in science and engineering education. Through repeated practice and peer interaction, students gain confidence, improve reasoning skills, and develop a positive attitude toward physics. The game also encourages cooperative learning and social interaction, making it suitable for diverse learners, including those with limited science background. By increasing engagement and understanding in STEM education, the product contributes to the development of future learners who are better prepared for technical and scientific fields.

5. Innovation and Entrepreneurial Impact

This project promotes innovation in teaching practice by introducing a creative, low-technology solution that educators can easily adopt in classrooms, workshops, and outreach programs. It encourages educators and students to view learning materials not only as instructional tools but also as products that can be designed, improved, and marketed. The development process, including content design, visual layout, testing, and refinement, cultivates problem-solving, creativity, and product development skills. Within the academic community, the project fosters a culture of educational innovation and opens opportunities for student involvement in design, testing, and promotion activities. It also demonstrates how educational ideas can evolve into entrepreneurial products, inspiring educators to explore commercialization of teaching aids and learning innovations.

6. Potential commercialization

Physics Battle: FBD Edition has strong potential as a marketable educational product due to its low production cost, portability, and ease of use. The game can be distributed to secondary schools, foundation programs, universities, and tuition centers as a supplementary teaching aid. It is also suitable for STEM camps, teacher training sessions, and educational workshops. The product can be packaged as a ready-to-use learning kit and expanded into additional series covering other physics topics such as vectors, energy, and electricity. Collaboration with educational publishers, training providers, and educational toy distributors could support wider

distribution. With proper branding and instructional support materials, the game has the potential to reach both local and regional educational markets.

7. Acknowledgment

The authors would like to express their sincere appreciation to Universiti Teknologi MARA (UiTM) Cawangan Pulau Pinang for the support, facilities, and encouragement provided throughout the development and implementation of this innovation.

8. Researchers' Biography

Intan Syaffinazzilla Zaine is a Senior Lecturer at Universiti Teknologi MARA (UiTM) Cawangan Pulau Pinang, Kampus Permatang Pauh. She has served at the institution since 2008, teaching physics to pre-diploma and diploma students. Her interest focuses on physics education, particularly in improving students' conceptual understanding through active learning and gamification. She develops educational card games as teaching aids, including Happy Family: Geometry Edition for secondary school mathematics, Advanced Happy Family: Prefix Edition for prefix learning, and Physics Battle: FBD Edition for free body diagram concepts. Her innovations aim to make abstract scientific concepts easier to understand while increasing students' engagement, confidence, and participation in STEM learning.

ChM Dr. Marina binti Mokhtar is a Senior Lecturer at the Faculty of Applied Sciences, Universiti Teknologi MARA (UiTM), Cawangan Pulau Pinang, Kampus Permatang Pauh, with over two decades of experience in teaching, supervision, research, and academic leadership. Her research includes physical and chemical approaches in materials science, environmental analysis, and STEM innovation. She studies and modifies functional nanomaterials, including carbon-based materials, composite films, and Cu-doped CeO_2, to enhance analytical and antibacterial performance through sustainable methods. In addition, she integrates research into innovative STEM education practices by designing technology-supported learning tools that promote scientific literacy, critical thinking, and problem-solving skills, contributing to meaningful educational and societal impact

Mohd Bukhari bin Md Yunus is a Senior Lecturer at Universiti Teknologi MARA (UiTM) Cawangan Pulau Pinang, Kampus Permatang Pauh, specializing in semiconductor and solid-state technologies. With over 15 years of experience, he has contributed extensively to advancements in materials, device performance, and reliability within modern electronic systems. His work bridges academic research and practical industry applications, supporting innovation in next generation of electronic and

energy efficient technologies through applied research and development initiatives.

Noorezal Atfyinna binti Mohammed Napiah is a Senior Lecturer in Physics at Universiti Teknologi MARA (UiTM), Cawangan Pulau Pinang, Kampus Permatang Pauh, specializing in Medical Physics. With over 20 years of experience in teaching and research, she has expertise in curriculum development, postgraduate supervision, and publication in Scopus-indexed journals. Actively involved in the innovation ecosystem as both a jury member and participant in various research and innovation competitions at school, university, and national levels, she has developed several educational innovations, including a gamified Scrabble-based learning tool, Flip Kit FBD, Physics Brain Booster On-the-Go, among others, and contributes to community engagement initiatives, particularly in promoting STEM awareness and education.

RVI at Scale: Re-Engineering Dissertation Governance Through Structured Supervisory Risk Mitigation in Construction Education

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ABSTRACT

RVI at Scale was developed in response to sustained volatility in undergraduate dissertation pass rates within the Construction Management programme, encompassing a wide range of research themes and methodological approaches. Prior to implementation, pass rates fluctuated between 79.1% and 88.6% across successive semesters, resulting in repeat submissions and delayed academic progression. The Research Verification Interview framework constitutes a structured supervisory governance system grounded in risk detection, positioned five weeks before final submission. Students are required to submit a substantive draft, while those identified through rubric-informed diagnostics undergo a formal verification interview supported by documented supervisory evidence. The framework formalises supervision accountability through mandatory meeting records and aligns supervisory engagement with assessment weighting, thereby recalibrating dissertation oversight from discretionary advisory practice to structured academic control. Following initial implementation with 113 students, pass rates increased to 90.2%. Subsequent consolidation across a larger cohort of 169 students yielded a further increase to 94%, indicating not merely performance recovery but measurable outcome stabilisation. The findings demonstrate that systematic supervision design, rather than remedial academic support alone, is central to securing dissertation completion on a scale. The framework is transferable to other built environment and engineering programmes and offers commercial potential through institutional licensing, structured implementation packages and supervisor development provision.

Keywords: Construction management, Dissertation, Education, High Impact Innovation

1. Product Description

The product comprises five integrated components. First, a documented supervision compliance requirement mandates a minimum of seven formally recorded supervisory meetings, maintained within an endorsed meeting log to ensure sustained and verifiable academic engagement. Students are required to document all formal attempts to contact their supervisors within working hours, including instances of non-response, thereby addressing prior patterns of undocumented supervisory disengagement. Supervisors must formally endorse and comment on each meeting record to confirm authenticity. Second, compulsory draft submission functions as an early detection mechanism for substantive academic deficiencies prior to final assessment. Third, a rubric-informed diagnostic instrument enables supervisors to identify students whose progress

evidences academic or structural risk. Where concerns arise, supervisors are required to submit documented evidence and relevant supporting materials through structured digital forms to ensure procedural transparency. Allegations of plagiarism must be substantiated by documented similarity reports and annotated extracts of the dissertation, rather than unsupported suspicion. Supervisors are required to conduct Turnitin similarity checks on the submitted draft to verify textual integrity. However, in the absence of formal institutional guidance governing AI-detection metrics, AI-generated scores are not incorporated into assessment decisions. This approach ensures that academic integrity is upheld through evidence-based verification while avoiding reliance on unregulated detection indicators. Fourth, assessment restructuring allocates 20% of dissertation marks to structured supervision engagement, including 10% explicitly attributed to demonstrated originality. Fifth, a formal Research Verification Interview is conducted by a three-member panel, including the supervisor, ensuring procedural consistency and collective academic oversight in evaluating methodological coherence, supervisory engagement and draft maturity.

2. Structural Logic and Empirical Stabilisation

The accompanying figures and table present the structural logic and empirical evidence underpinning RVI at Scale. Together, they illustrate the intervention workflow, supervision compliance architecture and measurable stabilisation of dissertation pass rates following implementation.

Structured RVI Workflow

The supervision workflow underpinning RVI at Scale is organised into five sequential stages (see: **Figure 1**): (i) compulsory draft and meeting log submission; (ii) rubric-based supervisory evaluation; (iii) identification of candidates requiring Research Verification Interview; (iv) panel-based verification assessment; and (v) continued supervisory monitoring until final submission. This structured sequencing formalises intervention five weeks prior to assessment and ensures that academic risks are addressed before final evaluation. By embedding verification within an institutionalised workflow, the framework replaces discretionary late-stage correction with structured pre-submission control.

Supervision Compliance and Accountability Mechanism

Students are required to document a minimum of seven supervisory engagements through an endorsed meeting log, recording formal interactions and attempts at communication within working hours. **Figure 2** presents the exemplary instances of supervision compliance structure integrated within RVI. Supervisors validate each entry to ensure authenticity and accountability. This documented mechanism introduces traceability into supervision practice, reducing undocumented disengagement and constraining subjective claims during final assessment. By aligning supervisory engagement with formal assessment weighting, RVI embeds accountability directly within academic evaluation.

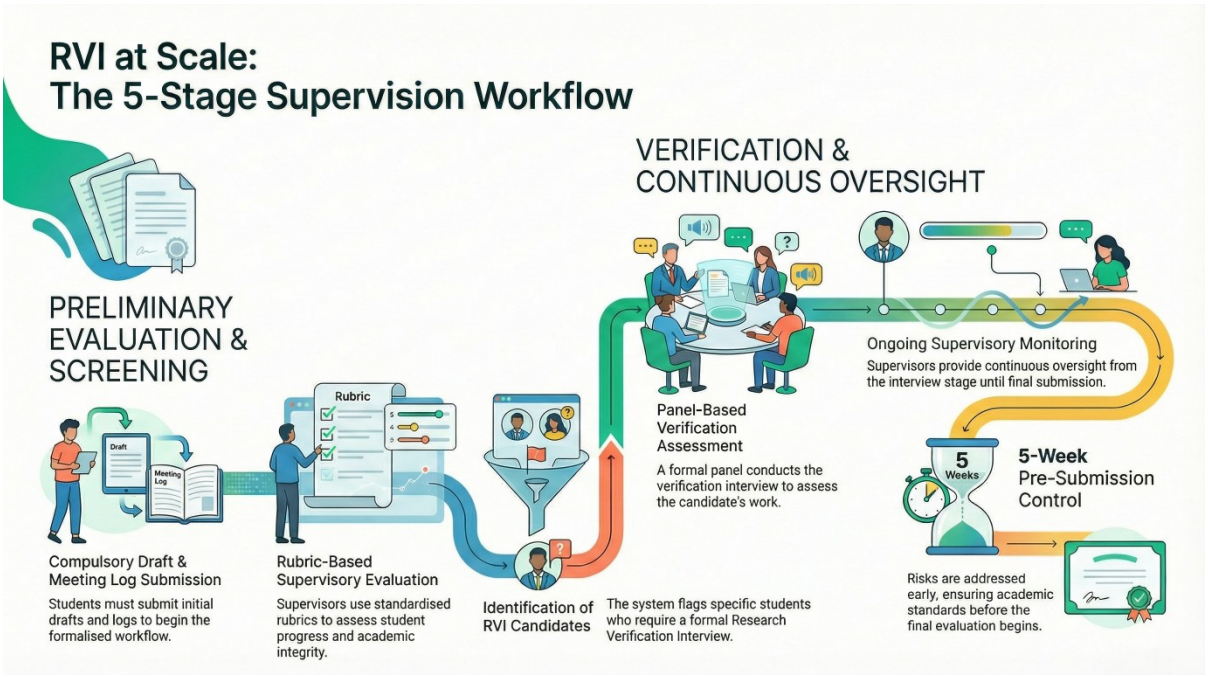

Figure 1. Structured RVI Intervention Workflow.

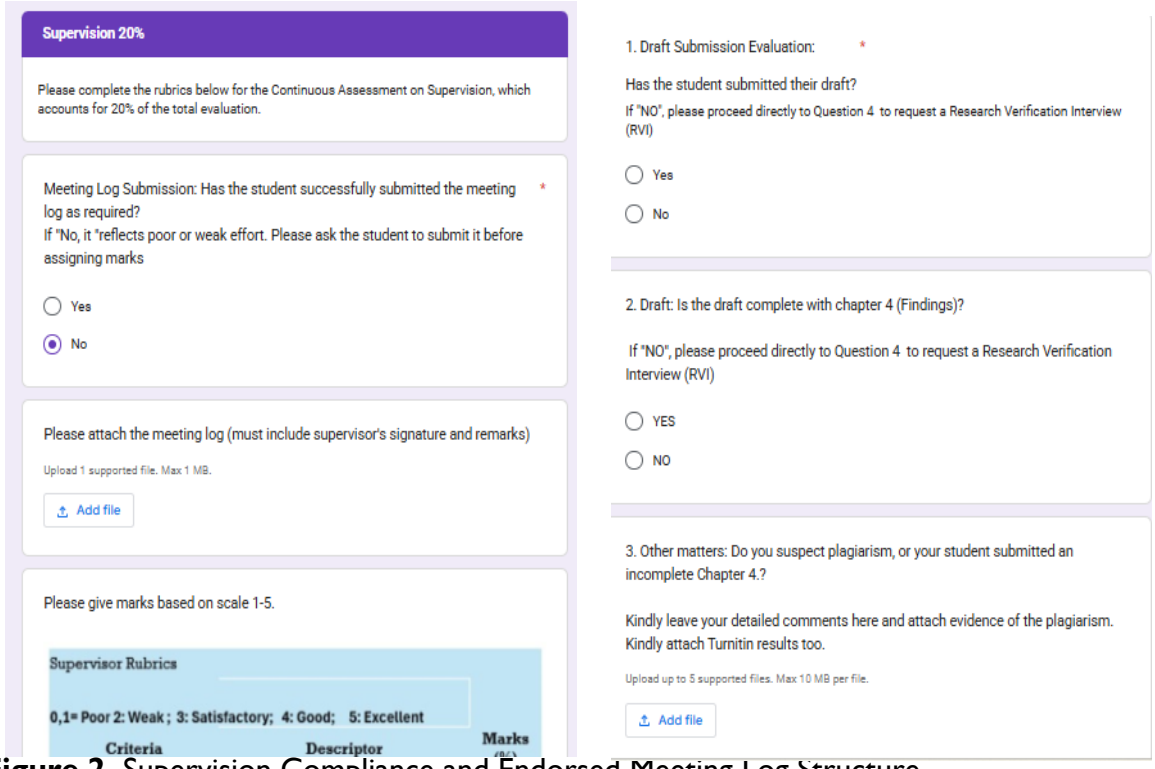

Figure 2. Supervision Compliance and Endorsed Meeting Log Structure.

Dissertation Pass Rate Stabilisation

The stabilisation of dissertation pass rates before and after RVI implementation is as shown in **Table 1**. Prior to intervention, pass rates fluctuated between 79.1% and 88.61% across successive semesters. Following structured implementation, rates increased to 90.2% and subsequently 94% across expanding cohorts. The trend reflects not merely improvement but reduction in performance volatility, indicating that structured supervision design contributes materially to outcome stability at scale.

Table 1. Dissertation Pass Rate Trends Before and After RVI Implementation.

UiTM Semester (Year/ Intake)	Dissertation Pass Rate (%)	Cohort Size (Number of Students)
2023/2	88.6	93
2023/4	86.1	159
2024/2	79.1	134
2024/4	85	128
2025/2	90.2	113
2525/4	94	169

Note: Green coloured semester denotes after RVI at Scale).

3. Novelty and uniqueness

RVI at Scale departs from conventional dissertation supervision frameworks or models by repositioning oversight as a structured and verifiable academic process rather than an informal advisory relationship. While most programmes rely on supervisory discretion and post-submission moderation, this framework institutionalises early risk detection, compulsory draft verification and documented supervisory accountability prior to final assessment. Its distinctiveness lies in embedding supervision engagement directly within formal assessment weighting, thereby aligning academic responsibility with measurable performance criteria. The requirement for endorsed meeting logs and evidence-based reporting mitigates unsupported claims of disengagement or misconduct and constrains subjective judgement. Unlike remedial academic support mechanisms that intervene after performance decline, RVI introduces a preventive checkpoint five weeks before submission, enabling corrective action within an actionable timeframe. The integration of panel-based verification further strengthens procedural consistency across diverse dissertation topics within Construction Management. By formalising supervision structure at cohort scale, the model transforms dissertation completion from an individual supervisory practice into a systematised institutional process.

4. Benefit to mankind

RVI at Scale contributes to improved educational progression within Construction Management, a discipline fundamental to infrastructure delivery and built environment development. By stabilising dissertation pass rates and reducing repeat submissions, the framework supports timely graduation and more efficient utilisation of academic resources. Students benefit from clearer expectations, documented supervisory engagement and protected procedural fairness. Institutions benefit from enhanced academic consistency and reduced volatility in assessment outcomes. In a broader socio-economic context, strengthening completion performance

contributes to workforce continuity within construction and built environment sectors, where delays in graduation may affect professional pipeline stability. The intervention therefore supports both academic integrity and sectoral resilience.

5. Innovation and Entrepreneurial Impact

RVI at Scale promotes innovation by reframing dissertation supervision as a designable and measurable system rather than an individualised academic practice. The framework encourages process optimisation, accountability and performance monitoring within higher education environments. By embedding structured oversight into assessment mechanisms, it cultivates a culture of evidence-based supervision and institutional responsibility. The scalable structure enables cross-programme adaptation, fostering institutional innovation in research governance. Through implementation toolkits and structured supervisor development modules, RVI encourages higher education institutions to treat completion assurance as a strategic operational domain. In doing so, it contributes to a culture of academic entrepreneurship grounded in system design, quality assurance and institutional competitiveness.

6. Potential commercialization

RVI at Scale offers commercialisation potential through institutional licensing of its structured supervision framework. The model may be packaged as an implementation toolkit comprising diagnostic rubrics, supervision compliance templates, panel protocols, digital verification instruments and structured training modules. Target markets include engineering and built environment faculties managing large dissertation cohorts and seeking to improve assessment stability. Commercial pathways may include consultancy-led deployment, institutional subscription models and supervisor certification workshops. As dissertation completion performance remains a critical metric within accreditation and ranking systems, demand for structured supervision assurance mechanisms is likely to grow across regional and international higher education institutions.

7. Acknowledgment

The author acknowledges the academic staff of the Construction Management programme for their participation in the structured implementation workshop and their cooperation in operationalising the RVI framework. Appreciation is extended to programme leadership for institutional endorsement and to the students whose engagement enabled empirical validation of the intervention.

8. Researchers' Biography

Ts Dr. Hafizah Mohd Latif is a Senior Lecturer at Universiti Teknologi MARA with over 18 years of academic experience. She holds a PhD in Construction Management from the University of Reading, UK and currently serves as Coordinator of Dissertation for the Studies for Construction, UiTM Shah Alam. Her expertise centres on governance, implementation fidelity, ethics and policy in the built environment. This innovation stems from her leadership in Research Methodology and Dissertation courses, strengthening academic quality, supervisory practices and research governance.

Professor Dr. Emma Marinie Ahmad Zawawi is the Dean of the Faculty of Built Environment, Universiti Teknologi MARA. She holds a PhD from The University of Manchester, UK. Her expertise includes building maintenance, building science and performance, environment and construction management. She actively teaches Research Methodology for Construction Management programme, contributing significantly to research capacity building and academic governance. With extensive academic leadership experience, she plays a key role in strengthening research governance, innovation and strategic development within the faculty.

Associate Prof Ts. Dr. Julitta Yunus is a Senior Lecturer at Studies for Construction at Universiti Teknologi MARA. She holds a PhD in Built Environment from UiTM. Her expertise focuses on environmental performance of buildings and green innovation. With extensive experience in teaching, research and academic leadership, she actively contributes to sustainable construction practices, innovation initiatives, and industry collaboration at national and international levels. Dr. Julitta is also actively involved in innovation and international competitions, earning recognition for green retrofit and microalgae façade applications, contributing to sustainable construction advancement and academic leadership,

Ts. Sr. Dr Muhamad Zaihafiz Zainal Abidin is a Lecturer at the Centre of Studies for Construction, Universiti Teknologi MARA. He is a Professional Building Surveyor (RISM) and Professional Technologist (MBOT). His expertise includes project and construction management, competency assessment, Industrialised Building System and built environment studies. He teaches project planning, construction management and structural design at both undergraduate and postgraduate levels. Actively involved in innovation and professional certification initiatives, he contributes to strengthening industry-linked education and competency development in construction management.

A Better Me: Bridging Emotional Awareness and English Language Skills

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ABSTRACT
A significant number of youth struggle to translate complex emotions into clear English, leading to a breakdown in communication. This "emotional-language gap" is often fueled by a lack of writing practice and low emotional awareness in digital spaces. To bridge this gap, this project introduces "A Better Me", a self-care journaling initiative, a method that merges English writing practice with emotional expression. By using social media to share precise vocabulary and phrases for feelings, the project makes language learning more engaging and accessible to a global audience. Findings show that this approach improves writing skills and boosts the ability to communicate emotions effectively. What makes this project unique is its use of digital platforms to support both language mastery and mental health. With potential for digital subscriptions and creative workshops, this project proves that practicing English can be a relaxing, positive experience that promotes both self-reflection and linguistic growth.

Keywords: Journaling, self-care, English language learning, emotional awareness, digital learning

1. Product Description
The "A Better Me" project integrates English language learning with self-care journaling to help young people develop linguistic skills alongside emotional awareness. Research indicates that journaling enhances expressive writing, expands vocabulary, and provides a safe outlet for emotions, which is particularly vital for teenagers and young adults (Adams et al., 2019). Despite these benefits, digital distractions and the rise of social media have reduced the time spent on reflective writing. Consequently, many young individuals struggle to express complex thoughts clearly in English (Chakraborty & Banerjee, 2019). "A Better Me" addresses this gap by providing structured tools for those facing stress or anxiety who want to practice English in a meaningful way. This digital journal helps with both mental health and language learning by combining self-care prompts with specific writing exercises. The project features daily affirmations and creative prompts designed specifically for ease of use by young learners. To complement the journal, a dedicated Instagram page provides daily vocabulary, self-care tips, and interactive content, allowing participants to practice writing in short, accessible, and engaging formats.

2. Methods and Results

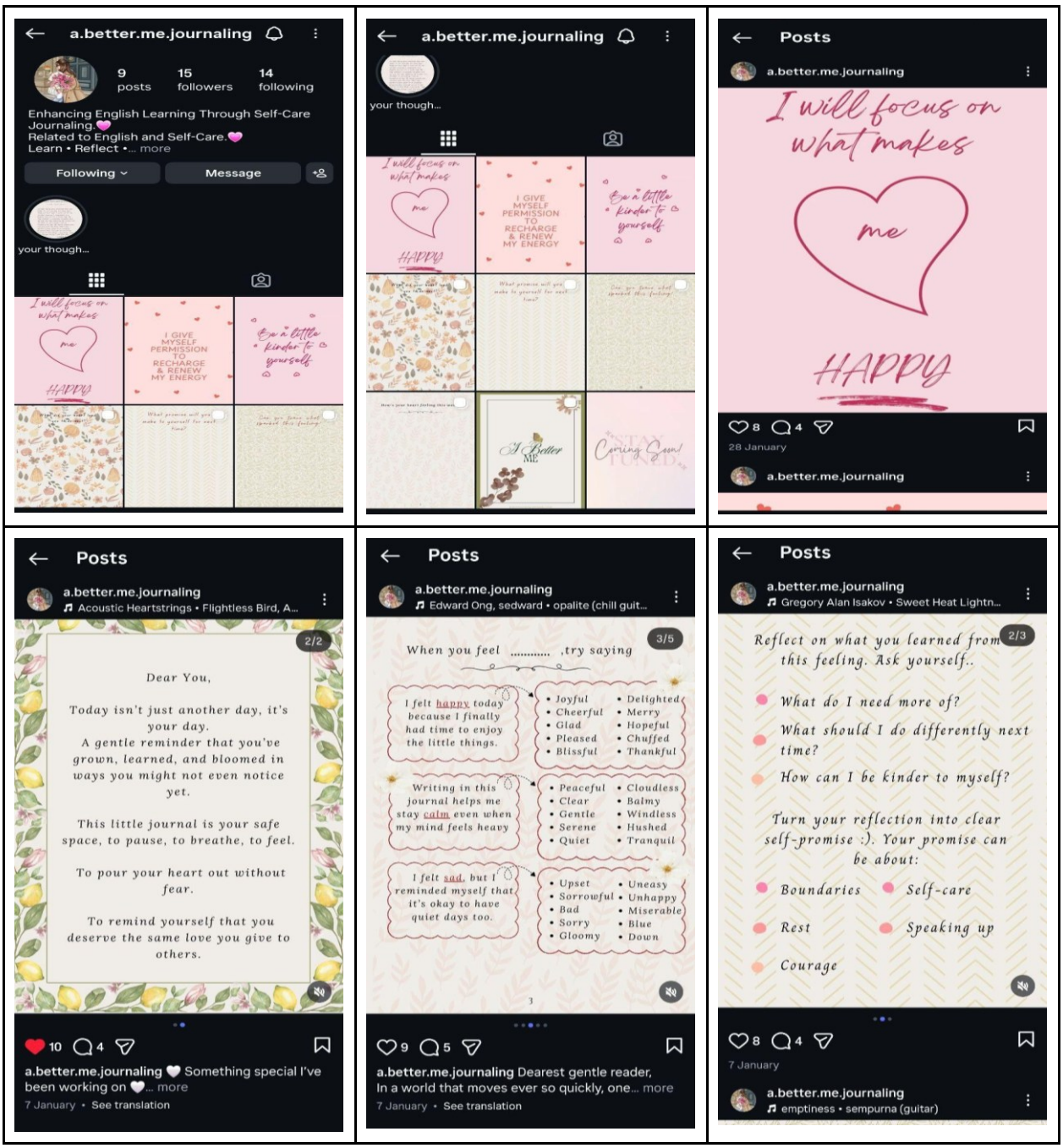


Figure 1. Some Instagram posts of "A Better Me" account.

Figure 1 shows a few Instagram posts of this project. Instagram is used as the supportive online community where users can interact with others, share their writing, and receive positive feedback, helping to encourage self-expression and creativity while improving English language skills.

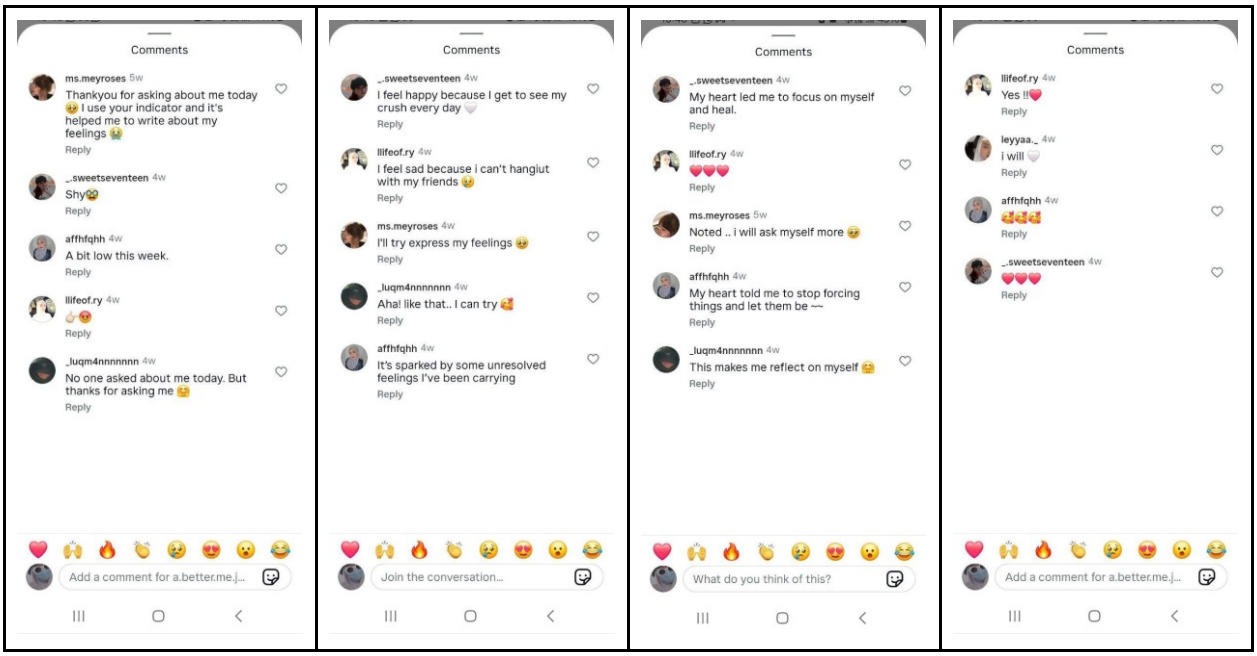


Figure 2a. Instagram engagement - comments.

Figure 2a depicts the Instagram of A Better Me self-care journalling engagement from posts' comments made by the viewers. These responses are positive dialogues that offer emotional support and reflect viewers' collective affirmation.

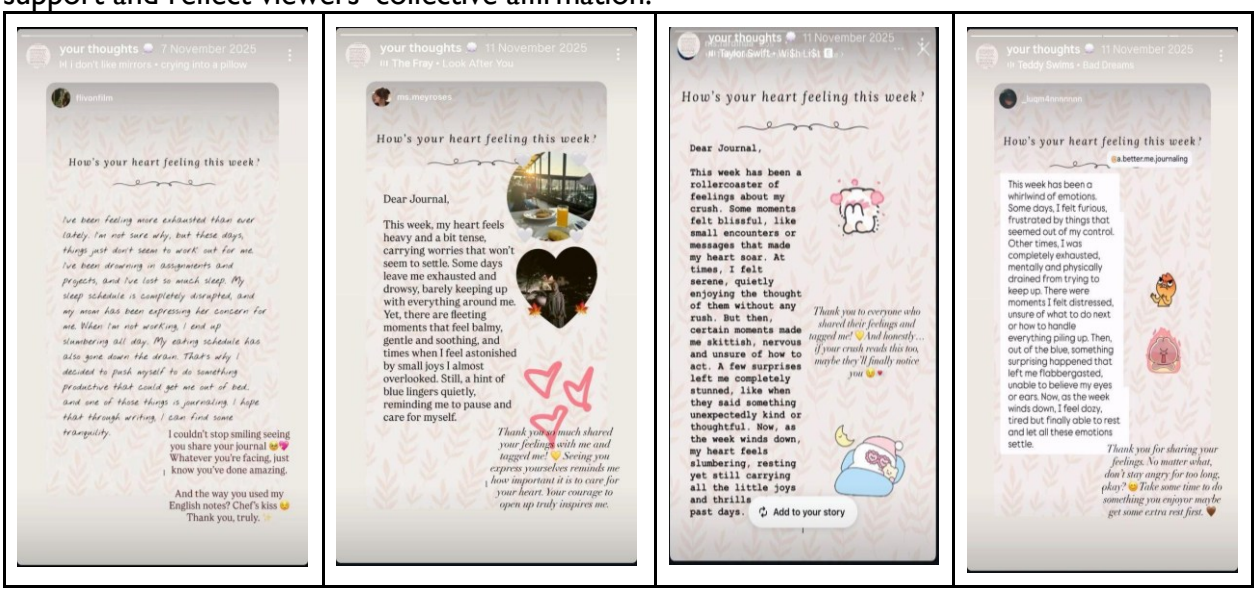


Figure 2b. Instagram engagement - story posts and replies.

Figure 2b shows the Instagram of A Better Me self-care journalling engagement from story posts and replies. These responses demonstrate that the content of this self-care journal offers encouragement and personal validation and also act as a catalyst for a supportive environment, turning a standard social interaction into a meaningful space for connection and communication.

3. Novelty and uniqueness

This project demonstrates how effective journaling and social media are as learning tools for language practice and emotional expression. A Better Me successfully meets its main objectives by combining English writing and self-care. This project successfully created a tool that practices English writing and emotional awareness, confirming the practicality of journaling in digital platforms to support both learning and well-being.

4. Benefit to mankind

Young people are increasingly drawn to interactive, aesthetically pleasing writing activities. By blending the visual appeal of Instagram with the practice of journaling, this project fosters a consistent writing habit while expanding vocabulary. It demonstrates that self-care is a vital component of language learning, proving that emotional well-being and academic growth can and should evolve together. It benefits users, especially youngsters,

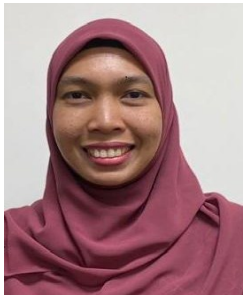
5. Innovation and Entrepreneurial Impact

The innovative approach to language learning combines daily self-care journaling with the visual appeal of social media, encouraging users to respond to digital entries that transform repetitive and traditional writing exercises into a creative hobby. A familiar platform like Instagram offers a unique entrepreneurial solution for the digital age by transforming passive social media scrolling into an active, productive tool for the commercialization of teaching aids and learning innovations.

6. Potential commercialization

A Better Me is not just a self-care journal, but it offers a service that facilitates mindful social media use by bridging the gap between emotional awareness and English language skills. The high demand of digital wellness creates a path for commercial value through premium offers such as journaling bootcamps or subscription-based content for prompts and community feedback. Collaboration with other health practitioners, language experts, and social media influencers could expand with various related content to benefit a bigger audience.

7. Researchers' Biography



Maisarah Noorezam is an English lecturer at the Academy of Language Studies, Universiti Teknologi MARA Johor, Pasir Gudang campus. Her areas of expertise include applied linguistics, Teaching English as a Second Language (TESL), and discourse analysis. With nearly 15 years of experience in teaching, she has a number of educational innovations, publications, and awards. She is a consultant for a series of English bootcamps at schools and higher institutions.

Hawa Syamsina Md Supie is an English lecturer at the Academy of Language Studies, Universiti Teknologi MARA Johor, Pasir Gudang campus. She graduated with a Bachelor of Science with Education (TESL) for her bachelor's degree and later pursued Measurement and Evaluation in Education for her master's degree. She has been teaching for a total of 14 years at two different higher education institutions. Her areas of interest include measurement and evaluation, psychometric assessment, and feedback in supervision.

Ainur Fardina Mohamad Faizal is a diploma student in English for Professional Communication at the Academy of Language Studies, Universiti Teknologi MARA Johor, Segamat campus. She is currently in her final semester of the five-semester programme. The program's structure provides an opportunity for her to be involved in innovation that reflects her knowledge and skills in e-content development, creative writing, entrepreneurship, and professional communication.

OM-Central: A Centralized Digital Ecosystem for Operations Management Mastery.

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ABSTRACT

OM-Central is a high-impact digital learning hub designed to centralize the Operations Management (MGT345) curriculum into a single, mobile-friendly visual interface. Developed to solve "information fragmentation"; which can be defined as the confusion caused by multiple disconnected academic platforms, OM-Central uses agile, visual learning principles to map the entire semester's journey into a chronological, easy-to-navigate pathway. Its uniqueness lies in a non-linear, visual architecture and zero-barrier accessibility, offering real-time updates and interactive feedback loops that significantly reduce cognitive load compared to traditional text-heavy systems. The project supports SDG 4 (Quality Education) and environmental sustainability by eliminating physical handouts and fostering an inclusive learning environment that accommodates diverse learning speeds, directly improving student engagement and academic outcomes. Beyond the classroom, the framework is highly scalable, serving as a subscription-ready pedagogical template for other academic disciplines or as a streamlined digital onboarding portal for operations-heavy industries like manufacturing and logistics. By digitizing knowledge management, OM-Central offers a sustainable, efficient, and commercially viable future for modern education and corporate training alike.

Keywords: Digital Pedagogical Ecosystem, Operations Management Education, Agile Micro-learning, Sustainable Education Technology

1. Product Description

OM-Central is a high-impact digital learning ecosystem designed to revolutionize how students engage with the Operations Management (MGT345) curriculum. Addressing the growing challenge of "information fragmentation," this innovation consolidates lecture notes, tutorial recordings, and assessment trackers into a single, mobile-friendly visual hub. By applying agile micro-learning principles, it transforms the traditional, linear syllabus into a chronological, easy-to-navigate pathway that guides students through their academic journey. The uniqueness of OM-Central lies in its non-linear architecture and zero-barrier accessibility. Unlike conventional, text-heavy Learning Management Systems (LMS), it offers real-time resource synchronization and interactive feedback loops, significantly reducing cognitive load and fostering student autonomy. Aligning with the i-TIEC theme of a sustainable future, the project directly supports SDG 4 (Quality Education) by providing inclusive, high-quality resources while eliminating the carbon footprint of physical handouts. Beyond the classroom, OM-Central is highly scalable. It serves as a subscription-ready pedagogical template for diverse academic disciplines or as a streamlined

digital onboarding portal for operations-heavy industries like manufacturing and logistics. By optimizing the "operation" of learning itself, OM-Central offers a commercially viable solution for a sustainable, tech-driven educational future.

2. The Flow Charts and Screenshots

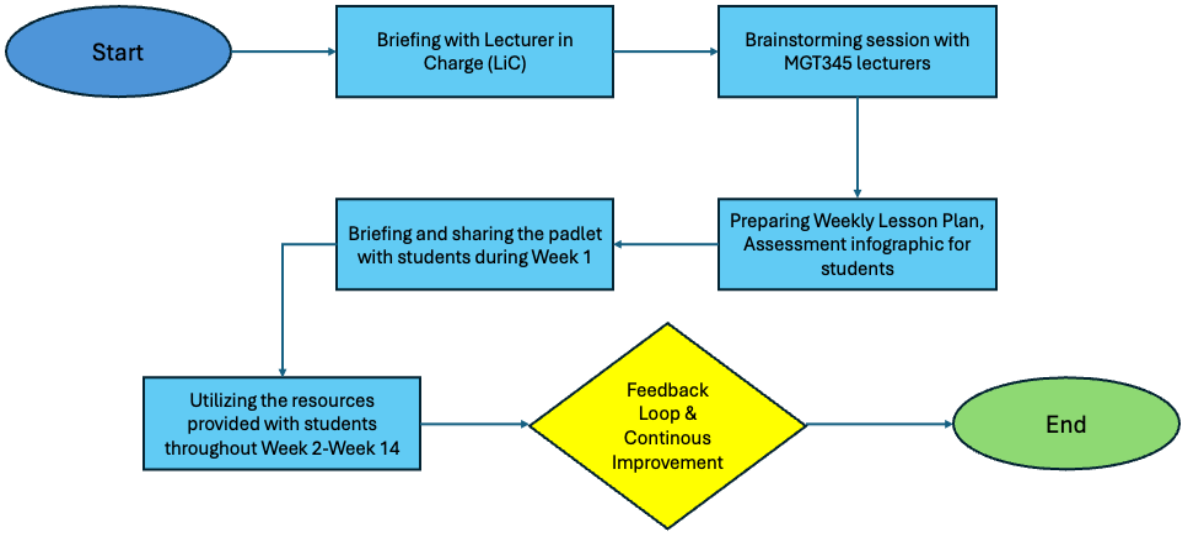

Figure 1. Development Lifecycle.

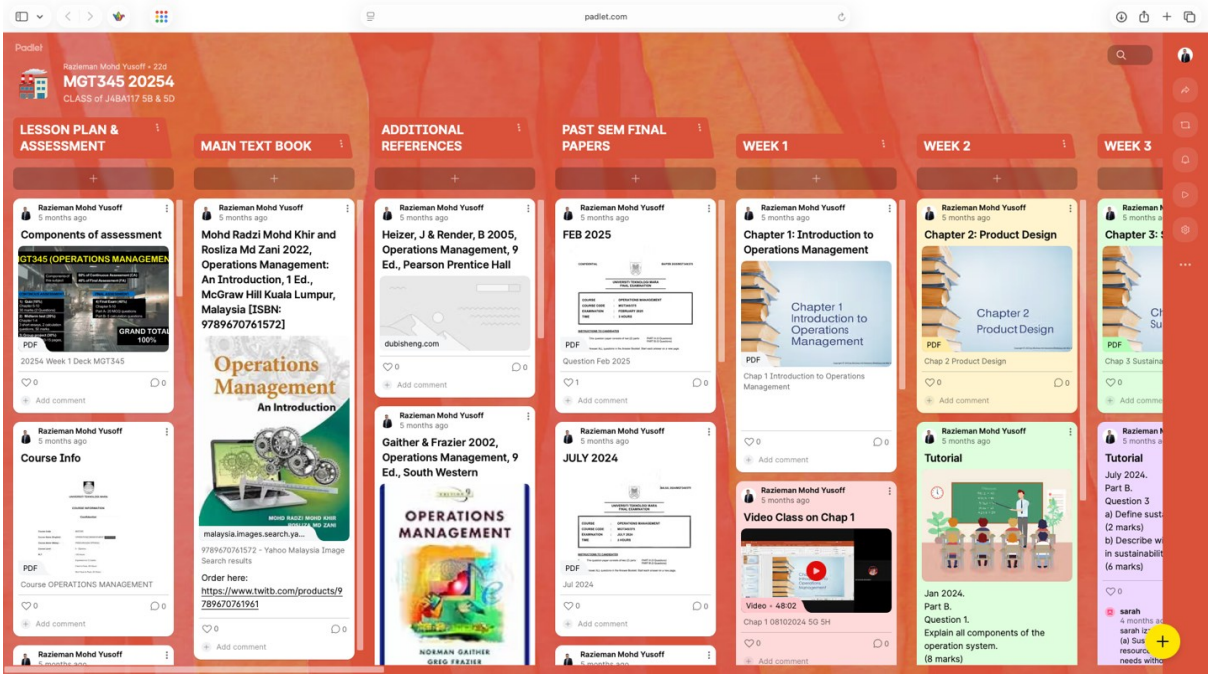

Figure 2. OM-Central. The product's link: https://padlet.com/raziemanmy/mgt345-20254-gimgeyj62aednln8.

3. Novelty and uniqueness

The novelty of OM-Central lies in its transition from a "static repository" to a "Dynamic Learning Ecosystem." While traditional education relies on fragmented communication across multiple platforms, OM-Central introduces a pioneer single-entry architecture. It innovatively applies Agile Micro-learning Principles to the field of Operations Management, mapping a complex 14-week syllabus into a visually synchronized, "at-a-glance" pathway. This represents a significant shift from linear, folder-based filing to a holistic, user-centric interface that mirrors the digital consumption habits of the modern student. What makes OM-Central unique is its Zero-Barrier Accessibility combined with Non-Linear Navigation. Unlike standard Learning Management Systems (LMS) that require multiple authentication steps and offer a rigid, text-heavy experience, OM-Central provides instant, mobile-optimized access to the entire course ecosystem. It uniquely integrates real-time tutorial recordings, live assessment trackers, and interactive Q&A walls into one visual plane. This reduces "search friction" and cognitive load, allowing students to focus entirely on content mastery rather than navigation. By "optimizing the operation" of the classroom itself, OM-Central stands as a bespoke, scalable pedagogical tool that bridges the gap between traditional academic delivery and modern digital efficiency.

4. Benefit to mankind

OM-Central significantly contributes to the advancement of SDG 4 (Quality Education) by democratizing learning. Through its zero-barrier digital interface, it ensures that students from diverse socio-economic backgrounds, including those with limited data or time, have equal access to high-quality resources. This effectively bridges the digital divide. Environmentally, the project champions a zero-waste pedagogical model. By digitizing the entire course ecosystem, it eliminates the need for physical handouts, drastically reducing the carbon footprint of educational institutions. Furthermore, OM-Central directly addresses "digital fatigue" and academic anxiety. By consolidating fragmented information into one intuitive hub, it reduces cognitive overload and supports student mental well-being. Ultimately, this scalable framework offers a sustainable, humane approach to knowledge management. Its global adaptability empowers the future workforce with efficient and accessible learning tools, fostering a more inclusive, organized, and environmentally responsible society.

5. Innovation and Entrepreneurial Impact

OM-Central fosters a culture of innovation by modeling Lean Operations within the educational experience. By replacing fragmented, traditional workflows with a centralized digital ecosystem, it encourages students to adopt an "optimization mindset"; a core entrepreneurial trait. This project moves the institution away from passive content consumption toward Agile Knowledge Management, demonstrating how digital transformation can solve real-world efficiency gaps. Within the industry, OM-Central serves as a prototype for low-cost, high-impact digital solutions. It promotes a culture of "Intrapreneurship" by showing educators and industry trainers that they can build sophisticated, scalable tools using existing resources. By democratizing the ability to create professional-grade information hubs, it empowers the community to innovate independently of large IT budgets. Ultimately, OM-Central prepares a future workforce that values streamlined processes, digital literacy, and sustainable problem-solving, creating a ripple effect of entrepreneurial thinking across the academic and industrial landscapes.

6. Potential commercialization

OM-Central possesses significant commercial viability through its scalable "Blueprinting" model. The primary market is the Global EdTech sector, where it can be licensed as a subscription-based pedagogical template for higher education institutions. By offering a standardized yet customizable "Digital Course Hub" framework, university departments can achieve uniform branding and optimized student engagement across all subjects. Beyond academia, the project has high potential in the Corporate Training and Development (L&D) market. Large-scale manufacturing and logistics firms can utilize the OM-Central architecture as a streamlined digital onboarding portal. This allows companies to consolidate complex operational SOPs, training videos, and compliance trackers into a single, mobile-accessible interface, reducing employee training time and administrative costs. With its low-cost infrastructure and high-impact delivery, OM-Central is positioned as a versatile B2B solution for any organization seeking to optimize knowledge management and digital literacy in a sustainable, tech-driven economy.

7. Acknowledgment

The researcher extends sincere appreciation to Dr. Suhana Mohamed (Lecturer in Charge) and Mrs. Mursyda binti Mahshar (Resource Person) for their professional guidance. Gratitude is also expressed to Miss Nurhidayah Hani for her collaborative contributions. Their collective support was instrumental in the successful development and implementation of the OM-Central project.

8. Researchers' Biography

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Razieman Mohd Yusoff is a lecturer at Universiti Teknologi MARA (UiTM) Johor, Pasir Gudang Campus, specializing in Transportation and Logistics. He earned his PhD in Transportation Planning from the University of Malaya. With significant industry experience in policy planning at the Land Public Transport Commission and Agency, he successfully integrates real-world frameworks into his teaching. An accomplished researcher and prolific writer, he received the Best Paper Award at SiDE2025. Currently, his academic work focuses on developing innovative pedagogical solutions that align with modern transportation policies, ensuring students gain industry-relevant expertise through his specialized research and teaching methods.

Dr. Suhana Mohamed is a Senior Lecturer of Finance at the Faculty of Business and Management, UiTM. With twenty-six years of experience across academia and industry, she has pioneered significant works relating to Finance and Education. Dr. Suhana is actively involved in investment research, specifically real estate finance, where she concentrates on specialized investment analysis. Recognizing her outstanding contributions to research and community services, she has received several prestigious accolades, including the Women Icon award. She devotes her life to knowledge transfer and supporting exciting projects for UiTM, ensuring her academic expertise benefits the university and surrounding community.

Nurhidayah Hani is a part-time lecturer from the Faculty of Business and Management, UiTM. She holds a Master's degree in Islamic Banking and Finance and a Bachelor's degree in Business Administration (Finance) from UiTM. She actively participated in global innovation initiatives during her postgraduate studies, where her team's project was formally recognized for showcasing her strong research and analytical skills. She worked in the accounting and finance industry after graduating, specializing in regulatory compliance and financial reporting. Her business and academic background now allows her to incorporate real-world viewpoints into her lessons and encourage students to think critically.

TransformWrite™: A Hybrid Cognitive Architecture for Structured Knowledge Transformation in Academic and Professional Writing

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ABSTRACT

TransformWrite™ is a validated hybrid cognitive architecture designed to operationalize structured knowledge transformation across academic and professional writing contexts. Derived from empirical research on the cognitive processes of paraphrasing, the model extends the planning–translating–reviewing cycle of Cognitive Process Theory into a structured rewriting system supported by diagnostic and monitoring layers. Innovation addresses a global gap in writing pedagogy and professional documentation where information rewriting is often reduced to superficial word substitution rather than meaningful reconstruction. Using Think-Aloud Protocol (TAP) analysis and qualitative cognitive mapping, the framework integrates three embedded components: a Diagnostic Layer distinguishing novice and fluent transformation patterns, a Cognitive Load Indicator identifying stress points in working memory, and a Metacognitive Regulation Index supporting monitored meaning equivalence. Unlike traditional rewriting instruction, TransformWrite™ takes invisible cognitive operations visible and measurable. The framework enhances ethical knowledge production, reduces unintentional plagiarism, and strengthens higher-order thinking in multilingual environments. The model is scalable for integration into writing centers, higher education curricula, corporate knowledge management systems, and AI-assisted writing environments, offering commercialization potential through training modules, certification programs, and digital cognitive rewriting tools.

Keywords: Cognitive Knowledge Transformation; Structured Rewriting; Metacognitive Regulation; Cognitive Load Management; Academic and Professional Writing

1. Product Description

The TransformWrite™ Framework is a hybrid cognitive architecture structured around a recursive Planning–Translating–Reviewing engine adapted from Cognitive Process Theory and operationalized for structured knowledge transformation. The framework integrates three functional components: (1) a Cognitive Processing Engine, (2) a Diagnostic and Regulation System, and (3) an Applied Implementation Toolkit. The Cognitive Processing Engine guides users through structured idea extraction, conceptual restructuring, and monitored meaning reconstruction. The Diagnostic System distinguishes novice and fluent transformation patterns, enabling targeted cognitive calibration. Embedded within the architecture is a Cognitive Load Indicator to identify

working-memory strain during rewriting and a Metacognitive Regulation Index that supports systematic self-monitoring and revision. The Implementation Toolkit translates the architecture into practical instruments, including concept-chunking grids, lexical transformation matrices, structural reformulation guides, and equivalence-validation checklists. These tools enable measurable and repeatable knowledge transformation across academic, professional, and multilingual environments. By converting cognitive theory into structured operational scaffolds, TransformWrite™ functions as both a diagnostic framework and a performance-enhancement system, making structured rewriting teachable, monitorable, and scalable across global contexts.

2. TransformWrite™ Integrated Cognitive Architecture

Figure 1 illustrates the TransformWrite™ Integrated Cognitive Architecture and Operational Flow System, which explains how structured knowledge transformation occurs within AI-assisted writing environments.

Figure 1. TransformWrite™ Integrated Cognitive Architecture and Operational Flow System.

The model integrates diagnostic, regulatory, and operational components to support effective text processing and knowledge reconstruction. The top section presents the Diagnostic and Regulation Layer, which serves as the system's monitoring mechanism. It includes three key indicators: the Novice–Fluent Diagnostic Layer, the Cognitive Load Indicator, and the Metacognitive Regulation Index. These components assess the user's level of expertise, monitor cognitive effort during information processing, and regulate metacognitive activities such as planning, monitoring, and evaluating writing performance. As a result, the system can adapt to different user abilities while maintaining an optimal cognitive load. The core of the model is the Structured Knowledge Transformation Engine, which operates through a cyclical process consisting of Planning, Translating, and Diagnostic stages. In the planning stage, ideas are organized and writing strategies are determined. The translating stage converts conceptual knowledge into written text, while the diagnostic stage evaluates the coherence and quality of the output. These stages are connected through a feedback loop that supports continuous revision and improvement. The lower section presents the Operational Flow of text transformation. The process begins with input text, followed by meaning extraction to identify key ideas. These ideas are organized through concept chunking and integrated through structured reconstruction. The system then performs monitoring and load checking to ensure clarity and cognitive efficiency before producing the validated output. Overall, the framework integrates cognitive regulation and systematic processes to enhance writing quality in AI-supported environments. The model is designed to function across multiple contexts, including academic contexts, professional contexts, and AI writing environments, demonstrating its applicability to various writing tasks.

3. Novelty and Uniqueness

The novelty of TransformWrite™ lies in its integration of cognitive process theory with a structured, measurable rewriting architecture that extends beyond traditional paraphrasing pedagogy. While existing models such as the Planning–Translating–Reviewing framework and the Knowledge-Telling/Knowledge-Transforming paradigm conceptualize writing as a cognitive process, they do not operationalize knowledge transformation into a structured, diagnostic system. TransformWrite™ advances these models by embedding three innovation layers: (1) a Novice–Fluent Diagnostic Layer that maps transformation depth, (2) a Cognitive Load Indicator that identifies working-memory strain during rewriting, and (3) a Metacognitive Regulation Index that structures monitored meaning validation. These components are empirically derived through real-time cognitive mapping using Think-Aloud Protocol (TAP) data, providing evidence-based calibration of rewriting performance. Unlike conventional rewriting instruction which focuses on lexical substitution or plagiarism avoidance, TransformWrite™ converts cognitive operations into measurable, teachable, and scalable scaffolds. The framework transforms rewriting from a surface linguistic task into a structured knowledge reconstruction system applicable across multilingual academic and professional environments. This integration of cognitive diagnostics, operational tools, and scalability distinguishes TransformWrite™ as a hybrid innovation rather than a theoretical adaptation.

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4. Benefit to Mankind

TransformWrite™ contributes to global educational and professional ecosystems by strengthening ethical and structured knowledge production. In academic settings, the framework reduces unintentional plagiarism by shifting rewriting from superficial word substitution to monitored meaning reconstruction. This promotes intellectual integrity and higher-order cognitive engagement, particularly in multilingual contexts where students often struggle with knowledge transformation. Beyond education, architecture supports professional documentation, policy drafting, corporate reporting, and AI-assisted writing environments by providing structured mechanisms for accurate information reconstruction. The embedded Cognitive Load Indicator and Metacognitive Regulation Index enable individuals to manage cognitive stress during complex rewriting tasks, improving clarity, accountability, and precision in knowledge communication. By making cognitive transformation measurable and teachable, TransformWrite™ fosters critical thinking, responsible authorship, and adaptive expertise, skills essential for sustainable knowledge economies and ethical information exchange in a rapidly digitizing world.

5. Innovation and Entrepreneurial Impact

TransformWrite™ holds strong entrepreneurial potential due to its modular and scalable architecture. The framework can be developed into institutional training programs, writing center implementation toolkits, faculty certification modules, and digital cognitive rewriting platforms. Its diagnostic components, including the Novice–Fluent Mapping System and Cognitive Load Indicator enable measurable performance analytics, creating opportunities for integration into Learning Management Systems (LMS) and AI-assisted writing environments. The model supports the development of structured rewriting software, corporate documentation training packages, and professional certification programs in ethical knowledge transformation. As organizations increasingly prioritize information accuracy, intellectual integrity, and AI-human collaboration, TransformWrite™ provides a structured cognitive foundation adaptable across global educational institutions and knowledge-based industries. Its hybrid design bridges research and application, positioning the framework for commercialization through academic licensing, digital tools, executive workshops, and cross-sector training initiatives.

6. Potential Commercialization

TransformWrite™ can be commercialized through a multi-tier deployment strategy. At the institutional level, the framework can be licensed to universities and writing centers as a structured cognitive rewriting toolkit, accompanied by faculty training and certification programs. Digital adaptation into an LMS-integrated module would allow institutions to embed diagnostic rewriting analytics within academic support systems. At the professional level, architecture can be packaged as corporate training programs focused on structured documentation, policy rewriting, and AI-assisted knowledge management. The Cognitive Load Indicator and Metacognitive Regulation Index offer potential for development into digital assessment tools or writing analytics dashboards. Revenue models may include institutional licensing, professional certification programs, executive workshops, and subscription-based digital rewriting platforms. By bridging research-driven cognitive architecture with applied training systems, TransformWrite™ offers scalable commercialization opportunities across global education and knowledge-based industries.

7. Acknowledgment

The authors extend sincere appreciation to Institute of Business Administration and Universiti Teknologi MARA for the support, academic guidance and invaluable feedback throughout the research process that led to the development of the TransformWrite™ Framework.

8. Researchers' Biography

Dr. Shumaila Omar holds a PhD in Applied Language Studies with specialization in cognitive processes of academic writing and knowledge transformation. Her doctoral research employed Think-Aloud Protocol (TAP) methodology to develop the TransformWrite™ Framework, a hybrid cognitive architecture for structured rewriting. With over 16 years of experience in higher education, faculty development, and professional training, she designs research-driven systems that integrate cognitive theory with scalable writing innovation across multilingual academic and professional contexts.

Dr. Wan Nazihah Wan Mohamed holds a PhD in Education and she is a senior lecturer at Akademi Pengajian Bahasa, Universiti Teknologi MARA Cawangan Kelantan. Her career as a lecturer began in 1998 with teaching experience in the fields of English language, education and linguistics. She has published and presented papers in various fields through collaboration with other academics. Her research interests include technology acceptance, educational technology, mobile learning, e-learning, English language, linguistics and education.

SmartDrive EDU: Project-Oriented Experiential Learning Through Arduino-Based Bluetooth Controlled Smart Car

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ABSTRACT
SmartDrive EDU is another Project-Oriented Experiential Learning (POEL) innovation meant to improve the system integration competency of TVET students by designing an Arduino-based smart car controlled by Bluetooth. The initiative combines microcontroller programming, wireless communication, motor control system, and mechanical assembly into a systematic learning framework that is in line with the industry 4.0 needs. Basing the project on the theory of experiential learning, it can be said that it provides students with a complete engineering cycle, including design, build, program, test, troubleshoot, and optimize, which encourages higher-order thinking and abilities of addressing real-life issues. The smart car is operated through a mobile application with the help of the HC-06 Bluetooth module, and the directional movement is performed in real-time. SmartDrive EDU can be scaled to TVET institutions, polytechnics and secondary STEM education and can be commercialized using learning module kits and training modules.

Keywords: Project-Oriented Learning; Experiential Learning; Arduino; Bluetooth Control; TVET Innovation; Microcontroller Integration

Product Description
SmartDrive EDU is a smart car prototype that is developed on the basis of an Arduino microcontroller combined with an HC-06 Bluetooth module to be controlled wirelessly with the help of a smartphone. The system comprises of Arduino board, L298N motor driver module, DC motors, chassis frame, rechargeable battery and mobile interface application. Students put together hardware components, write Arduino codes, set up Bluetooth communication, and test real-time directional movement. It is not only an example of a robotic kit, but a structured experiential education platform with emphasis on system architecture, debugging, and incremental improvement.

2. Methods and Results
Recommended visuals for submission include:
• Learning Flow Chart (Design → Build → Code → Test → Reflect → Optimize)

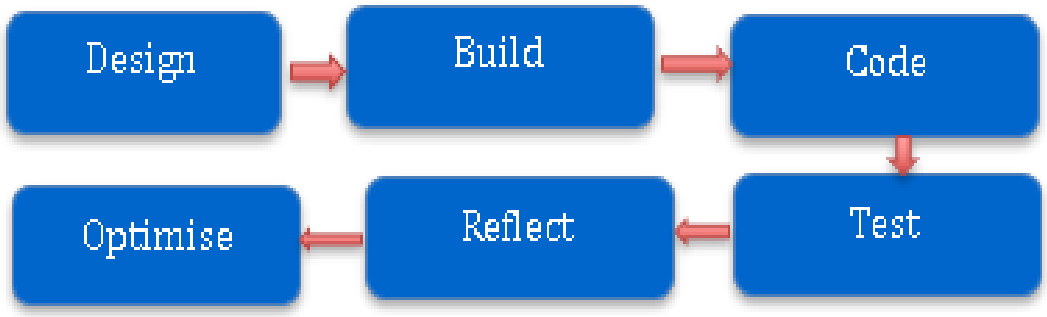

Figure 1. Project-Oriented Experiential Learning Process.

There are six steps that comprise the Project-Oriented Experiential Learning process; the first step is the Design phase during design the system architecture of the Arduino Bluetooth Smart Car as shown in **Figure 1**. The process starts with the Design phase that involves students designing the Arduino Bluetooth Smart Car system architecture. At this point, students determine the needed elements of the Arduino board, HC-06 Bluetooth module, L298N motor driver, and DC motors. They also draw circuits, calculate wiring and layout control. This stage emphasizes on analytical thinking and planning of systems prior to their implementation. The second level is Build where students literally construct the hardware components based on their design. They assemble the motor driver to the Arduino and wire the Bluetooth module through the TX/RX communication, install power supply and assemble the components to be mounted to the chassis. This phase changes the idea of planning into actual construction. Then there is the Code where students create and upload the Arduino program. They program control code that also decodes Bluetooth commands (e.g., Forward(F), Backward(B), Left(L), Right(R), Stop(S) and converts such commands into motor control signals (HIGH/LOW outputs). This phase combines software with the hardware capabilities. Test is the fourth phase and students check the operation of the system. They connect the smartphone and the Bluetooth module and monitor the answer of the car. The mistakes which are detected at this stage include failures in connection, wrong direction of the motor or unstable movement. After the testing, the learners proceed to Reflect where they examine what worked and what failed. They check coding structure, accuracy of wiring, signal logic and flow of communication. Reflection enhances critical thinking and conceptualization. Lastly, during the Optimize phase students make the prototype better according to the reflection. They optimize the code efficiency, control the speed of the motor by using PWM, improve signal stability or add other functionalities like ultrasonic sensors. Optimization also results in the increase in the performance of the system and a new learning cycle begins. Such an orderly progress guarantees the constant enhancement, the active interaction, and the significant interaction of the theory and the practice.

System Architecture Diagram (Smartphone→ Bluetooth→ Arduino→ Motor Driver -> Motors) as shown in **Figure 2.**

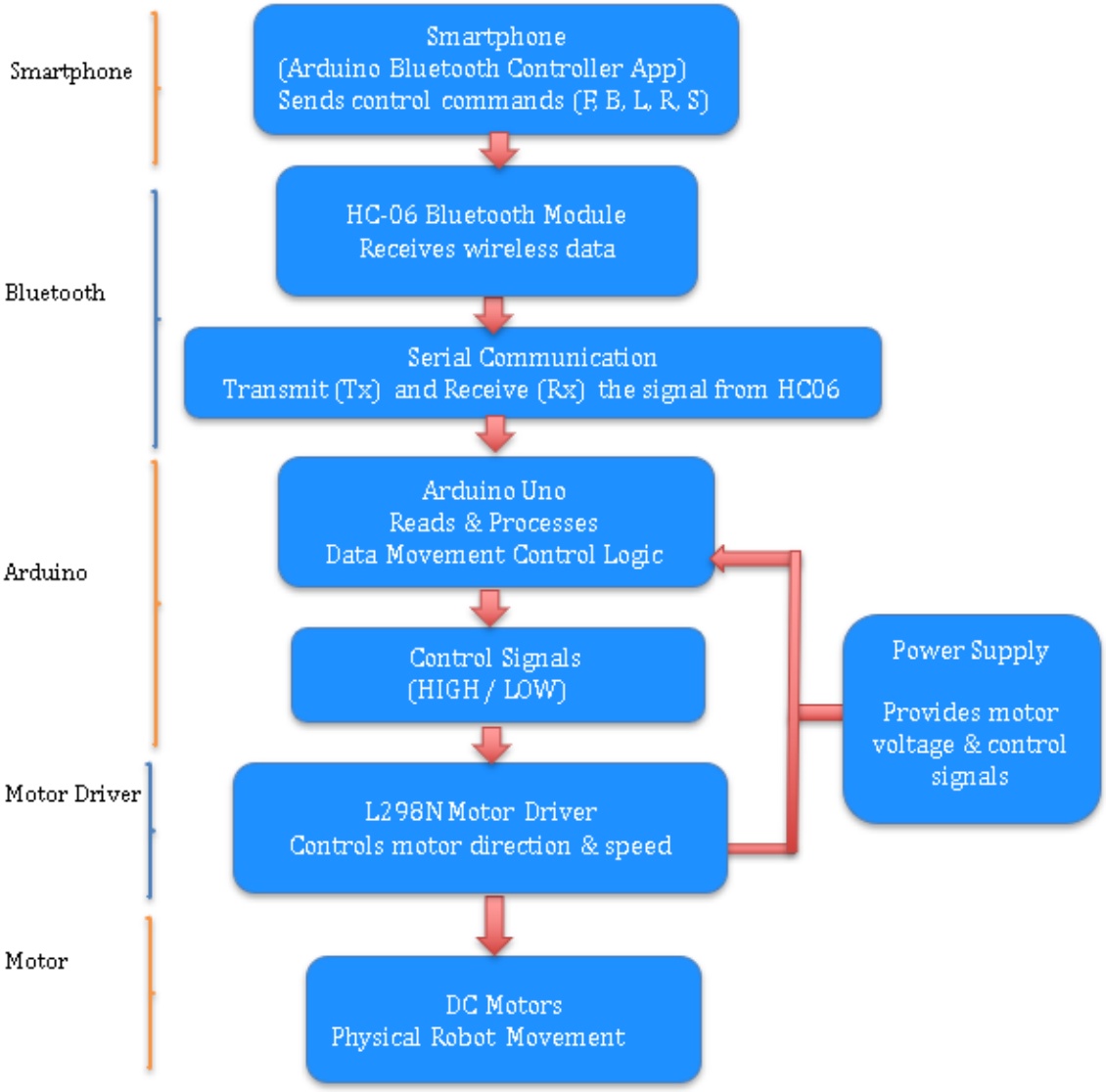

Figure 2. System Architecture Diagram.

The product of POEL is shown in **Figure 3**. The Experiential Learning Cycle apply taught by Kolb explains learning as an ongoing process in which knowledge is acquired as a result of direct experience and reflection. The first step is the Concrete Experience, during which the learners are actively involved in doing something. This is the case with the Arduino Bluetooth Smart Car project where learners would also assemble parts, attach the Arduino board, set up the Bluetooth module, and get the car to move. Such practical interaction is the basis of valuable learning. The second level is Reflective Observation, during which the learners take a step back and critically reflect upon what occurred when they were going through the experience. Learners consider

problems like connection failure, wrong wiring, wrong coding or some unusual motor action. They ask themselves why some results had been experienced and establish patterns or issues that require betterment.

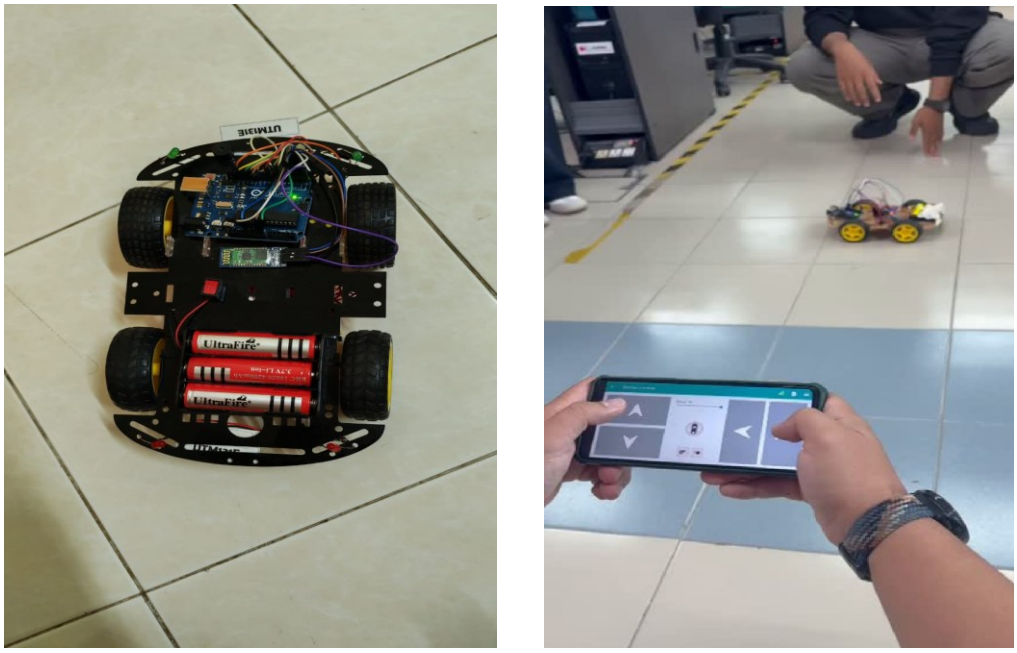

Figure 3. Product of Project-Oriented Experiential Learning.

Third is the Abstract Conceptualization where learners form the theoretical knowledge relying on their considerations. Learners at this level relate the real world experience to the concepts behind the practical (serial communication (TX/RX), voltage control, logic signals (HIGH/LOW) and the functionality of the motor driver). They make experience a structured knowledge and technical principles. Lastly, in Active Experimentation learners use their new knowledge to correct and better the system. Learners rewrite their code, re-assemble circuits, or tune motor speed, or include new functionality, like sensors. This results in a new experience and the process repeats itself. This process of constant cycles makes learners become more competent, critical, and solve practical problems skills.

3. Novelty and Uniqueness

SmartDrive EDU includes the organized Project-Oriented Experiential Learning model based on the experiential learning cycle by Kolb. It focuses on the complete engineering solution of design to optimization, unlike typical Arduino workshops. The innovation is the integration of the wireless Bluetooth control, real system architecture knowledge, and reflective learning concepts. It has a balance between theory and application of problem-solving in electronics, thus suited to TVET, polytechnics, and STEM institutions.

4. Benefit to Mankind

The project improves the industry 4.0 preparedness through intensifying practical system integration, critical thinking, and collaboration. It advances low-cost education of robots in schools, and digital transformation agendas in technical education. SmartDrive EDU helps to reduce theory-practice gap, which in turn will help produce industry-ready graduates and enhance technological capacity in the society.

5. Innovation and Entrepreneurial Impact

The SmartDrive EDU encourages innovation through involvement of students in the process of development and optimization of prototypes. It promotes design thinking of the product, cost estimation, and market positioning approaches. The project helps to develop educational robotics kits and training modules, promote the culture of entrepreneurship in educational establishments.

6. Potential Commercialization

The project has a possibility of commercialization with modular Arduino Smart Car kits, micro-credential training packages, teacher certification workshops, and institution licensing packages. The fact that it is scalable and cheap to produce makes it affordable to schools and TVET institutions. Local and international market expansion can be done through strategic alliances with suppliers in the education industry.

7. Acknowledgment

The authors would like to express sincere appreciation to Department Technical and Vocational Education and Training, Faculty of Educational Sciences and Technology, Universiti Teknologi Malaysia (UTM) and Politeknik Ibrahim Sultan for institutional support, particularly in prototype testing and educational engagement activities.

8. Researchers' Biography

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Learning Innovation Through Teaching, Literacy & Entrepreneurship: L.I.T.T.L.E Model

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ABSTRACT
The L.I.T.T.L.E Model (Learning Innovation Through Teaching, Literacy and Entrepreneurship) is an experiential teaching and learning framework designed to transform academic learning into innovation-driven and entrepreneurial outcomes. The model was developed to address the gap between theoretical classroom instruction and real-world application in higher education. Many learning activities remain confined to academic assessment without generating tangible products or entrepreneurial value. Therefore, this model integrates media literacy, project-based learning, and innovation development to guide students in transforming knowledge into practical outputs with commercialization potential. The model consists of five interconnected stages: Inspiration, Learning Integration, Innovation Development, Testing and Validation, and Entrepreneurship Translation. Through this structured process, students are encouraged to identify real-world problems, apply relevant theoretical knowledge, develop innovative products, test their solutions with target audiences, and explore commercialization opportunities. The uniqueness of the L.I.T.T.L.E Model lies in its ability to combine teaching innovation with entrepreneurial learning, enabling students to produce marketable educational products such as digital books, media literacy modules, and creative media content. The model contributes to socio-economic development by nurturing entrepreneurial competencies among students while promoting innovative teaching practices within higher education institutions.

Keywords: Teaching innovation, experiential learning, entrepreneurship education, media literacy, project-based learning

1. Product Description
The L.I.T.T.L.E Model is an innovative teaching and learning framework designed to bridge the gap between theoretical knowledge and practical entrepreneurial application in higher education. The model integrates experiential learning, project-based learning, and innovation development to guide students through a structured process of creating real-world products. The model consists of five main phases: Inspiration, Learning Integration, Innovation Development, Testing and Validation, and Entrepreneurship Translation. During the Inspiration phase, students identify societal or industry-related problems that can be addressed through communication and media solutions. In the Learning Integration phase, students apply relevant theories and concepts learned in the classroom to develop ideas that address the identified problems.

The Innovation Development phase involves the creation of innovative outputs such as digital educational materials, media literacy tools, and communication-based products. These innovations are then evaluated through user testing and feedback in the Testing and Validation phase. Finally, the Entrepreneurship Translation phase encourages students to explore commercialization opportunities through partnerships with industry collaborators and digital platforms. This model promotes active learning, innovation, and entrepreneurial thinking while enabling students to transform academic knowledge into impactful products.

2. Learning Innovation Through Teaching Literacy & Entrepreneurship: L.I.T.T.L.E Model

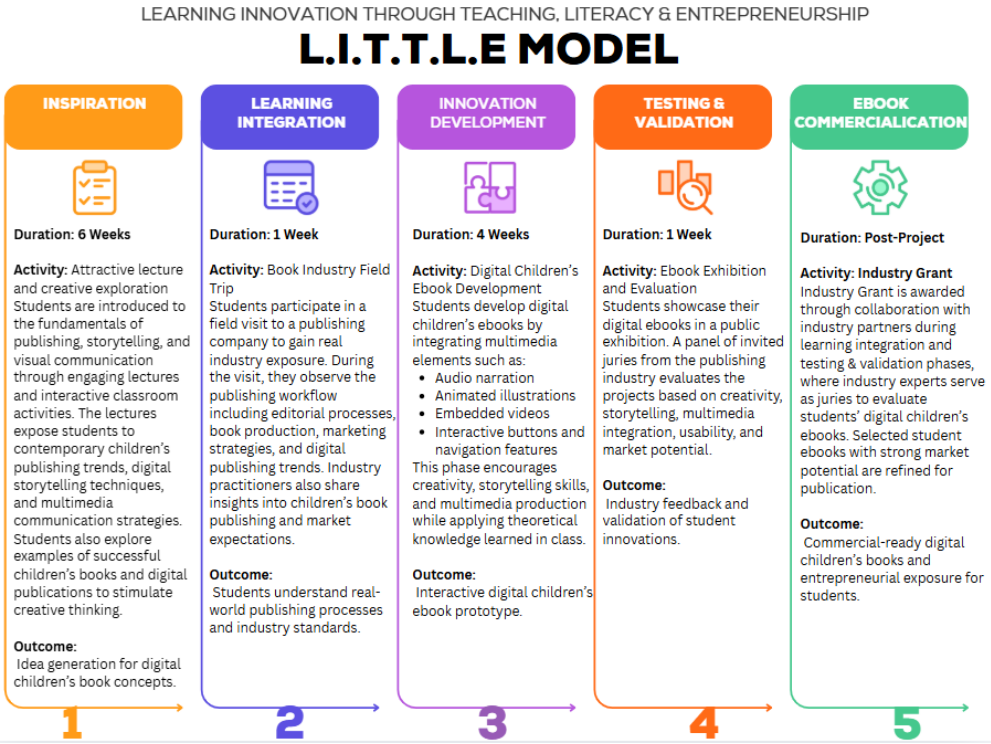

Figure 1. Learning Innovation Through Teaching Literact & Entrepreneuship (L.I.T.T.L.E).

The L.I.T.T.L.E Model (Learning Innovation Through Teaching, Literacy and Entrepreneurship) is an innovative teaching framework designed to guide students in transforming academic learning into creative and entrepreneurial outcomes through digital children's book development. The process **(Figure 1)** begins with the Inspiration phase (6 weeks), where engaging lectures introduce students to publishing fundamentals, storytelling, and visual communication to stimulate creative ideas. In the Learning Integration phase (1 week), students participate in a field trip to a publishing company to gain real industry exposure and understand professional publishing practices. Next, during the Innovation Development phase (4 weeks), students create interactive digital children's ebooks integrating multimedia elements such as audio narration, animations, videos, and interactive buttons. The Testing and Validation phase (1 week) involves an ebook exhibition where industry experts evaluate students' projects and provide professional feedback. Finally, the

Ebook Commercialisation phase encourages collaboration with industry partners through grants and mentorship, allowing selected ebooks with strong potential to be refined for publication and entrepreneurial opportunities.

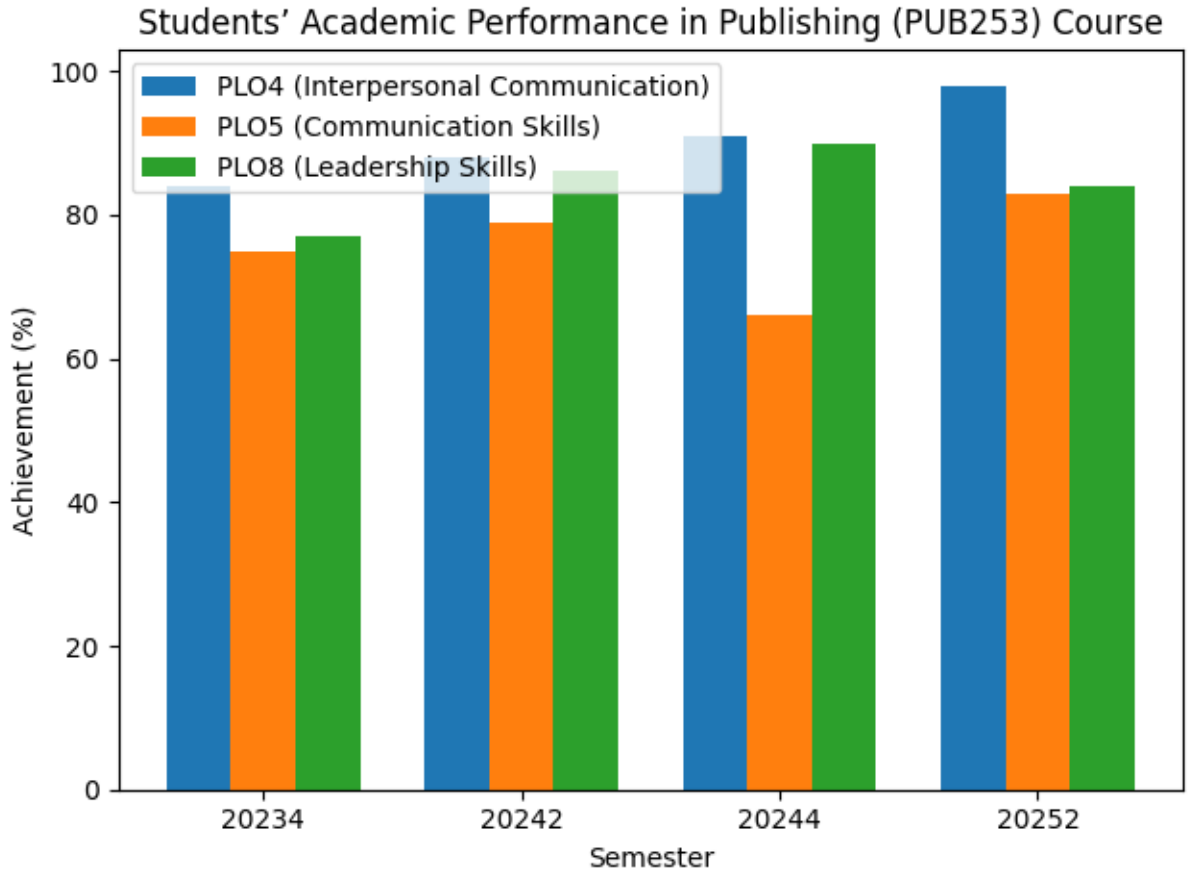

Figure 2. Students' Academic Performance towards Publishing (PUB253) Course.

Figure 2 illustrates the academic performance of Semester 4 Diploma in Communication and Media students in the Publishing (PUB253) course over four consecutive semesters (20234, 20242, 20244, and 20252). The figure presents students' achievement based on three Programme Learning Outcomes (PLOs) that are embedded within the course learning design. These include:

- PLO4 for Interpersonal Communication Skills
- PLO5 for Communication Skills
- PLO8 for Leadership Skills

The PUB253 course is designed to develop these competencies through experiential learning activities such as industry-based projects, group publishing tasks, presentations, and field engagement, enabling students to strengthen both professional communication and collaborative leadership capabilities.

Table 1. Students' Academic Performance towards Publishing (PUB253) Course.

Semester	POL4	POL5	POL8
20252	98%	83%	84%
20244	91%	66%	90%
20242	88%	79%	86%
20234	84%	75%	77%

The results presented in **Table 1** demonstrate that the implementation of the L.I.T.T.L.E Model (Learning Innovation Through Teaching, Literacy and Entrepreneurship) has significantly enhanced students' academic performance in the PUB253 Publishing course. The structured learning phases in the model encourage active participation, collaborative learning, and industry engagement, which contribute to stronger student competencies. During the Inspiration and Learning Integration phases, students develop foundational knowledge and industry awareness through engaging lectures and field exposure. This process strengthens PLO4 (Interpersonal Communication) and PLO5 (Communication Skills) as students actively discuss ideas and interact with industry professionals. The Innovation Development and Testing & Validation phases require students to work collaboratively to produce digital children's ebooks and present their projects during the ebook exhibition. These activities enhance teamwork, communication, and critical thinking skills.

Achievement of PLO4 (Interpersonal Communication Skills)

The data indicate a consistent upward trend in students' interpersonal communication performance across the four semesters.

- Semester 20234: 85%
- Semester 20242: 88%
- Semester 20244: 91%
- Semester 20252: 98%

This gradual increase suggests that students have progressively enhanced their ability to interact, collaborate, and engage effectively with peers and industry stakeholders. The high achievement in the most recent semester (98%) indicates that the learning strategies implemented in PUB253 successfully strengthened interpersonal engagement, particularly through collaborative publishing activities and external industry evaluation.

Achievement of PLO5 (Communication Skills)

The achievement for communication skills (PLO5) shows some fluctuation across semesters.

- Semester 20234: 75%
- Semester 20242: 79%
- Semester 20244: 66%
- Semester 20252: 83%

While the first two semesters show moderate improvement, there was a noticeable decrease in Semester 20244 (66%). However, the performance significantly recovered in Semester 20252 (83%). This improvement may reflect enhancements in teaching strategies, assessment design, and presentation-based learning, which emphasize students' ability to articulate ideas, deliver structured presentations, and communicate effectively within professional publishing contexts.

Achievement of PLO8 (Leadership Skills)

Students' leadership skills (PLO8) demonstrate generally strong performance across all semesters.

- Semester 20234: 77%
- Semester 20242: 84%
- Semester 20244: 89%
- Semester 20252: 84%

The increasing trend from 20234 to 20244 indicates that students progressively developed team coordination, project management, and decision-making abilities, particularly through group publishing projects. Although a slight decrease occurred in Semester 20252, the achievement level remained high, suggesting that the course effectively nurtures leadership competencies within collaborative academic environments. Overall, **Table 1** demonstrates that the PUB253 course effectively contributes to the development of key professional competencies among Semester 4 Diploma Communication and Media students. The consistently high scores across PLO4, PLO5, and PLO8 indicate that the course successfully integrates interpersonal communication, professional communication, and leadership development within its learning framework. The results also highlight the positive impact of experiential and industry-oriented learning approaches, which are widely recognized as effective pedagogical strategies for enhancing communication and leadership competencies in higher education (Kolb, 2015; Prince & Felder, 2006).

3. Novelty and uniqueness

The L.I.T.T.L.E Model represents a novel pedagogical innovation that integrates teaching innovation, media literacy education, and entrepreneurial development within a single structured framework. Unlike conventional teaching approaches that focus primarily on knowledge delivery and academic assessment, this model systematically transforms classroom learning into innovation-driven outputs with commercialization potential. The novelty of the model lies in three key aspects. First, it introduces a five-stage innovation pathway that guides students from problem identification to entrepreneurial translation. This structured approach ensures that academic learning leads to practical solutions that address real societal and industry needs. Second, the model integrates media literacy competencies with innovation development, enabling students to produce meaningful digital content such as educational media products and

communication tools. Third, the model embeds entrepreneurial thinking within the learning process, encouraging students to explore commercialization opportunities through industry collaboration and digital platforms. By combining experiential learning, innovation development, and entrepreneurship within a single pedagogical model, the L.I.T.T.L.E framework offers a scalable and transferable teaching innovation that can be adopted across various disciplines in higher education. This integration distinguishes the model as a unique teaching innovation capable of generating both academic and economic value.

4. Benefit to mankind

The L.I.T.T.L.E Model contributes to societal development by promoting innovation, creativity, and entrepreneurial thinking among university students through experiential learning and digital publishing activities. The model encourages students to develop creative solutions that address real world needs related to media literacy, communication, and digital education. Through the development of interactive digital children's ebooks and multimedia learning materials, students produce educational resources that can support learning among young audiences and communities. These digital publications can be used by schools, educators, parents, and children as engaging and accessible educational tools. In addition, the model empowers students with practical experience in digital content creation, publishing processes, and product promotion. This exposure encourages students to become potential self publishers and digital content entrepreneurs. By nurturing these entrepreneurial competencies, the L.I.T.T.L.E Model helps prepare graduates who are capable of creating their own opportunities and contributing to the growth of the digital publishing industry.

5. Innovation and Entrepreneurial Impact

The L.I.T.T.L.E Model promotes a culture of innovation and entrepreneurship within higher education institutions by encouraging students to transform academic learning into marketable products and services. Through the implementation of this model, students are guided to identify opportunities for innovation and develop creative solutions that can generate economic value. The model also fosters collaboration between academia and industry partners, enabling students to gain exposure to real-world entrepreneurial practices. This collaboration provides opportunities for product development, industry validation, and potential commercialization. By embedding entrepreneurial elements into teaching and learning activities, the L.I.T.T.L.E Model cultivates an entrepreneurial mindset among students. This approach supports the development of future innovators and entrepreneurs who are capable of contributing to the growth of knowledge-based industries and the digital economy.

6. Potential commercialization

The L.I.T.T.L.E Model demonstrates strong commercialization potential through the development of innovative digital educational products created by students, particularly interactive digital children's ebooks that integrate multimedia technologies such as audio narration, animation, video elements, and interactive navigation features. The integration of digital publishing tools and interactive multimedia platforms enhances the attractiveness, usability, and marketability of these products in the expanding digital education ecosystem. Through strategic collaboration with industry partners, particularly publishing companies such as Prestasi Publication Sdn. Bhd., the model strengthens industry and academia engagement while ensuring that the developed

products meet professional standards and market expectations. Industry participation provides professional mentorship, product evaluation, and opportunities for publication. Importantly, the model empowers students with entrepreneurial competencies by providing opportunities to become potential self publishers and digital content creators. By leveraging technology and industry collaboration, students are encouraged to commercialize their digital children's books through digital publishing platforms and online marketplaces, supporting sustainable entrepreneurship initiatives in digital publishing.

7. Acknowledgment

The authors would like to thank Universiti Teknologi MARA (UiTM) Melaka Branch and Prestasi Publication Sdn. Bhd for their support in the development of the L.I.T.T.L.E Model. This project received an Industry Grant from Prestasi Publication Sdn. Bhd. (Ref: UiTM.800-3/3 PRI (088/2025)), supporting innovative teaching and entrepreneurship initiatives in digital children's publishing.

8. Researchers' Biography

Dr. Siti Nurshahidah Sah Allam is a Senior Lecturer at the Faculty of Communication and Media Studies, Universiti Teknologi MARA Melaka Branch. Her expertise lies in publishing studies, particularly in children's book publishing and creative content development. She is actively involved in guiding students to produce engaging children's books that integrate storytelling, visual communication, and educational values. Through experiential learning and collaboration with industry partners such as Prestasi Publication Sdn Bhd, she promotes innovative publishing practices that support literacy development, creativity, and entrepreneurial skills among students and emerging content creators.

Ranjit Singh is the Managing Director of Prestasi Publication Sdn Bhd, a respected Malaysian publisher specializing in educational resources. With extensive experience in the publishing industry, he is passionate about creating impactful learning materials that support students and educators. Under his leadership, Prestasi Publication has produced numerous language and reference books widely used in schools. Ranjit actively collaborates with academic institutions to promote innovative learning, bridging the gap between education, creativity, and industry-driven publishing.

Dr. Mohd Sufiean Hassan is a Senior Lecturer at the Faculty of Communication and Media Studies, Universiti Teknologi MARA Melaka Branch. His expertise includes photo communication, graphic design, and interactive multimedia in digital publishing. He teaches Interactive Multimedia Platform, guiding students to integrate visual storytelling, graphics, and multimedia elements. Through project-based learning, he emphasizes entrepreneurial skills, encouraging students to transform creative ideas into marketable digital products while fostering innovation, creativity, and industry-relevant competencies in digital media and publishing.

Dr. Noor Afzaliza Nazira Ibrahim is a Senior Lecturer at the Faculty of Communication and Media Studies, Universiti Teknologi MARA Melaka Branch, specializing in publishing and content development. Her academic interests focus on publishing management, editorial processes, and creative content production. She actively guides students in developing publishing projects, including digital and printed publications, that combine creativity with industry practices. Through experiential learning, she encourages students to produce innovative publishing products while strengthening professional competencies in editorial work, publication design, and contemporary publishing practices.

Constismart

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ABSTRACT

ConstiSmart is an innovative learning platform designed to enhance students' understanding of the Malaysian Constitution in the CTU152 Introduction to Ethics and Civilization course, a compulsory MPU subject for Semester 2 diploma students at Universiti Teknologi MARA (UiTM). This innovation adopts a modern, interactive, and user-friendly approach to make constitutional studies more engaging compared to traditional text-based learning. Its main objective is to integrate civic education, legal analysis, and digital technology into a dynamic learning experience. By incorporating visual infographics, interactive modules, and digital quizzes, ConstiSmart helps students grasp constitutional principles and legal concepts more quickly, clearly, and effectively. Complex topics are simplified into concise and accessible content, making them easier to understand. The uniqueness of ConstiSmart lies in its combination of visual materials, gamification elements, and compact content tailored to current learning needs. It is flexible and suitable for both classroom and online learning environments. Beyond academic use, ConstiSmart has commercialization potential through the development of educational modules, digital publications, mobile applications, and infographic-based books for institutions and the wider public. Overall, the project supports constitutional literacy, nurtures patriotism, and contributes to building a society that respects and upholds the Malaysian Constitution.

Keywords: Teaching and learning, Digital Education, Interactive Learning, Gamification, Malaysian Constitution,

1. Product Description

ConstiSmart is a digital learning innovation developed to enhance students' mastery of the Malaysian Constitution for the CTU152 Introduction to Ethics and Civilization course at Universiti Teknologi MARA (UiTM). Designed to support modern learning preferences, ConstiSmart transforms complex constitutional topics into concise, engaging, and visually appealing digital content. The digital materials are developed using NotebookLM to generate structured slide decks, interactive infographics, and comprehensive video overviews. These resources simplify legal principles and constitutional concepts into organized micro-content that promotes faster understanding and better knowledge retention. The visual and multimedia approach enhances student engagement compared to conventional text-based methods. To strengthen formative assessment and active participation, ConstiSmart integrates gamified quizzes through Wordwall. The quiz games provide immediate feedback, encourage self-paced learning, and create a competitive yet fun classroom environment. ConstiSmart is flexible for both face-to-face and online learning settings. By combining digital content creation, visual learning strategies, and gamification elements, the platform supports constitutional literacy, critical thinking, and civic awareness while aligning with current digital education trends.

2. Screenshots

Figure 1. Slide Deck.

Figure 2. Infographic.

Figure 3. Video Overview.

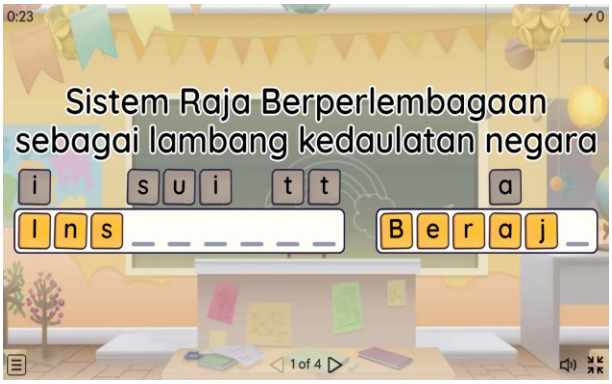

Figure 4. Wordwall Game-Anagram and Match Up.

3. Novelty and Uniqueness

Unlike conventional text-heavy approaches, ConstiSmart integrates artificial intelligence-assisted content development with gamified assessment to create a fully interactive constitutional learning ecosystem. The novelty of ConstiSmart lies in its strategic use of NotebookLM to transform complex constitutional provisions into a structured slide deck, infographic, and video overview. **Figure 1**. Slide deck functions as the logical backbone of a lesson by helping learners understand which concepts are primary and which are subordinate. **Figure 2**. Infographics allow the brain to see the "big picture" and the relationships between different parts of a system simultaneously. It also functions to simplify complex systems and show connections. Then, **Figure 3**. Video overviews demonstrate processes and provide emotional context. This AI-supported workflow enables faster content production while ensuring clarity, coherence, and academic alignment.

Legal and civic concepts that are often perceived as abstract are simplified into visually organized, learner-friendly formats. In addition, ConstiSmart incorporates gamification, as shown in **Figure 4**. Wordwall Game-Anagram and Match Up, turning constitutional assessment into interactive quiz games that promote active recall, instant feedback, and healthy competition. The integration of AI-generated instructional materials with game-based formative assessment creates a seamless digital learning cycle—content exploration, visualization, reinforcement, and evaluation. Its uniqueness also lies in its compact, modular design, making it adaptable for hybrid classrooms, online learning, and micro-credential modules. By merging civic education, legal literacy, AI tools, and gamified pedagogy, ConstiSmart offers a contemporary, scalable, and commercially viable educational innovation.

4. Benefit to Mankind

ConstiSmart contributes to society by strengthening constitutional literacy and civic awareness through accessible digital education. Developed for students at Universiti Teknologi MARA, the innovation equips learners with a clearer understanding of the Malaysian Constitution, fostering informed, responsible, and ethical citizens. By simplifying complex legal concepts into structured digital content using NotebookLM, knowledge becomes more inclusive and easier to grasp across diverse learning abilities. The integration of gamified assessments through Wordwall enhances engagement, motivation, and long-term retention, encouraging active participation rather than passive memorization. Beyond academic settings, ConstiSmart has the potential to benefit educators, institutions, and the wider public through digital modules, community workshops, and online platforms. By promoting critical thinking, patriotism, and respect for constitutional principles, ConstiSmart supports nation-building efforts and contributes to a more legally aware society. Ultimately, it empowers individuals with knowledge that strengthens democratic values, social harmony, and responsible citizenship.

5. Innovation and Entrepreneurial Impact

ConstiSmart promotes innovation by integrating AI-powered content development and gamified learning into constitutional education at Universiti Teknologi MARA. By leveraging NotebookLM to generate structured slide decks, infographics, and video overviews, the project demonstrates how emerging technologies can enhance curriculum delivery efficiently and creatively. The use of Wordwall further introduces interactive assessment models that align with digital-native learners. Entrepreneurially, ConstiSmart opens opportunities for commercialization through digital modules, e-books, infographic compilations, subscription-based learning platforms, and institutional licensing. It encourages educators to adopt innovative mindsets in developing market-ready educational products rather than relying solely on traditional teaching materials. Within the community and academic ecosystem, the project nurtures a culture of creativity, problem-solving, and digital transformation. By transforming academic content into scalable digital products, ConstiSmart bridges education and edutech entrepreneurship, contributing to sustainable innovation in the learning industry.

6. Potential Commercialization

ConstiSmart has strong commercialization potential as a scalable digital education product. Initially developed for students at Universiti Teknologi MARA, the platform can be expanded to other higher learning institutions, matriculation colleges, and secondary schools offering civic or

constitutional studies. The structured digital content generated using NotebookLM allows for efficient adaptation into licensed slide decks, interactive e-modules, infographic compilations, and video-based micro learning packages. Revenue models may include institutional licensing, subscription-based access, workshop training for educators, and the publication of infographic-based constitutional guidebooks. The gamified assessment component developed through Wordwall can also be packaged as premium quiz banks tailored to curriculum standards. In the long term, ConstiSmart can evolve into a dedicated mobile application or an integrated Learning Management System (LMS) plugin. By aligning with digital education trends, the innovation offers sustainable market value within the growing edutech and civic education industry.

Acknowledgement

The authors would like to express their sincere appreciation to Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, for its continuous support and encouragement in fostering innovation in teaching and learning. Special thanks are extended to the Academy of Islamic Contemporary Studies (ACIS) for providing academic guidance and institutional backing in the development of ConstiSmart. The team also acknowledges the contribution of digital platforms such as NotebookLM and Wordwall, which have supported the creation of interactive content and gamified assessments.

9. Researchers' Biography

Siti Fairuz Sujak is a lecturer at the Academy of Islamic Contemporary Studies (ACIS), Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, Malaysia. She specializes in Islamic studies, ethics and civilization, and constitutional literacy, with a strong interest in innovative and technology-enhanced pedagogy. Her academic work focuses on integrating digital tools, gamification, and micro-content strategies to improve students' understanding of complex legal and civic concepts.

Noraishah P. Othman is a lecturer at the Academy of Islamic Contemporary Studies (ACIS), Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, Malaysia. Her academic expertise focuses on Islamic studies, ethics, and contemporary issues in the study of civilization. She is actively involved in curriculum development and innovative teaching practices, particularly in integrating digital tools to enhance learning engagement and understanding.

Rohaya Sulaiman serves as a lecturer at ACIS, Universiti Teknologi MARA. Her research interests include civic education, moral and value-based learning, and higher education pedagogy. She has contributed to various academic and instructional development initiatives aimed at strengthening students' constitutional awareness and critical thinking skills.

Mohd Huefiros Efizi Husain is a lecturer at ACIS, Universiti Teknologi MARA, with academic interests in Islamic contemporary studies, digital education innovation, and interactive learning strategies. He is committed to advancing technology-integrated teaching methods and promoting impactful educational innovations in higher education.

BIM Auto-Checking E-Profiling System (BIMCheck Pro™)

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ABSTRACT

Malaysia's National BIM e-Submission (NBeS) initiative demonstrates that automated code checking can compress approval lead times by up to 70%. Still, pilots also report persistent readiness gaps among local authority (PBT) operatives and principal submitting persons (PSP), undermining consistent adoption. BIM Auto-Checking e-Profiling System™ (BIMCheck Pro™) is a competency-based analytics system that operationalizes the BIM Auto-Checking Competency Framework™ (BIMCheck Core™) by formalizing the BIM Checker™ role and profiling knowledge, skills, and attitudes across five domains: BIM Modelling, BIM e-Submission Operations, Automated Building Code Compliance Checking, Digital Data Management, and Administrative Functions. The platform delivers online diagnostic assessment, generates personalized micro-upskilling pathways, enables mastery-oriented retesting, and issues HRMIS/CPD-ready competency evidence. Its uniqueness lies in combining an occupationally validated competency ontology with automated scoring, cohort dashboards, and traceable credentials, allowing institutions to target training budgets to the highest-risk gaps. Socio-economic impact is achieved by reducing resubmissions, improving regulatory consistency, and accelerating investment-linked permitting; socio-environmental impact follows from earlier detection of safety and code risks. Commercialization is planned via subscription licensing for PBTs and PSP firms, institutional packages for HEI/TVET, and micro-credential add-ons.

Keywords: Competency-based learning; e-learning analytics; BIM e-Submission; Training needs analysis; Micro-credentialing

1. Product Description

BIM Auto-Checking e-Profiling System™ (BIMCheck Pro™), as shown in **Figure 1**, is a digital competency e-profiling and micro-learning system designed to operationalize Malaysia's BIM Auto-Checking Competency Framework™ (BIMCheck Core™). It supports local authorities (PBT) officers, principal submitting persons (PSP), higher education institutions (HEI), and technical and vocational education and training (TVET) institutions by converting an occupationally validated competency ontology into measurable learning outcomes and actionable training pathways. Users complete a guided diagnostic assessment mapped to five domains (C01–C05) and to Knowledge–Skills–Attitudes (K-S-A) dimensions.

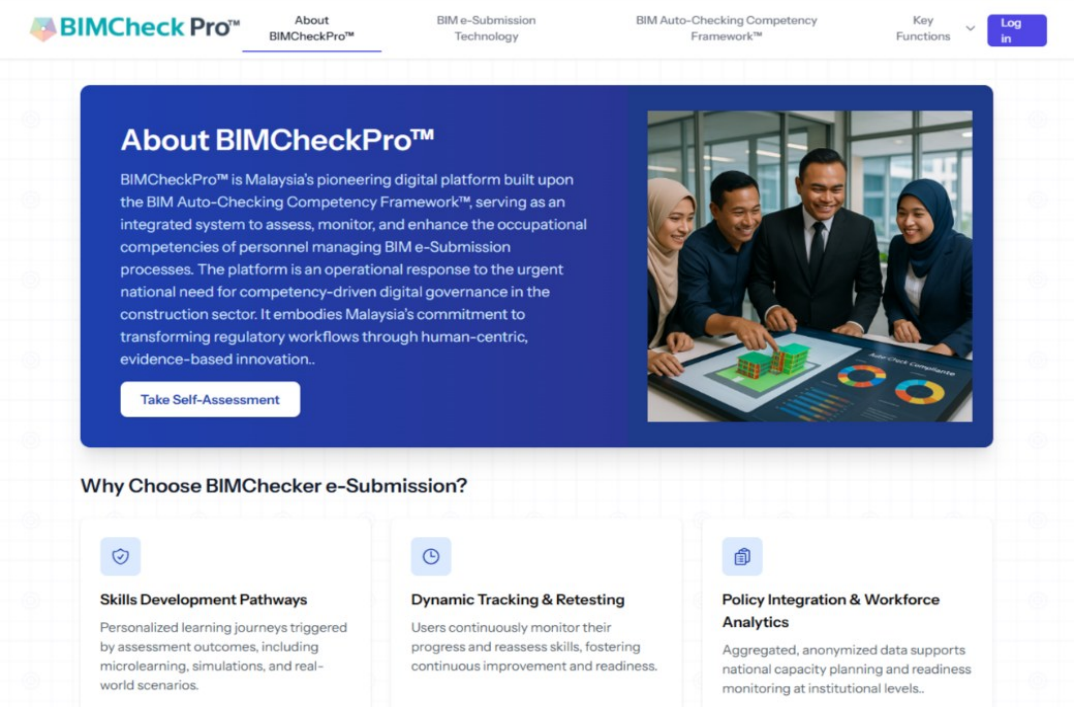

Figure 1. BIMCheck Pro™ Interface (Visit – https://bimchecker.my/).

The underlying competency ontology is represented in **Figure 2**, where the BIMCheck Core™ organizes five domains (C01–C05) that structure the assessment blueprint, module library, and learning analytics. Construct traceability strengthens validity and supports defensible training needs analysis. The system then generates a personalized upskilling plan comprising short micro-modules, practice tasks, and mastery-based retests. A learning analytics layer aggregates attempt history, time-on-task, and domain trajectories to support learner self-regulation and institutional decision-making (e.g., targeted coaching for high-risk competencies such as automated compliance checking).

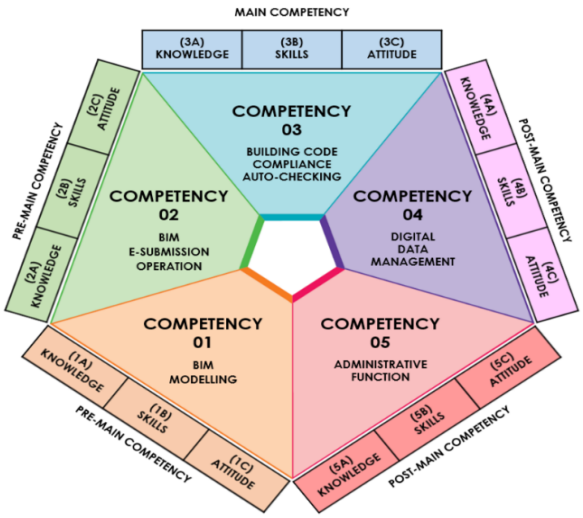

Figure 2. BIM Auto-Checking Competency Framework™ (BIMCheck Core™).

Upon meeting criterion-referenced mastery thresholds, BIMCheck Pro™ issues a verifiable competency report and certificate (see **Figure 3**) suitable for HRMIS/CPD evidence. The platform is deployable as a standalone training needs analysis (TNA) tool or as an integrated component of organizational capacity-building programs aligned to NBeS and OSC 3.0 Plus Online.

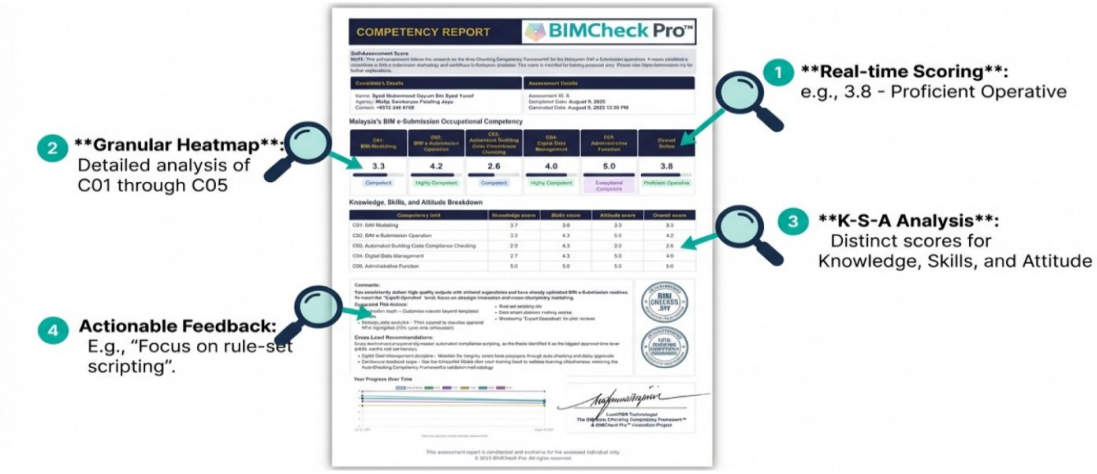

Figure 3. BIMCheck Pro™ Competency Report.

2. Flow Charts of the BIMCheck Pro™

The competency-based learning workflow is shown in **Figure 4**, illustrating the diagnostic assessment, K-S-A gap profiling, adaptive micro-upskilling, and mastery retesting that culminate in credential issuance. The return arrow represents periodic reassessment and cohort-level learning analytics.

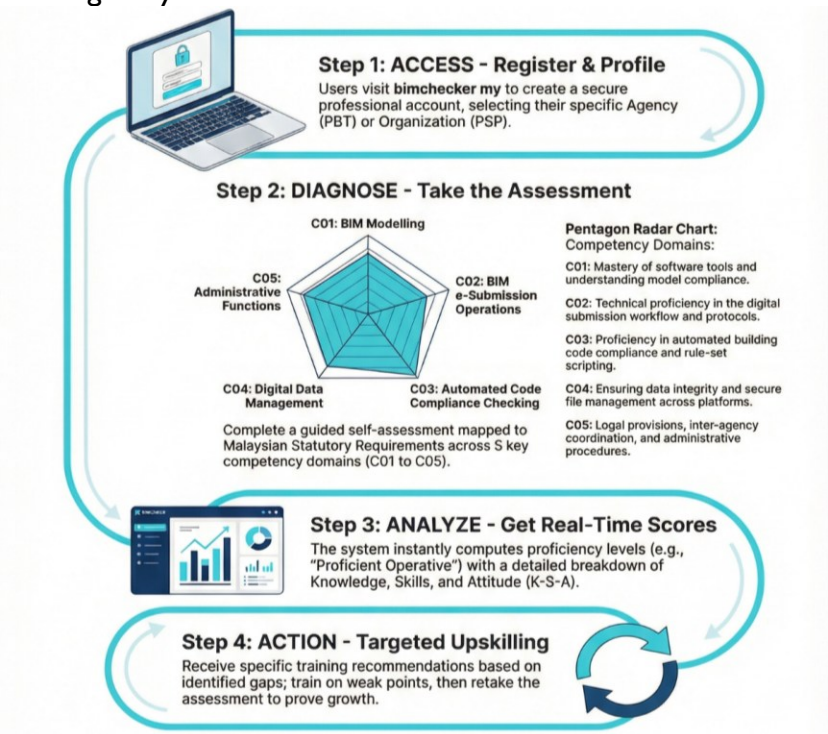

Figure 4. BIMCheck Pro™ competency-based learning loop and evidence pathway.

3. Novelty and uniqueness

BIMCheck Pro™is novel in that it fuses (i) a BIM e-Submission occupational competency framework derived through Design and Development Research (DDR) and DACUM methods and validated by experts from Malaysia, Japan, and the UK, with (ii) a competency-based e-learning system that applies constructive alignment and mastery learning to generate traceable evidence of capability. Unlike conventional BIM courses that are time-based and content-driven, each assessment item and micro-module is mapped to an explicit construct in the BIMCheck Core™, enabling defensible TNA and targeted remediation as shown in **Figure 4**. The platform's K-S-A decomposition distinguishes conceptual deficits from procedural performance issues and professional dispositions, while criterion-referenced mastery thresholds (typically 80-90%) support progression to verified competence rather than relative ranking. In addition, the embedded learning analytics layer elevates the platform from an online questionnaire to an institutional decision-support instrument by producing cohort heatmaps, progression curves across retests, and auditable credentials (QR verification) suitable for HRMIS/CPD. This integration of competency ontology, blueprint-based assessment, mastery workflow, and analytics remains uncommon in BIM e-Submission capacity-building and offers a transferable model for jurisdictions seeking to institutionalize digital permitting.

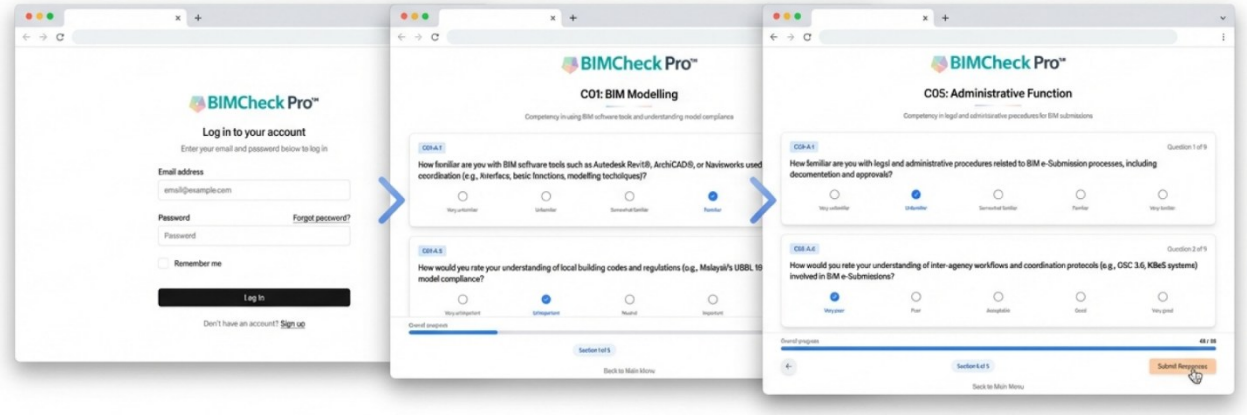

Figure 4. Structured self-assessment mapped to K-S-A constructs in the BIMCheck Core™.

4. Benefit to mankind

By professionalizing BIM e-Submission capability, BIMCheck Pro™ contributes to safer, faster, and more consistent regulatory decision-making while strengthening public trust in digital permitting. For learners, it reduces uncertainty by clarifying what competence looks like, providing personalized pathways and timely feedback, and recognizing achievement through verifiable micro-credentials. For organisations, it reduces wasted training expenditure by targeting interventions to evidence gaps, enabling equitable workforce development and more transparent performance management through HRMIS/CPD-ready outputs. At the ecosystem level, improved competency reduces avoidable resubmissions and rectification work, shortens investment-linked approval timelines, and supports earlier detection of safety and code risks, thereby improving resource efficiency across the built-environment lifecycle.

5. Innovation and Entrepreneurial Impact

The project promotes innovation and entrepreneurship by creating a scalable, analytics-driven upskilling product that sits at the interface of policy, industry practice, and TVET delivery. It enables institutions to package competency-based micro-credentials, offer subscription access to diagnostic assessment and readiness dashboards, and continuously refine module libraries using learning analytics rather than anecdote. The platform's auditable credentialing (QR verification) provides defensible signals of capability for workforce mobility, onboarding, and specialised BIM compliance services. Entrepreneurially, BIMCheck Pro™ supports a modular content ecosystem in which domain experts can author accredited micro-modules and rule sets aligned to local regulations, creating new revenue streams and strengthening innovation culture through measurable learning outcomes and cohort benchmarking.

6. Potential commercialization

Commercialisation is feasible through a tiered licensing model, namely, institutional subscriptions for PBT departments provide cohort dashboards, custom competency thresholds, and administrative reporting for BIM e-Submission readiness, professional packages for PSP firms bundle diagnostic profiling, targeted micro-modules, and certificate issuance as CPD-ready evidence, reducing onboarding friction and compliance risk, and TVET/HEI licences embed the competency map into curricula and micro-credential programmes, with analytics for programme assurance and tracer studies. Revenue can be augmented via bespoke module authoring, domain-specific rule sets aligned to local regulations, and enterprise integrations (e.g., HR systems, digital badge platforms). This model aligns recurring platform revenue with measurable competency uplift and auditable outcomes, creating a defensible value proposition for public and private adopters.

7. Acknowledgment

Sincere appreciation is extended to CIDB for their institutional guidance on Malaysia's National BIM e-Submission agenda; to KPKT, JKT, and JKR for regulatory and implementation perspectives; and to participating PBT—PPj, MBPJ, MPK, DBKU, MBMB, and MPKK—for their openness in sharing operational realities, constraints, and practice-based insights that strengthened the framework's fidelity to real-world adoption conditions. The study also benefitted substantially from academic and technical contributions from UTM, UPM, and UMPSA, particularly in refining competency constructs and assuring methodological rigour. Finally, the authors record their appreciation to the international expert reviewers and research partners from University College London (UCL), Cardiff University, buildingSMART Japan/Building Research Institute, and Aston University for their critical appraisal that enhanced the framework's validity, transferability, and alignment with international e-permitting and digital construction practices. All individual contributions are acknowledged with respect for confidentiality and research ethics; any remaining limitations are solely those of the authors.

8. Researchers' Biography

Ts. Dr. Mohd Fawwaz Najmi bin Mohd Fuzi holds a PhD in Building Technology from the University of Malaya with specialization in Malaysia-specific BIM e-Submission occupational competencies. His research addresses the "missing layer" of BIM e-Submission—workforce readiness—as infrastructure for regulatory approvals. He also had attended the Visiting Research Programme in Sustainable Construction at the University College London, UK, where he incorporated international benchmarking to advance Malaysia's shift from 2D plan submissions to 3D model-based approval. Grounded in statutory practice, he designs measurable, auditable BIM+ACC competency frameworks for PBT and PSP up- and reskilling, catalyzing the BIMCheck Pro™, underpinned by a 2024–2030 roadmap, MyIPO protections, multiple awards, and the AI-focused BIMCheckPro.ai.

The Power of Music: Leveraging Secondary Brand Association to Build Brand Equity

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ABSTRACT

The project introduces an innovative teaching method that integrates music videos into the selected topic in the Strategic Brand Management course. It addresses gaps in students' comprehension of secondary sources of brand association, enhancing critical thinking and communication skills for developing strategies to strengthen brand equity. Brand equity is commonly defined as the momentum of the brand, the intangible value that comes from consumers' perceptions of the brand. The sources of secondary brand associations include people, things, and places. The teaching method involves eight steps, namely: 1. Select a brand topic, learning objective and music video, 2. Develop questions, 3. Select a targeted group of learners, 4. Teaching mode, 5. Interactive platform, 6. Delivery, 7. Outcome, and 8. Implication and conclusion. Two popular YouTube music videos are used in this teaching method: *'Masing-Masing'* and *'From the beginning until now'*. The music videos and questions are posted on Menti.com, an interactive platform, to gather learners' feedback on the topic discussed. It demonstrates that music can effectively capture learners' attention and expand their perspective on the brand. With its adaptability across diverse marketing topics and business contexts, this innovation offers commercialization opportunities in training environments on brand equity strategies.

Keywords: Music, Brand Management, Teaching and Learning Method

1. Product Description

This innovation revolutionizes Brand Management education by integrating music videos in teaching. Its structured process involves eight steps as follows (**Figure 1**):

i. Select brand topic, learning objective and music video

Leveraging secondary brand associations is significant in helping the company build its brand equity. According to Keller and Swaminathan (2020), it provides different means by which the companies can optimize secondary brand associations by linking the brand to the following sources (**Figure 2**): companies (through branding strategies), countries or other geographic areas (through identification of product origin), channels of distribution (through channel strategy), other brands (through co-branding), characters (through licensing), spokespersons (through endorsements), events (through sponsorship) and other third-party sources (through awards or reviews). Theoretically, as highlighted by Keller and Swaminathan (2020), consumers can infer any aspect of knowledge from other entities to the brand, although some types of entities are more likely to inherently create or affect certain kinds of brand knowledge than

others (**Figure 3**). Next, two popular and impactful music videos, namely, "Masing-Masing" (**Figure 4**) and "From the Beginning Until Now" (**Figure 5**), are selected to align with the topic and its learning objective. 'Masing-Masing' is a strategic collaboration between Malaysian artist Erni Zakri and Indonesian composer Ade Govinda, showcasing regional talent and cultural diversity. The official music video has been viewed more than 100 million times. The music video serves as an example of how an individual's talent and team (people) can generate mutually beneficial outcomes for both brands across the two nations and beyond. On the other hand, "From the Beginning Until Now" is a popular original soundtrack from the Korean drama series "Winter Sonata," this song has gained significant attention, with over 10 million YouTube views. The series, which aired in 2002, effectively enhanced global visibility for South Korean brands. The country's beautiful scenery has inspired many to explore it, highlighting the substantial impact of cultural products on tourism and brand perception. This example illustrates how the country-of-origin effect (place) can serve as a secondary source of brand association, strategically benefiting South Korean brands in global markets.

ii. Develop questions

Aligned with the learning objective, the key questions for the topic are developed and posted to learners. **Table 1** lists the questions.

iii. Select a targeted group of learners

The project involved a group of full-time Master of Business Administration (MBA) students. The description of the following steps of the teaching method referred to the delivery, outcome, and conclusion based on the class conducted with these selected MBA students.

iv. Select teaching mode

This innovative teaching method was utilized through a face-to-face (F2F) classroom setting. It aims to foster direct interaction and engagement with learners. Nonetheless, the method can also be used in an online class, provided learners can take an active role in shaping their learning experience.

v. Selection of interactive platform

YouTube was utilized as a source of the selected music videos, while Menti.com served as the interactive platform for the project. Both platforms were chosen for their ease of use, interactivity, and accessibility, thereby enhancing the learning experience for students and facilitators alike. Menti.com provided real-time feedback and responses, enriching the engagement during discussions

vi. Delivery

The Menti.com link is shared, allowing learners time to watch both music videos, engage with the questions, and express their thoughts. This takes place in the physical classroom.

vii. Outcome

The responses collected from the exercise were both encouraging and insightful, demonstrating that music can effectively capture learners' attention and expand their educational perspective. Participation in the interactive session was robust, with most learners successfully grasping the concept of leveraging secondary brand associations in relation to the music videos. Many learners

also put forth additional examples and identified their sources, showcasing their critical thinking skills. Some of the brands and strategies highlighted are shown in **Figure 6**.

viii. Implication and Conclusion

Through this project, learners were able to thoughtfully connect the discussed topic, exploring it enjoyably and engagingly. It underscores the potential of integrating music into business management education, particularly in brand management. This approach serves as a vibrant medium for illustrating the concept in action. It fostered innovative thinking, encouraging learners to "think outside the box" by identifying other examples of brands and industries that have leveraged or could leverage secondary brand associations. The topic highlights the importance of strategic collaboration in brand management, emphasizing that working together can yield more significant results than competing alone in the quest for customer loyalty and brand sustainability.

2. Methods and Results

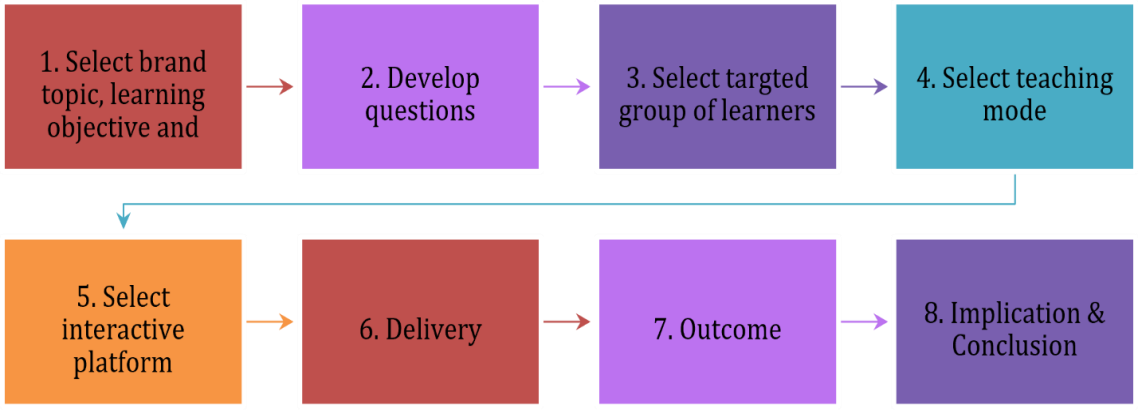

Figure 1. Flowchart of teaching method: Integrating music video into Brand Management course.

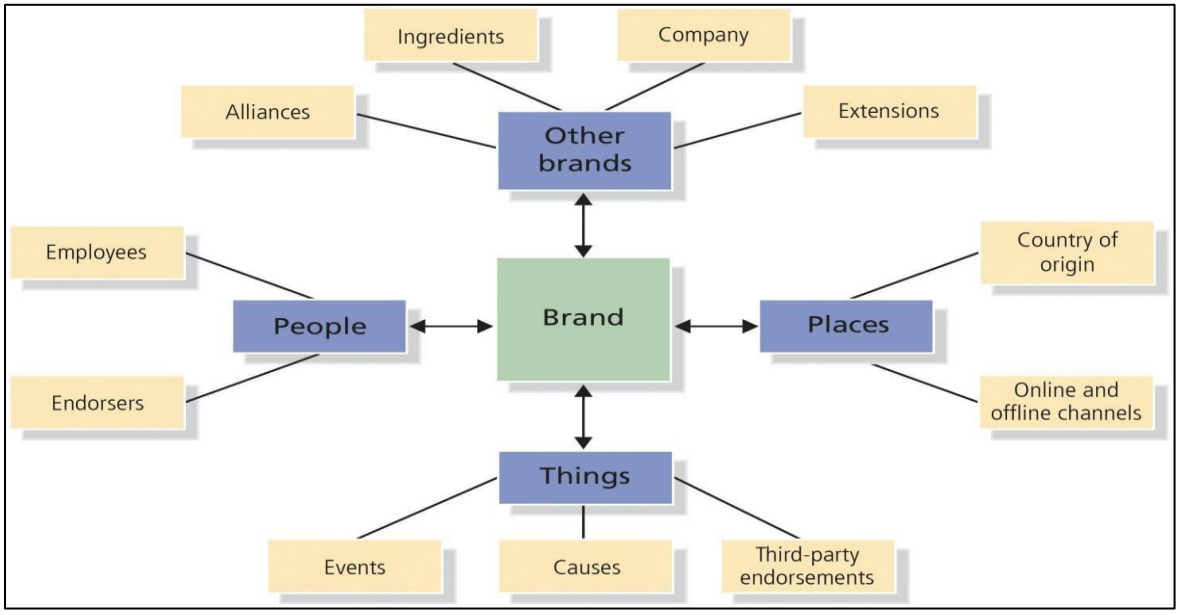

Figure 2. Sources of secondary brand association. (Source: Keller & Swaminathan, 2020).

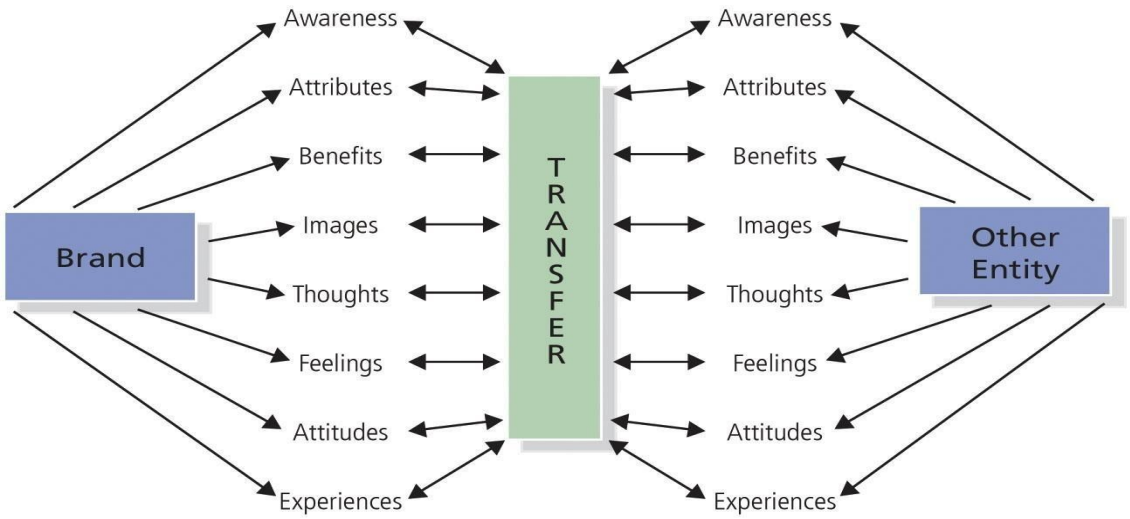

Figure 3. Understanding transfer of brand knowledge. (Source: Keller & Swaminathan, 2020).

Figure 4. Music video "Masing-Masing".
(Source: https://www.youtube.com/watch?v=XJpXtlVKgIg).

Figure 5. Music video "From the Beginning Until Now".
(Source: https://youtu.be/pisbO7J_AYs?si=iQbuTmZok19I3hcf).

Table 1. List of questions .

	Question
1.	1st music video (Masing-Masing) - What is the key secondary source of brand knowledge employed?
2.	2nd music video (From the Beginning Until Now) - What is the key secondary source of brand knowledge employed?
3.	Referring to the 1st music video (Masing-Masing), what are the advantages of leveraging secondary brand association to both parties? Be specific.
4.	Referring to the 2nd music video (From the Beginning Until Now), what are the advantages of leveraging secondary brand association to both parties? Be specific.
5.	Any other examples of leveraging secondary sources of brand associations? Name the brand and the secondary source of brand associations used.
6.	What is the most useful part of this exercise?

"Nike's collaboration with Apple for fitness product: Apple Smart Watch "- Huzaili

"Boh Tea and Cameron Highland – Boh Tea leverages Cameron Highland's image of lush greenery and pristine environment to enhance its brand as a natural and premium tea producer" – Anonymous

"Disney. Theme park experiences. Disney uses its iconic theme park (Disneyland) to create immersive experiences, reinforcing the brand's association with imagination and story telling " – Aressa

Figure 6. Some examples of brands and strategies highlighted by learners.

3. Novelty and Uniqueness

The primary objective of the teaching method is to encourage learners to explore the sources of secondary brand associations in building brand equity by integrating music videos into the lesson. It represents an innovative, interactive approach that diverges from traditional teaching methods. The responses collected from the exercise were both encouraging and insightful, demonstrating that music can effectively capture learners' attention and expand their educational perspective. Participation in the interactive session was robust, with most learners successfully grasping the concept of leveraging secondary brand associations in relation to the music videos. Many learners also put forth additional examples and identified their sources, showcasing their critical thinking skills.

4. Benefit to Mankind

This teaching and learning approach em phasize integrating music into the brand management course. It facilitates the facilitator and learners in communicating the knowledge creatively.

Building brand equity is vital to any company. By adopting the approach, learners and practitioners can search for and utilize other relevant sources of secondary brand association. This would help them create or reinforce significant points of difference and competitive points of parity

5. Innovation and Entrepreneurial Impact

Through this project, learners were able to thoughtfully connect with the discussed topic, exploring it in an enjoyable and engaging way. It underscores the potential of integrating music into business management education, particularly in brand management. This approach serves as a vibrant medium for illustrating the concept in action. Additionally, the project fostered innovative thinking, encouraging learners to "think outside the box" by identifying other examples of brands and industries that have leveraged or could leverage secondary brand associations. The topic highlights the importance of strategic collaboration in brand management, emphasizing that working together can yield more significant results than competing alone in the quest for customer loyalty and brand sustainability.

6. Potential Commercialization

This innovation and its flowchart can be embedded in any Brand Management module on the identified topic: leveraging secondary brand association to build brand equity. The same approach and flowchart can also be applied to any other relevant topic (s) or course(s). It promotes creativity and could make learning enjoyable. Considering its adaptability across diverse marketing topics and business contexts, this innovation also offers commercialization opportunities in training environments on brand equity strategies

7. Acknowledgment

The author would like to express her sincere gratitude to the artists, songwriters, and music video production teams of 'Masing-Masing' and 'From the Beginning Until Now', as well as to YouTube, for their outstanding creativity and for producing such beautiful and inspiring music. The author would also like to acknowledge Professor Kevin Lane Keller and Professor Vanitha Swaminathan, whose book Strategic Brand Management: Building, Measuring, and Managing Brand Equity (2020, Pearson) served as a vital source for key brand management concepts referenced in this work.

8. Researcher's Biography

Dr. Siti Zaleha Sahak, a Certified Professional Marketer (CPM-Asia), is an Associate Professor of Marketing at Arshad Ayub Graduate Business School (AAGBS), UiTM. She obtained her Ph.D. in Marketing from the University of Salford, UK. She is committed to making learning an enjoyable experience and embraces learners' diverse backgrounds. She is a Council Member of the Institute of Marketing Malaysia (IMM) and a member of the Malaysian Consumer and Family Economics Association (MACFEA). She is also an active consultant involved in marketing and policy-related projects. Her research interests are consumer behavior, branding, market segmentation, and strategies.

Picture up the Career

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ABSTRACT

"Picture Up the Career" is an innovative augmented reality (AR) poster designed to enhance career awareness and job-hunting skills among polytechnic students. Some students find themselves with limited insight into the diverse job opportunities available in their chosen fields and often depend solely on basic job advertisements, resulting in limited career prospects. This innovation was developed as an interactive educational resource for the Communicative English 3 (DUE50132) course to support career understanding through visual and hamds-on learning. By scanning the poster using their smartphones and tabletss, students can access information on job roles, responsibilities, and related industries. The content incorporates real examples obtained from the alumni database, allowing students to connect academic learning with authentic workplace experiences. The use of AR technology transforms conventional career guidance materials into an engaging and student-centred learning experience. The innovation improves employability awareness, assists students in selecting suitable internship placements for Work-Based Learning, and strengthens links between education and industry. From a socio-economic perspective, it promotes informed career planning and graduate readiness. The product has strong commercialization potential as it can be adapted across different academic programmes, implemented in polytechnics nationwide, and utilised as an interactive promotional tool to showcase programme career pathways.

Keywords: Augmented Reality, Career Awareness, Job Exploration, Employability Skills, Work-Based Learning

1. Product Description

"Picture Up the Career" is an educational innovation developed in the form of an augmented reality (AR) poster that introduces students to various job positions related to their field of study. The poster functions as an interactive learning medium where students scan visual markers using mobile devices to activate digital content. Once scanned, the system displays detailed job descriptions, responsibilities, and industry information. The content is enhanced with real examples collected from the polytechnic alumni database, including companies associated with each job role and insights into daily workplace tasks. This provides students with practical exposure beyond textbook learning. The innovation is used as a teaching aid for the DUE50132 Communicative English 3 course, particularly in topics related to job seeking and career preparation. It also supports students during Work-Based Learning by helping them identify suitable internship placements aligned with career expectations. As it is currently developed at prototype level, the innovation emphasizes interactive learning, accessibility, and scalability. The

design allows adaptation across various academic programmes and institutions while also serving as a promotional platform highlighting career opportunities offered by polytechnic education.

2. Methods and Results

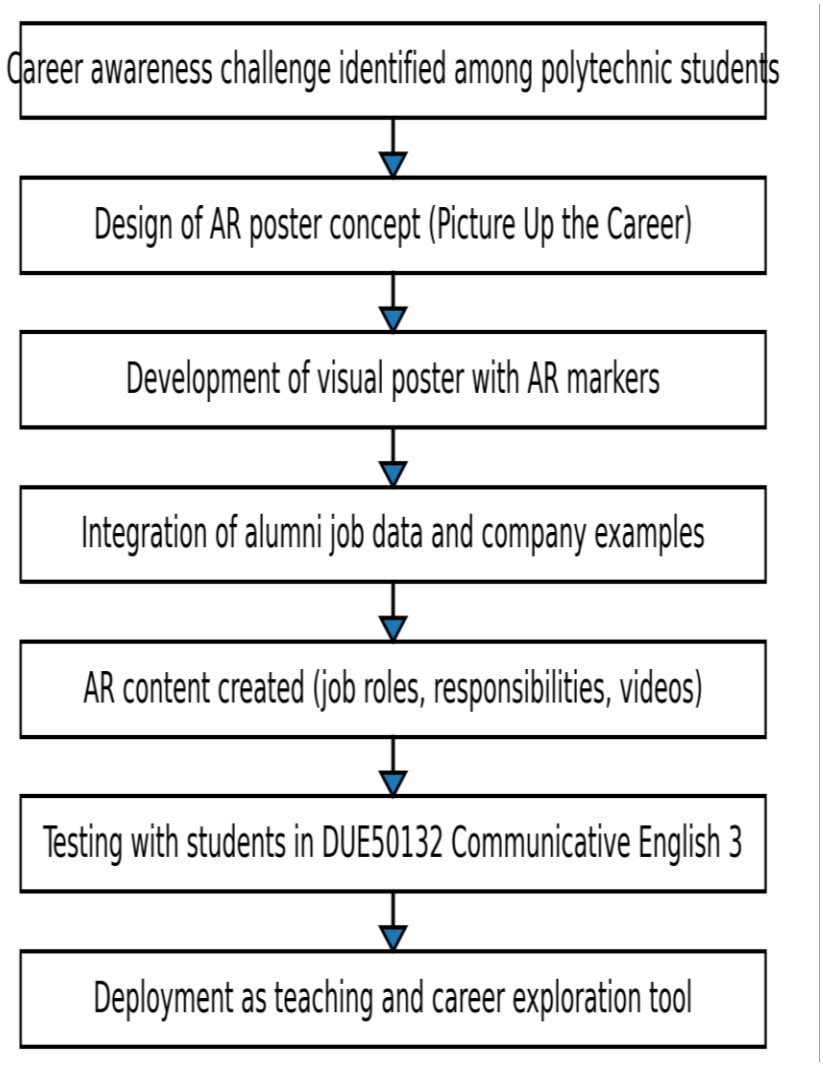

Figure 1. Picture Up the Career development process.

This diagram (see **Figure 1**) illustrates the process of developing the "Picture Up the Career" innovation from problem identification to classroom implementation. Students initiate the AR experience by scanning the QR marker displayed in **Figure 2**, which links users to the interactive career exploration environment. Students scan the 'Picture-Up the Career' Marker as in **Figure 3**, where the Augmented Reality (AR) list will pop up. **Figure 4** shows the interactive 'Picture Up the Career' interface featuring the "Tap Me" button that enables users to proceed to the next content page.

Figure 2. QR marker.

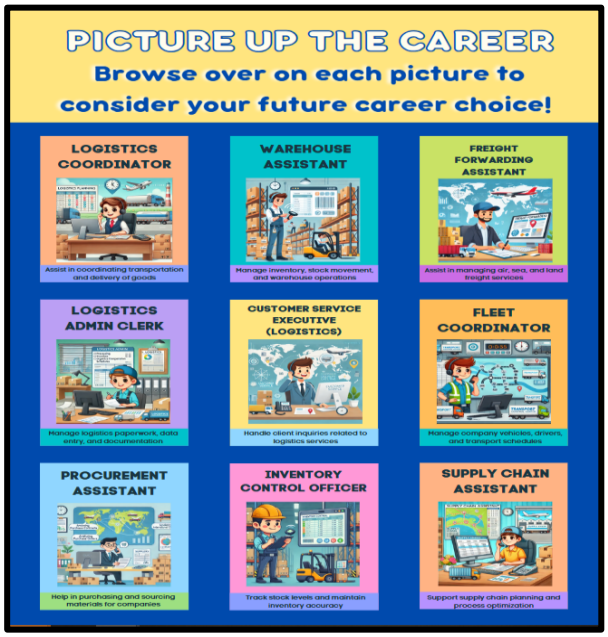

Figure 3. Augmented reality list.

Figure 4. Interactive 'Picture Up the Career' interface.

3. Novelty and uniqueness

"Picture Up the Career" stands out by merging augmented reality with career insights from alumni, all within one educational tool. This approach moves beyond the static nature of typical career guidance, offering students an engaging, hands-on way to discover career paths. What truly sets it apart is the use of real alumni experiences. This means students get a genuine look at a job duties and industry demands, moving beyond abstract concepts and connecting academic knowledge with the practicalities of the working world. Another distinctive feature is the incorporation of authentic alumni data, enabling students to understand real job responsibilities and industry expectations rather than theoretical descriptions. This bridges the gap between academic learning and workplace realities. The innovation also combines career exploration, language learning, and internship preparation into one platform, making it multidisciplinary in nature. Its poster-based format ensures ease of implementation without requiring complex infrastructure, allowing institutions to adopt the innovation with minimal cost.

4. Benefit to mankind

This innovation benefits students by improving career awareness, employability understanding as well as decision-making skills related to internships and future employment. Through interactive exposure to real job roles, students gain clearer insight into industry expectations and required competencies. Educators gain valuable advantage from more engaging teaching tool that supports experiential learning, while institutions strengthen their connection with alumni and industry partners. The innovation also contributes to produce graduates who are better prepared for employment, supporting work readiness and reducing skill mismatches.

5. Innovation and Entrepreneurial Impact

"Picture Up the Career" promotes innovation by integrating digital technology into career education and encouraging creative teaching practices within TVET institutions. The project fosters an entrepreneurial mindset by demonstrating how educational challenges can be addressed through technology-driven solutions. The innovation encourages collaboration between academic community, alumni and industry in which creating opportunities for continuous content development and institutional partnerships. It also introduces students to digital learning environments aligned with Industry 4.0 practices, nurturing adaptability and innovation culture within the educational ecosystem.

6. Potential commercialization

The innovation has strong commercialization potential due to its scalability and adaptability across programmes and institutions. The AR poster framework can be tailored to suit different academic disciplines, schools or training centres. Potential commercialization strategies include licensing the AR content system to educational institutions, offering customized career exploration packages, and developing institutional promotional materials showcasing programme career pathways. Collaboration with industries and alumni networks may further enhance content value and sustainability. The product can also evolve into a subscription-based digital career exploration platform, expanding its market beyond polytechnics to schools, universities, and career guidance centres.

7. Acknowledgment

The authors would like to thank Politeknik METrO Johor Bahru, participating alumni, and students who contributed feedback and real-world insights during the development of this innovation.

8. Researchers' Biography

Siti Faezah binti Ahmad Sazali is a Lecturer at Politeknik METrO Johor Bahru with over 15 years of experience in the Polytechnic and Community College (POLYCC) system. She focuses on enhancing students' communication competencies for academic and professional environments. Her teaching emphasizes practical language use, including workplace communication, presentation skills, and employability-related language skills. She is also involved in producing academic publications and developing teaching materials related to language education and innovative teaching practices. Through her initiatives, she supports students in building confidence and effective English communication to become industry-ready graduates.

Hana binti AB Nasir is a Lecturer at Politeknik METrO Johor Bahru with over 15 years of experience in the Polytechnic and Community College (POLYCC) system. She specializes in Communicative English with a particular focus on e-learning and digital teaching practices, including the use of CIDOS in supporting online and blended learning. Her work emphasizes integrating technology into language teaching to create engaging, flexible, and student-centered learning environments. Through her teaching and involvement in digital learning initiatives, she supports students in strengthening their English communication skills while adapting to technology-enhanced learning in higher education.

D-EMA Learning Framework (Dialogic Environmental Management Accounting)

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ABSTRACT

The D-EMA Learning Framework (Dialogic Environmental Management Accounting) is an innovative teaching and learning approach designed to transform traditional lecture-based accounting education into an interactive, sustainability-driven learning experience. Conventional teaching methods in accounting often rely on one-way knowledge delivery, which limits student engagement, critical thinking, and awareness of environmental responsibility in business practices. The D-EMA framework addresses this gap by integrating dialogic pedagogy with experiential learning activities that actively involve students in sustainability-related projects. Through structured learning variations such as Capture the Nature, Eco-Friendly Walk, Cooking Without Smoke, Virtual Run, TikTok Environmental Awareness Campaign, and the EMAzing Race, students collaboratively explore environmental challenges and apply Environmental Management Accounting concepts in real-life contexts. Compared to traditional teaching approaches, the framework significantly enhances student participation, creativity, teamwork, and problem-solving abilities. Students move from passive recipients of knowledge to active contributors who critically reflect on the role of accounting in addressing environmental and sustainability issues. The approach also promotes socio-environmental awareness by encouraging responsible attitudes toward sustainable practices and community engagement. The D-EMA Learning Framework demonstrates strong potential for broader adoption and commercialization as a replicable teaching toolkit, training module, or instructional framework for universities, professional accounting programs, and sustainability education initiatives seeking innovative approaches to accounting pedagogy.

Keywords: Accounting Pedagogy, Dialogic Learning, Environmental Management Accounting, Experiential Learning, Sustainability Education

1. Product Description

The D-EMA Learning Framework (Dialogic Environmental Management Accounting) is an innovative teaching and learning model developed to transform conventional accounting education into an interactive and sustainability-oriented learning experience. Traditional lecture-based approaches often limit student engagement and provide minimal opportunities for students to critically connect accounting knowledge with real environmental and social challenges. The D-EMA framework addresses this limitation by integrating dialogic pedagogy with experiential learning activities that actively involve students in sustainability-focused projects.

The framework functions as a structured teaching toolkit that combines dialogue, collaboration, reflection, and real-world application of Environmental Management Accounting concepts. It is implemented through a variety of student-centred learning activities including Capture the Nature, Eco-Friendly Walk, Cooking Without Smoke, Virtual Run, TikTok Environmental Awareness Campaign, and the EMAzing Race. These activities encourage students to explore environmental issues, apply accounting concepts creatively, and engage in collaborative problem-solving while promoting environmental awareness. As part of the course assessment, the experiential activities constitute 20% of the overall evaluation, replacing conventional classroom presentations and encouraging more interactive and applied learning. The D-EMA Learning Framework enhances students' critical thinking, teamwork, communication skills, and sustainability awareness. It also provides educators with a practical approach for integrating sustainability into accounting curricula across universities and business programs. The framework can be replicated and adapted across universities, business schools, and professional training programs, making it a scalable teaching innovation for sustainability education in accounting and business disciplines.

2. Methods and Results

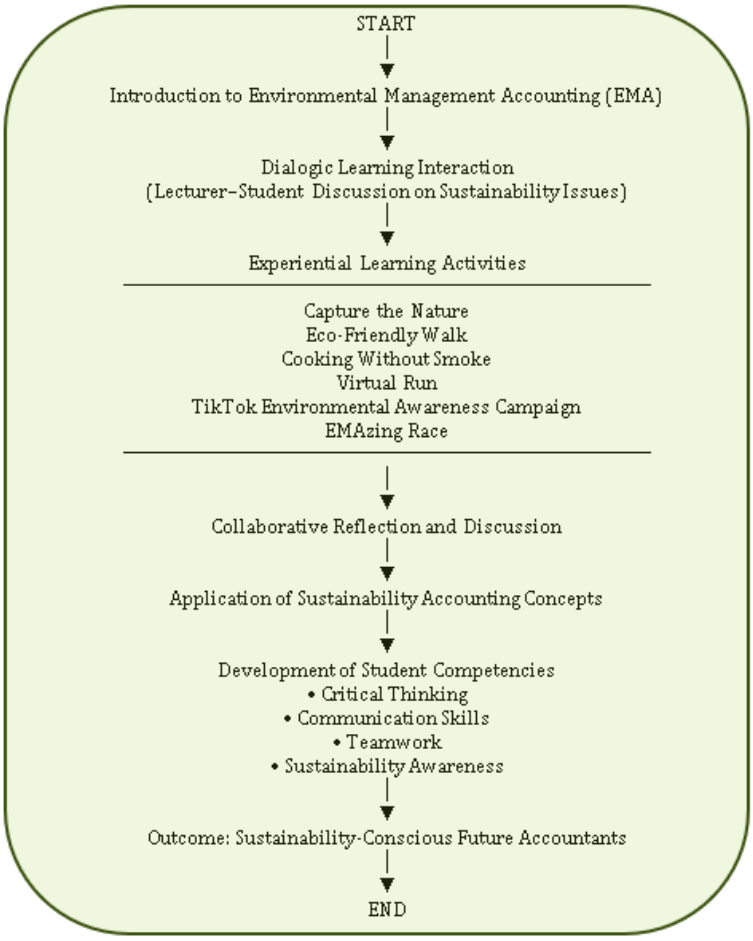

Figure 1. Flowchart of the D-EMA (Dialogic Environmental Management Accounting) Learning Framework.

Table 1. Components and Learning Stages of the D-EMA Learning Framework.

Stage	Component	Learning Activities	Learning Purpose	Outcomes
1	Introduction to EMA	Introduction to Environmental Management Accounting concepts and sustainability issues	Build foundational knowledge of sustainability accounting	Understanding of environmental responsibility in accounting
2	Dialogic Learning Interaction	Lecturer–student dialogue and discussion on environmental challenges and accounting roles	Encourage critical thinking and exchange of ideas	Active student participation
3	Experiential Learning Activities	Capture the Nature, Eco-Friendly Walk, Cooking Without Smoke, Virtual Run, TikTok Environmental Awareness Campaign, EMAzing Race	Apply accounting knowledge through real-world sustainability activities	Experiential learning and environmental awareness
4	Reflection & Collaborative Discussion	Group reflection and discussion on activity outcomes	Connect practical experiences with accounting concepts	Deeper conceptual understanding
5	Application of Sustainability Accounting	Students analyse environmental issues using EMA perspectives	Integrate sustainability into accounting decision making	Problem-solving and analytical skills
6	Competency Development	Critical thinking, communication, teamwork, sustainability awareness	Develop professional and soft skills	Sustainability-conscious future accountants

3. Novelty and uniqueness

The novelty of the D-EMA Learning Framework (Dialogic Environmental Management Accounting) lies in its integration of dialogic pedagogy, experiential sustainability activities, and accounting education within a single structured teaching model. Traditional accounting education commonly relies on lecture-based instruction and exam-oriented learning, where students passively receive information with limited engagement in real-world sustainability issues. The D-EMA framework introduces a shift from this monologic approach to an interactive learning environment that encourages dialogue, collaboration, and critical reflection on environmental challenges. A unique feature of the framework is the incorporation of diverse experiential learning activities such as Capture the Nature, Eco-Friendly Walk, Cooking Without Smoke, Virtual Run, TikTok Environmental Awareness Campaign, and the EMAzing Race**.** These activities transform conventional classroom learning into practical sustainability experiences that enable students to

actively explore environmental issues while applying Environmental Management Accounting concepts. The framework combines creative engagement, gamified learning, and reflective discussions to strengthen students' understanding of sustainability in accounting. Another distinctive aspect is the framework's flexibility and scalability. It can be adapted across different accounting and business courses and implemented in various higher education settings. By integrating sustainability awareness with dialogic learning and experiential activities, the D-EMA framework represents an innovative pedagogical model that prepares future accountants to address environmental and sustainability challenges in professional practice.

4. Benefit to mankind

The D-EMA Learning Framework (Dialogic Environmental Management Accounting) contributes to society by preparing future accounting professionals who are more aware of environmental responsibility and sustainability challenges. Unlike traditional teaching approaches that focus mainly on technical knowledge, the framework encourages students to critically understand the relationship between business activities, accounting practices, and environmental impacts. Through experiential sustainability activities such as Capture the Nature, Eco-Friendly Walk, Cooking Without Smoke, Virtual Run, TikTok Environmental Awareness Campaign, and the EMAzing Race, students develop practical awareness of environmental issues and sustainable practices. The framework helps nurture responsible graduates who are capable of promoting environmentally conscious decision-making in organisations and communities. By strengthening critical thinking, teamwork, communication, and sustainability awareness, the D-EMA approach contributes to the development of socially responsible accountants who can support sustainable business practices. Ultimately, the framework supports broader societal goals of environmental protection, sustainable development, and responsible resource management for the benefit of present and future generations.

5. Innovation and Entrepreneurial Impact

The D-EMA Learning Framework (Dialogic Environmental Management Accounting) promotes innovation and entrepreneurial thinking by encouraging students to design creative sustainability initiatives that address real environmental challenges. Through experiential activities such as Capture the Nature, Eco-Friendly Walk, Cooking Without Smoke, Virtual Run, TikTok Environmental Awareness Campaign, and the EMAzing Race**,** students actively develop ideas, plan activities, and implement sustainability-focused projects. These activities cultivate innovation, leadership, and problem-solving skills while linking accounting knowledge with real-world sustainability practices. A distinctive entrepreneurial element is the *Cooking Without Smoke* activity, which demonstrates environmentally friendly cooking methods that reduce pollution and promote healthier living. The concept can be further developed into sustainable food products or eco-friendly cooking services that support green entrepreneurship. Students are encouraged to explore how such initiatives can be commercialised, sold, and scaled while contributing to environmental protection**.** By combining sustainability awareness, creativity, and entrepreneurial thinking, the D-EMA framework nurtures innovative graduates who can develop green business ideas and lead sustainability-driven initiatives within communities, organisations, and industries.

6. Potential commercialization

The D-EMA Learning Framework (Dialogic Environmental Management Accounting) has strong potential for commercialization as a structured teaching toolkit and training module for sustainability-focused accounting education. The framework can be packaged into instructional materials, activity guides, facilitator manuals, and digital learning resources that can be adopted by universities, professional training institutes, and business schools. Institutions seeking to integrate sustainability and experiential learning into their curricula can implement the framework as part of accounting, business, or sustainability courses.

In addition, selected activities within the framework, such as Cooking Without Smoke**,** have potential to be developed into green entrepreneurship initiatives that promote environmentally friendly practices while generating economic value. Workshops, training programs, and sustainability awareness campaigns based on the D-EMA model can also be offered to organisations, educators, and communities. Through these opportunities, the framework can be expanded beyond classroom implementation to become a scalable educational innovation that supports sustainability education, green business awareness, and professional development programs.

7. Acknowledgment

The authors would like to express their sincere appreciation to Universiti Teknologi MARA (UiTM) for its continuous support in facilitating teaching and learning innovation initiatives. Special thanks are extended to the Hal Ehwal Akademik (HEA) for providing financial support through the Tabung Amanah Akademik**,** which enabled the implementation of the student experiential activities within this project. The authors also gratefully acknowledge the enthusiastic participation and commitment of the students enrolled in MAF651 – Seminar in Management Accounting**,** whose creativity, teamwork, and active engagement contributed significantly to the successful implementation of the D-EMA Learning Framework. Their dedication and innovative ideas played an important role in bringing the sustainability-focused learning activities to life.

8. Researchers' Biography

Associate Professor Dr. Raja Adzrin Raja Ahmad is an academic at Universiti Teknologi MARA (UiTM) with over 20 years of experience in higher education, specializing in management accounting and accounting education. She has extensive experience in teaching undergraduate and postgraduate courses, particularly in management accounting and sustainability-related topics. She previously served as a sessional academic at Curtin University, Perth, Australia, for two years, to assist in delivering accounting courses and supporting international learning environments. Dr. Raja Adzrin is actively involved in developing innovative teaching approaches that enhance student engagement and experiential learning. She is also the author of a management accounting textbook titled "Management Accounting for Decision Making," Her work focuses on improving accounting education through innovative pedagogy, sustainability integration, and student-centered learning practices.

Professor Radiah Othman is a Professor of Accounting and Forensics at Massey University, New Zealand, with extensive experience in accounting education, auditing, and forensic accounting. She holds a Master of Accounting (Distinction) from Curtin University, Australia, and a PhD from Aston University, United Kingdom. Professor Othman is a Certified Fraud Examiner (ACFE) and a Certified Practising Accountant (CPA Australia). Her research interests include forensic accounting, sustainability, accounting education, and public sector accountability. She has published widely in reputable international journals such as the *Journal of Business Ethics* and *Accounting Education*. She is an award-winning educator and researcher, receiving the Massey Business School Special Achievement in Teaching Award and several international research recognitions.

Ahmad Marzuki Amiruddin Othman is a lecturer at Universiti Teknologi MARA (UiTM) specializing in management accounting and accounting education. He is actively involved in teaching undergraduate courses, particularly in management accounting and related accounting subjects. His academic interests focus on sustainability in accounting, environmental management accounting, and innovative teaching approaches. Ahmad Marzuki has participated in several research and teaching initiatives aimed at integrating sustainability perspectives into accounting education. His work supports the development of innovative pedagogical practices that encourage students to connect accounting knowledge with real-world environmental and social challenges.

Global Voices: AI Persona Lab (Consumer Persona Chatbot)

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ABSTRACT

Global Voices: AI Persona Lab (Consumer Persona Chatbot) transforms content-heavy modules into immersive, interactive learning. First piloted in a Consumer Behaviour course at a Malaysian college, the Lab connects students with lifelike persona chatbots that mirror generational, cultural, and behavioural diversity. These personas deliver emotionally attuned, contextually relevant viewpoints, turning passive lectures into inquiry-led, experiential dialogue. The aims extend beyond grades: the Lab cultivates empathy, strengthens critical thinking, and builds cross-cultural sensitivity. Designed to be tool-agnostic and web-accessible, the framework scales easily across disciplines and class sizes. Under the hood, amongst several AI capabilities, GPT-4o powers natural language understanding and generation, ElevenLabs provides natural voice rendering, and Deepgram ensures accurate voice recognition, together enabling dynamic, unpredictable yet on-topic exchanges. Students then analyse their conversations using structured theoretical models and convert insights into practical outputs such as product concepts, marketing strategies, or campaign prototypes. The Lab's distinguishing strength is its fusion of AI-driven persona dialogue, gamified decision-making, and culturally rich simulations. This combination elevates engagement while developing adaptable, human-centred skills that employers value. Current results indicate clear gains in student performance and teaching effectiveness, positioning Global Voices as a compelling, scalable model for AI-enhanced education.

Keywords: Generative AI, Experiential learning, Cross-cultural simulation, Gamified pedagogy

1. Product Description

Global Voices: AI Persona Lab (Consumer Persona Chatbot & Virtual Shopping Simulation) is an educational innovation that transforms traditionally theory-heavy modules into dynamic, interactive, and experiential learning experiences through advanced AI-powered global simulations. Originally developed for a consumer behaviour module at a Malaysian higher education institution, the Lab enables students to interact by chatting with hyper-realistic AI personas representing diverse generations, cultural backgrounds, and consumer archetypes. These personas respond with cultural nuance, emotional depth, and realistic decision-making logic, creating learning environments that mirror authentic, real-world consumer engagements. In an era where empathy, adaptability, and applied problem-solving are critical graduate skills, the Lab addresses the limitations of conventional lecture delivery by immersing students in scenarios that demand active participation, critical thinking, and theory-to-practice application.

2. Pictures of Innovation

Figure 1. Homepage.

Figure 2. Collection of AI Chatbot Personas.

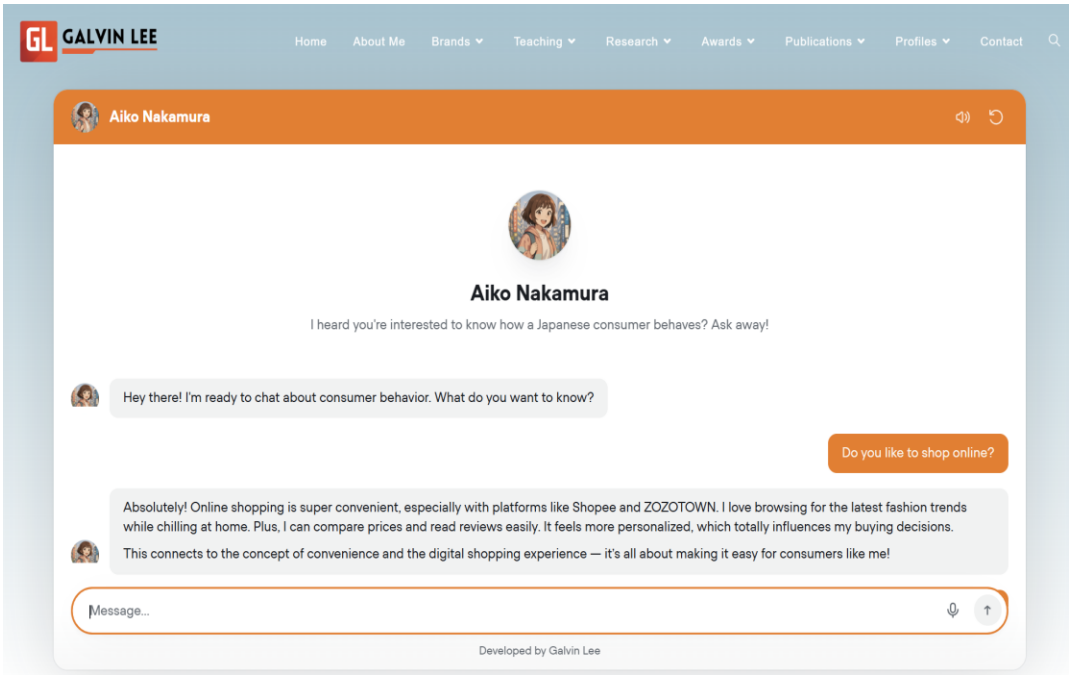

Figure 3. AI Chatbot Interface.

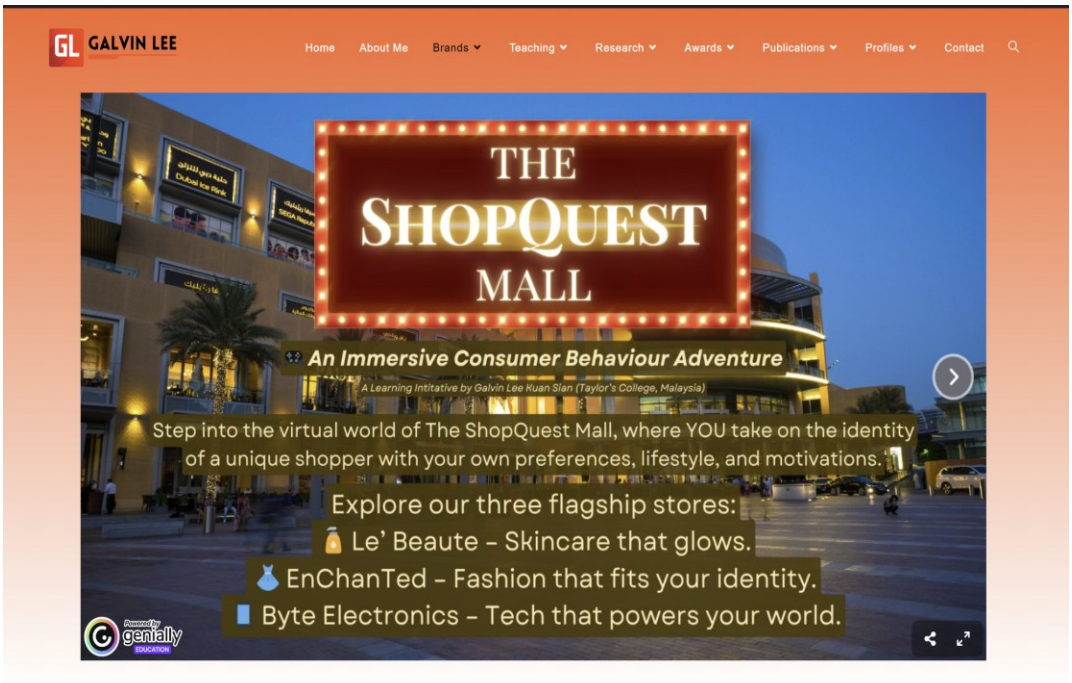

Figure 4. The ShopQuest Mall.

3. Novelty and Uniqueness

The Lab is significant because it reimagines how AI can be harnessed not as a passive content generator, but as a pedagogical partner for deep, inquiry-driven learning. By combining unscripted persona interaction with gamified marketplace simulations, it creates an ecosystem where knowledge acquisition, critical thinking, and cross-cultural empathy converge. This responds to a global call for higher education to produce graduates who are adaptable, empathetic, and capable of applying theory to ambiguous, real-world scenarios (Bilderback & Thompson, 2025). The design contributes to scholarship in technology-enhanced learning by advancing the field of AI-enabled experiential pedagogy. Unlike conventional simulations or scripted chatbots, the Lab introduces dynamic unpredictability, demanding students to think critically in real time. Its significance lies in scalability, adaptability across disciplines, and alignment with graduate attributes such as communication, empathy, and intercultural competence (Rajaram, 2023).

4. Benefit to Mankind

Grounded in Kolb's Experiential Learning Theory, the Lab follows a structured multi-phase learning journey powered by custom-engineered AI chatbots (Ayasrah & Khasawneh, 2025). Each persona is hosted on a web-based interface that integrates GPT-4o for natural language processing, ElevenLabs for lifelike voice synthesis, and Deepgram for accurate speech-to-text recognition. These chatbots act as hyper-realistic consumer personas capable of engaging in unscripted, context-aware conversations that adapt to the student's line of questioning. Their responses incorporate individualised cultural values, behaviours, and emotional tones, simulating authentic consumer interviews in a safe yet unpredictable environment. Students begin by interacting with the personas to elicit behavioural insights, then analyse the data using structured frameworks to build comprehensive consumer profiles. Based on these insights, they design products, campaigns, or strategies aligned with persona needs.

The journey also includes an immersive virtual marketplace simulation, where students present offerings to their persona and receive dynamic, persona-specific feedback, allowing them to test and refine their approach. Later phases focus on self-reflection and cross-cultural adaptation, encouraging students to adapt strategies for different markets.

The Lab is entirely web-based, requiring no coding skills or specialised hardware, ensuring ease of adoption across institutions.

5. Innovation and Entrepreneurial Impact

Throughout the entire period of administering the Lab, students have been observed to develop holistically in cognitive, affective and behavioural aspects. Due to the novel approach in classroom learning, students have welcomed knowledge with an open and passionate mindset, leading to greater attainment of learning outcomes. In the most recent mid-term test and group assignment, students have shown a 9.63% average increase and 8.02% average increase respectively from the preceding year. Furthermore, in the Teaching Engagement Scale (TES) administered across all taught modules, this module was scored 4.9/5.0 by students, a near perfect score reflecting the overall impact and learning satisfaction delivered by the Lab. Notably, this has greatly impacted international students, as they could leverage on the multi-lingual capabilities of OpenAI's models to chat and learn in their native languages. Given the substantial international student population at the college, this Lab empowers personalized learning by letting students immerse in an environment they are familiar with, while learning alongside their classroom peers. The Lab has

been awarded with numerous Gold and Special awards at national and international teaching and learning innovation competitions and conferences, validating its impactful value among the education community.

6. Potential Commercialization

The Lab has demonstrated measurable success, with higher teaching engagement ratings and improved student performance. Students reported stronger theory application, greater cultural awareness, and increased confidence in managing real-world challenges.

With planned expansion through educator toolkits and adaptable persona modules, Global Voices: AI Persona Lab represents a future-ready, human-centred model for AI-enhanced education, bridging the gap between knowledge and practice in the digital age.

7. Researchers' Biography

Galvin Lee Kuan Sian is a Lecturer of Marketing and Economics & Programme Coordinator (Diploma in Business) at Taylor's College, specialising in the scholarship of teaching and learning via educational technology. He is a distinguished, award-winning education innovator through his Innovation Lab with more than a dozen Gold Awards in international competitions and conferences, and has recently been named "Lecturer of the Year" and "Innovative Educator of the Year" at the Global Education Awards 2025.

Eco-Digital Scholar: AI-Driven Paperless CV Architect for Modern Academicians

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ABSTRACT

Academicians require dynamic digital portfolios to enhance global visibility, yet building web-based Curriculum Vitae (CV) demands time and technical coding skills. "Eco-Digital Scholar" introduces an innovative, paperless web CV architect utilizing the Vibe Coding paradigm. By uploading a standard Word or PDF CV, the system intelligently extracts data and guides users through an intuitive design studio to customize themes, colors, and features. The platform then synthesizes a highly optimized prompt. Users input this prompt into the Gemini AI model to instantly render a modern, interactive web-based CV. This zero-code solution eliminates technical barriers, empowering educators to seamlessly share their achievements via a single URL. Its uniqueness lies in replacing hard-coded website builders with automated prompt engineering, ensuring high adaptability and lightweight performance. The innovation significantly reduces paper waste, supporting ESG sustainability goals. With a highly scalable freemium and B2B institutional licensing model, this tool possesses immense commercial prospects, transforming how academic excellence is showcased globally while promoting a green, eco-digital academic ecosystem.

Keywords: Vibe Coding, Prompt Engineering, Digital Portfolio, Artificial Intelligence, Paperless CV.

1. Product Description

Eco-Digital Scholar (AcademiCV Pro) is a revolutionary web-based platform designed to transform traditional, static academic CVs into interactive online portfolios without requiring any programming knowledge. The core engine is built upon the "Vibe Coding" paradigm that leverage natural language instructions to generate functional code. The system features a streamlined six-step workflow. First, the user uploads their existing CV document, which the system's parser instantly analyzes and structures. Next, users enter a Design Studio where they select modern themes, color palettes, section layouts, and specific academic features such as publication lists or grant histories. Finally, instead of generating rigid HTML, the system produces a highly optimized, production-ready "Smart Prompt". The user copies this prompt and pastes it into the Gemini AI model, which acts as the rendering engine to instantly generate and host a fully functional, mobile-responsive web CV. This approach makes the product exceptionally lightweight, adaptable, and user-friendly for academicians of all IT proficiency levels.

2. Screenshot of the system

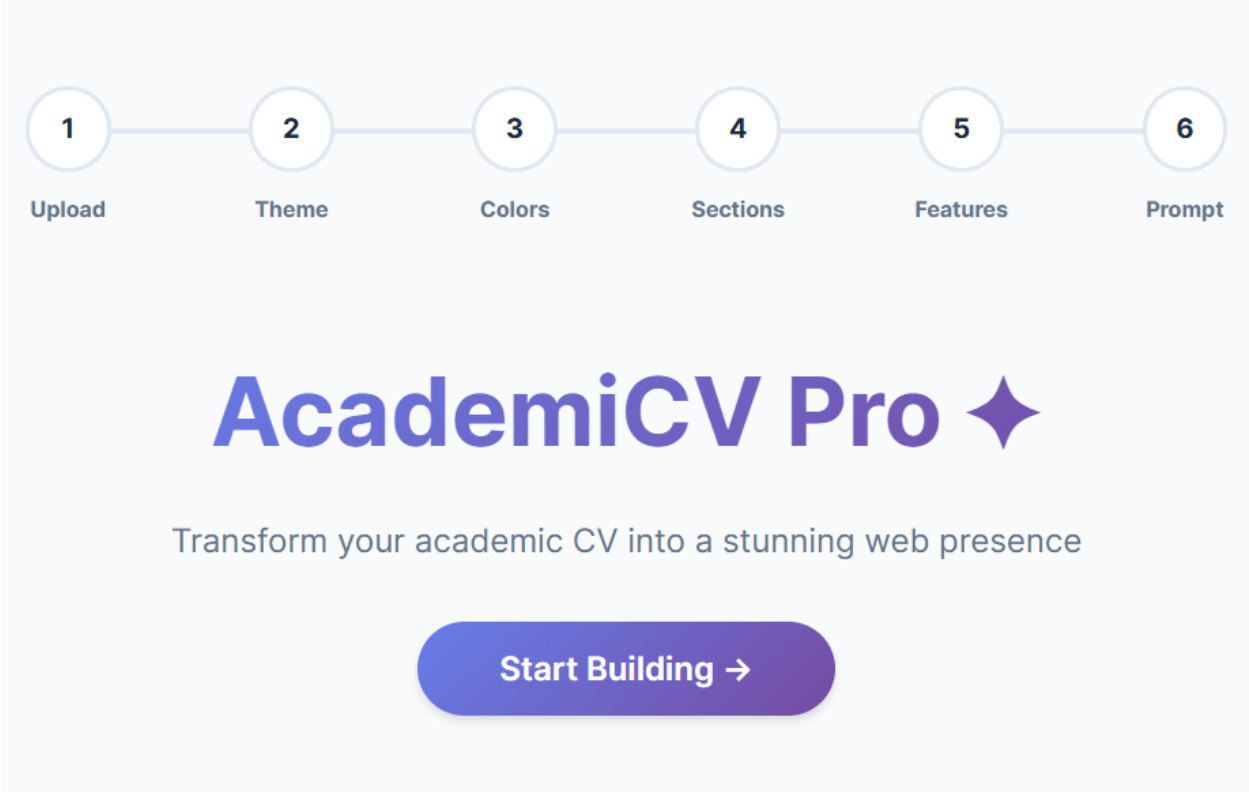

Figure 1. The user interface of AcademiCV Pro.

The user interface of AcademiCV Pro in **Figure 1** illustrating the intuitive 6-step workflow that starts with Upload & Analyze, Theme customization, Setting the desired colours, Choosing Sections, and Include features to adds-on before finally proceed to the generation of a Smart Prompt for AI-assisted web rendering.

3. Novelty and uniqueness

The primary novelty of this innovation lies in its pioneering application of the Vibe Coding paradigm within the academic portfolio domain. Unlike traditional website builders that rely on bulky, hard-coded templates and drag-and-drop mechanics, this system completely offloads the development execution to Generative AI. It functions as an advanced prompt synthesizer rather than a website host. By converting user preferences and extracting CV data into a meticulously engineered prompt, it allows the AI tools to dynamically generate the front-end code. This "Zero-Code" approach ensures that the output is highly customizable through natural language; if a lecturer wants to change a layout, they simply type a request to the AI. This fusion of automated data extraction, prompt engineering, and AI-driven rendering creates a uniquely lightweight, scalable, and future-proof tool.

4. Benefit to mankind

This innovation significantly benefits the global academic and professional community by democratizing digital presence. It eliminates the digital divide, allowing educators and researchers, regardless of their IT literacy, to create professional online portfolios that enhance their global

visibility for collaborations and funding opportunities. Environmentally, it strongly advocates for the "Eco-Digital" movement by substituting physical paper printing with a single, shareable digital link. This drastically reduces the carbon footprint associated with millions of pages printed annually for academic appraisals, job interviews, and grant applications, directly supporting global goals for environmental sustainability.

5. Innovation and Entrepreneurial Impact

The project fosters a strong culture of innovation by introducing academicians to the practical, everyday utility of Artificial Intelligence and prompt engineering. It shifts the mindset from relying on traditional IT departments to self-empowered, AI-assisted creation. Entrepreneurially, the system introduces a highly scalable Software-as-a-Service (SaaS) framework. For universities, it sparks institutional innovation by providing a standardized, modern way to showcase faculty talent, directly improving university branding and global rankings. Furthermore, it opens avenues for academic entrepreneurs to build upon the Vibe Coding ecosystem to create niche prompt-generation tools.

6. Potential commercialization

The commercialization strategy is highly viable due to the platform's low overhead costs as it acts as a powerful prompt synthesizer rather than a data-heavy hosting provider. The primary revenue model includes a Business-to-Consumer (B2C) "Freemium" tier targeting individual researchers globally, offering basic prompt generation for free, with premium features for advanced analytics. Simultaneously, a Business-to-Business (B2B) licensing model will be marketed to Public and Private Universities. Institutions can purchase bulk annual licenses to standardize their staff directory profiles, ensuring a unified, professional web presence for accreditation and university ranking purposes.

7. Acknowledgment

The authors would like to thank the Universiti Teknologi MARA (UiTM), for the support and resources provided throughout the development of this project. We also acknowledge the contributions of our peers who provided valuable feedback during the initial design phase.

Researchers' Biography

A tech-forward academician, Ts. Noridah Abu Bakar serves as the Digital Learning Coordinator at Faculty of Sports Science and Recreation, Universiti Teknologi MARA. She specializes in Information Technology in Sports and online learning. She is a driving force in online tools and AI literacy to ensure lecturers and students remain at the forefront of the evolving digital landscape in higher education.

Nagoor Meera Abdullah is an experienced lecturer at Faculty of Sports Science and Recreation, UiTM. His core research interests include coaching sciences, disability sports, and adapted physical activity, particularly for Paralympic athletes. He has contributed extensively to sports psychology literature, authored books on fitness and health, and published research regarding athletic performance.

Prof. Dr. Wan Edura Wan Rashid is a Professor and Director of the Institute of Business Excellence, Universiti Teknologi MARA (UiTM), holding a PhD in Business Administration from the International Islamic University Malaysia. Her expertise centers on work-life balance and its integration with governance, sustainability, and value-based institutional frameworks that support socio-economic stability and family well-being. She has been actively involved in award-winning research initiatives and FRGS projects focusing on ethical governance and sustainable Islamic institutional models. Her work reflects a commitment to integrity-driven practices that promote financial clarity, social harmony, and holistic well-being among individuals, families, and communities.

Dr. Shariman Ismadi Ismail is a Senior Lecturer at Faculty of Sports Science and Recreation, UiTM. He holds a PhD in Sports and Health Science from Fukuoka University, Japan. His expertise lies in sports biomechanics and technology, focusing on human interaction with sports equipment and footwear science. Recently, he was appointed as a Visiting Research Fellow in Denmark and co-authored a textbook on sports technology.

Blockchain-Based Tokenomics Incentive Model for Enhancing Sarawak Community-Based Tourism: A Study Toward Sustainable Tourism Behavior

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ABSTRACT

This innovation proposes a Blockchain tokenomics-driven incentive model to encourage sustainable tourism behavior within Sarawak's community-based environments. While current platforms prioritise booking efficiency, the Sarawak Tourism Token (STT) utilises a blockchain-enabled digital wallet to reward tourists for participating in verified cultural and environmental activities. Guided by motivation and technology adoption theories, this innovation demonstrates that perceived reward value and system usability significantly shape intentions toward sustainable engagement. The innovation delivers profound socio-economic and socio-environmental impacts by establishing a circular digital economy. It ensures that tourism spending directly supports homestay operators and local suppliers while incentivising the preservation of Sarawak's unique cultural heritage and ecosystems. By utilising a Decentralised Autonomous Organization (DAO) and a transparent public ledger, the framework builds stakeholder trust and empowers community-led development. The commercialisation prospects for STT are robust. The model is highly scalable for regional tourism boards and can be integrated with existing digital payment gateways to enhance local economic involvement. Registered under MyIPO (IP/CR/09830), this innovation serves as a pioneering blueprint for policymakers and developers to demonstratrate how social innovation and digitalisation can deliver effective, equitable and sustainable outcomes for local communities and the broader tourism industry.

Keywords: Blockchain, Sustainable Tourism Behavior, Decentralised Finance, Tokenomics, Community-Based Tourism

1. Product Description

The Sarawak Tourism Token (STT) is a blockchain-enabled digital incentive platform designed to encourage sustainable tourism participation within community-based tourism environments in Sarawak. The system integrates tokenomics with tourism activities by allowing visitors to earn digital tokens when they participate in environmentally responsible, cultural and community-oriented tourism experiences such as homestay programs, cultural workshops, local craft activities and conservation initiatives. The Sarawak Tourism Token innovation has been registered under MyIPO with the reference number IP/CR/09830. STT operates through a Web3.0 digital wallet and decentralised blockchain infrastructure that records all tourism transactions transparently in a public ledger. Tourists receive token rewards after verified participation in approved activities. These tokens can be redeemed for tourism services, local products or future experiences within participating community networks. It creates a circular digital ecosystem by connecting tourists, homestay operators, local artisans and tourism service providers.

The platform also includes a decentralised dashboard that enables community stakeholders to monitor transactions, manage tourism activities and participate in governance through a decentralised decision-making mechanism. It ensures transparency, accountability and fair participation among tourism stakeholders. By linking verified tourism activities with token incentives, STT encourages responsible travel behavior while strengthening local economic participation. The platform supports sustainable tourism development by increasing tourist engagement in community-based tourism and promoting greater visibility for local cultural and environmental initiatives.

2. Flow Chart of Sarawak Tourism Token Systems Processes

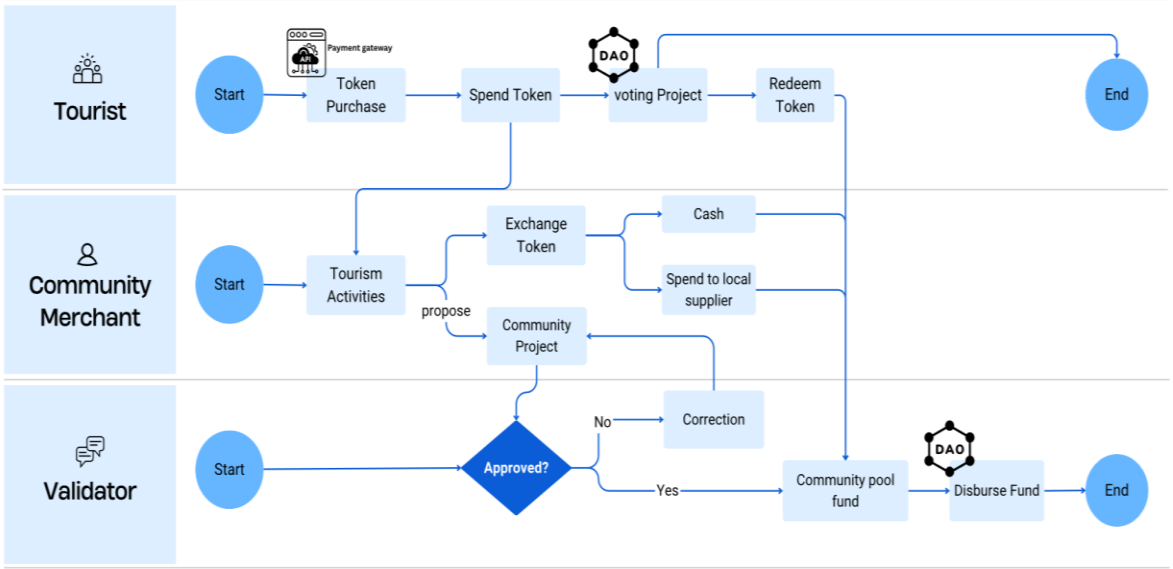

Figure 1. Flowchart of Sarawak Tourism Token Systems Processes.

Figure 1 shows the flowchart of Sarawak Tourism Token Systems Processes. The Sarawak Tourism Token (STT) creates a circular digital ecosystem where tourists, community merchant, and validators interact via blockchain. Tourists use STT for sustainable bookings and gain "Voting Power" in a DAO to fund local projects. This transparent framework ensures tourism revenue directly supports community-led development and environmental preservation.

Screen Shots of Dashboard

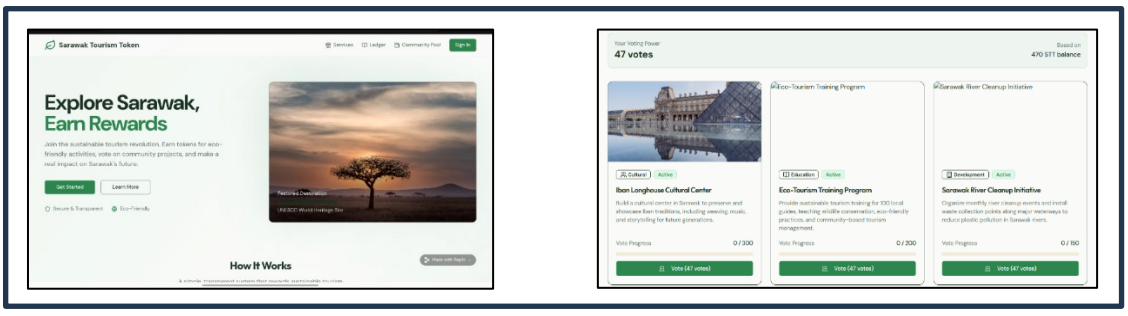

Figure 2. Dashboard of Sarawak Tourism Token Blockchain Web3.0.

Figure 2 illustrates the Sarawak Tourism Token Web3.0 dashboard by, highlighting a transparent user interface. The landing page encourages sustainable participation while the Decentralised Autonomous Organization (DAO) panel enables "Voting Power". Tourists utilise their token balances to vote on community projects which directly support local cultural and environmental preservation.

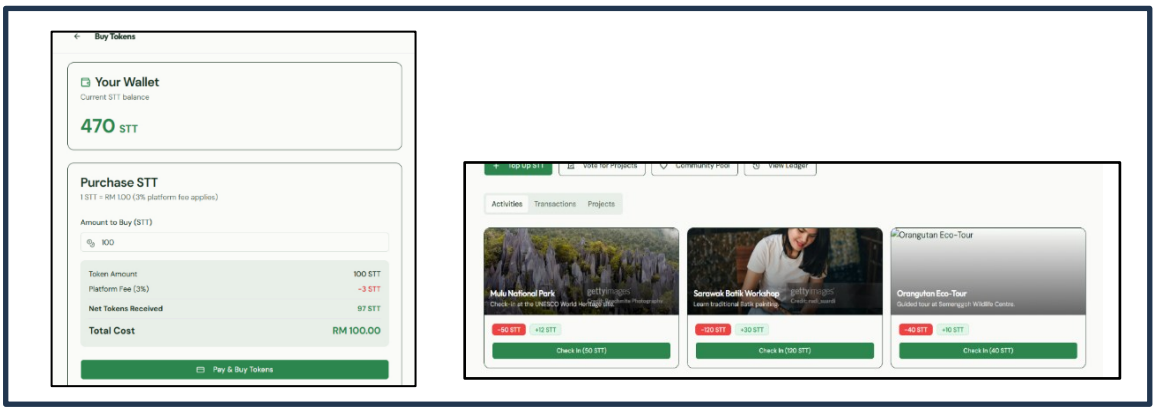

Figure 3. Topup Token and Booking Community Tourism Activities.

Figure 3 demonstrates the Sarawak Tourism Token (STT) acquisition and booking process. The digital wallet enables token purchases at a 1:1 RM rate, minus a 3% platform fee. Through the booking dashboard, tourists pay for community activities while earning rewards for participation, effectively incentivising sustainable engagement.

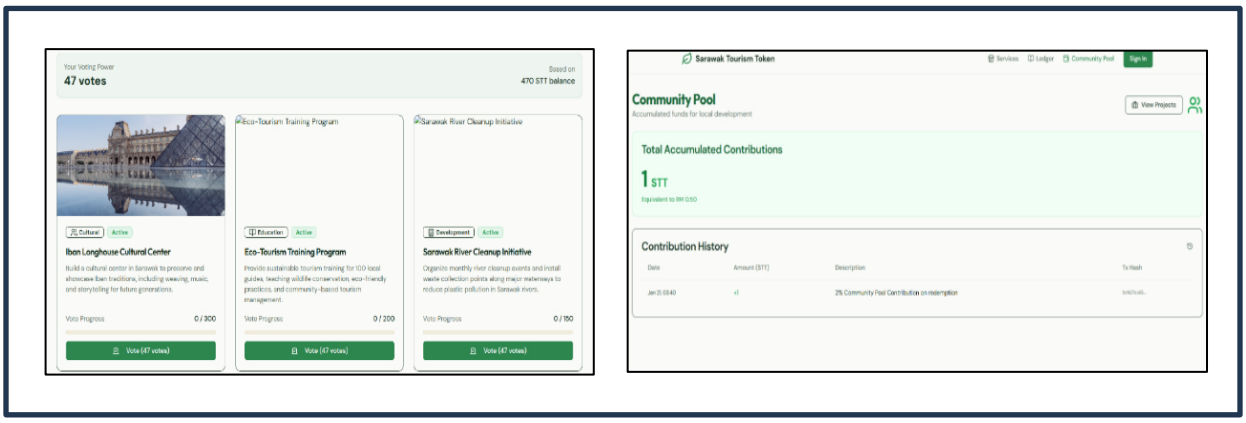

Figure 4. Decentralised Autonomous Decision Dashboard (DAO) and Community Pool Board.

Figure 4 illustrates the DAO and Community Pool dashboard which emphasise democratic and financial sustainability. The left panel enables tourists to use Sarawak Tourism Token balances as voting power for community projects. The right panel provides a transparent history of accumulated funds generated during merchant redemptions.

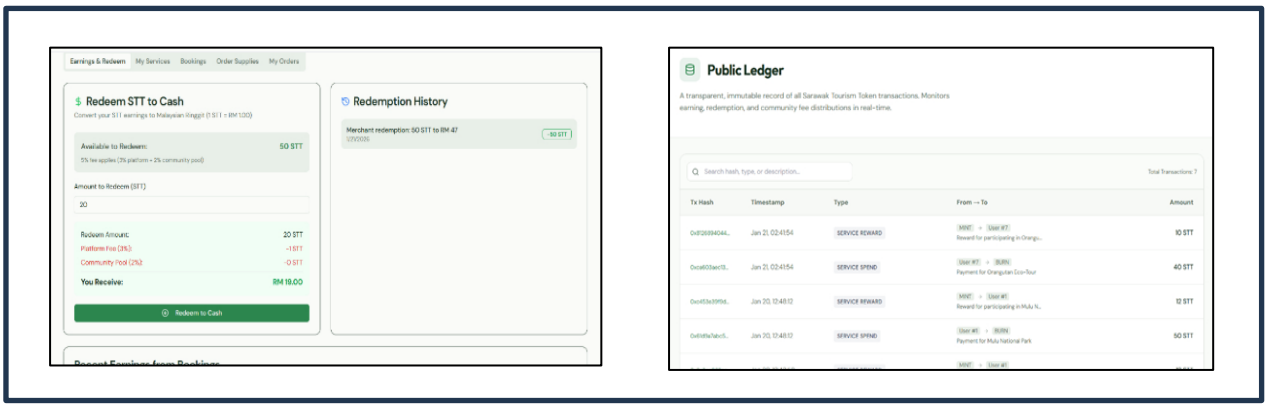

Figure 5. Redeemable tokens in public ledger.

Figure 5 illustrates the STT redemption and transparency phase. The left panel shows the "Redeem STT to Cash" module, allowing merchants to convert tokens at a 1:1 ratio, with a 5% total fee. The right panel displays the "Public Ledger," providing an immutable real-time record to ensure accountability and trust.

3. Novelty and uniqueness

The Sarawak Tourism Token presents an innovative tokenomics-based digital incentive framework aimed at promoting sustainable tourism practices in community-based contexts with particular emphasis on Sarawak's homestay networks. Although recent scholarship has examined blockchain applications in tourism, conventional implementations prioritise payment systems, booking platforms and data management over incentives for sustainable behaviors (Treiblmaier, 2021). Distinctively, the STT integrates token rewards directly with responsible tourism activities, including cultural workshops, environmental conservation efforts and local homestay engagements. This framework addresses the well-recognised intention-behaviour gap in sustainable tourism, wherein tourists endorse sustainability in principle yet seldom enact it in practice (Juvan & Dolnicar, 2016). By associating verified tourist actions with token incentives, the STT establishes a mechanism to stimulate participation in responsible practices. Additionally, blockchain integration augments transparency and traceability in tourism transactions (Balasubramanian et al., 2022). In contrast to conventional loyalty schemes, the STT interconnects tourists, homestay operators and local suppliers within a circular digital ecosystem that fosters local economic involvement and sustainable tourism participation. This synthesis of tokenomics, community-based tourism and blockchain technology signifies a pioneering digital advancement in sustainable tourism development.

4. Benefit to mankind

The Sarawak Tourism Token framework advances sustainable tourism development by fostering responsible tourist behaviors and bolstering community involvement in local tourism economies. Community-based tourism is widely acknowledged as an effective strategy for enhancing local livelihoods and conserving cultural heritage in rural areas (Anuar & Sood, 2017). Nonetheless, maintaining sustained tourist engagement in community-based tourism initiatives constitutes an enduring challenge. Digital incentive mechanisms, including tokenized reward systems, can mitigate this issue by promoting return participation and ethical tourism practices (Mohammadi et al., 2025).

Blockchain technology further enhances transparency in tourism transactions and cultivates stakeholder trust, which is indispensable for robust sustainable tourism systems (Gonzalez-Mendes et al., 2024). By integrating incentives with sustainable tourism activities, the STT system encourages tourists to support local businesses, participate in cultural experiences, and engage in environmentally responsible tourism practices. Through this approach, the system promotes greater participation in community-based tourism while strengthening local economic opportunities. Simultaneously, it supports long-term sustainable tourism development by encouraging tourism activities that benefit both the local community and the environment.

5. Innovation and Entrepreneurial Impact

The STT initiative promotes innovation and entrepreneurial activity within community-based tourism ecosystems by introducing a digital platform that connects tourists, local homestay operators and small suppliers through a tokenised incentive system. Community-based tourism has been recognized as a key driver of rural entrepreneurship and local economic development (Thanasi-Boce & Hoxha, 2024). However, many small tourism operators face challenges in marketing, digital adoption and customer engagement. The integration of blockchain-based digital incentives can provide new opportunities for tourism entrepreneurs by enabling transparent digital transactions, reward mechanisms and local supply-chain participation (Folgieri et al., 2025). Through STT, homestay operators and local artisans may benefit from increased tourist participation, improved visibility within digital tourism platforms and enhanced engagement with responsible travelers. It encourages the development of digital entrepreneurship within rural tourism communities while fostering innovation in sustainable tourism services.

6. Potential commercialisation

The commercialisation potential of the STT model lies in its ability to operate as a digital tourism incentive platform supporting responsible tourism behavior while generating value for tourism stakeholders. Tourism digitalisation initiatives are increasingly supported by government innovation grants. Agencies such as the Ministry of Tourism, Arts and Culture (MOTAC), and Malaysia Digital Economy Corporation (MDEC) provide funding opportunities for digital innovation and sustainable tourism research. Sarawak has also prioritised digital transformation through initiatives such as the Sarawak Digital Economy Strategy, which encourages technological innovation within tourism and community development sectors. Compared with other ASEAN countries, destinations such as Thailand and Indonesia have begun exploring blockchain applications in tourism services, particularly in digital payments and smart tourism ecosystems (Weltman et al., 2024). However, blockchain-enabled incentive systems remain limited in the region. Therefore, STT platform presents a commercialisation opportunity as a software-as-a-service (SaaS) tourism incentive platform that can support homestay networks, eco-tourism operators, and community-based tourism destinations. By integrating token incentives with sustainable tourism participation, the platform could be adopted by tourism destinations seeking to strengthen responsible tourism engagement while supporting local economic participation.

7. Acknowledgment

We express our deepest gratitude to the Sarawak local communities for their invaluable participation and cultural insights. Special thanks to the Sarawak Digital Economy Corporation (SDEC) for fostering technological innovation, and Universiti Teknologi MARA (UiTM) for their academic guidance and commitment to social sustainability

8. Researchers' Biography

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Sheela Faizura Nik Fauzi is a dedicated lecturer at Universiti Teknologi MARA (UiTM) Sarawak, Kota Samarahan Campus. Affiliated with the Academy of Language Studies, she specializes in Applied Linguistics, Education, and Leadership. She actively contributes to interdisciplinary research, focusing on sustainable tourism and digital innovation

AI-Powered Performance Playbook: Gamified Training for Future Sports Management Experts

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ABSTRACT

The AI-Powered Performance Playbook is an interactive, gamified web-based e-training platform designed to revolutionize how first-year diploma students grasp foundational sports management concepts. Traditional methods often fail to engage the digitally native, competition-driven generation. This innovation uses AI to generate fast, accurate, and varied quiz-based scenarios, providing instant feedback and creating a dynamic, personalized learning journey that adapts to individual performance. Its unique features include AI-curated questions based on authentic curriculum, a real-time leaderboard fostering healthy competition, and interactive game flows that transform theoretical knowledge into an enjoyable, action-oriented experience. The product directly enhances educational outcomes by improving knowledge retention and student engagement. With strong commercialization potential across universities and corporate training sectors, this playbook prepares future sports management experts efficiently and effectively, contributing to a more skilled and knowledgeable workforce in the multi-billion-dollar sports industry.

Keywords: Gamification, AI in Education, Sports Management, e-Learning.

1. Product Description

The AI-Powered Performance Playbook is a web-based gamified training system specifically for first-year diploma students in sports management. It transforms dense theoretical content from core chapters—such as management fundamentals, planning skills, and decision-making—into an engaging, quiz-based interactive game. The core gameplay is simple and enjoyable: students register, receive instructions, and enter a dynamic game interface where they answer AI-generated questions. Unlike static quizzes, the system leverages AI to deliver fast, accurate, and varied questions, ensuring each session is unique. This interactivity keeps students engaged and caters to their preference for competitive, fast-action learning. After each submission, instant AI-driven feedback is provided, explaining concepts and reinforcing learning. A live, individual leaderboard tracks progress, fostering a healthy competitive spirit that motivates students to improve. Designed for self-study or classroom use, the current prototype covers three chapters and is built to be scalable, allowing for easy expansion into other topics and courses. The result is a learning tool that is not only educational but also genuinely fun to use.

2. Game Flow and Screenshots.

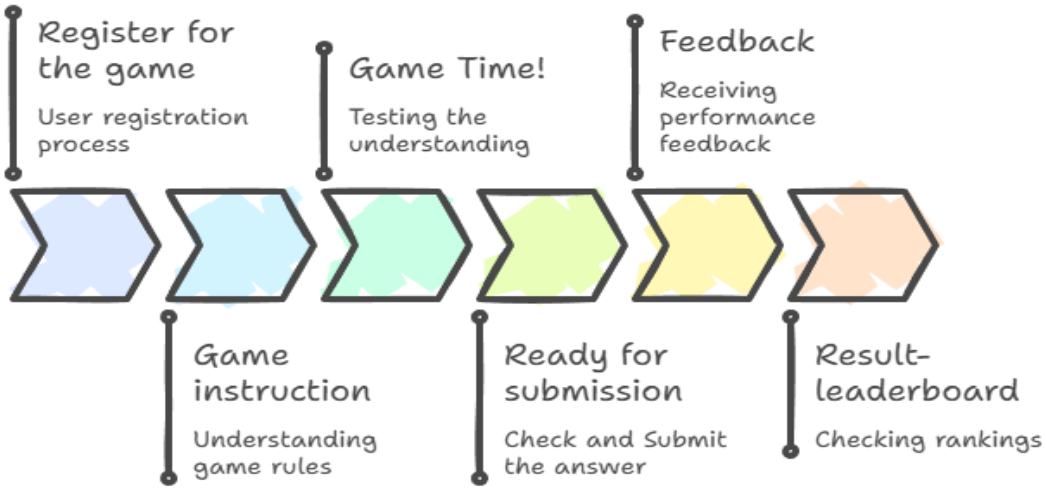

Figure 1. Flow for the AI-Powered Performance Playbook.

Figure 1 above illustrates the operational workflow of the AI-Powered Performance Playbook. The process begins with student registration and orientation through the game instruction interface. Once the session starts, the system generates AI-driven quiz scenarios aligned with the course curriculum. Students respond to these questions in a gamified environment, after which the system provides instant feedback explaining the correct concepts. The platform then displays the learner's performance results and updates a real-time leaderboard. This structured flow transforms conventional theoretical learning into an engaging, competitive, and feedback-driven educational experience.

Figure 2 below presents the main components of the system. The platform includes a user registration page, a game instruction screen, and a quiz gameplay interface where students interact with AI-generated questions. After completing a session, the system displays a performance result screen that summarizes the learner's score and provides conceptual feedback. The leaderboard dashboard then ranks participants based on their performance, encouraging healthy competition and continuous improvement. These integrated interfaces create a seamless and engaging gamified learning environment.

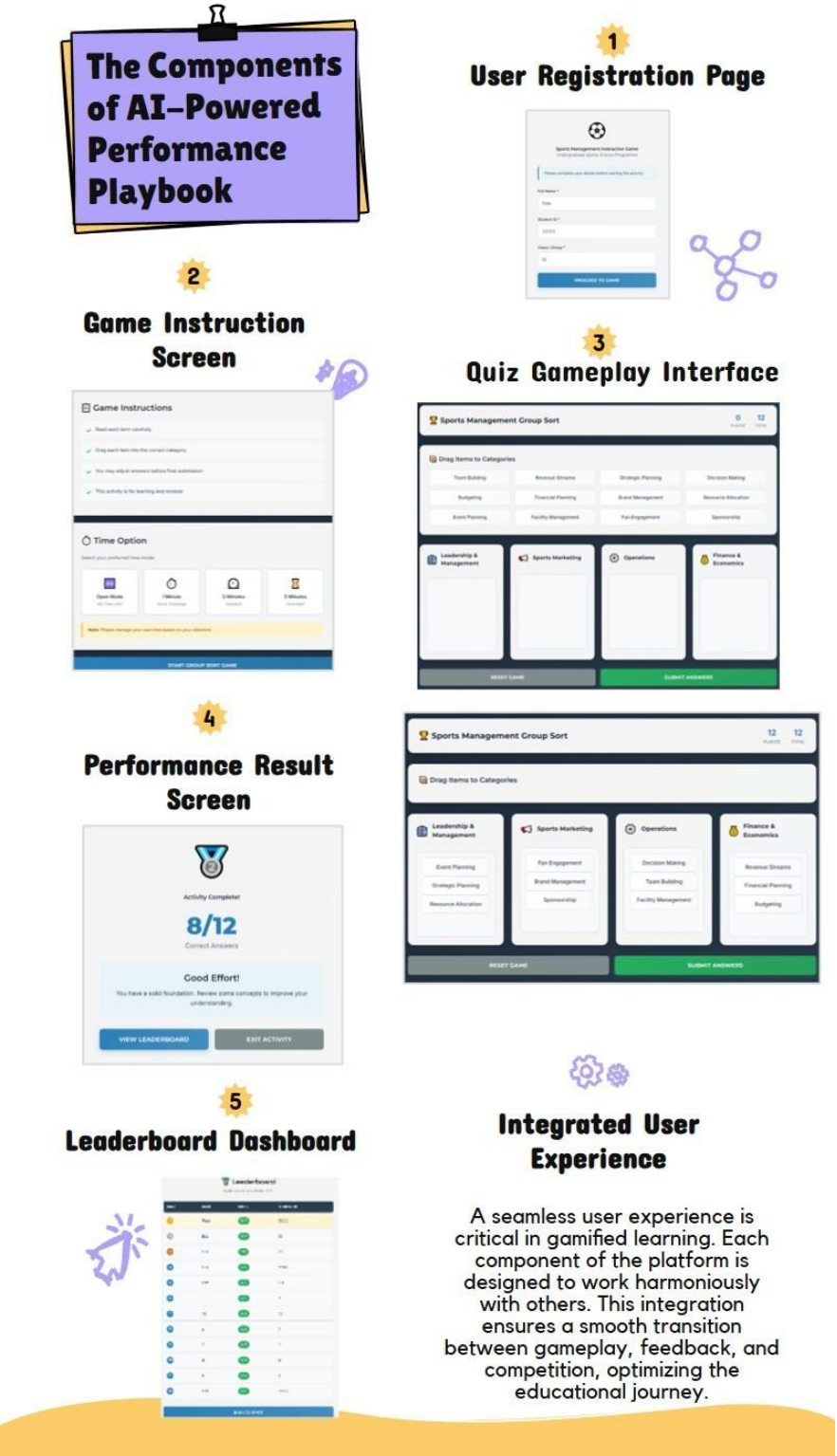

Figure 2. Screenshots from the components of the AI-Powered Performance Playbook.

3. Novelty and uniqueness

The novelty of the AI-Powered Performance Playbook lies in its intelligent fusion of curriculum-aligned content with dynamic AI generation. Unlike existing sports management apps that offer static content or simple quizzes, our platform uses AI to create a unique, personalized experience for each student. The AI ensures questions are fast, accurate, and contextually relevant, drawing directly from the students' own course materials. This transforms passive reading into active, engaging problem-solving. Its uniqueness is further amplified by its "competition-driven" design, specifically tailored for Year 1 diploma students who thrive on interactive and fast-paced activities. The instant, AI-powered feedback mechanism acts as a virtual tutor, clarifying misconceptions immediately and promoting self-directed learning. Furthermore, the platform's simple quiz-based format makes it easy to adopt, while its scalable architecture allows for seamless expansion into other chapters and sports-related courses, setting it apart as a versatile and future-proof educational tool.

4. Benefit to mankind

This project directly benefits the education sector and, by extension, the broader sports industry. By making the learning of fundamental management principles more engaging and effective, we are helping to produce a new generation of highly competent sports management professionals. Well-trained managers are crucial for the success and integrity of sports organizations at all levels, from local community clubs to national and international governing bodies. The platform promotes inclusive and accessible education by providing a self-paced, interactive learning tool that students can access anytime, anywhere. This is particularly beneficial for diverse learning styles, ensuring that theoretical knowledge is not a barrier to entry. Ultimately, by enhancing the quality of sports management education, the AI-Powered Performance Playbook contributes to the development of a more professional, sustainable, and impactful sports ecosystem that benefits athletes, communities, and society as a whole.

5. Innovation and Entrepreneurial Impact

This project is a prime example of innovation in educational technology, directly addressing the gap between traditional pedagogy and the learning preferences of modern students. By integrating AI with gamification, we are pioneering a new approach to delivering theoretical content in sports education in a practical, engaging format. This fosters a culture of entrepreneurship within the faculty and university by demonstrating how academic knowledge can be translated into a commercially viable digital product. The development process itself, which starts with identifying a market need (student disengagement), designing a tech-based solution, and planning for scalability, embodies the entrepreneurial mindset we aim to cultivate. The AI-assistance and web-based solution empowers students and faculty to see themselves not just as learners and teachers, but as innovators capable of creating solutions with real-world cutting-edge impact. This culture of innovation can inspire further spin-off projects and collaborations within the institution and the wider community.

6. Potential commercialization

The AI-Powered Performance Playbook has strong and immediate commercialization potential. Our primary market is higher education institutions offering sports science and management programs, both in Malaysia and internationally. The platform offers universities a modern, ready-to-deploy digital learning resource that enhances their curriculum and appeals to tech-savvy

students. It can be licensed as a supplementary tool for specific courses or as part of a broader institutional e-learning package. Beyond academia, there is significant potential in the corporate training sector. Sports organizations, national governing bodies, and even private companies require efficient training for staff in management, operations, and event coordination. This platform offers a scalable, cost-effective solution for onboarding and continuous professional development. The simple quiz-based model and AI-driven content generation mean it can be adapted for various sports management sub-disciplines, such as event management, marketing, and facility operations, opening multiple revenue streams and establishing it as a valuable asset in the professional training market.

7. Acknowledgment

The authors would like to thank the Faculty of Sports Science and Recreation, Universiti Teknologi MARA (UiTM), for the support and the curriculum that inspired this project. We also acknowledge the contributions of our peers who provided valuable feedback during the initial design phase.

8. Researchers' Biography

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Nur Syazwani Zulaikha Safwan is a lecturer at the Faculty of Sports Science and Recreation, UiTM Shah Alam, specialising in sports performance and related applied research. Through her scholarly publications and supervision, she advances evidence-based practice in sports science, emphasising innovative methodologies and interdisciplinary collaboration to support athlete development and community well-being.

Nurul Ain Muhammad Rafiai is a lecturer and Programme Coordinator for Sports Management at the Faculty of Sports Science and Recreation, UiTM Shah Alam, where she oversees curriculum implementation and industry-relevant programme development. Her academic work focuses on sport governance and sport policy, and she actively contributes to research and scholarly forums that promote innovative, accountable management practices within the sports industry.

Islamic Wealth Distribution Frontier: AI-Driven Web Tools for Community Prosperity

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ABSTRACT
Financial illiteracy surrounding Islamic wealth principles remains a critical gap in Muslim communities globally. This paper presents an AI-driven, web-based educational platform that has been designed to transform on how users understand and apply Islamic Wealth Distribution concepts, specifically Zakat, Waqf, Hibah, Wills, and Faraid. Developed through *vibe coding* methodology using advanced generative AI assistance, the platform delivers interactive slide-based modules enriched with gamification elements including quizzes, progress dashboards, and reflective exercises. The AI layer provides real-time tutoring and adapts content difficulty dynamically based on individual learner progress. Unlike conventional static resources, this tool creates a participatory, immersive learning experience that engages younger, digitally native generations. The socio-economic impact is substantial; by empowering Muslim individuals with accurate Shariah-compliant wealth management knowledge, Waqf endowment, and estate planning. Its scalable, cloud-hosted architecture presents strong commercialization prospects for Islamic financial institutions, universities, and madrasahs seeking modern financial literacy solutions.

Keywords: Islamic Finance, AI-Driven Education, Gamification, Web-Based Learning.

1. Product Description
The web-based product, accessible 24 x 7 is a comprehensive digital learning ecosystem for Islamic wealth management education. The platform is structured into targeted modules covering key Islamic wealth distribution topics: Introduction to Islamic Wealth, Hibah, and Wills & Trusts; each supported by interactive AI-powered content. A built-in Quiz module tests comprehension, while a Reflect section promotes deeper internalization of Shariah principles. The integrated Dashboard allows learners to monitor their own progress in real time. Developed using a *vibe coding* approach that allows leveraging AI code generation tools has resulted in a modern feature to engage younger generations. Real-time AI tutors embedded within the interface respond to user queries on wealth distribution rules. Unlike traditional static slides or PDFs, this platform enables users to simulate wealth growth and distribution scenarios through gamified challenges, making abstract Islamic financial concepts tangible and actionable.

2. Development Flow and Screenshots of the System.

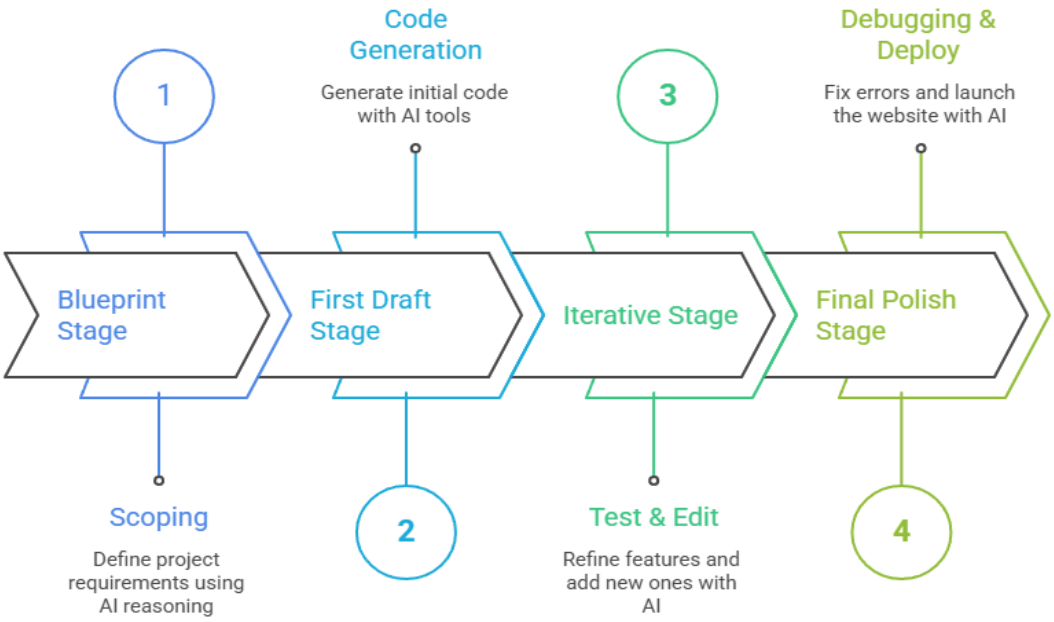

Figure 1. Flow for the AI-powered web development.

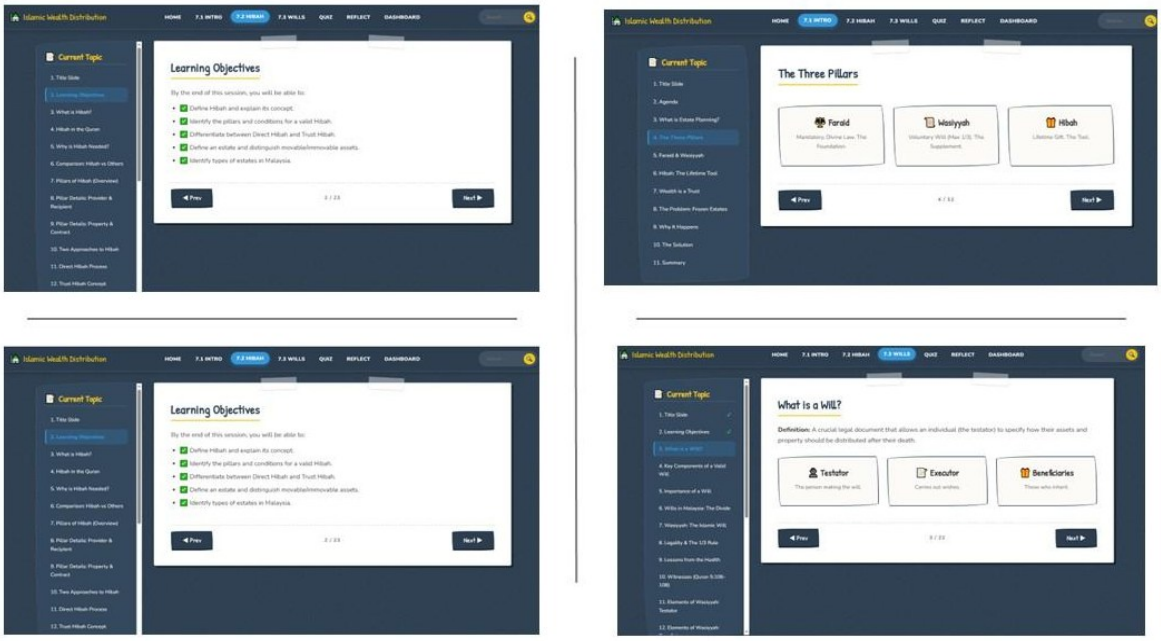

Figure 2. Interface of the Web-based learning for Islamic Wealth Distribution.

Figures 1 and **2** illustrate the development and implementation of the AI-driven web platform for Islamic wealth distribution education. **Figure 1** presents the AI-assisted development workflow using vibe coding, beginning with project scoping and blueprinting, followed by AI-

generated coding, iterative refinement, and final system deployment. **Figure 2** shows the user interface of the web-based learning platform, highlighting structured learning modules, interactive navigation, and digital features that support engaging learning of key Islamic wealth concepts such as Hibah, Wills, and Faraid.

3. Novelty and uniqueness

The primary novelty of this platform lies in the fusion of *vibe coding*, a generative AI-assisted development methodology with adaptive gamification to produce an educational interface that is both pedagogically sound and technologically innovative. Existing Islamic financial literacy tools are predominantly informational and static, offering little interactivity. This platform is fundamentally participatory: the integrated AI engine continuously analyses learner performance within gamified modules and recalibrates content complexity accordingly, ensuring neither cognitive overload nor under-stimulation. The combination of Hibah, Wills and Faraid into a single coherent digital journey, with reflection prompts and real-time quizzes is absent in current market offerings. Furthermore, the application of AI-assisted rapid prototyping in developing a Shariah-compliant educational product demonstrates a replicable model for Islamic EduTech innovation. The seamless integration of a progress dashboard further distinguishes this tool, enabling self-directed, personalized learning that is both measurable and motivating.

4. Benefit to mankind

This platform democratizes access to complex Islamic financial knowledge that is often confined to specialized scholars or costly consultants. By equipping Muslim individuals regardless of educational background with accurate Waqf endowments, Hibah gifting, and Faraid inheritance, the tool directly strengthens community socio-economic resilience. Accurate wealth distribution in accordance with Shariah principles reduces estate disputes, increases voluntary Zakat compliance, and amplifies Waqf contributions to social welfare. The platform is particularly impactful for underserved communities in Malaysia and the broader Muslim world where access to structured Islamic financial education remains limited. By making this knowledge accessible via any web-enabled device, it bridges the digital divide and fosters generational wealth literacy.

5. Innovation and Entrepreneurial Impact

This project exemplifies a new paradigm of EduTech entrepreneurship within the Islamic economy. By demonstrating that a fully functional, AI-enriched, Shariah-compliant educational platform can be prototyped rapidly through vibe coding, it lowers the barrier to innovation for aspiring Muslim entrepreneurs and academic institutions. The project fosters a culture of technology-driven problem-solving within the Islamic finance community, proving that sophisticated solutions need not require large development teams or substantial capital. Its open, web-based architecture encourages future integrations such as Zakat calculators, Waqf investment simulators, or Faraid distribution tools. Hence, positioning it as a launchpad for a broader Islamic wealth management ecosystem. Furthermore, this initiative demonstrates a replicable model for student-led innovation, where AI tools serve as force multipliers that transform domain knowledge into market-ready digital products. It directly contributes to the national agenda of nurturing a digitally literate, entrepreneurially empowered Muslim community aligned with the global Halal digital economy.

6. Potential commercialization

The platform carries strong commercialization potential as a Software-as-a-Service (SaaS) product targeted at Islamic banks, madrasahs, universities, and corporate training divisions specialising in Islamic wealth management. It can be licensed to financial institutions as a client education portal, reducing advisory costs while improving client financial literacy. Universities offering Islamic Finance programs can adopt it as a supplementary digital learning resource. A freemium model offering basic modules freely while getting advanced certifications and institutional dashboards behind subscription tiers would maximise user acquisition while ensuring revenue sustainability. The Halal economy and Islamic finance market, valued in the trillions globally, represents a large and underserved addressable market for such a solution.

7. Acknowledgment

The authors would like to thank the Universiti Teknologi MARA (UiTM), for the support and resources provided throughout the development of this project. We also acknowledge the contributions of our peers who provided valuable feedback during the initial design phase.

8. Researchers' Biography

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Noridah Abu Bakar is a senior lecturer and Smart Learning Coordinator at the Faculty of Sports Science and Recreation, UiTM Shah Alam, recognised for integrating educational technology into sports education. She leads innovative initiatives in digital pedagogy, blended learning, and outcome-based assessment that enhance student engagement and strengthen the faculty's academic ecosystem.

Wan Yusrol Rizal Wan Yusof is a senior lecturer at UiTM Kelantan and former Programme Coordinator for the Bachelor of Business Administration (Hons) Finance, where he strengthened curriculum relevance and industry linkage. His research in Islamic banking and financial efficiency has produced indexed publications that inform innovative practices in Islamic financial institutions and evidence-based teaching in finance education.

Prof. Dr. Wan Edura Wan Rashid is a Professor and Director of the Institute of Business Excellence, Universiti Teknologi MARA (UiTM), holding a PhD in Business Administration from the International Islamic University Malaysia. Her expertise centres on work-life balance and its integration with governance, sustainability, and value-based institutional frameworks that support socio-economic stability and family well-being. She has been actively involved in award-winning research initiatives and FRGS projects focusing on ethical governance and sustainable Islamic institutional models. Her work reflects a commitment to integrity-driven practices that promote financial clarity, social harmony, and holistic well-being among individuals, families, and communities.

PastPresentFuture: Time Tracker

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ABSTRACT
PastPresentFuture: Time Tracker is a storyboard with six frames to practice application of past tense, present tense and future tense as many find it confusing when using tenses in sentence writing. The learners who work individually or in pairs are allowed to use AI to generate sentences or references from physical pictorial and bilingual dictionary for each frame to check their grammar components as the story with the least grammatical errors completed in the shortest time wins the activity. The production cost is minimal as it requires a storyboard template and the Internet connection which is accessible to all socioeconomic levels. This product has the potential to be commercialized as the correct use of tenses can improve the productivity of English language users and reduce losses caused by miscommunication in English language.

Keywords: English language tenses, storyboard, writing

1. Product Description
PastPresentFuture: Time Tracker is a six-frame storyboard to practice the use of English language tenses. There are six frames namely setting, problem, rising action, turning point, resolution and reflection which required to be completed with a sentence for each. The learners are allowed to refer to AI for those with the Internet connection or references from physical bilingual dictionary to check their spelling and sentence structure as the participant completed the story quickest with minimal grammatical errors is the winner.

The Mean of Learners' Perception of Tenses Practice Using Storyboard

Table 1. The Learners' Perception of Tenses Practice Using Storyboard.

Item No.	Items	Mean
4	I can understand why different tenses are used in the story	4.52
7	I feel confident using tenses when writing through storyboard	4.54
11	I feel engaged when learning grammar through storyboard	4.53
19	I consciously think about sequence when choosing tenses	4.51
	Overall Mean	4.52

Item no. 4 with the mean of 4.52 in **Table 1** shows that participants in this pilot study could interpret the reasons of using different tenses in the storyboard. Item no. 7 with the mean of 4.54 in **Table 1** shows the participants feeling certain of their decision when using tenses in writing the storyboard. Item no. 11 with the mean of 4.53 in **Table 1** portrays the participants feeling committed in learning grammar using the storyboard. Item no. 19 with the mean of 4.51 in **Table 1** illustrates the participants being aware of the sequence in timeline when applying tenses for use.

1. Novelty and Uniqueness

The six-frame storyboard of PastPresentFuture: Time Tracker provides a meaningful narrative context which can help the comprehension of how a tense is used. The storyboard promotes functional grammar learning rather than dull mechanical drill in traditional grammar practice. The timeline of actions is described through the sequence of the storyboard frame visually which allows a learner to comprehend the connection of verb tenses with time progression. The use of storyboard encourages creativity of imagination when designing stories. The storyboard frames provide strong scaffold in complex tense usage such as past for completed actions, present for description and future for predictions which resulted in confidence.

2. Benefit to Mankind

PastPresentFuture: Time Tracker uses six frames which sequence images that benefit visual learners and learners of different proficiency levels by utilizing temporal systems in the brain to understand language more effectively. This can enhance academic success and lifelong communication skills that contribute to better educational equity and literacy. Interpreting storyboard support logical idea organization and meaningful narrative construction can contribute to critical thinking and problem solving. The use of storyboard fosters collaborative learning, boosting engagement, motivation and self-efficacy which correlates with the value of education. As individuals communicate better about past, present and future events, there is more participation using English which boosts intercultural understanding.

3. Innovation and Entrepreneurial Impact

Case studies are to be carried out from time to time to show improved proficiency and engagement to improve marketing and external funding support before PastPresentFuture: Time Tracker can be commercialized as a high-end educational technology product. Collaboration among the educators, content creators and illustrators can produce storyboarding kits which can be marketed as ready-made module. It can also be adapted onto a digital platform which guides learners frame-by-frame with writing prompts and tense-aware feedback which is integrated with AI-assisted drafting and automated assessment to demonstrate learning. Consumer subscription can be offered to individual language learners within a period together with promotional price for extra storyboards or templates.

4. Potential Commercialization

PastPresentFuture: Time Tracker will have a good return of investment (ROI) as it can boost interaction in English and lessen damage cause by language error. This product can be marketed to learners in schools for better results in high stake examinations. This product can help

companies to increase sales among English speaking customers internationally and save cost by minimizing dependency on translation.

5. Researchers' Biography

Ong Elly is active in developing communicative activities and integrating technology in diverse classrooms. Her academic interests include innovative teaching strategies and effective assessment to enhance learners' proficiency and confidence in English.

Muhd Syahir Abd Rani is an experienced English language educator with 16 years of teaching experience in the field of ESL. He holds a Master of Education (TESL) from Universiti Teknologi MARA (UiTM), Shah Alam, Malaysia. His professional interests include educational psychology, ESL pedagogy, language assessment, learner motivation, and classroom-based research. Throughout his career, he has been actively involved in teaching, curriculum development, and academic support for learners of diverse proficiency levels. His work reflects a strong commitment to enhancing English language learning through effective teaching strategies, reflective practice, and evidence-based approaches in education.

Mohamad Safwat Ashahri bin Mohd Salim is a passionate and committed lecturer at Universiti Teknologi MARA (UiTM) Perak Branch, Tapah Campus. With a strong background in English language education, his academic interests include Teaching English as a Second Language (TESL), mobile learning, and the integration of chatbots in ESL/EFL classrooms. He is also actively exploring innovative approaches such as 360-degree video-based learning to enhance student engagement and language acquisition. In addition to his research contributions, he is an avid creative writer, demonstrating a balanced passion for both academic and literary work.

Noble Quest: Interactive Islamic Adventures for Young Learners in the Metaverse

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ABSTRACT
Noble Quest: Interactive Islamic Adventures for Young Learners in the Metaverse is an educational game developed using Roblox platform to support Islamic learning for Year 1 students following KAFA curriculum in Malaysia. The projects aim to develop an engaging educational metaverse experience that employ gamification elements such as exploration and quests. This educational game is designed as a virtual learning world where students can interact through avatars, explore educational environments and complete missions that integrate Islamic knowledge with game-based learning. The platform integrates gamification, motivation, and active learning among young learners. The advantage of the system lies in its integration of immersive metaverse platform with culturally Islamic educational content that allow learners to experience learning through exploration rather than traditional instruction. The platform also introduces a structured usability evaluation framework to ensure the system is effective for young users. The project also has the potential to contribute to digital education while supporting socio-educational development. Noble Quest can also be expended as scalable educational product for schools and Islamic learning institutions, offering strong commercialization potential in the growing digital education market.

Keywords: Metaverse Learning, Islamic Learning, Game-based Learning, Educational Game

1. Product Description
Noble Quest is an interactive metaverse-based educational platform that is designed to support Islamic knowledge among young learners through an immersive learning environment. Developed using Roblox Studio and Blender, the game allows students to explore a virtual world while completing the quests and interacting with educational quest that related to Islamic teaching and value. The learning content is aligned with the Malaysian KAFA syllabus for Year 1 and focuses on moral values, basic Islamic knowledge and spiritual awareness. Players control the avatars and navigate a three-dimensional world through various locations to learn the Islamic knowledge where each location presents tasks and quest that required to be solve by learners. The systems also integrated gamification elements including rewards and exploration to maintain learner's engagement. In addition to the learning environment, Noble Quest also integrates a usability evaluation framework based on Jakob Nielsen's five usability components: learnability, efficiency, memorability, errors, and satisfaction. This data confirms that the platform is both easy to use

and highly satisfying for young learners. By combining Islamic education, immersive learning and gamification, Noble Quest provides an innovative digital learning experience that supports both cognitive development and Islamic education among young learners.

2. Screenshots and Table

Figure 1. The Process of Constructing Usability.

The development of this project follows a structured methodology to ensure its effectiveness for the young learners, as illustrated in **Figure 1**. The process combined theoretical adaptation with practical testing to ensure that the instrument was both culturally relevant and age-appropriate for young learners.

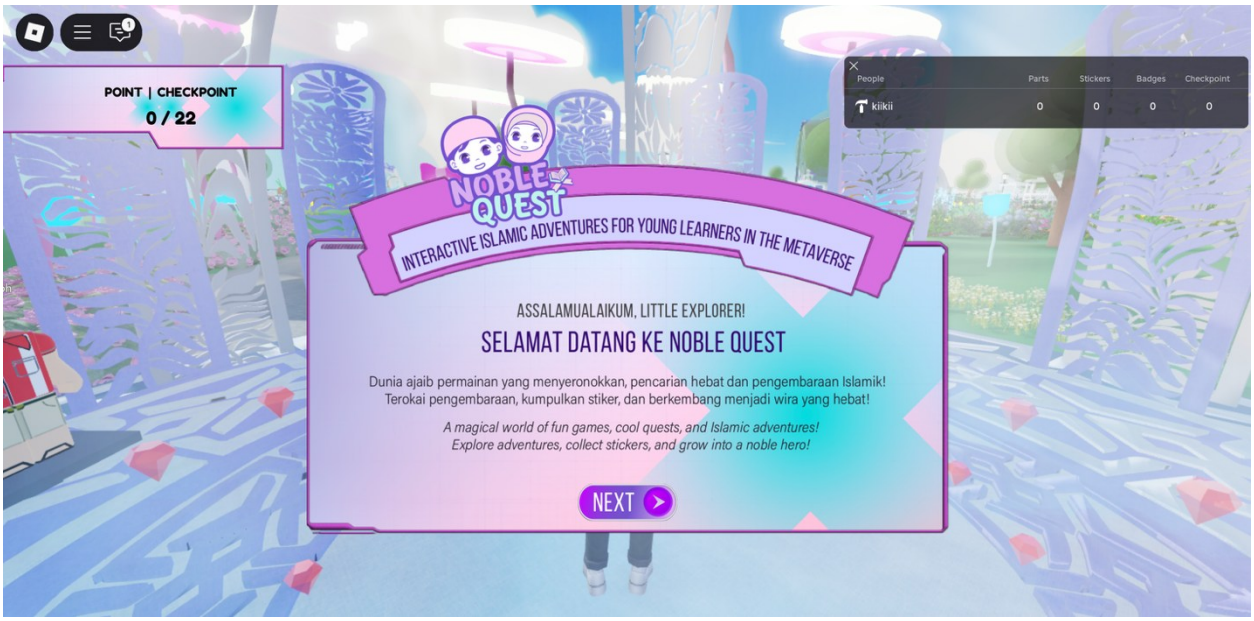

Figure 2. The Interface of Noble Quest.

An example of user interface that learners interact with is shown in **Figure 2**. The product basically have 22 checkpoint that contain multiple learning environement with gamification concept to maintain learner engagement. The content that have in this product were adpat from traditional text book KAFA year 1. The reliability of this instrument was tested, achieving an overall Cronbach's Alpha of 0.91, which is considers excellent. Detailed reliability statistics are provided in **Table 1**. The reliability level for Learnability and Efficiency slightly lower but still acceptable. Overall, this reliability results show that all five component acceptable.

Table 1. Reliability Statistics (Cronbach's Alpha).

Component	Number of Items	Cronbach's Alpha (α)	Reliability Level
Learnability	3	0.74	Acceptable
Efficiency	3	0.75	Acceptable
Memorability	3	0.80	Good
Errors	3	0.79	Acceptable
Satisfaction	3	0.90	Excellent
Overall Instrument	**15**	**0.91**	**Excellent**

Table 2. Descriptive Statistics of Usability Components (N = 30).

Component	Item	Mean	SD	Variance
A. Learnability	1. I quickly learn new things in Noble Quest.	4.67	.479	.229
	2. Noble Quest helps me learn Kafa more quickly.	4.77	.430	.185
	3. I knew what to do in the game without help.	4.37	.889	.792
B. Efficiency	4. I can finish tasks in the game quickly.	4.37	.850	.723
	5. It didn't take me long to understand the game instructions.	4.50	.861	.741
	6. I could do activities in the game easily.	4.80	.484	.234
C. Memorability	7. I still remember how to play Noble Quest after a few days.	4.46	.819	.671
	8. I can easily remember how to play the game.	4.60	.563	.317
	9. I didn't forget what I learned in the game.	4.70	.535	.286
D. Errors	10. I didn't make many mistakes while playing.	4.36	.765	.585
	11. If I made a mistake, I could fix it easily.	4.70	.535	.286
	12. The game didn't confuse me or make things hard to understand.	4.56	.935	.875
E. Satisfaction	13. I enjoy learning Kafa with Noble Quest.	4.86	.346	.119
	14. I like my experience in this game.	4.83	.379	.144
	15. This game made me feel happy and confident.	4.83	.379	.144

The descriptive statistics for each usability component, based on study of 30 participants are summarized in **Table 2**. The findings from the preliminary usability evaluation provide strong support for the reliability of the Noble Quest usability instrument. The results shows high internal consistency across all five of Nielsen's usability components indicating that the adapted items successfully measured.

3. Novelty and uniqueness

The novelty of Noble Quest lies in its integration of Islamic education that focused on Year 1 KAFA syllabus with immersive metaverse technology. While many digital learning applications focus on traditional e-learning methods, Noble Quest introduces a game-based metaverse experience where learners actively explore, interact and learn through quest and challenge. One unique aspects of this project are the contextualization of Islamic learning within virtual world that encourages exploration and decision-making. This a method transforms traditional classroom-based learning into an engaging digital experience that promote active participation and curiosity among students. By combining interactive gameplay, culturally relevant content, and Islamic learning framework, Noble Quest supports the development meaningful digital learning experiences that can enhance the quality of Islamic education and inspire future innovation in technology-based learning systems.

4. Benefit to mankind

Noble Quest contributes to the advancement of digital learning by demonstrating how metaverse technologies can be used to support religious education that also align with the National Education Policy in transitioning into digital era. The platform provides an engaging alternative to traditional learning systems by allowing students to explore educational through interactive experiences. For Educators, this game will be used as teaching aids to assess the understanding of students, and making learning more engaging and fun for young generations. For students, the game promotes motivation, curiosity and active participation in learning while reinforcing Islamic knowledge and value. By combing both entertainment and education, Noble Quest supports the development of positive learning attitude among young learners.

5. Innovation and Entrepreneurial Impact

Noble Quest promotes innovation in educational technology by integrating immersive environment, gamification and culturally contextualized learning content. The project demonstrates how metaverse platforms can be used to transform from traditional teaching approaches into digital learning experiences. The development of Noble Quest also encourages entrepreneurial thinking among developers by showcasing how educational innovations can be transformed into scalable digital products and also encourages collaboration between educators, developers and institutions to create innovative learning solutions. The platform in future can be expended to include teacher analytics system and additional educational modules. By combining educational innovation with practical Islamic education, the projects contribute to the growing ecosystem of digital learning solutions and encouraging the learners to use gaming in correct ways and also encourage the adoption of immersive technologies within educational institutions.

6. Potential commercialization

This educational Noble Quest has strong commercialization potential as a digital educational platform for Islamic learning. The game can be expanded into a scalable learning tools for schools, Islamic institutions, and educational organizations that wish to integrated interactive immersive technologies into their curriculum. Future development may include downloadable educational content, or may include subscription–based learning modules. The platform also could be adapted for different age groups with different KAFA syllabus. Furthermore, Noble Quest can be access through digital platforms such as Roblox and mobile friendly environment, enabling wider access

to learner globally. With increasing interest in gamified and immersive learning technologies, the project has strong potential to evolve into a sustainable educational product.

7. Acknowledgment

This product received funding from the Ministry of Higher Education (MoHE) Malaysia under the TVET Applied Research Grant Scheme (T-ARGS/2025/BK10/00589), which supported its development and implementation.

8. Researchers' Biography

Halizayanie binti Kimlin is a Head of Programmed and Lecturer at the Polytechnic Tuanku Syed Sirajuddin, specializing in interactive media. With more than 20 years of experience in digital media and creative technology, she specializes in digital media development and interactive media design. Her expertise includes multimedia production, interactive learning applications, and digital content creation for educational and creative industries. She has been actively involved in academic innovation projects and curriculum development related to digital creative technology. Her work focuses on integrating emerging technologies and interactive media to enhance digital learning experiences and creative education.

Muhammad Amiruddin bin Rosli is a Lecturer at the Polytechnic Tuanku Syed Sirajuddin, focusing in interactive media, augmented reality and educational technology. With over 10 years of experience in digital media field, he has contributed for development for Noble Quest as developer. Previously work at Silterra as System Engineer (UI/UX). As Lecturer, he is actively using his knowledge to help others to enhance student's engagement through interactive and technology – driven pedagogical approaches.

Dr. Sharifah Nadiya Syed Yahya is a senior lecturer at Politeknik Tuanku Syed Sirajuddin with more than 20 years of experience in education and curriculum development. She plays a key role in the development and organization of educational content for digital learning projects, including Noble Quest. Her expertise lies in instructional design, content structuring, and educational material development, particularly in technical and vocational education.

Suhaila Mustaffa is a lecturer at Politeknik Tuanku Syed Sirajuddin with more than 20 years of experience in Islamic studies and educational content development. She specializes in Islamic educational materials and plays an important role in ensuring the accuracy and authenticity of Islamic learning content. In the Noble Quest project, she contributes to the development and proofreading of Islamic educational content to ensure that it aligns with appropriate religious knowledge and learning objectives. Her expertise supports the integration of Islamic values into innovative digital learning platforms for young learners.

Finder Niaga: A Smart Market Analysis Platform for Aspiring Entrepreneurs

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ABSTRACT

Niaga Finder is a smart digital platform designed to assist aspiring entrepreneurs in identifying suitable business opportunities based on market analysis. The project was developed to address the challenges faced by new entrepreneurs, such as lack of market knowledge, high business failure risk, and limited access to professional consultation. The system operates by collecting user profiles, interests, and business preferences before generating market suitability scores and personalized business recommendations. The main advantages of Niaga Finder include its automated analysis, user-friendly interface, and data-driven decision support system. Unlike conventional methods, this platform offers instant insights without requiring expert intervention, making it accessible to all users. The innovation contributes positively to socio-economic development by encouraging entrepreneurship and reducing startup failure rates. Furthermore, this system will be able to support Sustainable Development Goal (SDG) 1 by promoting income generation and poverty reduction, as well as SDG 10 by reducing inequalities through equal access to business knowledge and market insights. From a commercialization perspective, the platform has strong potential through subscription-based services, premium analysis packages, and collaboration with entrepreneurship agencies and educational institutions. Niaga Finder serves as an innovative solution to empower future entrepreneurs and strengthen the entrepreneurial ecosystem.

Keywords: Market analysis, entrepreneurship, digital innovation, business decision, smart system

1. Product Description

Finder Niaga is a web-based application designed to support individuals in selecting viable business ideas based on personal capabilities and market conditions. Users begin by entering basic information such as experience level, business interests, available capital, and preferred operating mode. The system processes this input using an internal scoring algorithm to assess market suitability and business feasibility. The platform generates three main outputs: a market suitability score, recommended business ideas, and suggested marketing strategies. The interface is intuitive and simple, allowing users with minimal business knowledge to navigate the system easily. Finder Niaga also highlights potential risks and operational challenges associated with each recommended business, helping users make informed decisions. The platform is suitable for

students, fresh graduates, and small business owners who wish to start or expand a business with greater confidence and reduced uncertainty.

2. Pictures

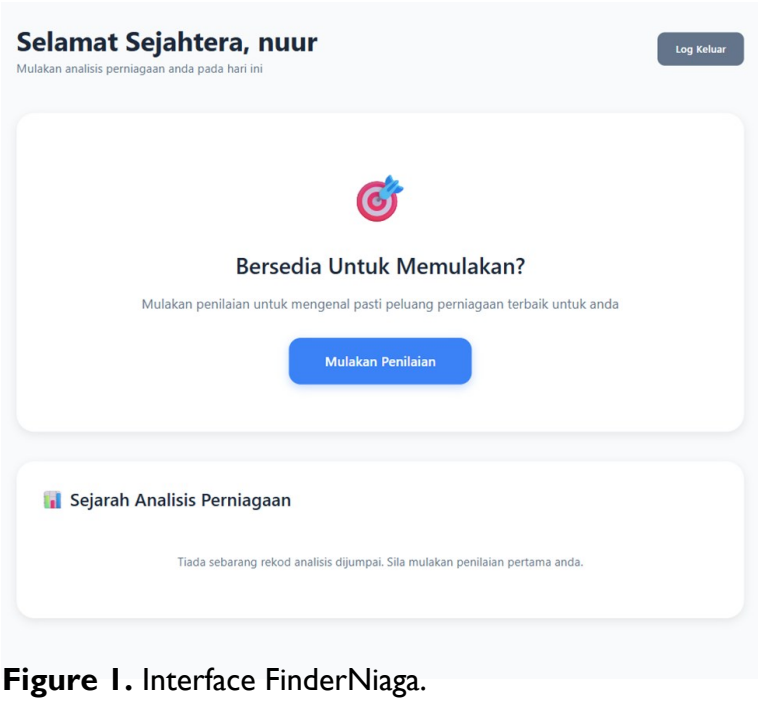

Figure 1. Interface FinderNiaga.

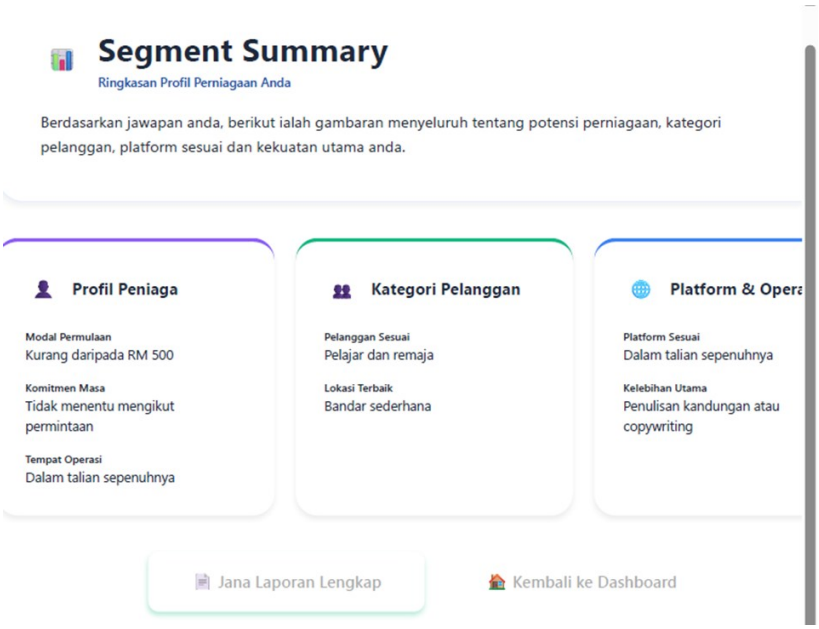

Figure 2. Segment Summary.

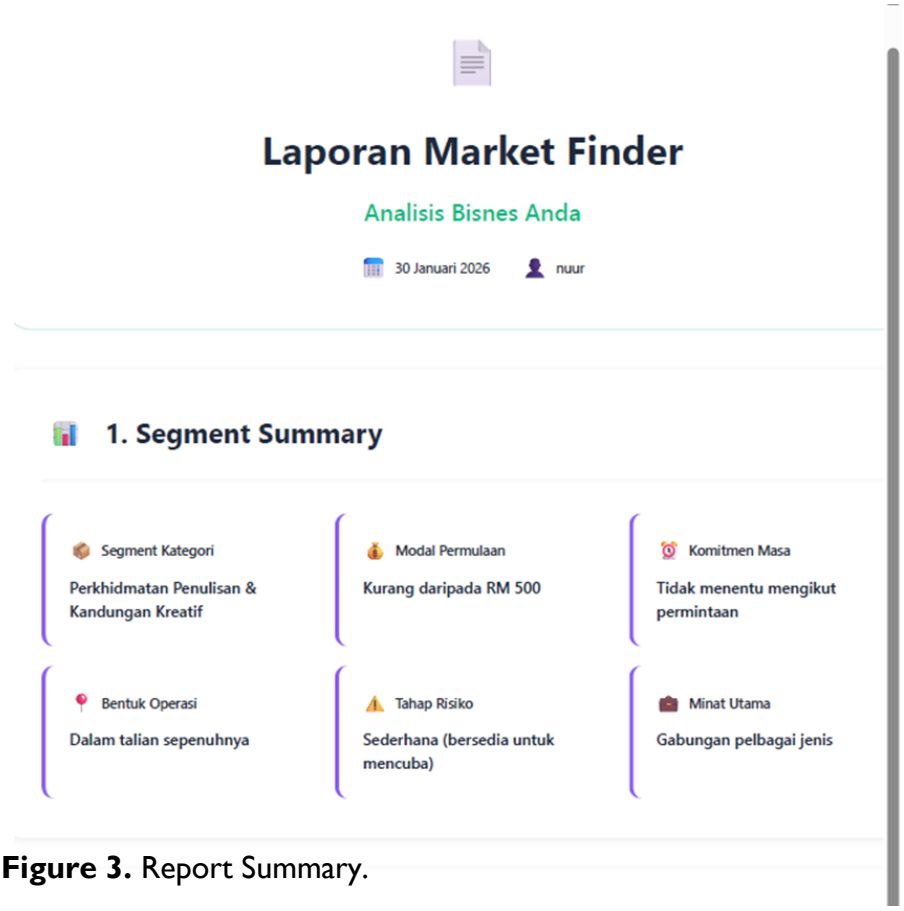

Figure 3. Report Summary.

3. Novelty and uniqueness

The novelty of Niaga Finder lies in its automated market analysis and personalized recommendation system. Unlike conventional business advisory services that require expert consultation, this platform offers instant, data-driven insights based on user profiles. The integration of a scoring algorithm to measure market suitability makes it unique, as users can clearly evaluate their business potential before starting. Another unique feature is the customized business suggestion system, which adapts to different user backgrounds, interests, and financial capabilities. The platform also provides basic marketing strategies, enabling users to plan their business launch effectively. Furthermore, Niaga Finder is designed to be beginner-friendly, making it accessible to individuals with limited business knowledge. This innovation bridges the gap between business theory and practical application, making entrepreneurship more inclusive and achievable.

4. Benefit to mankind

NiagaFinder benefits individuals and society by encouraging entrepreneurship and reducing business failure risks. Users gain confidence in starting businesses through accurate market insights and structured guidance. This helps improve financial stability and self-employment opportunities. At a societal level, the platform supports economic growth by increasing the number of successful small businesses. It also promotes innovation culture among youth and graduates, contributing to job creation and sustainable development. By simplifying market

analysis, Market Finder Pintar empowers communities to participate actively in economic activities.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by introducing a smart digital solution for business decision-making. Niaga Finder encourages users to explore entrepreneurship through technology-driven analysis. The platform supports institutions and communities by providing a structured entrepreneurial guidance report.

By integrating innovation with entrepreneurship, the project nurtures creative thinking and problem-solving skills among users. It also strengthens collaboration between academia and industry through potential partnerships. This contributes to building an entrepreneurial mindset and a culture of innovation within society.

6. Potential commercialization

Niaga Finder has high commercialization potential through subscription-based models and premium features. Users can access basic services for free, while advanced analytics are offered under paid packages.

The platform can collaborate with entrepreneurship agencies, universities, and business incubators to expand its market reach. Corporate licensing and customized enterprise versions can also generate revenue. With increasing demand for digital business solutions, Market Finder Pintar has strong market potential locally and globally.

7. Acknowledgment

The authors would like to thank Universiti Sultan Azlan Shah and the Faculty of Management and Information Technology (FPTM) for their invaluable support and guidance throughout this project. Their resources, encouragement, and expertise greatly contributed to the successful development and completion of this work. We also extend our appreciation to all individuals who provided assistance, advice, and constructive feedback along the way.

8. Researchers' Biography

Noor Anis Shamila Binti Ibrahim is a lecturer at Universiti Sultan Azlan Shah with over 12 years of experience in academia and professional practice. She specialises in human resource management, business, and entrepreneurship. Her academic and professional interests include digital work practices, work–life balance, and entrepreneurship development. She is actively engaged in teaching, research, and structured knowledge transfer initiatives aimed at enhancing business performance and workforce capability.

Nuur Atikah binti Ghazali is a lecturer at Universiti Sultan Azlan Shah with over 15 years of experience in higher education, including more than 10 years at Universiti Utara Malaysia as a tutor and contract lecturer. She currently serves as Program Coordinator for the Bachelor of Business Administration (Honours) Entrepreneurship programme and is actively involved in quality assurance and curriculum development. Her academic expertise includes organizational behavior, entrepreneurship, and industrial relations. Her research interests focus on employee retention and turnover intention, supported by conference presentations, book editorships, and funded research projects. She is also a freelance academic designer, providing professional academic and presentation services.

Helmy Hanyff Bin Hairudin Ruzaili is a Lecturer specialising in system integration and cybersecurity. His academic and professional interests include IoT systems, network security, embedded systems, and secure digital infrastructure. He is actively engaged in teaching, research, and applied technology development, focusing on building reliable, secure, and intelligent systems to enhance organizational and technological capabilities.

Muhamad Fhadli Syakirin Bin Mohd Jamalludin is a Lecturer specialising in economics and finance. His academic and professional interests include microeconomics, macroeconomics, financial management and economic development. He is actively engaged in teaching and research, with a strong focus on student-centred learning, applied economic analysis, and evidence-based approaches to enhance academic quality and societal impact.

EziTranz Kit: A Magnetic Modular Educational Aid for Teaching Transistor Circuits and Basic Electronics

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ABSTRACT
The EziTranz Kit is an innovative "paste and play" educational tool designed to enhance students' understanding of transistor circuits in Form 5 Physics. It was developed to overcome challenges in learning abstract electronic concepts and the limitations of conventional teaching methods using real components. The kit enables students to assemble circuits using magnetic symbols on a reusable board, providing immediate visual and functional feedback that promotes deeper conceptual understanding and reduces common misconceptions. Its main features include ease of use, risk-free hands-on learning, modular flexibility, and interactive design, making electronics learning engaging, practical, and accessible. Evaluation with 48 students divided into Alpha (conventional components) and Beta (EziTranz Kit) groups showed that the kit significantly improved academic performance, with post-test scores rising to an average of 90.83% for the Beta group compared to 67.2% for the Alpha group. Beyond educational benefits, the EziTranz Kit offers socio-economic advantages by reducing costs from damaged components, fostering STEM interest, and supporting teachers in delivering effective lessons. The kit has strong commercialization potential as a classroom-ready learning tool suitable for wider adoption in schools and STEM learning centers.

Keywords: Educational Innovation; Physics; Transistor; STEM Teaching Tools

1. Product Description
EziTranz Kit is an innovative educational tool that simplifies learning electronic circuits for secondary school students, especially exam-format transistor circuits. Using a "paste and play" approach, students assemble circuits on a magnetic board without wiring. This kit is shown in **Figure 1**. LEDs and buzzers are placed and held by magnets, while reed switches simulate circuit switching, allowing real-time observation of current flow and activation. Its magnetic, reusable design reduces setup complexity, prevents component damage, and supports classroom lessons, STEM activities, and self-directed learning. By linking schematic diagrams to real-time circuit responses, the kit enhances conceptual understanding, problem-solving skills, and student confidence, making electronics learning interactive and enjoyable. The flowchart of the creation of EziTranz Kit is shown in **Figure 2. Figure 3** compares the pre-test and post-test score distributions for Kumpulan Alpha and Kumpulan Beta. Both groups showed similar low-to-moderate performance in the pre-test, with most scores between 20 and 40 marks. After the intervention, both groups improved; however, Kumpulan Beta, which used the EziTranz Kit during the PdP session, showed greater improvement, with 11 students achieving full marks (100) compared to only 3 students in Kumpulan Alpha.

Figure 4 presents the average pre-test and post-test scores for both groups. The pre-test averages were comparable, indicating similar initial understanding. After the intervention, Kumpulan Beta recorded a much higher post-test average (90.83) than Kumpulan Alpha (67.20), where conventional real electronics were used as the ABM. These results clearly indicate that the EziTranz Kit is more effective in improving students' learning outcomes.

2. Visual and Analytical Overview of EziTranz Kit Study

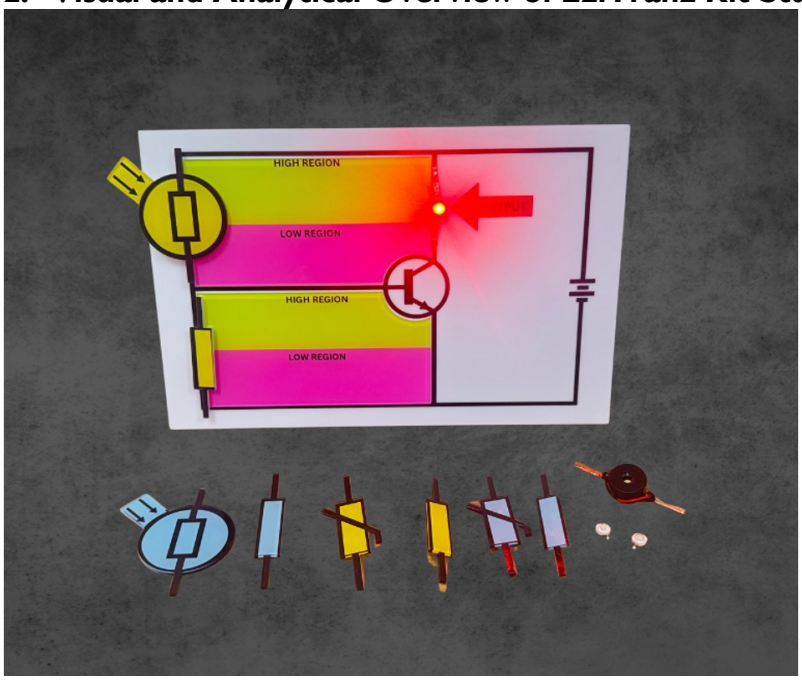

Figure 1. EziTranz Kit with magnetic acrylic electronic components symbol, including LEDs, buzzer.

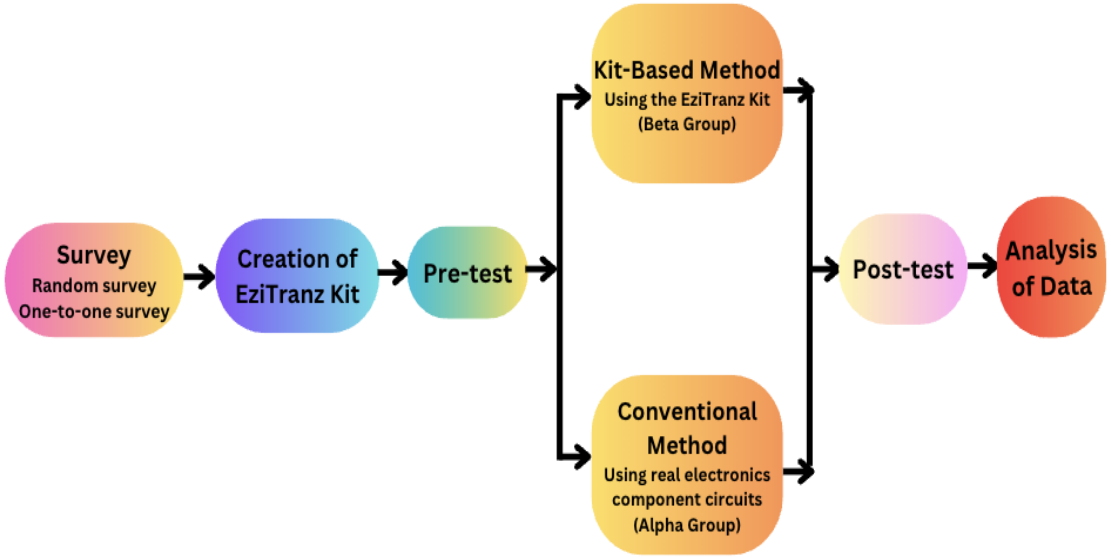

Figure 2. Flowchart of the creation of EziTranz Kit.

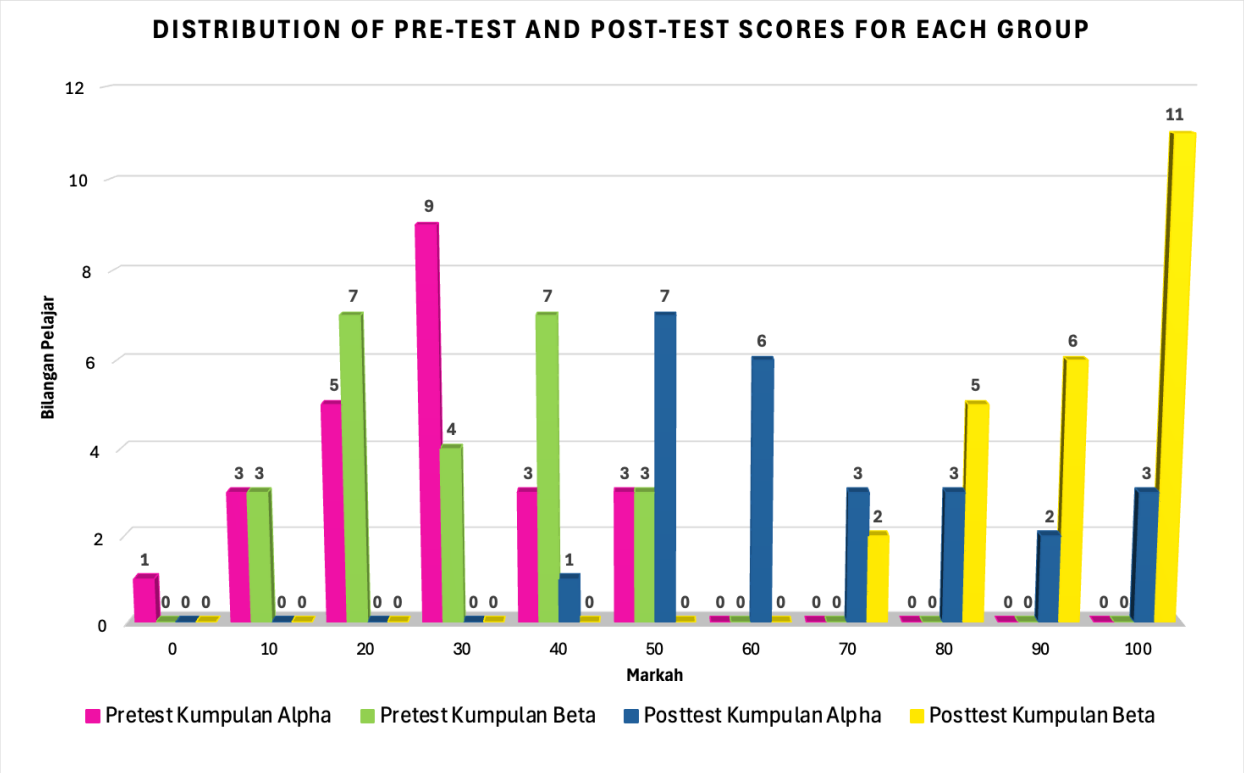

Figure 3. Distribution of Pre-Test and Post-Test Scores for Each Group.

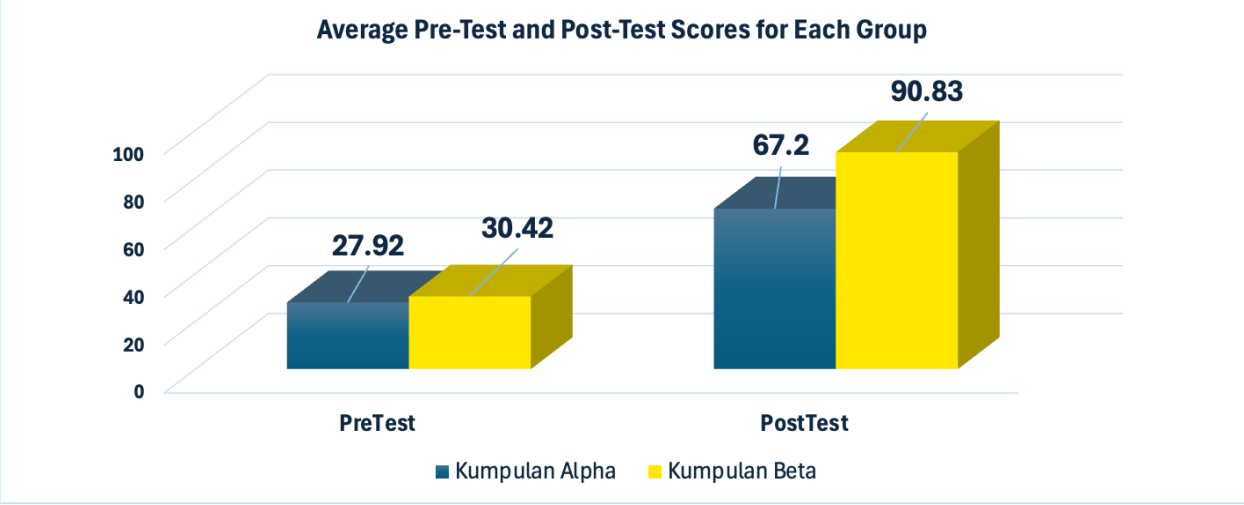

Figure 4. Average Pre-Test and Post-Test Scores for Each Group.

Table 1. Financial Implication.

No.	Materials	Price per unit (RM)	Quantity	Total (RM)
1.	Acrylic Box (300mm x 200mm x 40mm) + UV-Printed Schematic Diagram	89.00	1	89.00
2.	3D Acrylic Plate Electronic Component Symbol (2mm x 50mm)	5.00	8	40.00
3.	Reed Switch	1.10	1	1.10
4.	Neodymium Magnet	1.70	14	23.80
5.	LED (Blue, Purple, Red)	2.00	3	6.00
6.	Buzzer	2.40	1	2.40
7.	Copper Plate (20mm x 30mm)	0.10	2	0.20
8.	Resistor (470 Ω)	0.20	1	0.20
			Total	**162.70**

3. Novelty and uniqueness

The EziTranz Kit is a unique "paste and play" educational tool that transforms abstract electronics concepts into interactive, hands-on learning experiences. Unlike conventional electronic component kits, it uses simple magnetic to represent circuit elements, allowing students to assemble and test circuits directly on a board without wiring or risk of component damage. Its design is aligned with exam-format transistor schematics, making it directly relevant for secondary school assessments. The kit's combination of simplicity, interactivity, and educational alignment is original, providing a visually intuitive and practical approach that has not been widely available in traditional physics classrooms.

4. Benefit to mankind

The EziTranz Kit enhances STEM education by making electronics learning accessible, engaging, and safe. It improves conceptual understanding, builds confidence, and reduces anxiety in topics like transistor circuits. By linking schematic diagrams to real-time feedback, it develops problem-solving, critical thinking, and hands-on skills. Teachers benefit from a reusable, practical tool that lowers material costs. The kit fosters inclusive learning, motivation in STEM, and long-term skill development, empowering the next generation of engineers, scientists, and innovators.

5. Innovation and Entrepreneurial Impact

The EziTranz Kit fosters innovation by providing an interactive, modular approach to electronics learning that bridges theory and practice. It encourages creativity, experimentation, and problem-solving while promoting entrepreneurial thinking. Scalable and classroom-ready, the kit can be implemented in KPM secondary schools and universities, supporting STEM education, inspiring innovative teaching and learning methods, and creating opportunities for further development, commercialization, and collaboration within the educational and academic community.

6. Potential commercialization

The EziTranz Kit has strong commercial potential as a classroom-ready learning tool. Its scalable, reusable design allows adoption in schools, STEM centers, and private tutoring programs, providing an innovative, cost-effective solution for electronics education.

7. Acknowledgment

We would like to express our gratitude to the school administration, colleagues, and students who supported the development and testing of the EziTranz Kit. Their cooperation and feedback were invaluable in refining the kit and validating its effectiveness in enhancing electronics education.

8. Researcher Biography

Nurin Jazlina binti Ahmad is a Physics teacher at MRSM Baling, with 3 years of teaching experience. She holds a Master of Science (Physics) and has published research on graphene in the journal Carbon Letters. Passionate about STEM education, she focuses on developing innovative learning aids, particularly for electronics, to make abstract concepts more accessible and engaging. Her work emphasizes hands-on, practical learning that enhances conceptual understanding, problem-solving skills, and student motivation.

Nur Faraliyana binti Mohammad Nasri is a Physics teacher with 10 years of teaching experience at MRSM Baling. Throughout her career, she has demonstrated a strong commitment to nurturing students' understanding of Physics through innovative and student-centered approaches. She holds a Master of Education in Curriculum and Pedagogy, equipping her with advanced expertise in instructional design, curriculum development, and effective teaching strategies. Her passion for education continues to inspire learners to excel academically while developing critical thinking and problem-solving skills.

AI-Based Asynchrony Breathing Detection System

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ABSTRACT

Patients on mechanical ventilation in the Intensive Care Unit (ICU) often experience asynchrony breathing (AB), which occurs when spontaneous breathing patterns do not align with the ventilator-delivered respiratory cycle. Repeated AB patterns can affect the assessment of respiratory mechanics and ventilation management. Moreover, AB may appear in several types of breathing patterns, each distinguished by its own waveform characteristics. Thus, this study proposed an AI-based classification model for accurately identifying AB patterns and developed a graphical user interface (GUI) in Google Colab to assist clinicians in ventilator management. Traditional AB detection relies on one-dimensional airway pressure time-series data, which poses difficulties in identification due to variations in cycle duration and inconsistent patterns. To address limitations, the proposed method transforms the one-dimensional airway pressure signals into two-dimensional graphical representations, allowing a convolutional neural network to automatically extract features and enhance AB classification accuracy and reliability. The system facilitates earlier AB detection, reduces clinical workload, and improves the quality, safety, and efficiency of critical care services. With its non-invasive GUI integration, the system enhances patient safety, supports more responsive ventilator management, and demonstrates strong potential for clinical adoption and future commercialization, aligning with SDG3 by promoting safer and more effective healthcare delivery.

Keywords: Asynchrony Breathing (AB), Convolutional Neural Network (CNN), One-dimensional, Two-Dimensional

1. Product Description

The proposed system is an AI-based smart diagnostic tool designed to classify AB using airway pressure waveform data, contributing to SDG 9 by leveraging advanced digital technologies that strengthen innovation and enhance medical infrastructure. The system overcomes the limitations of traditional AB methods, which rely on one-dimensional airway pressure time-series data that are affected by variations in cycle duration and irregular breathing patterns. The prior step in this innovation involves converting conventional one-dimensional airway pressure data into two-dimensional airway pressure graphical representations, which provide a standard way to visualize each breathing cycle. These images are then analyzed using three layers of CNN architecture to minimize overfitting. In the classification phase, the final layer classifies the breathing cycles into three categories: (1) Normal Breathing (NB), (2) Reverse Triggering (RT), and (3) Premature Cycling (PC). Finally, a GUI was developed using Python in Google Colab to assist clinicians in managing ventilator settings, transforming into a practical and user-friendly tool for end users.

The system was trained and validated using a dataset of 3,600 annotated breathing cycles collected from ICU patients. Performance evaluation using 5-fold cross-validation demonstrated high accuracy, with an average of 98.8%, highlighting the system's potential as a reliable tool for supporting ventilator management in clinical settings.

2. Framework and Graphical User Interface (GUI)

Figure 1 presents the proposed framework for AB classification, illustrating the complete workflow of the proposed AB classification system, which is divided into three phases. The process begins with the input phase, where the input one-dimensional airway pressure data signals are converted into two-dimensional graphical images. These images are then processed in the Classification Phase using CNN architecture to extract features and minimize overfitting. Finally, the output phase categorizes the breathing cycles into 3 classes, NB, RT and PC, to facilitate accurate performance evaluation. Meanwhile, **Figure 2** displays the graphical user interface (GUI) that presents the results of AB detection. The interface begins with a user-friendly input section, shown in panel (a), where raw data can be easily uploaded for analysis. The subsequent panels demonstrate the system's diagnostic capabilities by displaying the visual signal alongside the prediction results. Specifically, panels (b), (c), and (d) show the system successfully classifying NB, RT and PC respectively, with each classification achieving a high confidence score of 100%.

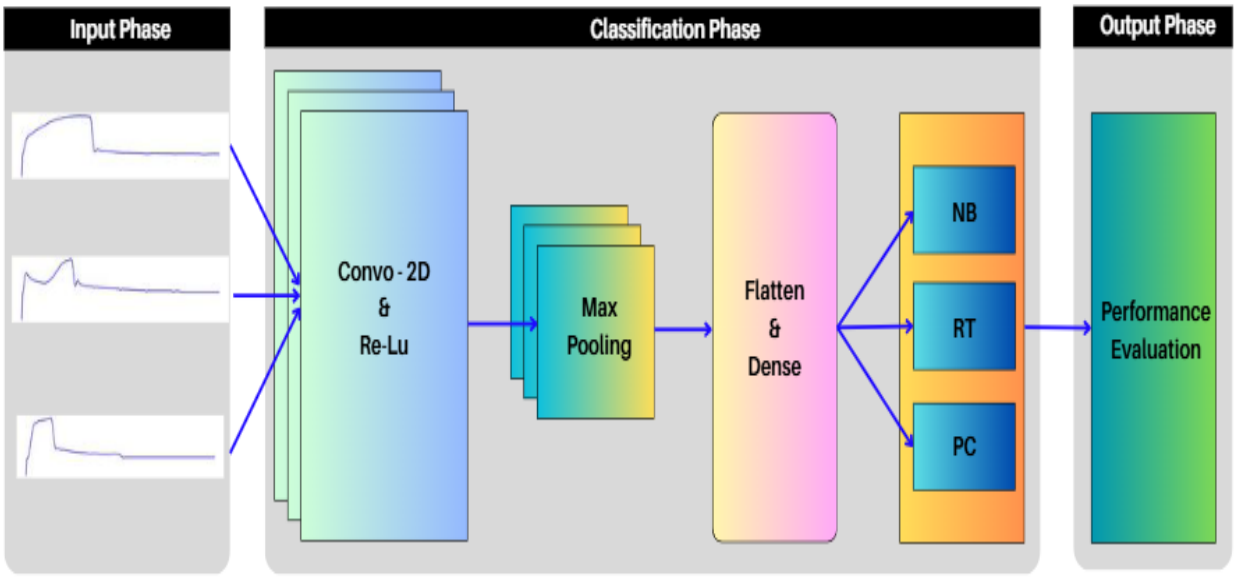
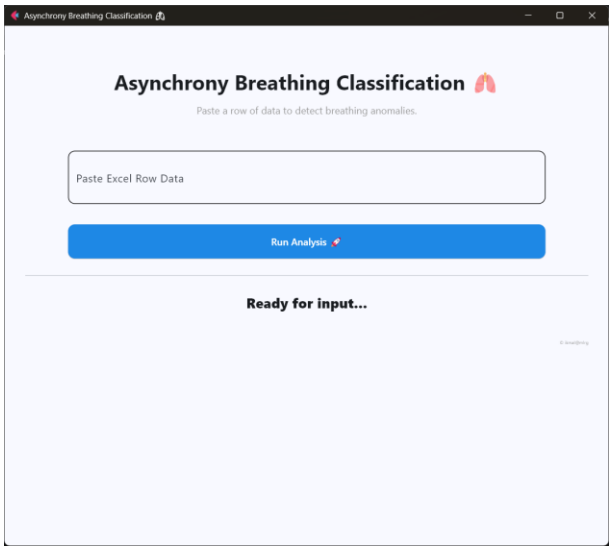
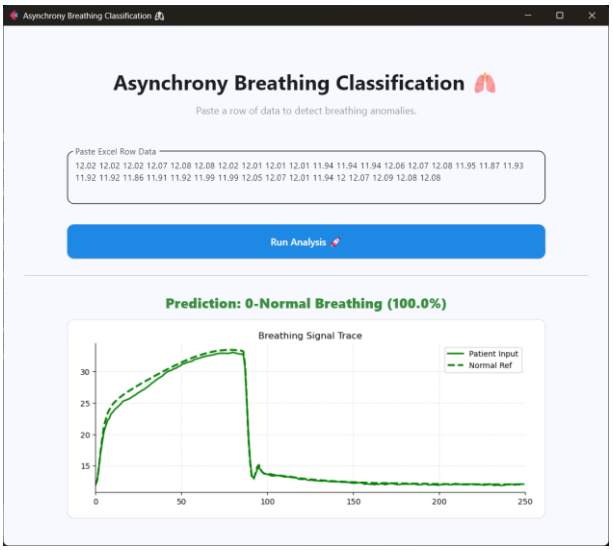


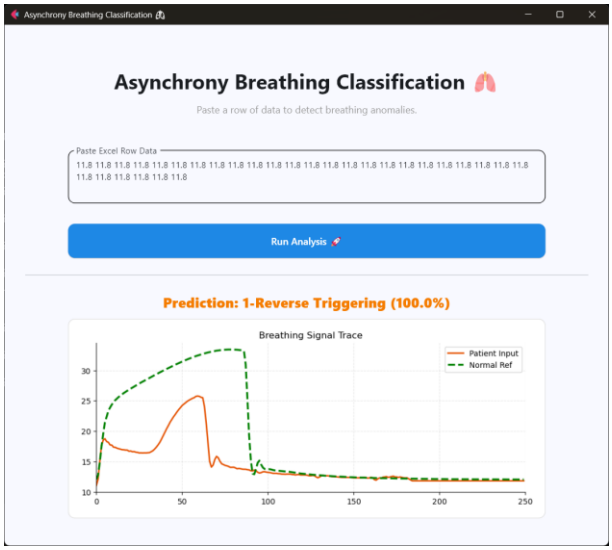
Figure 1. Asynchrony Breathing Classification Framework.



(a) User Interface



(b) Output when system predicted normal breathing with 100% accuracy


Asynchrony Breathing Classification
Asynchrony Breathing Classification
Paste a row of data to detect breathing anomalies.
Paste Excel Row Data
11.8 11.8 11.8

graphical format improves adaptability across different ventilator modes and patient conditions. Moreover, lightweight and non-invasive architecture design requires no additional equipment. Collectively, these features establish a distinct framework that enhances classification reliability and reduces clinical workload.

4. Benefit to mankind

The proposed system offers several benefits for patients requiring mechanical ventilation (MV). It enables earlier detection of AB, allowing clinicians to intervene promptly and reduce the risk of ventilator-induced lung injury. In addition, the system supports clinical decision-making through continuous monitoring. Moreover, reducing reliance on highly specialized staff allows less-experienced clinicians to monitor patients with greater confidence. Its automated and standardized assessment minimizes variations in individual clinical judgement, promoting a more consistent evaluation of patient-ventilator interactions. The non-invasive design ensures patients remain comfortable during continuous monitoring in the ICU.Overall, the proposed system facilitates more responsive ventilator management, delivers more personalized respiratory care, and enhances efficiency in clinical workflows, ultimately improving overall ventilation management.

5. Innovation and Entrepreneurial Impact

The system represents a significant advancement in applying deep learning methods to clinical decision-support practices in critical care. The newly developed system can integrate with existing ventilator monitoring systems, enabling healthcare institutions to implement AI-driven analysis without major hardware upgrades. This new approach fosters collaboration among clinical teams, engineers, and technology developers.

From an entrepreneurial standpoint, this innovation system demonstrates strong potential. It can be offered as an extension to the existing software or integrated into cloud-based ICU monitoring services. Its flexible design allows implementation in public and private hospitals, training facilities, and ICU environments. The system's scalability makes it a practical solution for enhancing AI-enabled healthcare technologies, both within Malaysia and internationally, supporting broader adoption of innovative medical tools.

6. Potential commercialization

The system demonstrates significant commercialization potential due to its high accuracy, non-invasive method, and ability to integrate with the existing MV equipment. As a software-based decision-support tool capable of assisting ventilator management, it offers simpler solutions that do not require additional hardware. In addition, the system is well aligned with the integration of AI in healthcare and the growing demand for automated patient monitoring. These features enhance its clinical relevance, support broader acceptance, and facilitate approval for real-world ICU applications. In conclusion, this innovation contributes to SDG 3 by enhancing the quality and safety of critical care, and to SDG 9 by integrating advanced AI technologies that drive innovation and reinforce modern healthcare infrastructure.

7. Acknowledgment

The authors would like to thank Universiti Teknologi MARA, Cawangan Pulau Pinang, for the research facilities provided throughout this study.

8. Researchers' Biography

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Integrated IoT-AI Smart Aquaponics for Autism Empowerment

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ABSTRACT

This project integrates sustainable agriculture, digital innovation, and inclusive development by implementing an IoT-enabled Nutrient Film Technique (NFT) aquaponics system designed to empower individuals with autism in developing sustainable entrepreneurship skills. The system combines aquaculture and hydroponics to optimize resource use and promote sustainable farming practices, directly contributing to SDG 10: Reduced Inequalities and SDG 12: Responsible Consumption and Production. A smart IoT monitoring system, built using sensors and a NodeMCU ESP8266 microcontroller, continuously tracks key water parameters such as temperature and pH in real time. Data is transmitted to the Blynk application, providing instant alerts and actionable insights to maintain optimal conditions for both fish and plants. Complementing this, an AI-powered harvest prediction system forecasts crop and fish readiness based on growth patterns and environmental data, enabling timely harvesting, minimizing waste, and improving yield quality and consistency. At the heart of the project is the active participation of learners with autism, who engage in the operation and management of the system. Through hands-on training in IoT technology, AI-assisted decision-making, data analysis, and agribusiness practices, these learners acquire practical technical skills and entrepreneurial knowledge, fostering greater independence, social inclusion, and long-term empowerment.

Keywords: IoT-enabled Aquaponics, Inclusive Entrepreneurship, Autism Empowerment, Smart Sustainable Agriculture, AI-based Harvest Prediction

Product Description

This product is an IoT-enabled Nutrient Film Technique (NFT) aquaponics system designed to support efficient, sustainable food production while enabling inclusive entrepreneurship for individuals with autism. The system integrates aquaculture and hydroponics in a compact, resource-efficient farming unit that optimizes water circulation, nutrient delivery, and energy consumption, contributing to SDG 10: Reduced Inequalities and SDG 12: Responsible Consumption and Production. It is equipped with water quality sensors connected to a NodeMCU ESP8266 microcontroller, enabling continuous real-time monitoring of key parameters such as temperature and pH. Collected data is transmitted to the Blynk mobile application, providing instant alerts, system status updates, and actionable insights to maintain optimal fish and plant growth conditions. The product also features an AI-powered harvest

prediction module that analyzes environmental and growth data to forecast crop and fish readiness, supporting timely harvesting, reducing waste, and ensuring consistent yield quality. Designed for ease of use and scalability, the system incorporates structured operational workflows that allow learners with autism to manage daily operations, monitor data, and perform basic agribusiness activities, positioning the product as both a smart farming solution and an inclusive entrepreneurship platform.

2. Methodology

System Block Diagram

Figure 1 illustrates the monitoring system for water quality in NFT aquaponics. The system includes multiple data sensors together with a microcontroller and output units which maintain consistent environmental conditions that benefit fish as well as plants. The monitoring system operates with six input devices that consist of three ultrasonic sensors alongside an ammonia sensor and a pH sensor and a temperature sensor. The ultrasonic sensors monitor water level in addition to filtered plant height and unfiltered plant height measurements. Real-time monitoring of water measurements occurs through ESP32 microcontroller processing received data from sensors. The received data undergoes processing on the ESP32 until the system identifies the need for any required intervention. The information travels through processing to two display terminals consisting of an I2C LCD that shows real-time conditions at the site and the Blynk application that provides IoT-based distant oversight capabilities. Users receive warning notifications from the system when any monitored parameter falls beyond its prescribed optimal range.

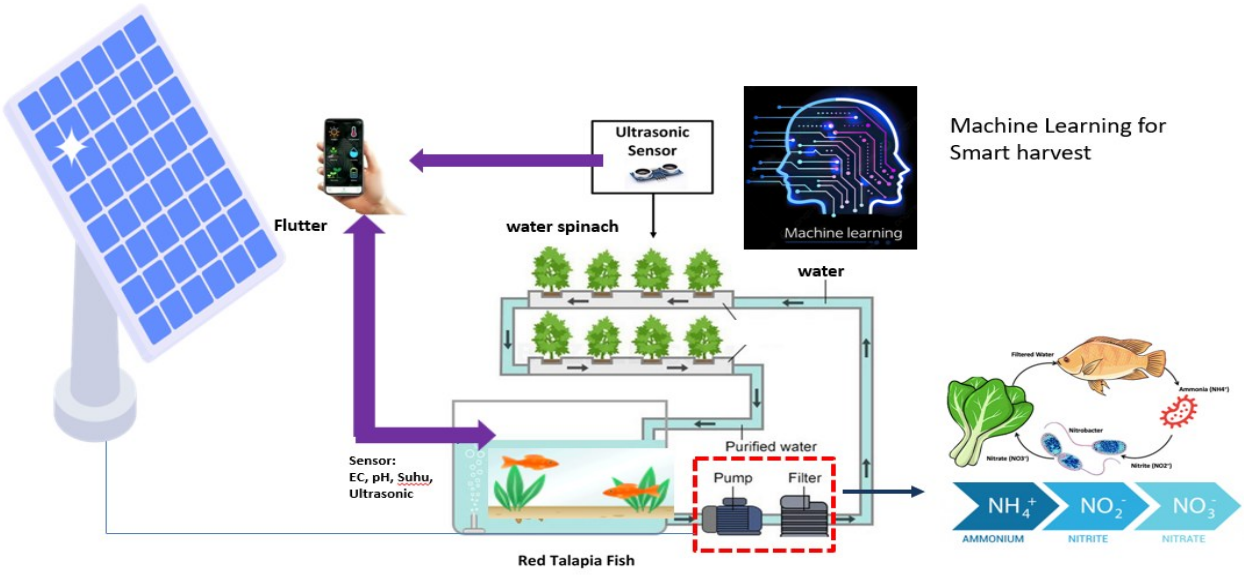

Figure 1. IoT and Artificial Intelligence-Based Aquaponics Monitoring System.

Figure 2 shows the simplified process of AI and IoT based for aquaponic system. The process begins with algorithm initialization, where predefined machine learning algorithms are configured to monitor aquaponics system performance by defining key parameters such as water

temperature, pH, dissolved oxygen, and growth duration for both fish and plants. Real-time data is then continuously collected from IoT sensors installed within the system and undergoes data cleaning, filtering, and analysis to identify trends, variations, and correlations between environmental conditions and growth performance. Using both historical and real-time data, the machine learning model learns and recognizes growth patterns, identifying optimal environmental ranges as well as conditions that contribute to healthy growth or reduced productivity. Based on these learned patterns, the system performs optimization and automation by adjusting operational parameters such as water circulation, feeding schedules, and nutrient balance, while generating alerts and recommendations to guide users or trigger automated responses. Finally, the trained machine learning model predicts the optimal harvest time for fish and crops by analyzing growth rates and environmental stability, enabling timely harvesting, reducing waste, improving yield consistency, and supporting more efficient production planning.

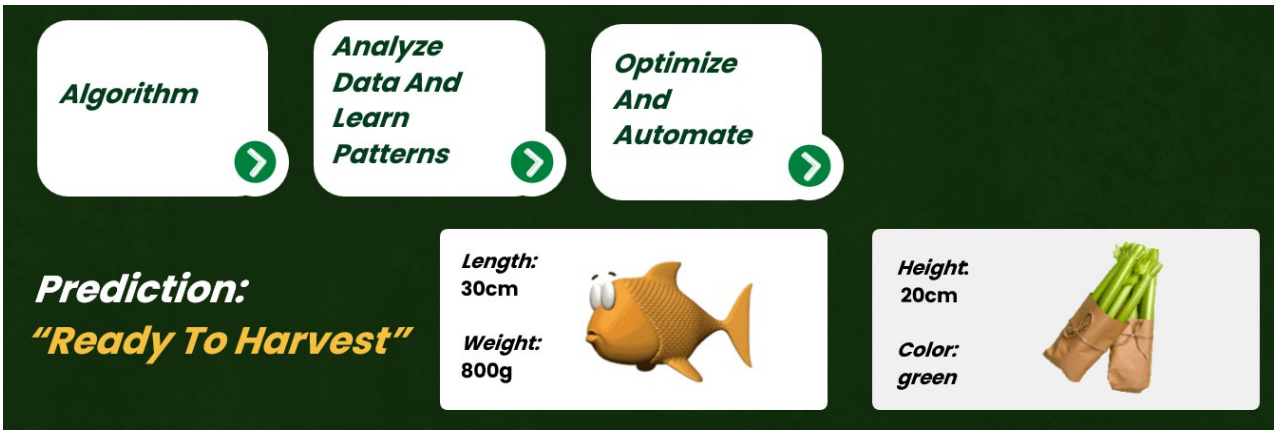

Figure 2. Simplified process for AI and IoT Based for Aquaponic System.

Flowchart of the System

Figure 3 displays how Blynk application uses real-time monitoring and process data collection to report critical parameters for quick user-triggered solutions when problems arise. The system starts its operation by attempting Wi-Fi connection since this capability enables both remote system access and notification features. The system tries reconnecting endlessly until it establishes a successful link with Wi-Fi. After establishing a connection, the system starts gathering real-time sensor data from ammonia sensors in combination with water pH sensors as well as water temperature 24 sensors with water level sensors and plant height measurement through ultrasonic sensors. The system shows information from data collection on a local LCD display screen. The system works to check every measured parameter to ensure they stay within proper limits after completion of data acquisition. The monitoring system starts by examining water ammonia concentrations. Blynk sends an alert notification through the platform when ammonia reaches 0.5 ppm because high ammonia concentrations are hazardous to fish 27. The pH measurement system checks water acidity to maintain a pH range from 6.5 to 8. The device sends warnings to users when pH levels become unstable thus affecting fish health and plant growth. Stable aquaponic ecosystems depend on proper water temperature management. The system operates to maintain water temperature inside the suggested parameters of 25°C to 30°C 27. When water temperature goes beyond the defined range a warning message will activate to prompt immediate remedial action against thermal stress on aquatic creatures.

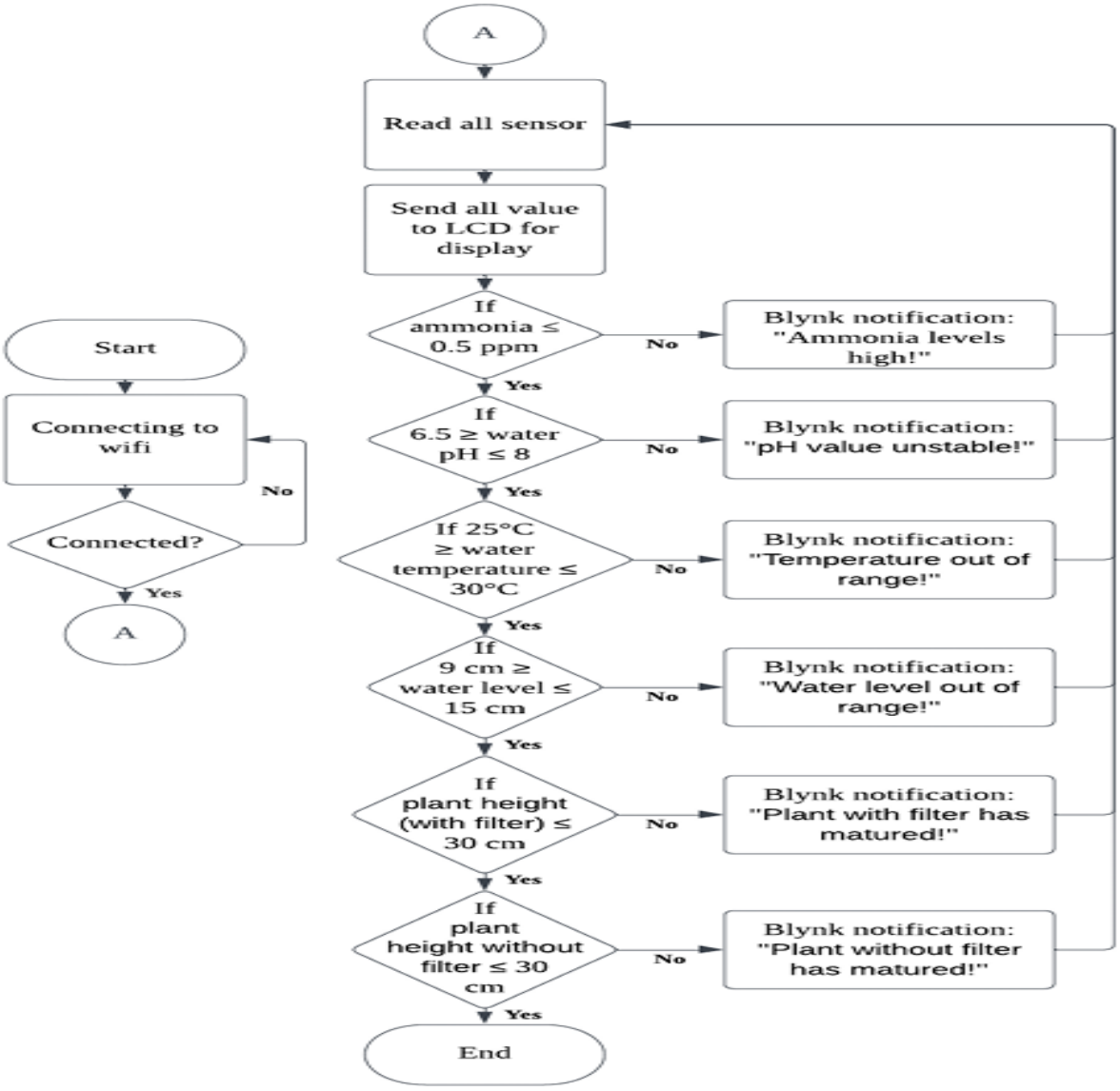

Figure 3. Flowchart of the System.

The monitoring system functions to check water levels and ensures they stay between 9 cm and 15 cm to stop the dehydration of plants while preventing water overflow. Users will receive automatic alerts whenever the water measurement falls beyond acceptable ranges. The monitoring system tracks plant growth through ultrasonic sensors aside from its water quality observing capabilities. The flowchart describes two groups: plants with filtration and those without filtration. The system will issue a confirmation message when a plant with the filter tool reaches a height higher than 30 cm. The system provides an alert for plants without filters when they achieve a height of 30 cm during growth. The system helps measure filtration effects on plant development through this comparison method. The IoT-based monitoring system enables this system to use automated processes while eliminating the need for continuous human supervision. Users receive instant Blynk application alerts that enable them to take immediate actions that preserve proper conditions for fish and plants. The flowchart presents the step-by-step how

decision-making occurs by using sensor feedback to maintain balanced aquaponics through automated alert systems.

Monitoring System

Figure 4 shows Blynk users develop an application with real-time sensor data display and maintain perfect connection between sensor data and mobile user interface. The provided picture of the Blynk mobile app showcases sensor data monitoring in real time thus verifying the app accurately presents live sensor outputs. The system provides accurate monitoring capabilities to users along with easy control functionalities through remote observation of essential parameters. A monitoring solution for the aquaponic system works efficiently through modern IoT technology utilization of the ESP32 module along with Blynk Cloud platform. Real-time accurate data presentation in the system enables effective user management because users can make informed decisions that boost productivity and sustainability.

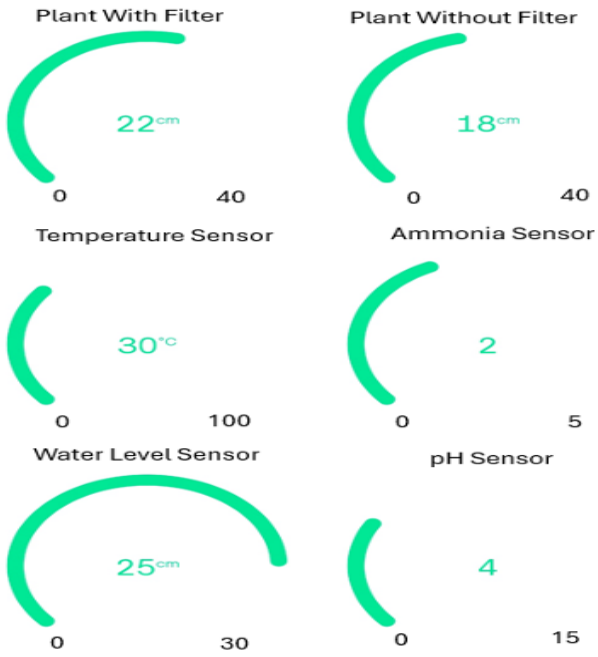

Figure 4. Monitoring System.

3. Novelty and uniqueness

This project is novel in its integration of IoT-enabled aquaponics with artificial intelligence–based harvest prediction specifically designed to support inclusive entrepreneurship for individuals with autism. Unlike conventional aquaponics systems that focus primarily on food production, this product embeds smart monitoring, AI-assisted decision-making, and simplified operational workflows to enable active participation by learners with autism. The use of real-time IoT sensors combined with machine learning allows continuous monitoring of environmental conditions and predictive analysis of fish and crop readiness, ensuring timely harvesting, reduced waste, and consistent yield quality. The AI-driven harvest prediction feature represents a unique advancement by transforming raw sensor data into practical, actionable insights that support production planning and business sustainability. Additionally, the system is designed with user-friendly interfaces, automated alerts, and structured task flows that align with the learning needs

of individuals with autism, making advanced smart farming technologies accessible and inclusive. This combination of sustainable food production, digital innovation, and social inclusion distinguishes the project from existing aquaponics solutions and positions it as both a technological and social innovation.

4. Benefit to mankind

This project benefits mankind by promoting sustainable food production, digital innovation, and social inclusion through an intelligent aquaponics system. By integrating IoT monitoring and AI-based harvest prediction, the system improves resource efficiency, reduces food waste, and ensures consistent crop and fish yields, contributing to global food security and environmental sustainability. The project also creates inclusive economic opportunities by empowering individuals with autism with practical technical and entrepreneurial skills, fostering independence, employability, and social participation. Communities benefit from access to affordable, locally produced, and environmentally responsible food, while small-scale farmers and social enterprises gain a scalable smart farming solution that enhances productivity and decision-making. Additionally, the project supports the broader adoption of precision agriculture technologies, encouraging responsible consumption and production practices. By combining technological advancement with inclusive development, the project contributes to a more resilient, equitable, and sustainable society.

5. Innovation and Entrepreneurial Impact

This project represents a pioneering innovation in Malaysia by integrating IoT-enabled aquaponics and AI-based harvest prediction to create an inclusive entrepreneurship platform specifically for individuals with autism. It transforms traditional farming practices into a technology-driven, accessible, and socially empowering enterprise. By providing learners with autism hands-on experience in smart agriculture, data analysis, and AI-assisted decision-making, the project fosters practical technical skills, business acumen, and independent income-generation opportunities. The system's scalability allows for community-based or small-scale social enterprises, enabling autistic individuals to participate in sustainable food production and agribusiness. Beyond skill development, this innovation promotes social inclusion, reduces economic inequality, and highlights Malaysia's potential as a hub for socially responsible tech-driven entrepreneurship. The combination of sustainable agriculture, digital technology, and tailored training positions this initiative as a unique model for inclusive economic growth and technological empowerment for marginalized communities in the country.

6. Potential commercialization

The IoT- and AI-enabled aquaponics system has strong commercialization potential, demonstrated through its successful implementation at Pusat Pemulihan Dalam Komuniti Teluk Bahang, Pulau Pinang, Pusat Jagaan Insan Istimewa Subang Jaya, Selangor, and Sekolah Rendah Padang Jawa, Selangor, supported by a total KPT grant of RM155,900. Beyond its technological innovation, the system serves as a platform to develop an entrepreneurial community among individuals with autism, providing practical training in smart agriculture, business operations, and AI-assisted decision-making. Its scalability and modular design allow deployment in rehabilitation centers, special care institutions, schools, and community farms, generating opportunities for inclusive agribusiness ventures. The system not only produces sustainable food but also creates income streams for autistic entrepreneurs while fostering social inclusion. With increasing

interest in smart farming and socially responsible enterprises, this product has strong market viability and the potential to expand across Malaysia as a model for inclusive, technology-driven agropreneurship.

7. Acknowledgment

The team would like to express sincere gratitude to Kementerian Pendidikan Tinggi (KPT) for the funding and continuous support that made this project possible. Special thanks are extended to Jabatan Pertanian and Jabatan Perikanan for their technical guidance and expertise in sustainable aquaponics and aquaculture practices. We also acknowledge Al- hikmah Agro Sdn. Bhd. for their invaluable industry insights and collaboration in system implementation. Appreciation is given to Kementerian Pendidikan Malaysia for facilitating educational access and opportunities for learners from the B40 community. We are especially grateful to PPDK Teluk Bahang, Pulau Pinang and Pusat Jagaan Insan Istimewa, Subang Jaya, Selangor for hosting the aquaponics system and enabling active participation from the autism community. Finally, we thank the Faculty of Electrical Engineering for their support in the development and integration of IoT and AI technologies, which formed the backbone of this smart aquaponics system. The combined contributions of these organizations and communities have been instrumental in achieving the objectives of this inclusive and innovative project.

8. Researchers' Biography

Assoc. Prof. Ir. Ts. Dr. Suzi Seroja Sarnin was born on January 28, 1974, in Selangor, Malaysia. She earned her Bachelor of Electrical and Electronics Engineering (Communication) from Universiti Teknologi Malaysia, Skudai, in 1999, completed her Master in Microelectronics from Universiti Kebangsaan Malaysia in 2005, and obtained her PhD in Electrical Engineering from Universiti Teknologi MARA, Shah Alam. She previously worked as a Quality Control Engineer at Memory Tech Sdn. Bhd., Subang Jaya, Selangor. She has been serving as a lecturer at Universiti Teknologi MARA, Shah Alam, since 2001 and is currently an Associate Professor. She has held several key leadership positions, including Head of the Communication Studies Centre, Head of Programme for the Bachelor of Electrical and Electronics Engineering Technology with Honours, Coordinator of Electrical Engineering Entrepreneurship, University Strategic Transformation Coordinator and Chair of Continuous Quality Improvement. She has won numerous Gold Awards and received recognition for outstanding innovation and invention from 2017 to the present, and has also authored a chapter in the book Best Practices at FKE 2018.

Dr. Norlela Ishak is a Senior Lecturer at the School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA (UiTM), Shah Alam. She holds a PhD in Electrical Engineering from UiTM with joint supervision from Universiti Teknologi Malaysia (UTM). Her research interests include computational modelling of control systems, control and automation, tracking control strategies, and Internet of Things (IoT) applications for smart monitoring. She is a member of IEEE, a registered Graduate Technologist with the Malaysia Board of Technologists (MBOT), and serves as a committee member for the IEEE International Conference on Automatic Control and Intelligent Systems (I2CACIS).

Zahari Abu Bakar obtained his Diploma in Electrical Engineering (Electronics) from UiTM Pulau Pinang, Bachelor of Electrical (Hons) Engineering and MSc. in Telecommunication and Information Engineering from UiTM Shah Alam. Currently, he serves as a senior lecturer at UiTM Cawangan Johor Kampus Pasir Gudang in Electronics Department. His primary research interests include e-learning, the Internet of Things, and Machine Learning.

Muhammad Adam Danish Bin Hisham is a student of Electrical Engineering (Electrical) at UiTM Pasir Gudang, who has consistently excelled academically, receiving the Dean's List Award every semester. He has demonstrated remarkable talent in innovation and invention, winning three Gold Awards in 2022, 2023, and 2024. His achievements reflect both technical proficiency and creativity, highlighting his potential as a future leader in engineering and technology.

Eco-Gemma: Context-Aware Smart Fertigation Agent Powered by Generative AI and Edge Computing

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ABSTRACT

Conventional fertigation systems predominantly rely on rigid timer-based schedules, which fail to adapt to dynamic weather conditions. This rigidity leads to fertilizer wastage during rainfall and crop damage, such as fertilizer burn, during extreme heat. Eco-Gemma introduces an industrial-grade solution by integrating the Internet of Things (IoT) with a Dual-Mode Hybrid Generative Artificial Intelligence (GenAI) architecture to create a context-aware fertigation agent. Unlike rule-based automation, Eco-Gemma operates on a two-tier intelligence model. During stable internet connectivity, it utilizes Google AI Studio via API for rapid, complex analytical processing. In the event of network failure, it automatically initiates a failover to Edge Computing, running a Small Language Model (Gemma 2B) locally via Ollama to analyze real-time data from soil moisture, pH, and temperature sensors. The system dynamically adjusts irrigation strategies—switching from fertilization to cooling modes when high temperatures are detected—ensuring zero downtime. Furthermore, it utilizes a synchronized dual-database system (local CSV and Google Sheets) to prevent data loss. This innovation significantly reduces operational costs by preventing chemical leaching and enhances crop survival rates. Eco-Gemma bridges the gap between high-tech precision agriculture and affordable farming solutions, offering a sustainable, failsafe tool for modern agropreneurs.

Keywords: Generative AI, Smart Fertigation, Edge Computing, IoT, Precision Agriculture

1. Product Description

Eco-Gemma is a smart fertigation controller designed to solve the rigidity of conventional timers and the total cloud dependency of standard IoT systems. Comprising a low-cost microcontroller (ESP32) and a mini-server (Raspberry Pi/Mini PC), it collects real-time temperature, soil moisture, and pH data. The system is driven by a custom Python script that manages a dual-mode failover mechanism. When online, it leverages Google AI Studio for high-speed processing. When offline, it instantly switches to a local AI model (Gemma 2B). It provides logical explanations for every irrigation action via Explainable AI (XAI) and automatically emails daily agronomic reports to users at 08:00 AM, along with synchronized dual-database logs (local CSV and Google Sheets).

2. Methods and Results

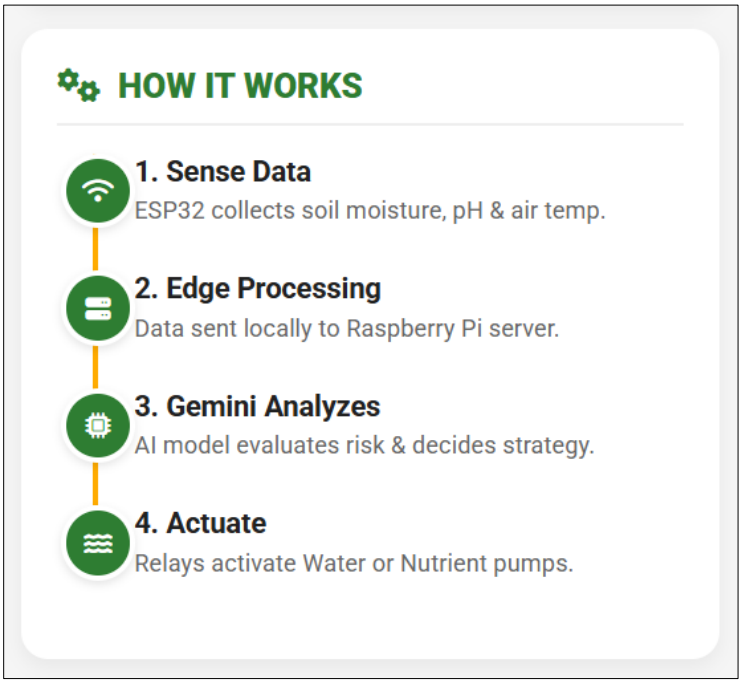

Figure 1. Flowchart illustrating the operational mechanism of the Eco-Gemma system.

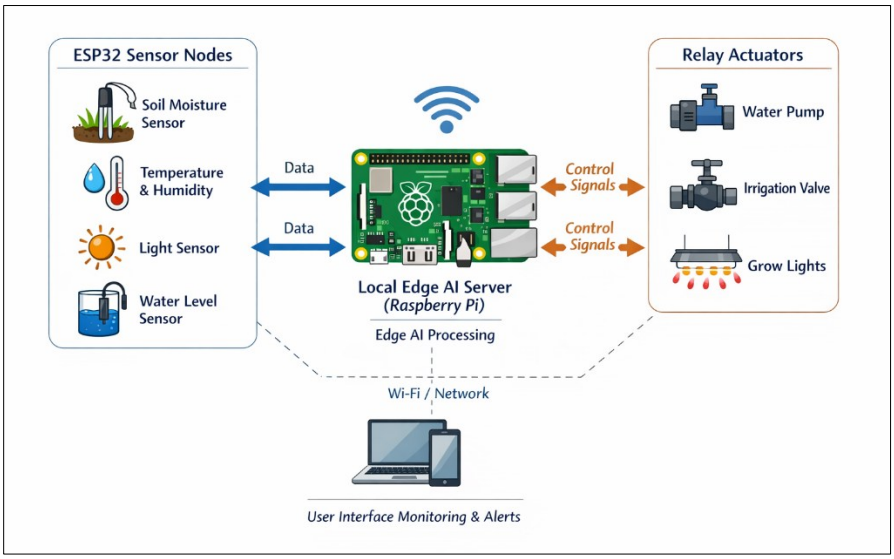

Figure 2. Schematic diagram of the Eco-Gemma system showing the integration between ESP32 sensor nodes, relay actuators, and the Local Edge AI Server (Computer).

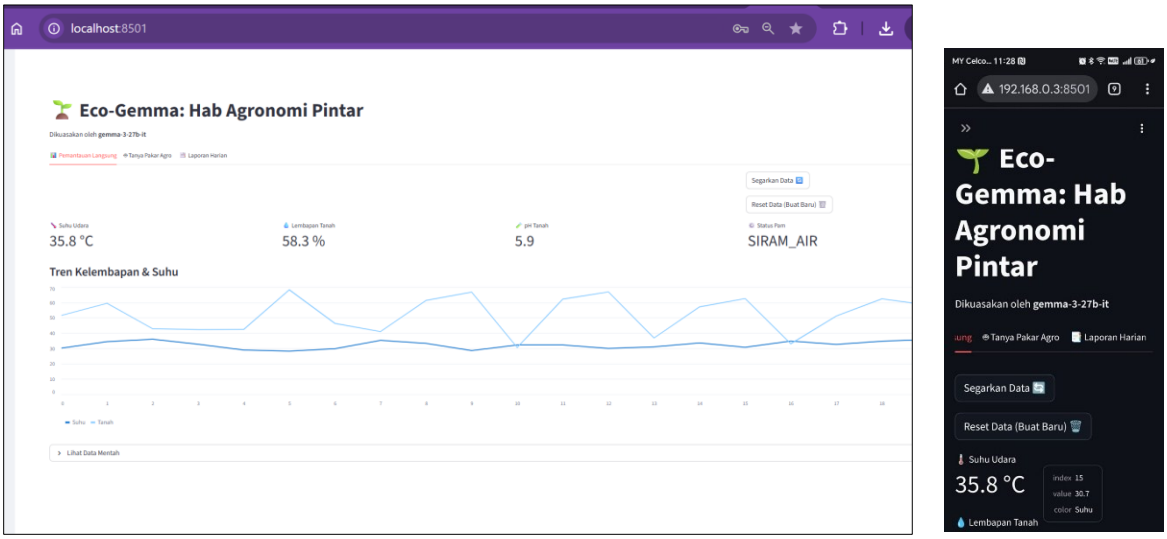

Figure 3. The Eco-Gemma Dashboard interface displaying real-time sensor metrics and the AI's reasoning log (Context-Aware Decision Making).

Figure 4. Chat session with gemma-3-27b-it providing agronomic advice based on sensor data.

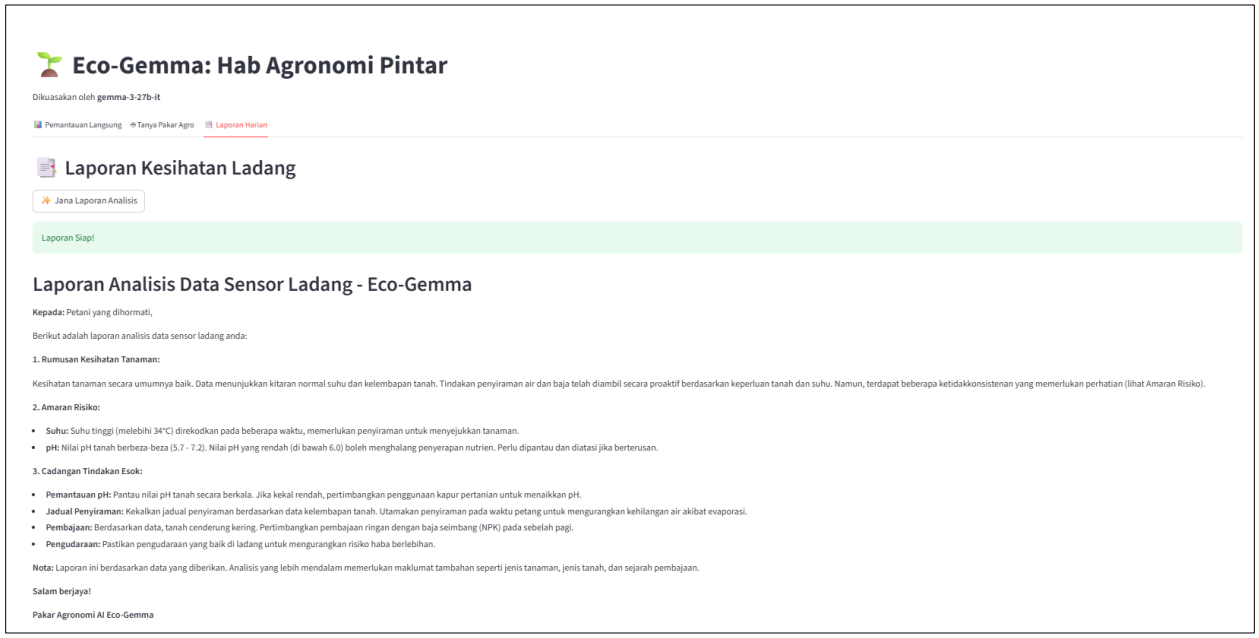

Figure 5. AI-generated 'Laporan Kesihatan Ladang' (Farm Health Report) displaying health summary, detected issues, and actionable recommendations based on historical sensor data.

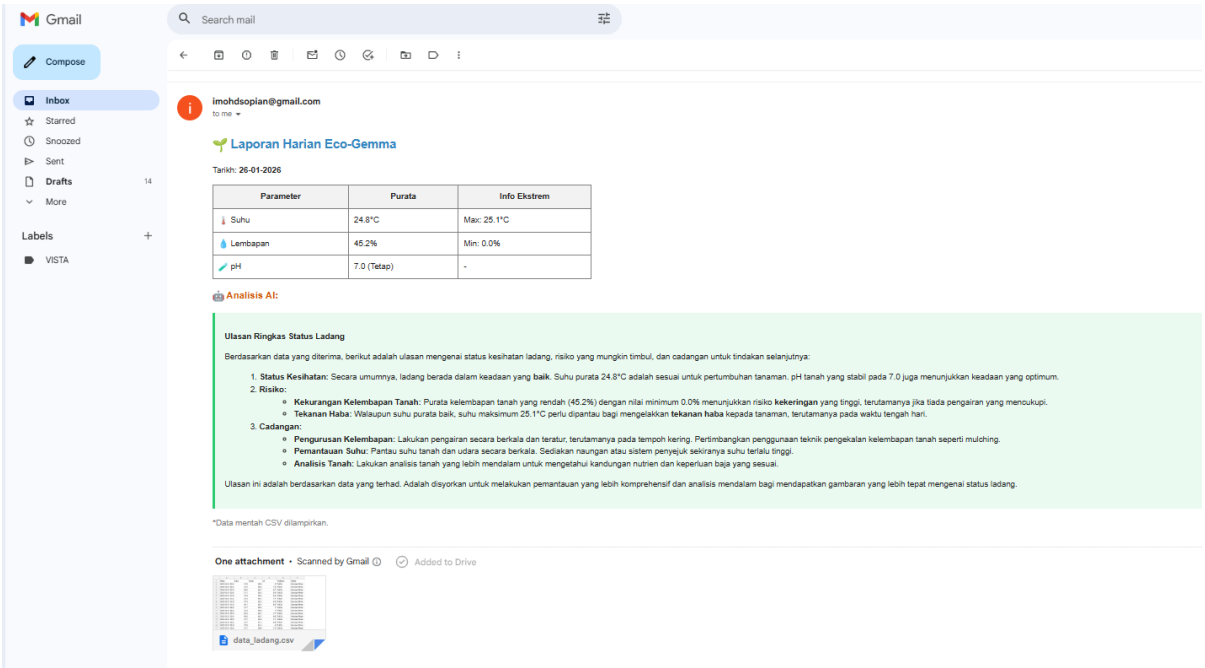

Figure 6. Automated daily email report sent to the farmer, summarizing environmental metrics (temperature, pH, moisture) over the last 24 hours and providing AI-generated agronomic advice.

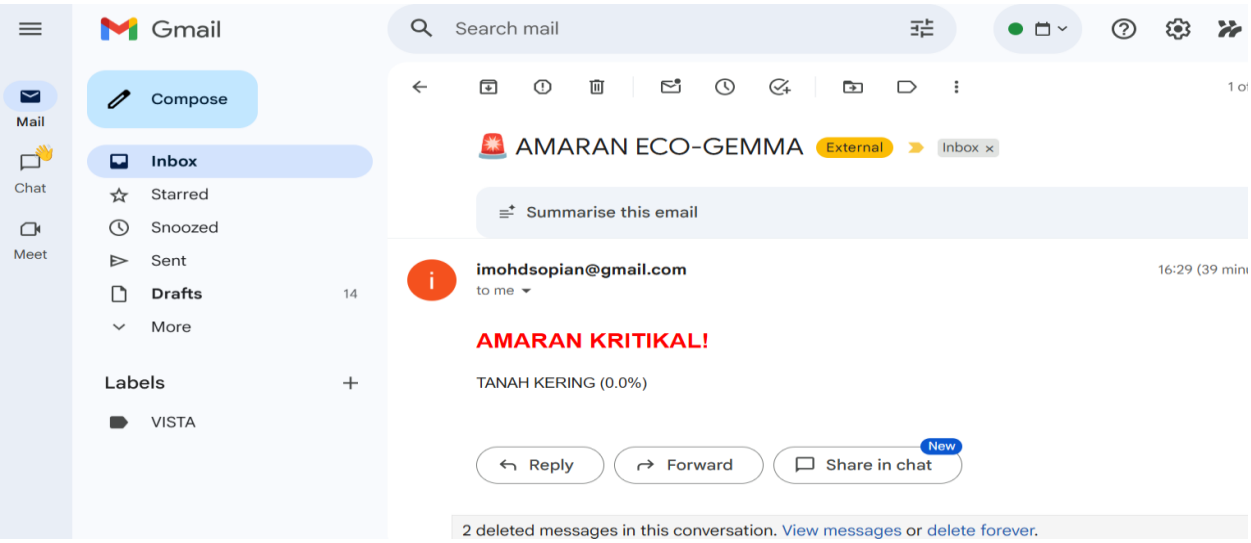

Figure 7. Email alert for critical warning.

Table 1. Performance comparison between Conventional Timer Systems and Eco-Gemma.

Metric	Conventional Timer System	Eco-Gemma (AI Agent)
Decision Logic	Fixed Time Schedule	Context-Aware (Real-time Data)
Heat Response	Continues Fertilizing (Risk of Burn)	Switches to Cooling Mode (Safe)
Internet Dependency	None (Analog) / High (Cloud IoT)	None (Local Edge Computing)
Fertilizer Efficiency	Low (Wastage during rain)	High (Only when needed)

3. Novelty and uniqueness

Eco-Gemma's primary novelty lies in its Dual-Mode Hybrid AI architecture and Explainable AI (XAI) capabilities. Unlike market systems that paralyze without cloud internet, Eco-Gemma features an automated failover to edge computing, running the Gemma 2B model directly on-site without a network signal. It is "context-aware" rather than relying on rigid "If-Else" logic, distinguishing between routine nutritional needs and environmental emergencies. For instance, the AI automatically cancels fertilizer distribution and switches to a pure water cooling mode when ambient temperatures exceed a critical 35°C to prevent root damage. Furthermore, the XAI system prints operational logs in natural language, justifying every pump action, making it highly transparent and intelligent.

4. Benefit to mankind

Eco-Gemma directly supports food security and environmental sustainability. It prevents chemical fertilizer leaching caused by overwatering during rainy seasons—a common flaw in timer systems—thus protecting groundwater quality and surrounding ecosystems. Additionally, its fault-tolerant nature (operating fully without internet) makes this technological solution equitable and widely accessible to rural farming communities. It democratizes advanced technology to effectively boost yields and income for B40 farmers..

5. Innovation and Entrepreneurial Impact

This project cultivates an entrepreneurial culture through a cross-platform business model. At the institutional level (TVET), it drives educational innovation by serving as a comprehensive technical training module combining Python programming, IoT, and AI analysis to produce future automation technologists. For the community agriculture industry, Eco-Gemma unlocks new business potential via a Software as a Service (SaaS) concept. Users do not merely operate hardware; they are encouraged to utilize predictive cloud-based analytics dashboards to optimize farm management. This initiative accelerates the transition from subsistence farming to highly planned agribusiness enterprises..

6. Potential commercialization

With a highly competitive production cost under RM200, Eco-Gemma undercuts conventional imported industrial controllers that cost over RM1,000. There are three main target segments for commercialization:

1. Product Kit: A plug-and-play control module comprising computing devices and ESP32 nodes, catering to hobbyists and small-scale farmers.
2. SaaS Subscription Model: A premium service providing access to cloud processing and historical data analytics for commercial-scale farm operations.
3. Educational Package: A hardware-syllabus module for STEM and TVET institutions.

This low-cost pricing model ensures a high potential for rapid market penetration in Southeast Asia.

7. Acknowledgment

The authors would like to thank IKBN Bandar Penawar for providing the facilities and funding support to develop this prototype. We also express our gratitude to the organizing committee of iTIEC 2026 for the platform to showcase this innovation.

8. Researchers' Biography

Ts Mohd Sopian Bin Ibrahim is currently the Head of the Mechanical/Welding Department at IKBN Bandar Penawar. He has 20 years of experience in TVET, specifically in electrical and air conditioning fields. He has a deep interest in IoT, AI, and DIY projects. As a part-time farmer, he aims to make smart agriculture solutions and industrial automation the primary focus of his innovations

Spill-the-TEA: A Tool for Technoeconomic Analysis of Chemical Production Process Plant

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ABSTRACT
Techno-economic assessment (TEA) of new chemical production process technologies involves two major parts: (i) process simulation, and (ii) calculations of economic parameters. The simulation (part (i)) is unique for each chemical process, but the complex calculations to determine economics feasibility of the process (part (ii)) follow a standard procedure across. **"**Spill-The-TEA" is a spreadsheet that has been developed to serve as a tool for complex economic assessment calculations, offering the advantage of performing quick evaluation. It is designed in Microsoft Excel to perform calculations (capital/operational expenditures, manufacturing costs, fixed capital investments, revenue) by applying equations from Turton et al. (2018). The categories (fixed capital and operating costs/expenses, the sensitivity analysis based on the price movements) are organized by tabs. Users input data (energy/materials' amounts/prices/costs) specific to the chemical process its production plant location. Profitability indicators (net present value, payback period, and discounted cashflow rate of return) and tornado charts presenting the sensitivity analysis, are generated as output. Investors in chemical industries can quickly evaluate the economic feasibility of various potential chemical technologies. Software with interesting graphical user interface can be developed for purchase by licensing. App can be developed for mobile phones.

Keywords: chemical process technologies; feasibility assessment tool; plant feasibility; techno-economics assessment; techno-economics spreadsheet

1. Product Description
"Spill-The-TEA" (Copyright CRLY2025W03889) is a technoeconomic analysis (TEA) spreadsheet, which is a tool designed to assess the feasibility of any new chemical production process technologies (**Figure 1**). Process descriptions and flow, together with the process simulation (**Figure 2**) need to be ready prior to applying "Spill-The-TEA". The process simulation is typically performed using process engineering software tools such as Aspen Plus/Hysys to estimate the energy load requirements for major unit operations and auxiliary equipment (**Figure 3**), and to optimize the process that can add value to the plant economics such as recovering waste heat to generate steam. Users enter relevant input data (e.g., energy from simulation (**Figure 3**), and materials' prices and costs from open sources (**Figure 4**)) involved in the applied equations, which are adopted mainly from Turton et al. (2018). Developed using Microsoft Excel, important economic assessment calculations such as capital and operational expenditures,

manufacturing costs, fixed capital investments, revenue (**Figures 5 – 7**), profitability (net present value, payback period, and discounted cashflow rate of return) (**Figure 8**), and sensitivity analysis due to price movements (**Figure 9**) can be conveniently generated. A software with interesting graphical user interface and its app will be developed for commercialization of "Spill-The-TEA".

2. Interfaces of "Spill-The-TEA"

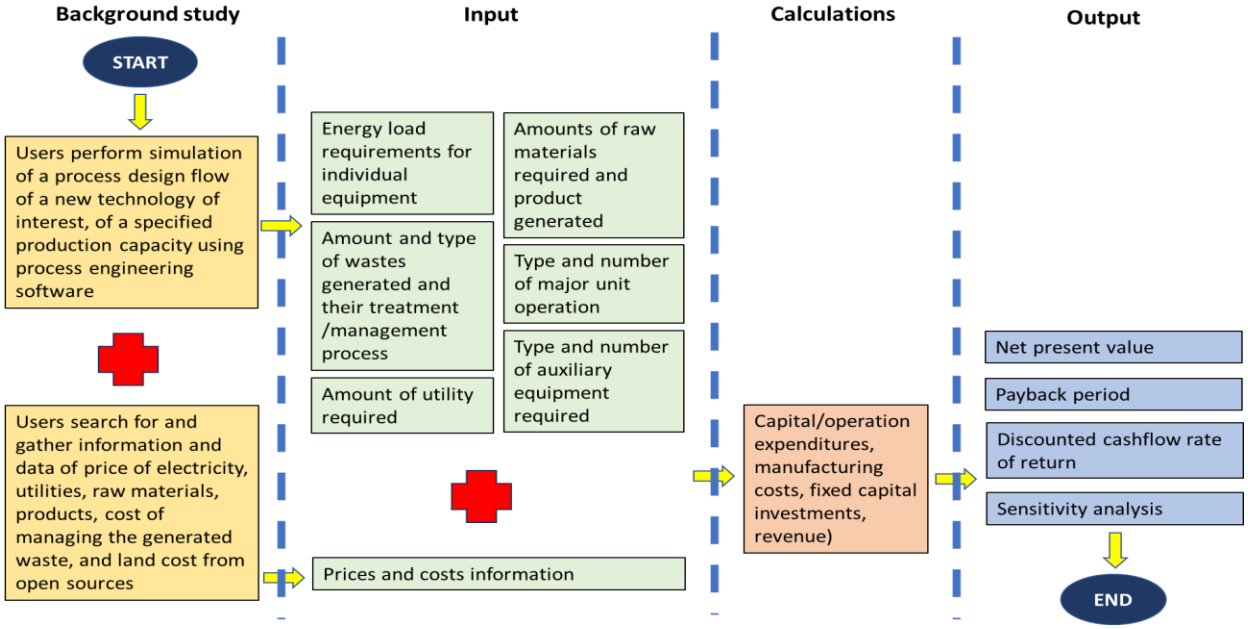


Figure 1. Process workflow to generate output from "Spill-The-TEA".

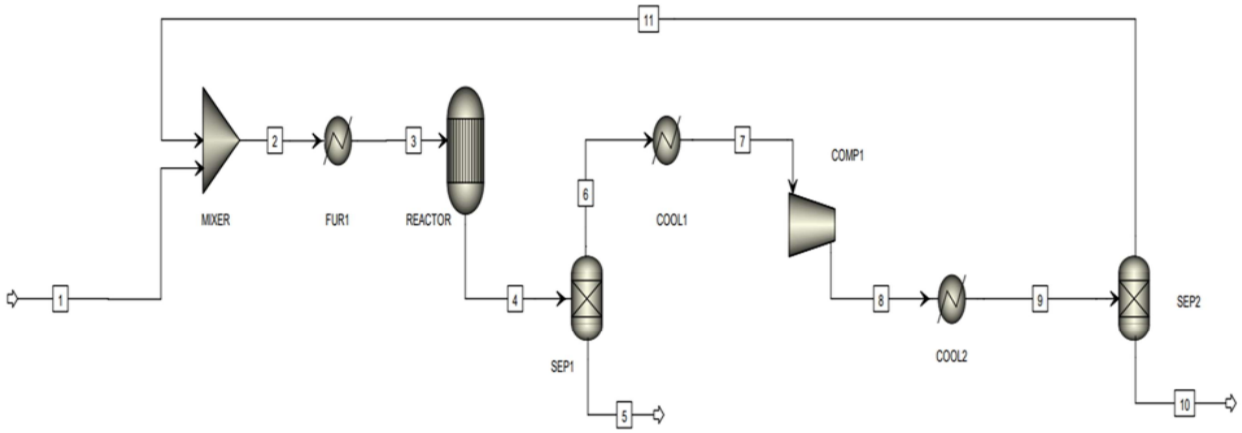


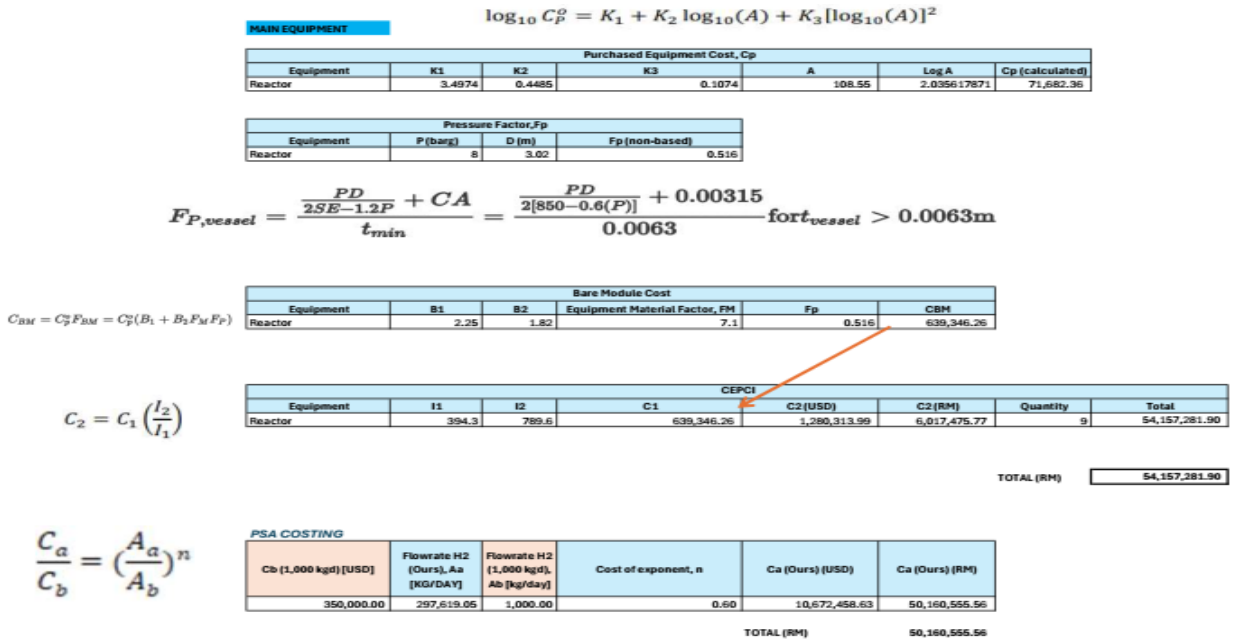
Figure 2. Sample of process simulation of a new chemical process technology.

Material						
Stream Name	**Units**	1	2	3	4	5
Phase		Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase	Vapor Phase
Temperature	**°C**	30.00	33.01	600.00	1,050.00	1,050.00
Pressure	**bar**	13.00	13.00	12.00	9.00	9.00
Molar Vapor Fraction		1.00	1.00	1.00	1.00	1.00
Mass Vapor Fraction		1.00	1.00	1.00	1.00	1.00
Enthalpy Flow	**kW**	(59,081.12)	(84,238.07)	(50,832.13)	628,868.94	582,101.96
Average MW		16.04	16.02	16.02	6.68	12.01
Mole Flows	**kmol/hr**	2,852.22	4,078.56	4,078.56	9,780.56	2,851.00
CH_4	**kmol/hr**	2,852.22	4,072.85	4,072.85	1,221.86	-
H_2	**kmol/hr**	-	5.71	5.71	5,707.70	-
C	**kmol/hr**	-	-	-	2,851.00	2,851.00
Mole Fractions						
CH4		1.00	1.00	1.00	0.12	-
H2		-	0.00	0.00	0.58	-
C		-	-	-	0.29	1.00
Mass Flows	**ktonne/year**	401.11	572.87	572.87	572.87	300.18
CH_4	**ktonne/year**	401.11	572.77	572.77	171.83	-
H_2	**ktonne/year**	-	0.10	0.10	100.86	-
C	**ktonne/year**	-	-	-	300.18	300.18
Mass Fractions						
CH_4		1.00	1.00	1.00	0.30	-
H_2		-	0.00	0.00	0.18	-
C		-	-	-	0.52	1.00
Volume Flow	**l/min**	89,706.94	129,682.47	412,345.12	1,978,752.89	512,048.30

Figure 3. Sample of process simulation output to obtain energy load and utility amount requirements to serve as input data into "Spill-The-TEA".

No.	Component	Current Price	Change in Price (%)	Increase to	Decrease to
1	Methane [USD/Tonne]	181.61	20%	217.93	145.29
2	Hydrogen [USD/Tonne]	4,830.00	20%	5,796.00	3,864.00
3	Carbon [USD/Tonne]	1,122.00	20%	1,346.40	897.60
4	B catalyst	22,000.00	20%	26,400.00	17,600.00
5	A catalyst	2,000.00	20%	2,400.00	1,600.00
6	C catalyst	35,000.00	20%	42,000.00	28,000.00
7	CAPEX [RM]	2,115,919,625.09	20%	2,539,103,550.11	1,692,735,700.07
8	Steam (RM/year)	3,342,113.95	20%	4,010,536.74	2,673,691.16
9	Cooling Water [RM/m3]	2.94	20%	3.53	2.35
10	Natural Gas Fuel [RM/kW]	0.13	20%	0.16	0.11
11	Land [RM/Acre]	2,395,800.00	20%	2,874,960.00	1,916,640.00
12	Electricity [RM/kWh]	0.22	20%	0.27	0.18
13	Schedule Waste [RM/Tonne]	2,200.00	20%	2,640.00	1,760.00

Figure 4. Sample of "Spill-The-TEA" price input data for raw materials, products, utility, power consumption/generation, and cost of waste management, and sensitivity of price movement.



$$\log_{10} C_p^o = K_1 + K_2 \log_{10}(A) + K_3[\log_{10}(A)]^2$$

MAIN EQUIPMENT

Purchased Equipment Cost, Cp						
Equipment	K1	K2	K3	A	Log A	Cp (calculated)
Reactor	3.4974	0.4485	0.1074	108.55	2.035617871	71,682.36

Pressure Factor,Fp			
Equipment	P (barg)	D (m)	Fp (non-based)
Reactor	8	3.02	0.516

$$F_{P,vessel} = \frac{\frac{PD}{2SE-1.2P} + CA}{t_{min}} = \frac{\frac{PD}{2[850-0.6(P)]} + 0.00315}{0.0063} \text{ for } t_{vessel} > 0.0063\text{m}$$

$$C_{BM} = C_p^o F_{BM} = C_p^o(B_1 + B_2 F_M F_P)$$

Bare Module Cost					
Equipment	B1	B2	Equipment Material Factor, FM	Fp	CBM
Reactor	2.25	1.82	7.1	0.516	639,346.26

$$C_2 = C_1\left(\frac{I_2}{I_1}\right)$$

CEPCI							
Equipment	I1	I2	C1	C2 (USD)	C2 (RM)	Quantity	Total
Reactor	394.3	789.6	639,346.26	1,280,313.99	6,017,475.77	9	54,157,281.90

TOTAL (RM) 54,157,281.90

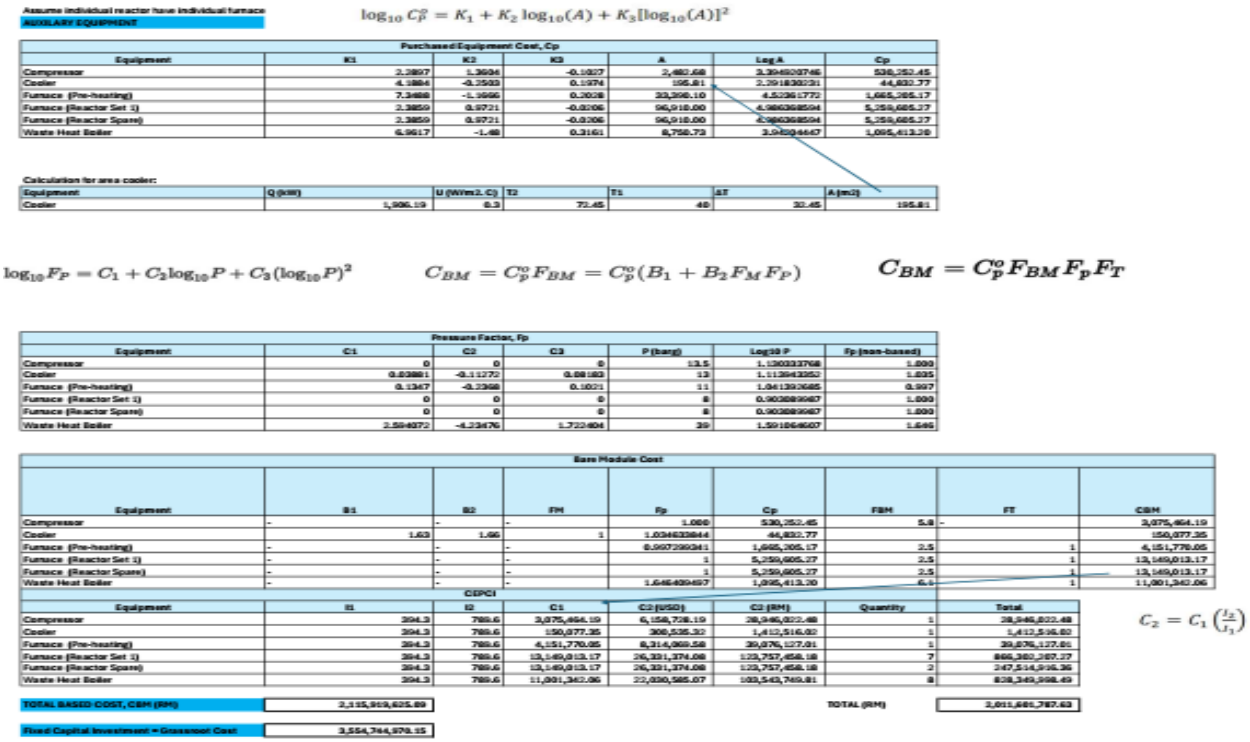
$$\frac{C_a}{C_b} = \left(\frac{A_a}{A_b}\right)^n$$

PSA COSTING

Cb (1,000 kgd) [USD]	Flowrate H2 (Ours), Aa [KG/DAY]	Flowrate H2 (1,000 kgd), Ab [kg/day]	Cost of exponent, n	Ca (Ours) (USD)	Ca (Ours) (RM)
350,000.00	297,619.05	1,000.00	0.60	10,672,458.63	50,160,555.56

TOTAL (RM) 50,160,555.56

Figure 5. Sample of background calculations of "Spill-The-TEA" to calculate capital costs of major equipment in the process.



Assume individual reactor have individual furnace

AUXILARY EQUIPMENT

$$\log_{10} C_p^o = K_1 + K_2 \log_{10}(A) + K_3[\log_{10}(A)]^2$$

Purchased Equipment Cost, Cp						
Equipment	K1	K2	K3	A	Log A	Cp
Compressor	2.2897	1.3604	-0.1027	2,482.68	3.394503746	536,252.45
Cooler	4.1884	-0.2503	0.1974	195.81	2.291830231	44,830.77
Furnace (Pre-heating)	7.3488	-1.1666	0.2028	33,266.10	4.52361772	1,665,265.17
Furnace (Reactor Set 1)	2.3850	0.9721	-0.0206	96,010.00	4.982368594	5,259,605.27
Furnace (Reactor Spare)	2.3850	0.9721	-0.0206	96,010.00	4.982368594	5,259,605.27
Waste Heat Boiler	6.9617	-1.48	0.3161	8,750.72	3.942094447	1,095,413.20

Calculation for area cooler:

Equipment	Q (kW)	U (W/m2.C)	T2	T1	ΔT	A (m2)
Cooler	1,906.19	0.3	72.45	40	30.45	195.81

$$\log_{10} F_P = C_1 + C_2 \log_{10} P + C_3 (\log_{10} P)^2 \qquad C_{BM} = C_p^o F_{BM} = C_p^o(B_1 + B_2 F_M F_P) \qquad C_{BM} = C_p^o F_{BM} F_p F_T$$

Pressure Factor, Fp						
Equipment	C1	C2	C3	P (barg)	Log10 P	Fp (non-based)
Compressor	0	0	0	13.5	1.130333768	1.000
Cooler	0.03881	-0.11272	0.08183	13	1.113943352	1.035
Furnace (Pre-heating)	0.1347	-0.2368	0.1021	11	1.041393685	0.997
Furnace (Reactor Set 1)	0	0	0	8	0.903089987	1.000
Furnace (Reactor Spare)	0	0	0	8	0.903089987	1.000
Waste Heat Boiler	2.594072	-4.23476	1.722404	39	1.591064607	1.646

Bare Module Cost								
Equipment	B1	B2	FM	Fp	Cp	FBM	FT	CBM
Compressor	-	-	-	1.000	536,252.45	5.8	-	3,075,464.19
Cooler	1.63	1.66	1	1.034633844	44,830.77			150,377.35
Furnace (Pre-heating)	-	-	-	0.997289241	1,665,265.17	2.5	1	4,151,770.05
Furnace (Reactor Set 1)	-	-	-	1	5,259,605.27	2.5	1	13,149,013.17
Furnace (Reactor Spare)	-	-	-	1	5,259,605.27	2.5	1	13,149,013.17
Waste Heat Boiler	-	-	-	1.646409497	1,095,413.20	6.9	1	11,001,340.06

CEPCI							
Equipment	I1	I2	C1	C2 (USD)	C2 (RM)	Quantity	Total
Compressor	394.3	789.6	3,075,464.19	6,158,708.19	28,946,022.48	1	28,946,022.48
Cooler	394.3	789.6	150,377.35	306,535.32	1,412,516.80	1	1,412,516.80
Furnace (Pre-heating)	394.3	789.6	4,151,770.05	8,314,969.58	39,076,127.01	1	39,076,127.01
Furnace (Reactor Set 1)	394.3	789.6	13,149,013.17	26,331,374.08	123,757,458.18	7	866,302,207.27
Furnace (Reactor Spare)	394.3	789.6	13,149,013.17	26,331,374.08	123,757,458.18	2	247,514,916.36
Waste Heat Boiler	394.3	789.6	11,001,340.06	22,030,585.07	103,543,749.81	8	828,349,998.49

$$C_2 = C_1\left(\frac{I_2}{I_1}\right)$$

TOTAL BASED COST, CBM (RM) 2,115,919,625.89

TOTAL (RM) 2,011,681,787.63

Fixed Capital Investment = Grassroot Cost 3,554,744,870.15

Figure 6. Sample of background calculations of "Spill-The-TEA" to calculate capital costs of auxiliary equipment in the process.

MANUFACTURING COST

Fixed Capital Investment

$$Fixed\ capital\ investment, FCI = C_{GR}$$

Fixed Capital Investment	3,554,744,970.15

Cost of Operating Labor

P	0
Number of operator per shift, Nol	11.68

1 year	12	month
Operating days	336.00	days
Operating weeks	48	weeks
Hours per shift	8	hours
Shift per week	5	shift
Shift per day	3	shift

Shift per year (weeks)	240
Shift per year (days)	1,008.00
Operators	4.20

Operators needed	49
Salary per month (per person)	1,800.00
Total salary operators per year	1,059,173.00

$$N_{OL} = (6.29 + 31.7P^2 + 0.23N_{np})^{0.5}$$

Equipment	No. of equipment	Nnp	P
Reactor	2.00	-	2.00
PSA	1.00	1.00	-
Compressor	1.00	1.00	-
Cooler	1.00	1.00	-
Furnace (Pre-heating)	1.00	1.00	-
Furnace (Reactor)	2.00	2.00	-
Waste Heat Boiler	8.00	8.00	-
TOTAL		14.00	2.00

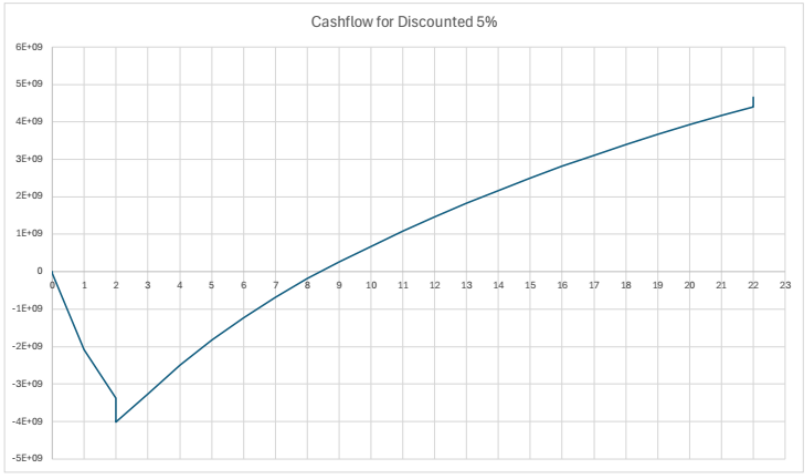
Cost of Utilities

Cost of Electricty

Working days in a year	336.00
Hours in a day	24.00
Taarif (RM/kWh)	0.22

Equipment	Power (kWh/year)	Power (kW/year)	Price (RM/year)
Compressor	2,482.68	20,020,331.52	4,444,513.60
PSA	73,604.17	593,544,004.75	131,766,769.05
Waste Heat Boiler	70,005.87	564,527,335.68	125,325,068.52
		TOTAL (RM/year)	261,536,351.17

Figure 7. Sample of background calculations of "Spill-The-TEA" to calculate manufacturing costs of the process operation.



Payback Period (Non-Discounted)	
Year	Positive Cashflow
6	2,776,457,514.10
6.98	3,320,986,230.62
7	3,333,038,390.62
Payback Period	4.98

Net Present Value (NPV)	4,664,095,121.05
Present Value Ratio (PVR)	2.081251008
Discounted Cash Flow Rate of Return (DCFROR)	9%

Figure 8. Sample of discounted cashflow rate of return output generated by "Spill-The-TEA".

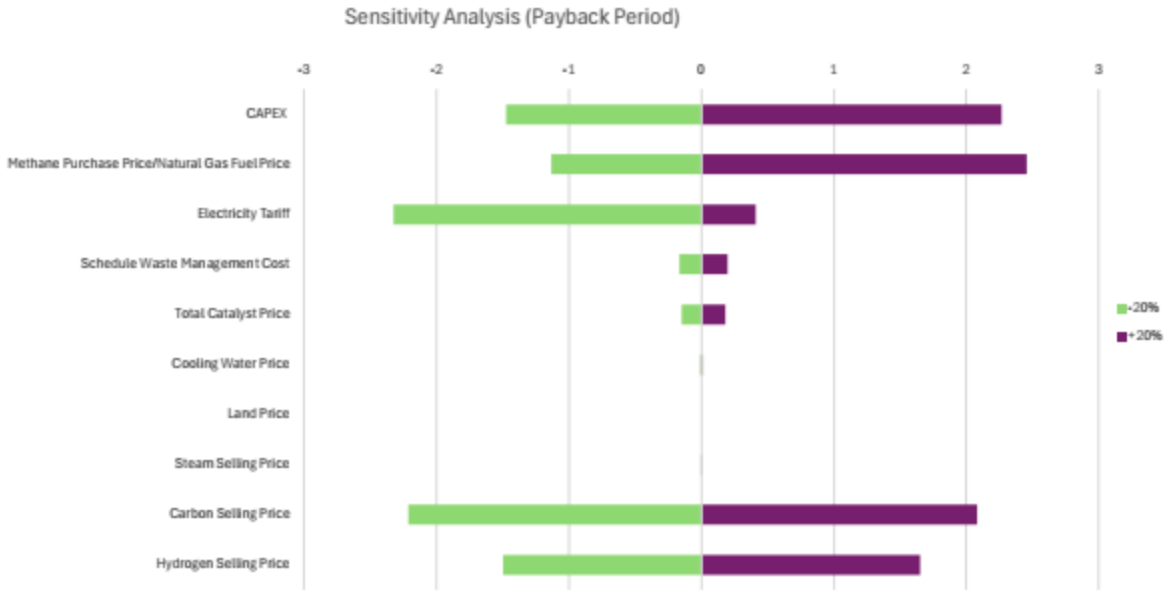


Figure 9. Sample of sensitivity analysis of payback period output generated by "Spill-The-TEA".

3. Novelty and uniqueness

"Spill-The-TEA" suits any chemical production processes. It is novel because the stakeholders (e.g., assessors and potential investors) in the chemical industry who are interested in projecting the feasibility of any new chemical process technologies of their interest can now save a significant amount of time to conveniently produce a sound economic judgement when making their due diligence, which has been known to be a tedious process. The uniqueness of this product is that not only can the stakeholders refer to the economic indicators generated in the spreadsheet output quickly, but they also can identify and analyze the main factors that contribute to the feasibility/infeasibility of the assessed technology to strategize their investment plan. The reliability of the generated economic indicators' output is dependent on the reliability of data being input in the spreadsheet, which is the responsibility of the users. Compared to existing software of similar functions that perform the calculations based on estimated cost values from various external sources that are fixed in the equations, "Spill-The-TEA" is unique as the calculations are based on price values entered by users themselves, and therefore, are more accurate specific to the location and the country of the chemical plant.

4. Benefit to mankind

Among the continued efforts in the exploration of new technologies include innovations in reducing the carbon footprint in the overall process life cycle, exploring alternative renewable resources, applications of smart technologies in predicting process response due to operation dynamics, and developing new materials such as catalysts and adsorbents to improve process efficiency. "Spill-The-TEA" benefits the mankind by:

- Providing financial risks assessment to ensure business sustainability. The assessment outcomes aid in influencing the government policies such as tax exemption for initiatives in reducing carbon emissions.

- Ensuring the importance of economies of scale is not sidelined. For instance, hydrogen production via water electrolysis technologies, even though releases zero carbon emissions, has limited production capacity for it to be feasible due to expensive infrastructures required for its implementation.
- Considering environmental impact costs associated with waste treatments and management to ensure development of the technologies will not harm the environment.

5. Innovation and Entrepreneurial Impact

This product promotes innovations for various potential new chemical process technologies in chemical industry to be explored with proper understanding of their commercial prospects, that can aid a coherent investment strategy. The application of "Spill-The-TEA" has been demonstrated in a project funded by Petronas Research Sdn. Bhd. (Project No.: UTVSB/CS/P.20230413010), who was interested in understanding the economic potential of developing a catalytic molten media methane pyrolysis technology, which is a potential technology for sustainable hydrogen production from natural gas, as an alternative to the conventional steam methane reforming technology. Using "Spill-The-TEA", our team managed to highlight crucial findings to our client. For example, we recommended strategies to ensure the feasibility of commercializing this technology such as to improve energy consumption by optimizing the reactor operation through temperature reduction with a proper selection or development of active catalyst and improving the carbon black byproduct yield and quality to allow better marketability.

6. Potential commercialization

A software and its app named "Spill-The-TEA" will be developed for commercialization. This can be purchased by licensing within a stipulated period, and license renewal will be required when the licensed period ends, to ensure business sustainability. The spreadsheet has been developed by dividing and organizing the output features (fixed capital and operating costs/expenses, the sensitivity analysis based on the price movements) in different tabs. Therefore, its app application on mobile phones will have limited features. For users to have a comprehensive access, they will be required to pay for the additional features through the "in-app purchase" of the app. The software/app will have several user interfaces to input their data (energy/materials' amounts/prices/costs) specific to the chemical process of their interest, and the output profitability indicators (net present value, payback period, and discounted cashflow rate of return) and tornado charts presenting the sensitivity analysis will be generated and displayed.

7. Acknowledgment

We would like to thank the Faculty of Chemical Engineering, UiTM Shah Alam for the support rendered in encouraging our creative work; BITCOM for managing our Copyright registration; and Petronas Research Sdn. Bhd. for being our first client to use "Spill-The-TEA" in consultancy project No.: UTVSB/CS/P.20230413010. The project outcome was presented in 1st International Conference on Chemical and Energy Engineering (ICChEE 2025).

8. Researchers' Biography

Ir. Dr. Luqmanulhakim Baharudin joined the Faculty of Chemical Engineering, Universiti Teknologi MARA (UiTM) in January 2021 as Senior Lecturer. He earned his PhD in Chemical and Process Engineering from the University of Canterbury, New Zealand, MPhil in Advanced Chemical Engineering from the University of Cambridge, UK, and BEng in Engineering (Chem.) from Universiti Malaya, Malaysia. He has had approximately 10 years of significant international industrial experience in the chemical industry working for multinational companies such as HaldorTopsoe, Petronas, Petron and ExxonMobil. He is currently active in academic research and consultation work exploring alternative energy to support net zero initiatives.

Dr. Muzakkir Mohammad Zainol holds a BSc. (2012) and Ph.D. (2017) in chemical engineering from Universiti Teknologi Malaysia. He then completed a postdoctoral at the same university for 3 years before starting his academic career at Universiti Teknologi MARA, Malaysia in 2020. He is active in research work and publications for research projects on the catalytic thermal conversion of biomass to biochemicals and biochar, carbon black functionalization, and adsorption study for removal of dyes and heavy metals in wastewater. Currently, he is working on research on technoeconomic analysis focusing on biochemical synthesis from biomass components.

Dr. Norhasyimi Rahmat is a Senior Lecturer in Chemical Engineering at Universiti Teknologi MARA and has over 18 years of industry and academic experience combined. She has a PhD in Process Chemical Engineering and an MSc degree from Imperial College London. She has expertise in clean hydrogen production and applications, catalysis and reaction engineering, sustainable energy solutions, and engineering innovation and development. She has involved in several research grants of multi-million ringgit in combination and has multiple publications in top-ranked journals. She also acts as an ad-hoc reviewer and has achieved multiple Gold Awards for innovation in IIDEX in 2019 and 2015.

Prof. Ir. Dr. Syed Shatir Asghrar Syed Hassan is a Professor of Chemical Engineering at Universiti Teknologi MARA (UiTM), and a Fellow of the Institution of Chemical Engineers, UK (FIChemE). He holds a PhD in Chemical Engineering from Curtin University, Australia. Recognised as a World's Top 2% Scientist (2024–2025), his research expertise encompasses thermochemical conversion, catalysis, biomass, energy & fuels, and advanced carbon materials. He has served as a Visiting Scholar at Imperial College London and Huazhong University of Science and Technology, China, and has led and collaborated on industry-driven R&D initiatives with partners including Indah Water Konsortium (IWK) and PETRONAS.

MolCat 1.0: Molten Media Catalyst Bubble Column Lab Reactor for Chemical Process

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ABSTRACT

Developing molten catalysts requires a comprehensive system for their performance evaluation to be conducted. This system is complex and expensive to build in house, and hence, has become a huge constraint for this research field to evolve. "MolCat 1.0" is a lab-scale molten media catalyst bubble column reactor system invented for testing the effectiveness of the developed catalysts. It is a one-size-fits-all system, offering flexibility to investigate any molten catalyst formulations for any gas phase heterogeneous chemical reactions. The reactant gas mixture is introduced into the molten catalyst through an internal orifice immersed in the molten bath, creating bubbles that interact with the catalytic media to allow the reaction to occur. The product gas leaves the molten bath, flowing upward to reactor exit for gas analysis/storage. The need to invest heavily in a complex testing system is eliminated, encouraging growth of new potential reaction pathways in chemical technologies. We provide performance test service provision for potential clients, charging a competitively reasonable fee cost as "MolCat 1.0" has been designed at a size that uses sufficiently small amounts of catalyst materials and sufficiently low flowrate of feed gas, benefiting chemical technology innovations in dollars-and-cents.

Keywords: bubble column; catalyst formulation; heterogeneous reactions; molten media; reactor system

1. Product Description

"MolCat 1.0" (Copyright CRLY2025W12479) is our first generation of a comprehensive lab-scale molten media catalyst bubble column reactor system (**Figures 1** and **2**). It has been designed, fabricated (**Figure 3**), installed, and commissioned for testing the effectiveness of molten media catalyst formulations by analyzing their catalytic activity performance in a desired chemical reaction by measuring the reactant conversions. It offers flexibility to investigate various catalyst formulations for any gas phase heterogeneous chemical reactions conveniently and at low cost as the system is designed at a size and scale that has been optimized by calculations to test sufficiently small amounts of catalyst materials using sufficiently low flowrate of feed gas but give meaningful data (**Figure 4**) for comprehensive analysis to be conducted. The overall system is equipped with a gas chromatography (GC) to analyze the product gas compositions. The system is supported with a custom-designed furnace to heat the reactor to the desired reaction temperatures of up to 1000 °C safely near atmospheric pressure. It is also equipped with safety features such as a temperature indicator to indicate if there is any temperature runaway in the reactor, and a gas detector to trigger the operator for any gas leakage.

2. Schematic Diagrams and Pictures of "MolCat 1.0" and Sample of Generated Data

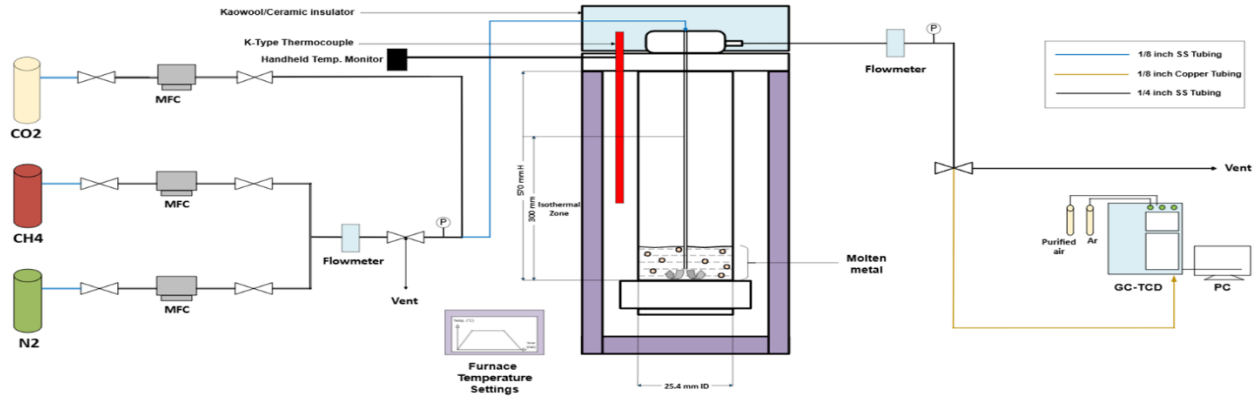

Figure 1. Schematic diagram of "MolCat 1.0".

Figure 2. Actual setup of "MolCat 1.0" and its size relative to a human being. The setup from left to right: Gas bottles – Mass flow controllers – Furnace with reactor inside it – Gas chromatography (GC) – PC to acquire recorded data from GC.

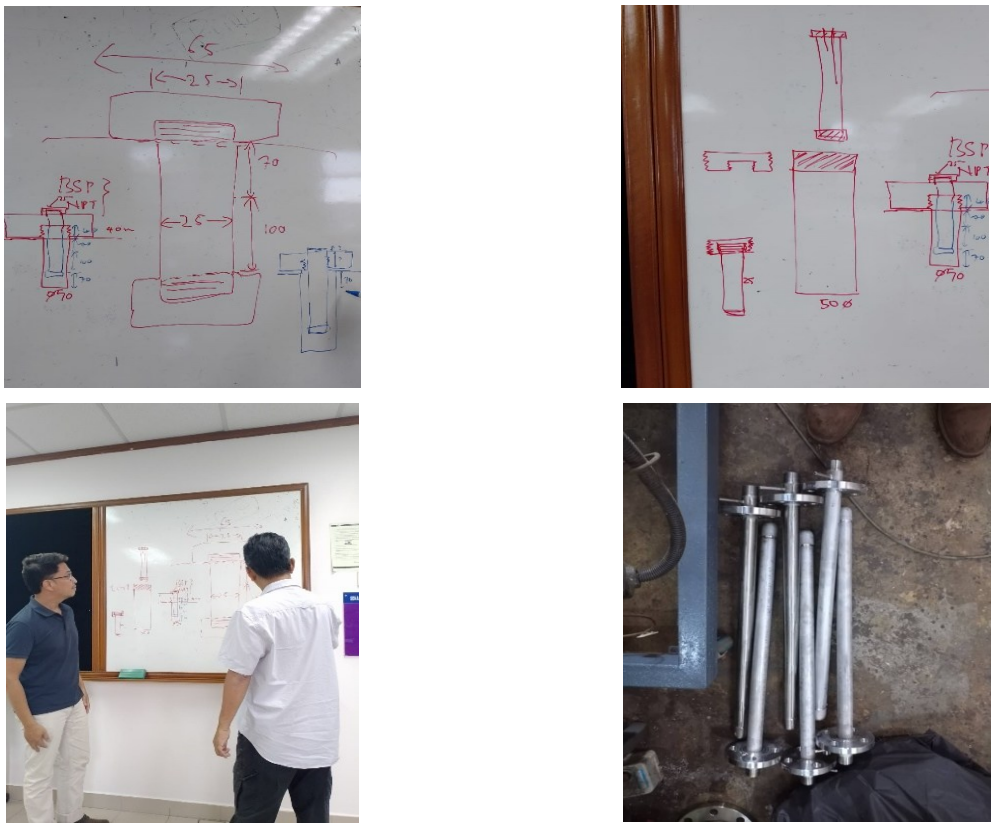

Figure 3. Collection of pictures during design phase of the reactor of "MolCat 1.0" and discussion stage with fabricator prior to fabrication.

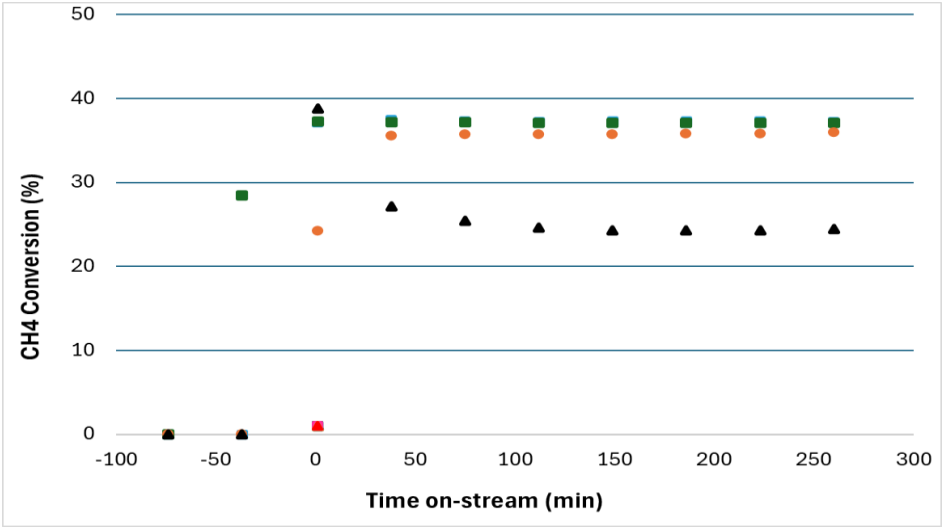

Figure 4. Sample of reactant conversion data at different operating conditions (manipulated variable may include temperature, gas flowrate and/or catalyst material content/composition) generated by "MolCat 1.0" from methane pyrolysis reaction run through a specially formulated molten media catalyst performed for our client, Petronas Research Sdn. Bhd. (PRSB) (Project No.: UTVSB/CS/P.20230413010).

Figure 5. Collection of pictures during visit by client and series of communication of findings on the performance of client's specially formulated molten catalyst tested using "MolCat 1.0".

3. Novelty and uniqueness

"MolCat 1.0" is equipped with GC to analyze the product gas compositions. Reactions that require high temperatures of up to slightly above 1000 °C can be tested safely near atmospheric pressure as the system is supported with a custom-designed furnace to heat the reactor to the desired reaction temperatures. The reactant gas (pure or mixture) is introduced at a desired rate into the catalytic molten media through an internal orifice, whose end tip is immersed in the molten bath. This creates gas bubbles that interact with the catalytic media to allow the reaction to occur as the bubbles ascend. The setup offers the novelty of being a system that can test the performance of any gas phase chemical reactions in any molten media catalyst formulations at low cost using small amounts of catalyst materials and low flowrate of feed gas. It is a new reactor technology for operating gas phase chemical reactions in molten catalyst bath that offers the advantage of avoidance of catalyst activity degradation over time and over multiple utilization cycles. Catalyst loss may happen by its molecules getting carried along with the product gas leaving the reactor and through evaporation, but it only occurs at negligible rate.

4. Benefit to mankind

Research community in the field of catalysis and chemical reaction engineering and leaders in chemical, petrochemical, oleochemical, oil and gas, and manufacturing industries will benefit from this lab scale molten media catalyst bubble column reactor system as it will serve as a quick "testing kit" to conduct performance test of their developed catalyst products for commercialization in any desired gas phase heterogeneous reactions. The system benefits mankind by supporting innovative catalyst product development for various possible applications,

which can also include gas phase reactions that minimize carbon footprints such as conversion of greenhouse gases (e.g., methane and carbon dioxide) into value-added fuels, chemicals or intermediates. Since it is designed at a size and scale that has been optimized by calculations to test sufficiently small amounts of catalyst materials using sufficiently low flowrate of feed gas, the amount of resources required and cost in the catalyst product development will be minimal.

5. Innovation and Entrepreneurial Impact

"MolCat 1.0" has been designed to not only allow any catalyst formulations to be tested but also provide flexibility in testing them in any desired gas phase heterogeneous reaction applications, at a scale that is sufficient to generate meaningful datasets using minimal amount of materials (i.e., catalyst materials and reaction feed gases) and hence, low cost. The application of "MolCat 1.0" has been demonstrated in a project funded by PRSB (Project No.: UTVSB/CS/P.20230413010) (**Figure 5**), who was interested in formulating a novel molten media catalyst for methane pyrolysis reaction for hydrogen production. Our team have successfully tested the catalytic activity performance of the client's specially formulated catalyst for application in the said reaction by testing it using "MolCat 1.0" that generated comprehensive sets of methane conversions and hydrogen yields data, at various reaction conditions (i.e., temperature and feed flowrate). Their successful catalyst formulation has been filed for a patent (PI2025002948).

6. Potential commercialization

The business model for commercializing "MolCat 1.0" is by providing service to potential clients who are interested to test their molten catalyst formulation on a chemical reaction of interest during their catalyst product development but do not have the facilities to do so. "MolCat 1.0" requires well trained personnel/researcher to operate it safely, run the GC and analyze the GC data. Service will be charged based on the number of test runs, skilled operator wages, space rental charge, amount of chemicals and gas purchased for the test runs, and data analysis. Since "MolCat 1.0" has been designed at a size that uses sufficiently small amounts of catalyst materials and sufficiently low flowrate of feed gas, the service charge will be competitively reasonable while benefiting the clients in terms of dollars-and-cents in their chemical technology innovations, as the need for them to invest in the performance test setup is eliminated.

7. Acknowledgment

We would like to thank the Faculty of Chemical Engineering, UiTM Shah Alam for the support rendered in encouraging our creative work and PRSB for being our first client to use "MolCat 1.0" in the development of their novel catalyst for methane pyrolysis through consultancy project No.: UTVSB/CS/P.20230413010. The project outcome was presented in 1st International Conference on Chemical and Energy Engineering (ICChEE 2025).

8. Researchers' Biography

Ir. Dr. Luqmanulhakim Baharudin joined the Faculty of Chemical Engineering, Universiti Teknologi MARA (UiTM) in January 2021 as Senior Lecturer. He earned his PhD in Chemical and Process Engineering from the University of Canterbury, New Zealand, MPhil in Advanced Chemical Engineering from the University of Cambridge, UK, and BEng in Engineering (Chem.) from Universiti Malaya, Malaysia. He has had approximately 10 years of significant international industrial experience in the chemical industry working for multinational companies such as HaldorTopsoe, Petronas, Petron and ExxonMobil. He is currently active in academic research and consultation work exploring alternative energy to support net zero initiatives.

Prof. Ir. Dr. Syed Shatir Asghrar Syed Hassan is a Professor of Chemical Engineering at Universiti Teknologi MARA (UiTM), and a Fellow of the Institution of Chemical Engineers, UK (FIChemE). He holds a PhD in Chemical Engineering from Curtin University, Australia. Recognised as a World's Top 2% Scientist (2024–2025), his research expertise encompasses thermochemical conversion, catalysis, biomass, energy & fuels, and advanced carbon materials. He has served as a Visiting Scholar at Imperial College London and Huazhong University of Science and Technology, China, and has led and collaborated on industry-driven R&D initiatives with partners including Indah Water Konsortium (IWK) and PETRONAS.

Dr. Norhasyimi Rahmat is a Senior Lecturer in Chemical Engineering at Universiti Teknologi MARA and has over 18 years of industry and academic experience combined. She has a PhD in Process Chemical Engineering and an MSc degree from Imperial College London. She has expertise in clean hydrogen production and applications, catalysis and reaction engineering, sustainable energy solutions, and engineering innovation and development. She has involved in several research grants of multi-million ringgit in combination and has multiple publications in top-ranked journals. She also acts as an ad-hoc reviewer and has achieved multiple Gold Awards for innovation in IIDEX in 2019 and 2015.

MolCat 2.0: Prototype of Catalytic Molten Media Bubble Column Reactor Setup for Gas Phase Chemical Reactions and Gas Product Separation

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ABSTRACT
A comprehensive prototype is needed for commercializing chemical process technology so that industry players can conveniently learn about managing and operating the system safely while handling operational issues seamlessly to demonstrate successful production of the desired product(s). "MolCat 2.0" is a prototype system that is invented with automatic process control system to control gas flowrate and operating temperature and pressure. It can cover a wide range of gas phase chemical reactions because the reactor can be operated up to 1050 °C continuously, with capability to vary feed flowrate up to 0.5 L/min and/or feed gas pressure (15–45 bar). It consists of molten media catalyst bubble column reactor for reaction to occur, placed in a furnace that supplies heat for the reaction up to 1050 °C, a cooler to cool the reaction product gas mixture down to a safe-handling temperature (approximately 70 °C), a holding tank to collect the cooled product gas, and a membrane separator to purify the gas product. Using this prototype, the need to invest heavily in a complex prototype system is eliminated, encouraging growth in commercializing new inventions in chemical process technologies and their upscaling. The commercial prospect of this prototype is the provision of its operation service for potential clients.

Keywords: bubble column; chemical technologies; molten media; prototype system; reactor system

1. Product Description
"MolCat 2.0" (Copyright CRLY2025W12478) is our second-generation setup of molten media catalyst bubble column reactor system for gas phase chemical reactions where the reactant gas will be fed into the system and then bubbled through the molten media for the reaction to take place under extreme temperatures up to 1050 °C. It incorporates advancements from our first-generation lab-scale reactor system, "MolCat 1.0" (Copyright CRLY2025W12479) (**Figure 1**) that can be operated only at near atmospheric pressure. "MolCat 2.0" has been designed to achieve operating pressures up to 45 bar. It is a comprehensive prototype system that includes major components at the downstream of the reactor furnace not available in "MolCat 1.0", which are a cooler to cool the reaction product gas mixture down to a safe-handling temperature (approximately 70 °C), a holding tank to collect the cooled product gas, and a membrane separator to separate the gas product from the unreacted reactant gases (**Figure 2**). Additionally,

"MolCat 2.0" is more comprehensive as it is equipped with safety venting system to release the process gas to the surrounding, and a control and instrumentation system that allows automation of the operating conditions (process gas flowrate, pressure and temperature).

2. Schematic Diagrams and Pictures of "MolCat 2.0" Design and its Internals

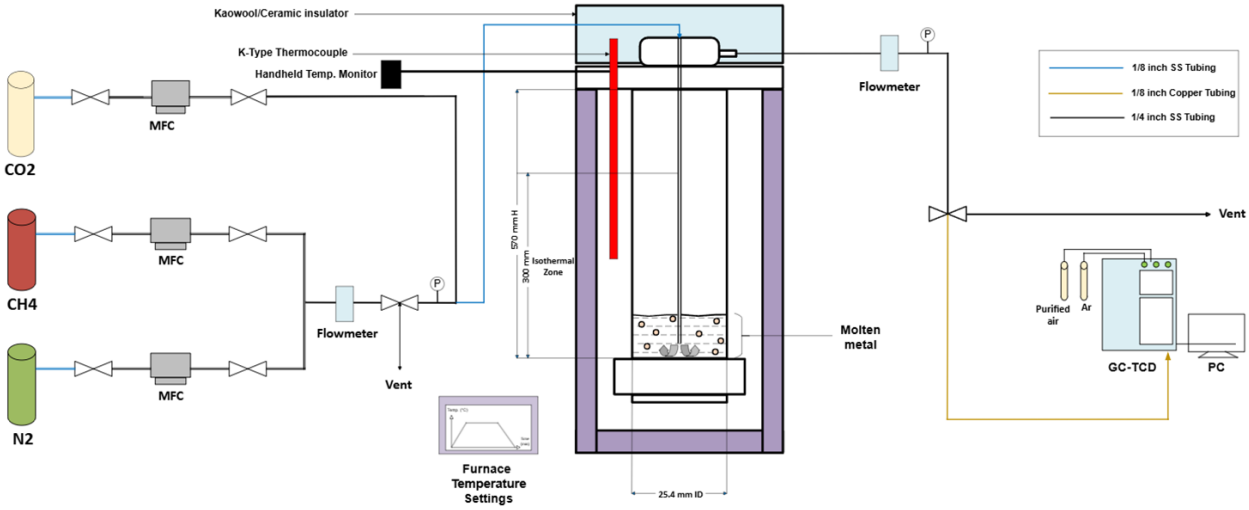

Figure 1. Schematic diagram of "MolCat 1.0".

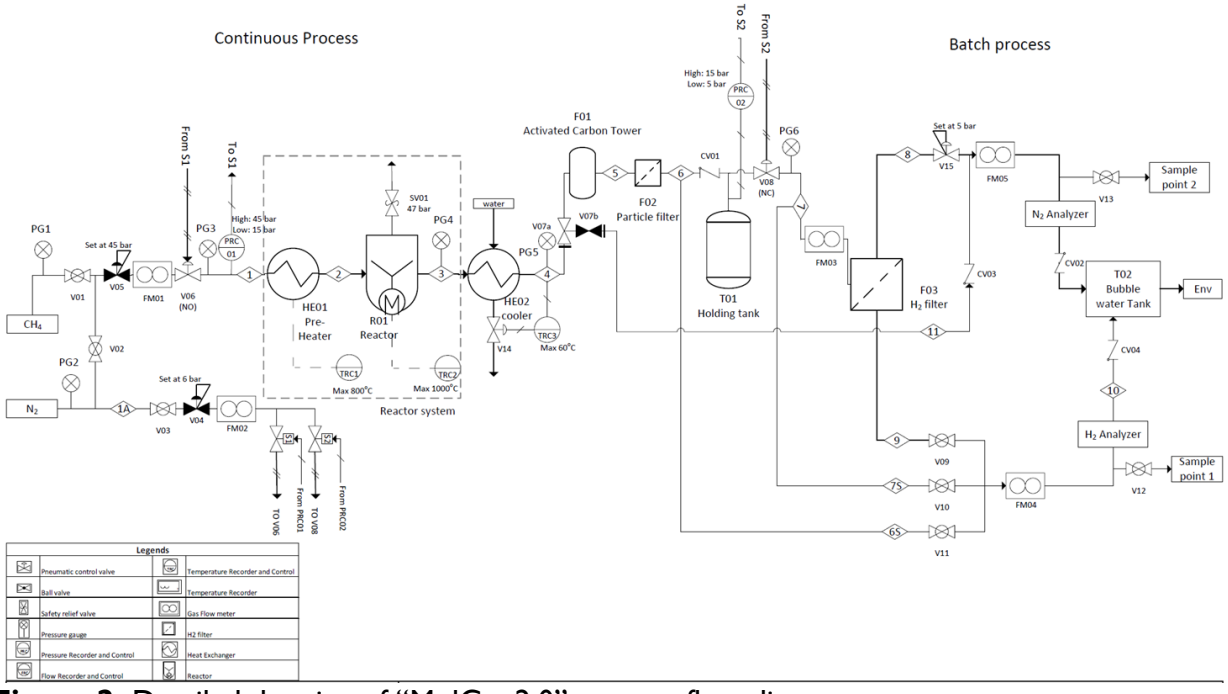

Figure 2. Detailed drawing of "MolCat 2.0" process flow diagram.

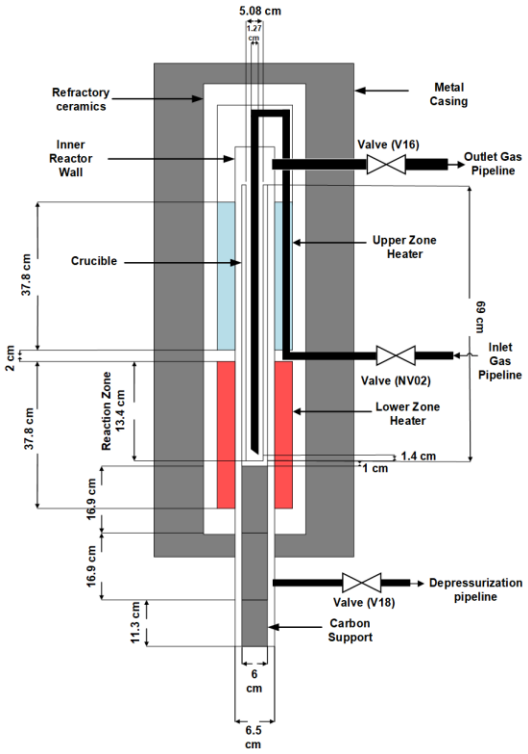

Figure 3. Cross-sectional view of the bubble column reactor in "MolCat 2.0" prototype showing key dimensions, heating zones, and internal parts.

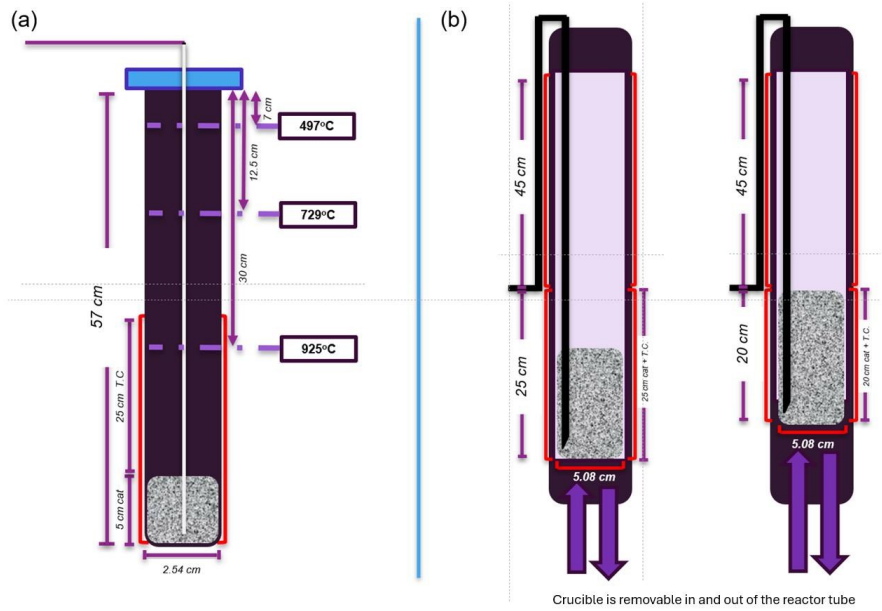

Figure 4. The difference between the feed gas and heating configurations in the reactor of: (a) "MolCat 1.0" and (b) "MolCat 2.0". The dimensioning is illustrated by estimation. only (not according to scale).

Figure 5. Picture of skilled operators operating "MolCat 2.0".

3. Novelty and uniqueness

Molten catalyst is placed in a removable crucible located inside the stainless-steel reactor tube to ease the catalyst retrieval for change-out. The crucible can be conveniently taken out of the reactor from the furnace bottom. Unlike "MolCat 1.0" where the gas is fed to the reactor from the top of the furnace through an internal orifice, in "MolCat 2.0" on the other hand, U-shaped orifice is used to channel the feed gas to the molten catalyst bath from the center of the reactor (**Figure 3**). The U-shaped orifice is part of the modifications made to overcome the limitation in "MolCat 1.0", where the cold feed gas is preheated before getting contact with the hot molten bath that can cause catalyst re-solidification in the orifice, which is the cause of blockage. The difference between the configurations of gas heating and feeding in "MolCat 1.0" and "MolCat 2.0" is shown in **Figure 4**. Reaction can run up to 1050 °C continuously. Gas hourly space velocity can be varied by manipulating the feed flowrate of up to 0.5 L/min (a scale-up factor of 4 of "MolCat 1.0") and/or feed gas pressure of 15–45 bar using ideal gas correlation P1V1 = P2V2.

4. Benefit to mankind

"MolCat 2.0" supports the activities towards commercializing potential chemical process technologies that are useful to mankind. The setup is comprehensive as it includes the reaction system, cooling system, product separation unit, and automation control and instrumentation system with safety features. Towards qualifying any technology to a higher Technology Readiness Level (TRL) so that further steps in commercializing and upscaling it to industrial scale can be achieved, this prototype invention can be employed to demonstrate the chemical technology of interest. Prior to getting more serious on injecting investments in technology commercialization, it is vital to first demonstrate a seamless operation and successful production of the desired gas product via a comprehensive process. At a smaller and manageable scale, the investors and innovators in especially chemical sector can conveniently learn about managing and operating the system safely and seamlessly and handling operational issues that occur during qualifying test runs using "MolCat 2.0".

5. Innovation and Entrepreneurial Impact

"MolCat 2.0" has been demonstrated in a later phase of the same project funded by PRSB (Project No.: UTVSB/CS/P.20230413010). Using their successfully formulated novel molten media catalyst for methane pyrolysis reaction for hydrogen production tested using "MolCat 1.0", the same catalyst formula was employed in "MolCat 2.0" to study the reaction performance on a larger processing scale, using a more complex system that resembles real production plant but in a prototype size. Towards industrial commercialization, the objective was to investigate the reproducibility or improvement of the methane conversion performance obtained earlier using "MolCat 1.0", at upscaled processing rates and higher operating pressures. Since the complexity of the system has increased, the dynamics of process changes and operational challenges have become more tedious to handle. The client benefited by learning to anticipate possible issues, understanding their root cause, and implementing effective rectification steps from incidents they experienced when using "MolCat 2.0".

6. Potential commercialization

Due to the size, the complexity to connect/disconnect its parts and components, and the 3-phase power requirement to operate the furnace, the location where "MolCat 2.0" is currently placed (Faculty of Chemical Engineering, Menara Kejuruteraan, UiTM Shah Alam) will remain throughout the period of space tenure. Indeed, "MolCat 2.0" is located right next to its first-generation "MolCat 1.0", and therefore, it will make a good marketing strategy to potential clients in promoting the application of these two systems as a full complementary set for qualifying a potential chemical process technology of interest from lab-scale to upscale. The business model for commercializing "MolCat 2.0" is the same as for "MolCat 1.0". Operated by skilled technicians (**Figure 5**), we provide service to potential clients by charging based on the number of qualifying test runs, wages, space rental charge, amount of purchased chemicals and gas used in the operations, and analysis of data.

7. Acknowledgment

We would like to thank the Faculty of Chemical Engineering, UiTM Shah Alam for the support rendered in encouraging our creative work and PRSB for being our first client to use "MolCat 2.0" in consultancy project No.: UTVSB/CS/P.20230413010.

8. Researchers' Biography

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Hanafiah Zainal Abidin is a lecturer with 18 years of experience in the Faculty of Chemical Engineering, UiTM Shah Alam. He is an expert in waste-to-energy technology (WtE), incinerator technology, solid waste management, computational fluid dynamics, process development, process integration and equipment design. He is currently involved in various industrial projects, being appointed as Technical Advisor for development of WtE project in Selangor, Process Technical Advisor for scheduled waste plant expansion in Pulau Pinang and rejuvenation of scheduled waste processing plant in Johor. He had previously been involved in development of rotary kiln incinerators as researcher and technology developer, lubricant oil additive pilot plant and hydrogen cracking prototyping project as process and equipment designer.

Dr. Norhasyimi Rahmat is a Senior Lecturer in Chemical Engineering at Universiti Teknologi MARA and has over 18 years of industry and academic experience combined. She has a PhD in Process Chemical Engineering and an MSc degree from Imperial College London. She has expertise in clean hydrogen production and applications, catalysis and reaction engineering, sustainable energy solutions, and engineering innovation and development. She has been involved in several research grants of multi-million ringgit in combination and has multiple publications in top-ranked journals. She also acts as an ad-hoc reviewer and has achieved multiple Gold Awards for innovation in IIDEX in 2019 and 2015.

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Eco-Friendly Construction Solutions with Composite Panel Systems

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ABSTRACT

The growing need for sustainable and affordable housing is driven by rapid urbanization and environmental challenges. To address these issues, innovative building materials are crucial. This project introduces a composite panel system designed for green construction, improving structural integrity, thermal performance, and reducing both costs and environmental impact. The system features a fiber-cement exterior combined with a foamed concrete (FC) core, providing an optimal balance of strength, insulation, and cost-efficiency. The sandwich panel design effectively minimizes heat transfer, making it ideal for extreme weather, while also offering superior acoustic insulation. The FC core is produced from eco-friendly materials, significantly reducing the carbon footprint, and the lightweight panels reduce transportation energy costs. The fiber-cement skin enhances safety with its fire, moisture, and corrosion resistance. Additionally, the modular panel design accelerates construction, reducing labor costs and project timelines, making it well-suited for large-scale housing developments. Prototypes tested in Iraq, Turkey, and Indonesia show the system's adaptability and effectiveness in diverse climates, offering a sustainable and efficient solution to the global housing shortage.

Keywords: composite panel; foamed concrete; fiber-cement; green building; affordable housing.

1. Product Description

The composite panel system (**Figure 1**) combines a fiber-cement exterior with a lightweight foamed concrete core, offering a solution for green construction that enhances insulation, fire resistance, and structural strength. This innovative system eliminates the need for cold-formed steel or screws, using a pre-assembled permanent formwork approach instead. Special connections are designed to securely hold reinforcement in place, preventing corrosion and ensuring long-term durability. Weighing no more than 40 kg per panel, the system is lightweight and allows for rapid installation, reducing labor costs and construction time. The foamed concrete core is applied on-site using the Portafoam system, which includes a foam generator, mixer, and pump, ensuring consistent quality and density across all panels. This design not only improves the thermal performance and structural integrity of buildings but also contributes to sustainability by reducing material waste and energy consumption during construction. The composite panels are ideal for use in both residential and commercial projects, especially in regions with extreme weather conditions, due to their excellent heat insulation and acoustic properties. With the ability to reduce overall building costs and accelerate project timelines, this composite panel system presents an efficient and eco-friendly solution for addressing the growing demand for sustainable, affordable housing.

Figure 1. Composite panel system.

2. Figures

The composite panel system is capable of load bearing, offering cost savings in construction. The design is flexible and can be adapted to various frame designs. Special jointing between the panels has been implemented to prevent cracking during installation and ensure structural integrity. **Figure 2** shows the pre-assembled panels being erected.

Figure 2. Pre-assembled panels being erected.

The foamed concrete infill is incorporated on-site using specialized equipment, including the Portafoam system as shown in **Figure 3**. This system consists of a foam generator, mixer, and pump, which together enable the efficient mixing and pumping of foamed concrete into the panels. The use of this technology allows for precise control of the foamed concrete's density and properties, ensuring that the panels provide optimal insulation and fire resistance. The composite panel system is adaptable to various foundation systems as shown in **Figure 4.** The formwork can be integrated with reinforcements and does not require removal after installation, unlike conventional formwork methods. The system's flexibility allows it to easily accommodate sewer pipes and other services within the wall structure, enhancing the overall efficiency of the construction process. Additionally, the system is cost-effective and enables fast laying, reducing

construction time significantly. One of the key advantages of this system is its speed of construction. The panels are lightweight before the foamed concrete is added, which makes handling and installation much faster as shown in **Figure 5.** The walls can be made with variable thicknesses up to 200 mm, allowing for greater flexibility in design. The larger-sized panels contribute to faster installation and finishing rates. Additionally, the panels can be easily cut to accommodate openings such as windows and doors, which reduces the need for further adjustments.

Figure 3. FC incorporated in-situ using Portafoam equipment.

Figure 4. Composite panel system is flexible to numerous foundation systems.

Figure 5. Handling and installation of the composite system much faster.

3. Novelty and uniqueness

The novelty and uniqueness of the composite panel system lie in its innovative combination of a fiber-cement exterior and a lightweight foamed concrete core, creating a building material that offers superior insulation, structural strength, and fire resistance. Unlike traditional panel systems that rely on cold-formed steel or screws for reinforcement, this system uses a pre-assembled permanent formwork approach with specially designed connections that securely hold

reinforcement in place and prevent corrosion. This unique design eliminates the need for additional hardware, reducing material costs and simplifying the construction process. The lightweight nature of the panels weighing no more than 40 kg each, makes installation quick and easy, allowing faster project completion and reduced labor costs. Additionally, the system's foamed concrete core is applied using the Portafoam system, which ensures consistent quality and density on-site, further enhancing the panel's performance. The sandwich panel design minimizes heat transfer, offering excellent thermal efficiency, while the fiber-cement skin provides resistance to fire, moisture, and corrosion, ensuring long-term durability. The composite system's modular nature accelerates construction, making it ideal for large-scale housing projects. This combination of sustainability, cost-effectiveness, and enhanced performance makes the composite panel system a groundbreaking solution for modern, green construction.

4. Benefit to mankind

The composite panel system offers significant benefits to mankind by addressing key challenges in sustainable construction. Its innovative design, combining fiber-cement and foamed concrete, enhances energy efficiency by providing superior thermal insulation, which reduces the need for excessive heating or cooling in buildings. This leads to lower energy consumption and a reduction in carbon emissions, helping combat climate change. Additionally, the system's fire resistance, moisture, and corrosion resistance ensure long-term safety and durability, enhancing the lifespan of buildings and reducing maintenance costs. Its lightweight nature makes installation faster and more cost-effective, lowering labor and transportation expenses, making it an affordable solution for large-scale housing projects, especially in urban areas with growing populations. By using eco-friendly materials and reducing construction waste, the composite panels promote environmentally responsible building practices. This system offers a sustainable, cost-effective solution to the global housing crisis, providing affordable, durable, and energy-efficient homes for people worldwide, benefiting both the environment and society.

5. Innovation and Entrepreneurial Impact

The innovation behind the composite panel system has a profound entrepreneurial impact, revolutionizing the construction industry by offering a sustainable and cost-effective alternative to traditional building materials. By integrating eco-friendly fiber-cement and foamed concrete, this system reduces environmental impact, addressing the growing demand for green building solutions. The unique, lightweight design simplifies installation, making it an attractive option for developers seeking to streamline construction processes and reduce costs. Entrepreneurs can capitalize on this innovation by introducing the system into new markets, particularly in regions facing housing shortages or extreme weather conditions. The system has already been used in pilot studies for emergency housing in Iraq, Turkey, and Indonesia, proving its effectiveness in addressing urgent housing needs in challenging environments. The system's scalability makes it ideal for both residential and commercial applications, providing a competitive edge in the construction sector. Additionally, the system's modular approach opens up opportunities for businesses to offer prefabricated panels, accelerating project timelines and increasing profitability. By promoting sustainable development and addressing global housing needs, this innovation offers significant entrepreneurial potential, driving both economic growth and environmental responsibility.

6. Potential commercialization

The potential commercialization of the composite panel system is significant, given its unique combination of sustainability, cost-effectiveness, and performance. With the growing global demand for affordable and energy-efficient housing, the system presents a promising opportunity for developers, contractors, and businesses involved in construction and real estate. Its lightweight and easy-to-install design allows for rapid deployment, making it an attractive solution for both large-scale residential projects and emergency housing, particularly in regions affected by natural disasters. The pilot studies in Iraq, Turkey, and Indonesia demonstrate the product's adaptability to various climates, enhancing its market appeal. Furthermore, the system's modular nature enables businesses to offer prefabricated panels, streamlining production and distribution, and reducing labor costs. The composite panel system is copyrighted and is currently being commercialized in Malaysia and nearby countries, positioning it for significant market expansion. As governments and private sectors focus on sustainable building practices, the product has the potential to capture a large share of the green construction market, contributing to both economic growth and environmental responsibility.

7. Acknowledgment

The authors gratefully thank for assistance and funding from the Ministry of Higher Education (MOHE) through the Fundamental Research Grant Scheme (FRGS/1/2022/TK01/USM/02/3)

8. Researchers' Biography

Assoc. Prof. Sr Ts Dr Md Azree Othuman Mydin is the Dean of the School of Housing, Building and Planning, Universiti Sains Malaysia. He is a renowned expert in the field of foamed concrete technology, widely recognized for his groundbreaking research and contributions to sustainable construction. His deep expertise in foamed concrete has established him as one of the leading researchers in this area. Over the years, he has published nearly 300 high-impact journal articles, many of which have been cited globally, reflecting his significant influence in the field. His work focuses on enhancing the properties of foamed concrete, making it more efficient and sustainable for use in various construction applications, particularly in lightweight and energy-efficient building materials. Dr. Md Azree's research has had a profound impact on both academic and industrial practices. He has developed innovative techniques that optimize the use of foamed concrete in terms of insulation, fire resistance, and structural integrity, all while minimizing environmental impact. His expertise is highly sought after, as evidenced by his consistent recognition as one of the world's top 2% scientists for five consecutive years, a testament to his enduring credibility and leadership in his field. In addition to his academic contributions, he has been involved in numerous collaborations with industry leaders and government bodies, contributing to the practical implementation of foamed concrete technologies in large-scale construction projects. His commitment to advancing sustainable building materials and his ongoing research in foamed concrete have solidified his status as a global authority in the field, pushing the boundaries of innovation in green construction technologies.

KitarPro Pellet: Formulation of Fermented Protein-Rich Food Waste Pellets for Aquaculture with Application in Tilapia Growth

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ABSTRACT

The aquaculture sector continues to face increasing pressure due to the rising cost of commercial feed, particularly those that depend on ingredients such as fishmeal and soybean meal. At the same time, large amounts of protein-rich food waste are produced every day and are commonly discarded in landfills. This situation not only leads to resource wastage but also contributes to environmental pollution. In this study, KitarPro Pellet was developed as an alternative aquaculture feed produced from fermented protein-rich food waste. The formulation includes discarded fish and chicken parts, eggshells, cucumber residues and banana peels. These materials were subjected to an anaerobic fermentation process for eight days using rice-wash water as a starter culture. The fermentation step helps release nutrients and reduce the presence of undesirable microbes. After fermentation, the material was dried at 50 °C, ground into powder and later processed into pellet form. A short feeding trial using juvenile red tilapia was carried out to evaluate the effectiveness of the pellets. Fish fed with KitarPro Pellet showed growth performance comparable to those fed with commercial feed. The feed conversion ratio was lower (0.68 ± 0.11) compared with commercial pellets (1.02 ± 0.82), suggesting more efficient feed utilisation. Survival was also slightly higher in fish fed with the KitarPro diet. These findings suggest that fermented food waste has promising potential as an alternative aquaculture feed while also contributing to more sustainable waste management.

Keywords: food waste valorization, aquaculture feed, anaerobic fermentation, circular bioeconomy, sustainable aquaculture

1. Product Description

KitarPro Pellet is an aquaculture feed developed from fermented protein-rich food waste. The idea behind this product is to address two ongoing issues: the increasing price of aquafeed and the growing amount of organic food waste. In this formulation, several types of food waste were utilised, including fish and chicken by-products, eggshells, cucumber residues and banana peels. These materials were first mixed and subjected to anaerobic fermentation for eight days. Rice-wash water was used as the starter culture. This fermentation process helps break down the materials and makes certain nutrients easier for fish to utilise.

Once fermentation was completed, the material was dried at 50 °C and then ground into a fine powder. The powder was later processed into pellet form suitable for aquaculture feeding. The pellets contain around 28.6% crude protein and also provide organic phosphorus originating from the recycled food waste. A feeding trial using juvenile red tilapia was conducted to observe the performance of the pellets. Fish readily consumed the pellets and showed growth performance comparable to those fed with commercial feed. In addition, the pellets remained relatively stable in water and did not easily disintegrate during feeding.

2. Process Flow of KitarPro Pellet Production

The overall production process of KitarPro Pellet is illustrated in **Figure 1**. The process begins with the collection of protein-rich food waste, followed by anaerobic fermentation using rice-wash water as the starter culture. After fermentation, the material is dried, ground into powder and processed into pellet form suitable for aquaculture feeding.

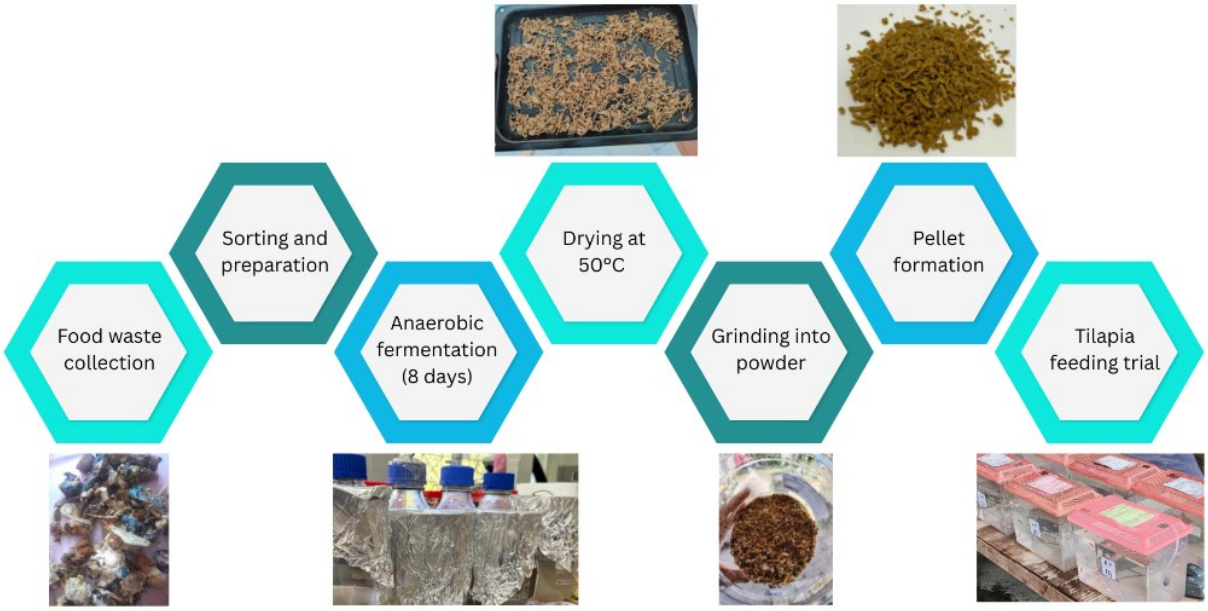

Figure 1. Production process of KitarPro Pellet.

Table 1. Growth performance comparison between KitarPro Pellet and commercial feed.

Type of Pellet	Commercial Pellet	KitarPro Pellet
Final Body Weight	2.01 ± 0.81 [a] g	2.11 ± 0.28 [a] g
Final Total Length	4.44 ± 0.34 [a] cm	4.43 ± 0.04 [a] cm
Survival	68.89 ± 48.23 [a] %	80.00 ± 34.64 [a] %
Specific Growth Rate	10.97 ± 4.57 [a] %/day	12.03 ± 1.26 [a] %/day
Condition Factor	2.26 ± 0.84 [a]	2.42 ± 0.27 [a]
Total Feed Intake	0.99 ± 0.00 [a] g/fish	0.99 ± 0.00 [a] g/fish
Feed Conversion Ratio	1.02 ± 0.82 [a]	0.68 ± 0.11 [a]

The growth performance results obtained from the feeding trial are summarised in **Table 1**. Fish fed with KitarPro Pellet demonstrated comparable growth to those fed with commercial pellets. In addition, the feed conversion ratio was lower in the KitarPro treatment, indicating more efficient feed utilisation.

3. Novelty and Uniqueness

The main novelty of KitarPro Pellet lies in the use of protein-rich food waste as the primary ingredient for aquaculture feed. Most commercial aquafeeds still rely heavily on ingredients such as fishmeal and soybean meal, which are increasingly expensive and sometimes unsustainable. In contrast, KitarPro Pellet focuses on recovering useful nutrients from discarded food materials. Through a simple fermentation process using rice-wash water as a starter culture, nutrients present in the waste materials can be made more available for fish utilisation. Another distinctive feature of the pellets is their ability to improve feed efficiency. During the feeding trial, fish fed with KitarPro Pellet showed a lower feed conversion ratio compared with those fed with commercial pellets. This indicates that the nutrients contained in the pellets were utilised effectively by the fish.Overall, the concept combines waste utilisation, simple fermentation technology and aquaculture nutrition to produce a practical alternative feed.

4. Benefit to Mankind

KitarPro Pellet contributes to more sustainable food production by transforming food waste into a valuable aquaculture feed resource. This innovation helps reduce reliance on expensive and unsustainable feed ingredients such as fishmeal and soybean meal, thereby lowering production costs for small-scale fish farmers.By diverting food waste from landfills, the technology can also reduce environmental pollution, greenhouse gas emissions and nutrient runoff that may harm aquatic ecosystems. The availability of a more affordable fish feed may also help support food security through more sustainable aquaculture production. Furthermore, KitarPro Pellet promotes circular economy practices by returning nutrients from food waste back into the food production system. The innovation aligns with several Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption and Production) and SDG 14 (Life Below Water).

5. Innovation and Entrepreneurial Impact

KitarPro Pellet has the potential to stimulate innovation and entrepreneurship within the aquaculture sector. The technology opens opportunities for small-scale feed production enterprises that utilise locally available food waste as raw materials.

Because the fermentation process is relatively simple and low-cost, the technology can be adopted by community-based aquaculture farmers and agro-entrepreneurs. This may create new economic opportunities in areas such as waste management, feed production and sustainable aquaculture. In addition, the development of KitarPro Pellet encourages collaboration between universities, aquaculture farmers, food industries and government agencies to promote sustainable resource utilisation. The innovation can serve as a model for community-driven circular economy initiatives that convert waste into valuable products while generating income and employment.

6. Potential commercialization

KitarPro Pellet shows strong potential for commercialization as an alternative aquaculture feed for both small-scale and commercial fish farmers. The increasing cost of conventional aquafeed has created growing demand for affordable and sustainable feed alternatives. The product could be developed either as a feed supplement or as a complete aquafeed formulation. With further optimisation of nutrient composition and larger-scale production trials, KitarPro Pellet may be produced at a lower cost than conventional feed while maintaining comparable performance. There is also potential for intellectual property protection and spin-off commercialization through university–industry collaboration. Partnerships with aquaculture farmers, feed manufacturers and government agencies such as the Department of Fisheries could support wider adoption of the technology.

7. Acknowledgment

The authors would like to acknowledge Universiti Teknologi MARA Sabah Branch, particularly the Faculty of Plantation and Agrotechnology and the Faculty of Applied Science, for supporting this research and providing the necessary laboratory facilities.

8. Researchers' Biography

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Development of a New Compost Fertilizer Processing Machine (MEPBK) by Optimizing an Integrated Control System Using a Programmable Logic Controller (PLC) and Human Machine Interface (HMI) for Teaching and Learning Requirements in TVET Institutions

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ABSTRACT

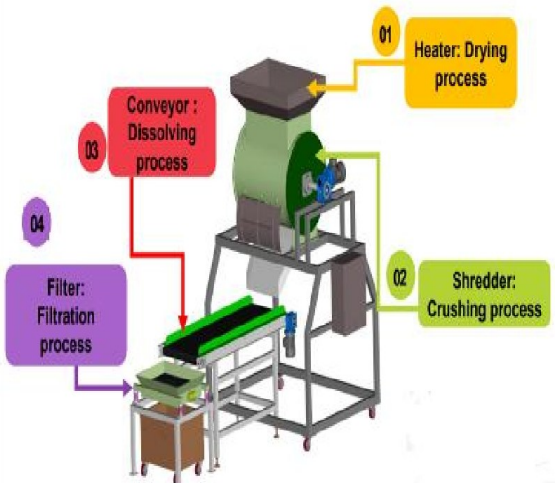
The Development of a New Compost Fertilizer Processing Machine (MEPBK) focuses on optimizing an integrated control system using a Programmable Logic Controller (PLC) and Human Machine Interface (HMI) to enhance teaching and learning applications in Technical and Vocational Education and Training (TVET) institutions. This research addresses the need for industry-relevant training equipment that integrates automation, process control, and sustainable agricultural technology within a practical learning environment.The proposed system incorporates a PLC-based control architecture to automate key compost processing parameters such as mixing, temperature regulation, moisture control, and processing duration. The HMI interface is designed to provide real-time monitoring, data visualization, and user-friendly interaction for students, enabling experiential learning aligned with Industry 4.0 concepts. Optimization of the control strategy aims to improve operational efficiency, reduce processing time, ensure consistent compost quality, and enhance system reliability.The development methodology includes system design, hardware integration, control programming, performance testing, and validation within a TVET instructional setting. The expected outcome of this project is a functional, safe, and modular compost processing machine that serves both as a production unit and as an educational training platform. Ultimately, this innovation contributes to strengthening hands-on competencies in automation, control systems, and sustainable technology among TVET students while supporting environmentally responsible waste management practices. According to socio-economic perspective, the machine can help reduce operational costs and labor dependency in compost production while increasing productivity and efficiency. From a socio-environmental standpoint, the machine contributes to sustainable waste management by converting organic waste into valuable compost fertilizer, thereby reducing landfill waste and environmental pollution. In terms of commercialization potential, the OCFPM has promising prospects for adoption by agricultural farms, compost producers, local communities, and educational institutions.

Keywords: Compost Fertilizer Processing Machine (OCFPM) , Human Machine Interface (HMI), PLC programming, TVET

1. Product Description

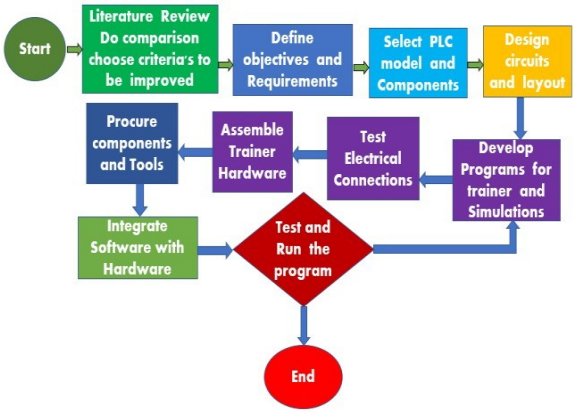
At present, there is still no integrated Organic Compost Fertilizer Processing Machine (OCFPM) or raw compost processing machine on the market which is combining the drying, crushing, dissolving and filtering concept. In addition its also can be used as teaching aid for TVET institution. Most breeders and farmers are still using traditional methods such as manually namely drying and reversing the raw compost under the sunlight. Most existing machines have a one or two-stage processing concept. Even though some of the OCFPM is slightly equal but they are using different concepts such as burner and bio enzyme techniques. The size of the fertilizer processing machine is also very large or too small. Some only work to grind food waste or coconut leaves, banana trees, corn and so on to be crushed and stored for composting. It is known that the manufacture of raw compost based on livestock and plant manure usually takes between 3 to 5 months to decompose. The main problem that occurs is that unprocessed compost manure is often damp and in large lumps. This situation makes it difficult for the packaging process to eliminate low quality fertilizer and make it difficult to sow fertilizer later. This project aims to develop a compost fertilizer processing machine that combines four parts, namely drying, crushing, conveyor (for better dissolving) and filtration by Optimizing an Integrated Control System Using a Programmable Logic Controller (PLC) and Human Machine Interface (HMI) for Teaching and Learning Requirements in TVET Institutions. Design method using pro-e software, vision wildfire 4. Composting machine measuring total length 3745 mm (12.34 feet) with grinding section measuring 800 mm diameter (2.75 feet) x shape Length 1100mm (3.7) feet with a sharp helical grinding blade capable of grinding up to the speed of 40 ppm with a total compost with a capacity of more than 30 kg for a rotation stage at a temperature range of around 60^0C to 65 ^{0}C has successfully produced compost in the form of sugar grains and better quality. reduction of power supply because the main supply is single-phase and converted to the use of 3 phase motor for 2.0 hp Nmrv Gear Motor grinder, 0.5 Hp Nmrv Gear Motor conveyor and filter (Vibrating Motor 0.18kw), inverter (inverter 0.375kw 1 phase To 3 phase) and (1.5kw 1phase To 3phase Inverter)

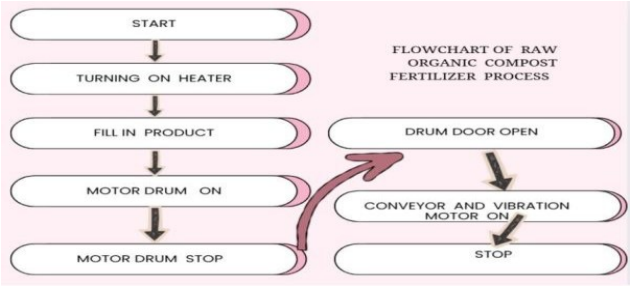
2. Pictures and Flowchart of the OCFPM



(a)

(b)





(c) (d)

Figure 1. (a) Isometric Design New OCFPM, (b)New Compost Fertilizer Processing Machine (OCFPM) Real Product (c) Flow chart of project (d) Flow chart of raw organic implementation compost fertilizer process.

3. Novelty and uniqueness

The novelty of this project lies in the development of an integrated Organic Compost Fertilizer Processing Machine (OCFPM) that uniquely combines four processing stages whereby drying, crushing, dissolving (via conveyor system), and filtration into a single compact system, which is currently not available in the market. Unlike existing compost processing machines that operate using only one or two-stage processes or apply alternative concepts such as burner systems or bio-enzyme techniques, this machine integrates a complete post-composting treatment system specifically designed to process damp and lumpy raw compost into fine, uniform sugar-grain-sized fertilizer.

4. Benefit to mankind

The Organic Compost Fertilizer Processing Machine (OCFPM) provides significant benefits to mankind by promoting environmental sustainability, agricultural productivity, economic development, and technical education advancement. By converting livestock and agricultural waste into high-quality organic fertilizer, the machine helps reduce environmental pollution, minimize landfill waste, and support sustainable waste management practices. This contributes to a cleaner ecosystem and reduces the harmful effects of unmanaged organic waste decomposition. In agriculture, the machine improves fertilizer quality by producing uniform, dry, and finely processed compost in sugar-grain form. This enhances soil fertility, improves nutrient absorption, and increases crop yield. Farmers benefit from better-quality organic fertilizer that is easier to apply, store, and package, while reducing dependency on expensive chemical fertilizers. As a result, farming becomes more sustainable, costeffective, and environmentally friendly. The machine also saves time and labor by automating drying, crushing, conveying, and filtration processes that are traditionally performed manually. This reduces physical workload, increases processing efficiency, and allows farmers and breeders to focus on other productive activities. The integration of a PLC and HMI control system ensures ccurate operation, stable temperature

control, and safer processing, minimizing human error and improving reliability. Economically, the system creates opportunities for agro-based entrepreneurship by transforming low-value organic waste into commercially valuable fertilizer products. It supports rural economic development, generates potential income sources, and encourages small and medium enterprises to participate in sustainable agriculture markets. Furthermore, the machine serves as an effective teaching and learning tool for TVET institutions. By integrating real industrial automation components such as PLC programming, HMI interfacing, motor control systems, and inverter technology, it enhances students' technical competencies and bridges the gap between theoretical knowledge and practical industrial application. Overall, the Organic Compost Fertilizer Processing Machine contributes to environmental protection, food security, economic growth, technological advancement, and education development, making it highly beneficial to mankind and society as a whole.

5. Innovation and Entrepreneurial Impact

The Organic Compost Fertilizer Processing Machine (OCFPM) introduces a significant technological innovation by integrating four processing stages namely drying, crushing, dissolving (via conveyor), and filtration into a single automated system. This integrated approach improves processing efficiency and fertilizer quality compared to conventional one- or two-stage compost machines.The incorporation of a PLC and HMI-based control system enhances automation, operational accuracy, and safety. Additionally, the use of single-phase to three-phase inverter technology allows industrial-grade motor operation in rural or small-scale environments where only single-phase power supply is available. This expands accessibility and practical implementation.The machine also serves as a dual-purpose innovation because its functioning as both an industrial compost processor and a teaching platform for TVET institutions which is bridging the gap between education and real industrial applications. Beside that, some of the Entrepreneurial Impact can be listed as below:

1. Business Creation Opportunities:Enables small and medium entrepreneurs to establish compost processing businesses with moderate capital investment.
2. Value-Added Agricultural Products :Converts low-value organic waste into highvalue commercial organic fertilizer.
3. Cost Reduction for Farmers :Reduces reliance on expensive chemical fertilizers, improving profit margins.
4. Rural Economic Development:Supports agro-based entrepreneurship and creates job opportunities in rural communities.
5. Commercial Scalability :The compact and modular design allows adaptation for small farms, cooperatives, or larger agro-industrial operations.
6. Market Potential :Growing demand for organic farming and sustainable agriculture increases marketability of processed compost fertilizer.

6. Potential commercialization

The Organic Compost Fertilizer Processing Machine (OCFPM) has strong commercialization potential due to increasing global demand for organic fertilizer, sustainable agriculture, and waste-to-wealth technologies. The machine addresses a real market gap namely the absence of a compact, fully integrated post-compost processing system that combines drying, crushing, dissolving, and filtration in a single automated unit.From a market perspective, the primary target

customers include small and medium-scale farmers, livestock breeders, agricultural cooperatives, organic fertilizer producers, and TVET institutions. Many rural operators face limitations such as manual processing methods, inconsistent fertilizer quality, and lack of three-phase power supply. This machine overcomes these constraints through inverter-based single-phase to threephase conversion, making it commercially viable even in areas with limited electrical infrastructure. In terms of product positioning, the machine can be commercialized under three scalable models: Firstly, as a standalone processing unit for agroentrepreneurs who produce compost commercially. Secondly, as a modular system adaptable to different capacity requirements.Thirdly, as an educational-industrial hybrid model supplied to TVET institutions for training and demonstration purposes

7. Acknowledgment

The authors would like to acknowledge the Deputy Director and Head of the Department of Electrical Engineering, Politeknik Ibrahim Sultan, as well as the Head of Department Advanced Technical and Vocational Education and Training, Faculty of Educational Sciences and Technology, Universiti Teknologi Malayisa for their invaluable support and encouragement throughout the development of this innovation. Their support and commitment have played a crucial role in the success of the Development of a New Compost Fertilizer Processing Machine (MEPBK) by Optimizing an Integrated Control System Using a Programmable Logic Controller (PLC) and Human Machine Interface (HMI) for Teaching and Learning Requirements in TVET Institutions

8. Researchers' Biography

Mr Ishak bin Taman is a Senior lecturer in the Department of Electrical Engineering at Politeknik Ibrahim Sultan,Johor. He has 26 years of experience teaching courses in Programmable Logic Controller (PLC),Final Project,ECAD and electrical wiring. Besides teaching, he is also involved in writing and publishing journals and research papers. Additionally, he frequently serves as a judge for innovation competitions, both at the internal and international levels. He has successfully been awarded a TARGS grant with approved allocation funding RM 67,000.00 and TAIGS grant with allocating fund RM 78,741.00 respectively for the development of a Compost Fertilizer Machine by the Pusat Penyelidikan dan Inovasi,JPPKK

Hanifah Jambari received her B.E. (Electrical) degree from Universiti Teknologi Mara Shah Alam, the M. Ed (Technical) and PhD in Electrical Engineering degrees from Universiti Teknologi Malaysia in 1996, 2001 and 2014 respectively. She is currently an Associate Professor at Department of Advanced Technical and Vocational Education and Training, Faculty of Educational Sciences and Technology Universiti Teknologi Malayisa (UTM), Johor, Malaysia. Her research interests include areas of technical and vocational education, engineering education, electrical engineering, special needs education, power electronics and food technology.

Ts. Dr. Saipol Hadi bin Hasim is a senior lecturer in the Department of Electrical Engineering at Politeknik Ibrahim Sultan, Johor. He has 26 years of experience teaching courses in Microcontroller, Final Project, Programming and Embedded Robotic. Besides teaching, he is also involved in writing and publishing journals and research papers. He frequently serves as a judge for innovation competitions, both at the national and international levels. Additionally, he has 9 years of experience in research and innovation management as a head of unit at Politeknik Ibrahim Sultan.

Ts.Dr.Nor Hidayu Shahadan received her Bachelor of Engineering (Electrical) with Honours and Master of Technical and Vocational Education degrees from Kolej Universiti Teknologi Tun Hussein Onn (KUiTTHO), Malaysia, and her PhD in Electrical Engineering from Universiti Teknologi Malaysia (UTM). She is currently a Senior Lecturer at the Electrical Engineering Department, Politeknik Ibrahim Sultan, Johor, Malaysia, and serves as the Head of the Southern Talent Reskilling and Upskilling Centre (STRUC). She is also a Professional Technologist registered with the Malaysia Board of Technologists. She has extensive experience in technical and vocational education and has been actively involved in teaching, curriculum development, research, and innovation since 2006. Her research interests include electrical engineering, antenna and wireless communication systems, engineering education, technical and vocational education and training (TVET), and technology innovation for sustainable development.

CitraNova Soap

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ABSTRACT
CitraNova is a plant-based antibacterial soap formulated using citronella essential oil as its primary active ingredient. The product was developed in response to growing consumer demand for safer, natural hygiene alternatives and increasing concerns regarding antimicrobial resistance and skin irritation associated with synthetic antibacterial agents. CitraNova was innovatively designed through optimized formulation techniques to ensure effective incorporation of citronella oil at concentrations that provide proven antibacterial activity while maintaining product stability and skin compatibility. The uniqueness of CitraNova lies in its multifunctional properties. In addition to inhibiting the growth of common pathogenic bacteria, the soap offers a refreshing natural fragrance and mild insect-repellent effect, enhancing its practical value for daily use. The formulation avoids harsh chemicals such as triclosan and prioritizes biodegradable ingredients, making it environmentally responsible and suitable for sensitive skin. From a socio-economic perspective, CitraNova supports the utilization of locally cultivated citronella, creating opportunities for agricultural communities and essential oil producers. Environmentally, its plant-derived composition helps reduce synthetic chemical discharge into wastewater systems. With the rising global preference for sustainable personal care products, CitraNova demonstrates strong commercialization potential in household, healthcare, hospitality, and institutional hygiene markets.

Keywords: Citronella oil, antibacterial agent, insect repellent, hygiene soap

1. Product Description
CitraNova is a natural antibacterial soap formulated with citronella (Cymbopogon nardus) essential oil as its main active ingredient. The soap is designed to provide effective cleansing while inhibiting the growth of common pathogenic bacteria **(Figure 1)**. Through optimized formulation techniques, citronella essential oil is incorporated at an effective yet skin-safe concentration to ensure antimicrobial efficacy, product stability, and user comfort. CitraNova produces a rich lather that removes dirt, excess oil, and microbes without excessively stripping the skin's natural moisture barrier. The formulation excludes harsh synthetic antibacterial agents such as triclosan and minimizes artificial additives, making it suitable for daily use and for individuals with sensitive skin. In addition to its antibacterial function, CitraNova offers a refreshing citrus aroma and mild insect-repellent properties, enhancing its functional value in tropical climates. The soap is developed using biodegradable ingredients, aligning with environmentally responsible practices. CitraNova is suitable for household, institutional, and commercial hygiene applications, including healthcare facilities, schools, and hospitality settings.

2. Antibacterial activity of citronella oil against pathogenic bacteria

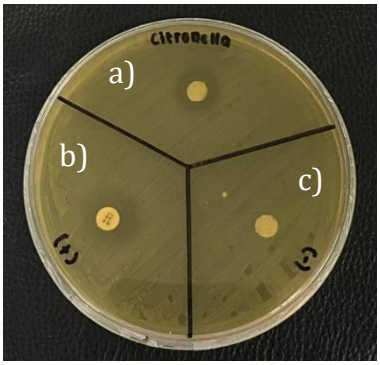

Figure 1. Zone of inhibition of *S. aureus* after being treated with a) citronella oil; b)positive control (Ampicillin) and c) negative control (distilled water).

3. Novelty and uniqueness

The novelty of CitraNova lies in its integration of natural citronella essential oil as a multifunctional bioactive agent in an optimized antibacterial soap formulation. While citronella is widely known for its insect-repellent properties, its antibacterial potential is strategically harnessed and standardized in this product to ensure consistent efficacy and safety. Unlike conventional antibacterial soaps that rely heavily on synthetic chemicals, CitraNova utilizes plant-derived compounds such as citronellal and geraniol, which exhibit antimicrobial activity. The formulation is carefully balanced to preserve the bioactivity of the essential oil while preventing skin irritation and volatility loss. Another unique feature is its dual-action performance: antibacterial protection combined with mild insect deterrence, making it particularly relevant for tropical and high-humidity environments. The biodegradable composition further differentiates it from many commercial antibacterial products that contribute to environmental chemical accumulation. By combining scientific formulation, natural bioactive compounds, and environmental consideration, CitraNova offers a safer, sustainable, and functionally enhanced alternative to conventional antibacterial soaps.

4. Benefit to mankind

CitraNova contributes to improved public hygiene by reducing the transmission of harmful bacteria through effective hand and body cleansing. Its natural formulation provides a safer alternative for individuals concerned about long-term exposure to synthetic antibacterial chemicals. The inclusion of citronella essential oil not only enhances antibacterial protection but also offers mild insect-repellent benefits, which may help reduce insect-related discomfort in tropical regions. The gentle formulation supports frequent handwashing without excessive skin dryness. Additionally, the use of plant-based and biodegradable ingredients promotes environmental sustainability by reducing chemical residues in wastewater systems. By encouraging the use of locally sourced citronella, CitraNova also supports agricultural communities and promotes sustainable economic development.

5. Innovation and Entrepreneurial Impact

CitraNova promotes innovation by transforming locally available citronella resources into a value-added, science-based hygiene product. The project encourages research-driven product

development, integrating knowledge from microbiology, natural product chemistry, and formulation science. Entrepreneurially, CitraNova supports small-scale farmers and essential oil producers by creating demand for locally cultivated citronella. It fosters collaboration between researchers, manufacturers, and community stakeholders, strengthening the local innovative ecosystem. Within academic or institutional settings, the project serves as a model for translating research findings into marketable products, encouraging students and researchers to pursue commercialization pathways. By combining sustainability, functionality, and market relevance, CitraNova contributes to a culture of innovation and entrepreneurship.

6. Potential commercialization

CitraNova demonstrates strong commercialization potential due to increasing global demand for natural and eco-friendly personal care products. Target markets include households, healthcare facilities, educational institutions, hospitality sectors, and outdoor communities. The product can be positioned as a premium natural antibacterial soap with added functional benefits suitable for tropical climates. Branding strategies may emphasize its plant-based formulation, safety profile, and environmental responsibility. Commercialization pathways include local retail distribution, online platforms, institutional supply contracts, and private-label manufacturing. With proper regulatory approval, quality standardization, and marketing strategies, CitraNova has potential for expansion into regional and international markets, particularly in countries prioritizing sustainable consumer goods.

7. Acknowledgment

The authors received no financial support for the research.

8. Researchers' Biography

Assoc. Prof. Dr. Ida Muryany is a Senior Lecturer in the field of Biology with a research focus on microbiology, antimicrobial resistance, and natural bioactive compounds. Her work centers on the phenotypic and genotypic characterization of bacteria, biofilm formation, and the exploration of plant-derived antimicrobials for health and agricultural applications. She is actively involved in teaching, research supervision, and the development of innovation-driven projects that translate scientific findings into practical and commercial solutions. Her research interests include essential oils, antibacterial formulations, and sustainable approaches to microbial control. Through her academic and research activities, she is committed to advancing scientific knowledge while fostering innovation and entrepreneurship among students and

Nurshanty Maula Bahar is a Forestry Engineering student at Hasanuddin University with a strong interest in biotechnology, tree breeding, and sustainable natural resource innovation. She has experience as a tissue culture laboratory assistant and has been actively involved in microbiology research and environmental project development. Through an international mobility program, she completed an internship at UiTM focusing on the antibacterial activity of essential oils. She actively participates in social project competitions and is involved in environmental and community empowerment organizations. She is committed to delivering innovative, impactful, and sustainable solutions.

Dr. Ilyanie Hj. Yaacob is a Senior Lecturer specializing in microbiology and probiotic research, with over 15 years of academic and research experience. Her work focuses on the isolation, characterization, and functional evaluation of beneficial microorganisms, particularly lactic acid bacteria from fermented foods and agricultural environments. She is actively involved in research on probiotic development, microbial biotechnology, and functional food applications. Dr. Ilyanie has published numerous scientific articles in international indexed journals and participates in collaborative research and community engagement activities related to microbial innovation. Her research aims to promote sustainable microbial solutions for health, agriculture, and food security.

Dr. Sarini Ahmad Wakid is a Senior Lecturer at the Faculty of Applied Sciences, Universiti Teknologi MARA (UiTM), with nearly 15 years of academic and research experience. She specializes in biodiversity and conservation of natural resources as well as environmental biotechnology. Her research focuses on ecosystem sustainability, biomonitoring of coastal and mangrove environments, and environmental stress and ecotoxicological studies. She integrates ecological assessment with biotechnological approaches to support sustainable resource management and conservation strategies. Dr. Sarini has produced numerous publications in various scientific journals and is actively involved in research supervision, academic leadership, and community engagement initiatives related to environmental protection.

Sustainable Production of Epoxidized Palm Kernel Oil (Epko) as a Bio-Based Plasticizer for Industrial Applications

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ABSTRACT
Palm Kernel Oil (PKO) is a renewable resource that is widely produced in Malaysia. However, its potential in high-value industrial applications is still not fully utilized compared to petroleum-based materials. This project focuses on converting PKO into a more valuable product through an epoxidation process. In this reaction, the carbon–carbon double bonds in PKO are converted into epoxy (oxirane) groups, producing Epoxidized Palm Kernel Oil (EPKO). The innovation emphasizes improving the efficiency of the epoxidation reaction while minimizing unwanted side reactions such as ring opening. By optimizing reaction parameters such as temperature, catalyst concentration, and reaction time, the process can produce epoxidized oil with improved stability and functional properties. The resulting EPKO can potentially be used as a bio-based plasticizer and stabilizer in polymer applications such as PVC. Compared to petroleum-derived additives, it offers a more sustainable and environmentally friendly alternative. This innovation supports the development of greener chemical products while increasing the value of palm-based resources and strengthening the palm-based downstream industry.

Keywords: Palm Kernel Oil, Epoxidation, Bio-based Plasticizer, Oxirane Oxygen, Green Chemistry

1. Product Description
The product developed in this project is Epoxidized Palm Kernel Oil (EPKO), which is produced by chemically modifying palm kernel oil through an epoxidation reaction. Palm kernel oil naturally contains unsaturated fatty acids with carbon–carbon double bonds. During the epoxidation process, these double bonds react with an oxidizing agent to form epoxy (oxirane) rings. This chemical modification enhances several important properties of the oil, including its chemical stability, viscosity, and compatibility with polymer materials. Reaction conditions such as temperature, reaction time, and catalyst concentration are optimized to increase the formation of epoxy groups while reducing side reactions that may affect the final product's quality. The resulting EPKO has potential applications as a bio-based plasticizer and stabilizer, particularly in polymer industries such as PVC production. In addition, epoxidized oils can also be used as intermediates in the production of polyurethane materials, coatings, adhesives, and environmentally friendly lubricants.

2. Results and Discussion
The progress of the epoxidation reaction was evaluated by monitoring the relative conversion to oxirane oxygen (RCO) as a function of reaction time. As shown in **Figure 1**, the RCO value increases during the early stage of the reaction, strongly suggesting the formation of oxirane

groups through the reaction between the carbon–carbon double bonds of palm kernel oil and the oxidizing agent. The conversion reaches its maximum value at approximately 30 minutes, suggesting that the epoxidation process is most effective within this reaction period. After 30 minutes, a slight decrease in the RCO value is observed. This decline may be attributed to secondary reactions such as oxirane ring opening, which can occur under acidic conditions or prolonged reaction time.

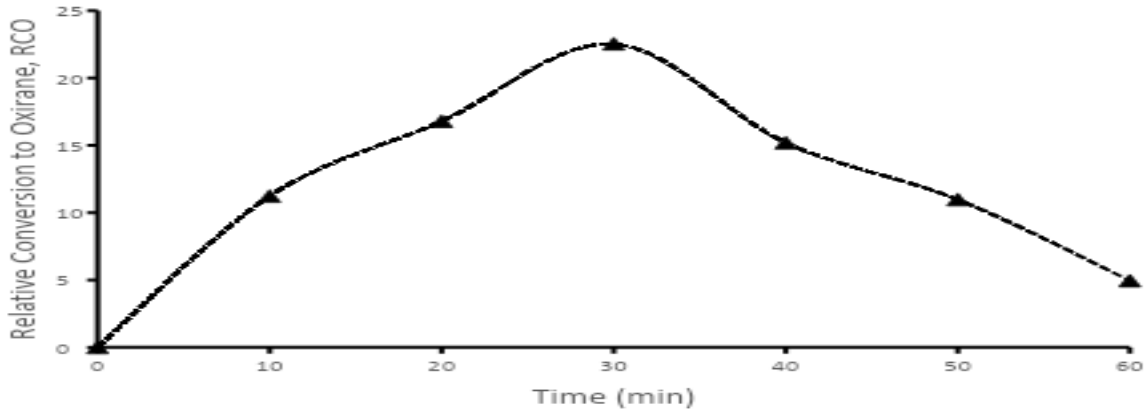

Figure 1. Relative conversion to oxirane oxygen (RCO) during the epoxidation of palm kernel oil.

FTIR spectroscopy was used to confirm the chemical modification of palm kernel oil after the epoxidation process. The FTIR spectra of raw palm kernel oil (PKO) and epoxidized palm kernel oil (EPKO) are presented in **Figure 2**. Both spectra exhibit strong absorption bands in the region of approximately 2920–2850 cm^{-1}, which correspond to the C–H stretching vibrations of the aliphatic chains in triglycerides. An absorption peak around 1740 cm^{-1} is attributed to the ester carbonyl (C=O) stretching vibration, confirming that the triglyceride backbone of the oil remains intact after the epoxidation reaction. A reduction in the intensity of peaks associated with carbon–carbon double bonds show the consumption of unsaturated bonds during the epoxidation process. In addition, the appearance of absorption band in the region of approximately 820–850 cm^{-1} can be related to the formation of oxirane (epoxy) groups. These spectral changes prove the successful conversion of palm kernel oil into epoxidized palm kernel oil through the epoxidation reaction.

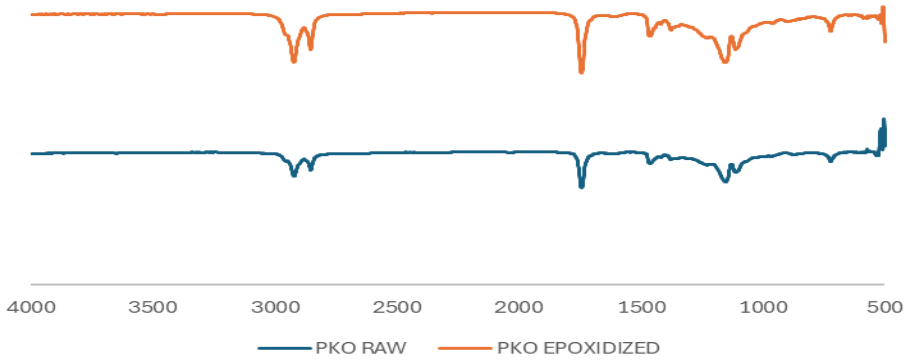

Figure 2. FTIR spectra of raw palm kernel oil (PKO) and epoxidized palm kernel oil (EPKO).

Table 2. Property of Palm Kernel Oil (PKO) vs Epoxidized Palm Kernel Oil (EPKO).

Property	PKO	Epoxidized PKO
Iodine Value	High	Reduced
Oxirane Oxygen Content	0	Increased
Viscosity	Moderate	Higher
Chemical Stability	Moderate	Improved

3. Novelty and uniqueness

The novelty of this project lies in the development of an improved method for producing epoxidized palm kernel oil as a sustainable industrial material. Although epoxidized vegetable oils are not new, this project focuses specifically on palm kernel oil and explores ways to improve the efficiency and selectivity of the epoxidation reaction. The process is designed to maximize epoxy group formation while minimizing unwanted side reactions, such as oxirane ring opening. This helps improve the quality and functionality of the final product. Another unique aspect of the innovation is the use of palm kernel oil, a widely available resource in Malaysia. By converting this agricultural product into a higher value chemical material, the project demonstrates how renewable resources can be utilized in sustainable industrial applications. The innovation also supports the growing demand for environmentally friendly alternatives to conventional petroleum-based additives.

4. Benefit to mankind

This innovation promotes the use of renewable resources in chemical production by utilizing palm kernel oil as the main raw material. By replacing petroleum-based additives with bio-based alternatives, the project supports more sustainable and environmentally responsible manufacturing practices. The resulting epoxidized oil has the potential to serve as a safer and greener plasticizer in polymer industries. This may help reduce the environmental impact associated with conventional additives. In addition, the innovation adds value to palm-based resources and supports the growth of downstream palm industries. This can contribute to economic development while encouraging the use of sustainable materials in modern industrial applications..

5. Innovation and Entrepreneurial Impact

This project demonstrates how scientific research can be translated into practical and valuable industrial products. By transforming palm kernel oil into a higher value chemical material, the innovation highlights the potential of renewable resources in developing sustainable technologies. The project also promotes an entrepreneurial mindset by exploring the market potential of bio-based chemical products. Students and researchers involved in the project gain experience in product development, process optimization, and innovation-based problem solving. Furthermore, the project encourages collaboration between academia and industry, particularly within the palm oil sector. Such collaborations can help accelerate technological development and support the growth of sustainable chemical industries.

6. Potential commercialization

Epoxidized Palm Kernel Oil has promising commercialization potential due to the increasing demand for bio-based and environmentally friendly materials. Many industries are seeking sustainable alternatives to petroleum-derived additives because of stricter environmental regulations and growing awareness of green technologies. EPKO can be used as a bio-based plasticizer and stabilizer in polymer applications, particularly in PVC production. It may also have potential uses in coatings, adhesives, lubricants, and polyurethane materials. Malaysia's strong palm oil industry provides a stable and cost-effective supply of raw materials for large-scale production. With proper process optimization and industrial collaboration, the product has good potential to enter both local and international markets as a sustainable palm-based chemical product.

7. Acknowledgment

The authors would like to express their sincere appreciation to Universiti Teknologi MARA (UiTM) Johor Branch, Pasir Gudang Campus for providing the facilities and academic support necessary for this project. Special thanks are extended to Ir. Dr. Mohd Jumain Jalil and Madam Siti Nadia Abdullah for their valuable guidance, supervision, and encouragement throughout the development of this work. The authors also acknowledge the support and cooperation from the laboratory staff and fellow students who contributed to the successful completion of this project. Their assistance and insights have greatly helped in improving the quality and progress of this innovation.

8. Researchers' Biography

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Catalytic Epoxidation of Waste Cooking Oil Using a Synergistic Acid System of Sulfuric Acid and Tartaric Acid

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ABSTRACT
This project was developed to address the environmental issues caused by improper disposal of waste cooking oil (WCO) while transforming it into a high-value bio-based product. WCO contains unsaturated double bonds suitable for epoxidation, making it a promising renewable feedstock for sustainable chemical production. The innovation lies in the synergistic catalytic system combining sulfuric acid and tartaric acid, which enhances in-situ peracid formation from hydrogen peroxide and acetic acid. This dual-acid approach improves oxirane formation efficiency, selectivity, and reaction stability compared to conventional single-acid systems. The process offers advantages such as low-cost raw materials, greener oxidant usage, improved catalytic performance, and reduced reliance on petroleum-based epoxides. Its uniqueness stems from integrating catalytic synergy with advanced modeling for better reaction control. Socioeconomically, the project supports waste valorization, circular economic practices, and sustainable material development. It holds strong commercialization potential in bio-lubricants, plasticizers, coatings, and polymer industries seeking environmentally friendly alternatives.

Keywords: epoxidation, waste cooking oil, catalyst, genetic algorithm, synergistic catalyst

1. Product Description
The product developed from this project is epoxidized waste cooking oil (EWCO), a sustainable and bio-based material produced through catalytic epoxidation using a synergistic system of sulfuric acid and tartaric acid. Instead of allowing waste cooking oil to be discarded and cause environmental pollution, this process transforms it into a valuable industrial product with enhanced functionality. EWCO contains oxirane (epoxy) groups formed by converting the carbon–carbon double bonds naturally present in the oil. These epoxy groups improve the oil's chemical reactivity, stability, and performance, making it suitable for applications such as bio-based plasticizers, stabilizers, lubricant additives, and raw materials for polymer and resin production. The use of hydrogen peroxide as an oxidant provides a cleaner and safer production route with minimal harmful by-products. The synergistic acid catalyst system further enhances epoxide formation, improving yield, selectivity, and overall efficiency. By converting waste into a high-value product, EWCO supports circular economic practices and reduces dependence on

petroleum-based materials. Its scalability and cost-effectiveness make it a promising green alternative for industries seeking more sustainable solutions.

2. Process Methodology, Reaction Performance and Product Characterization

Figure 1 illustrates the overall methodology for the epoxidation of waste cooking oil. The process begins with feedstock preparation to remove impurities and ensure suitable reaction conditions. The epoxidation reaction is then carried out via an in-situ peracid mechanism, followed by product sampling for further analysis. The formation of oxirane groups is confirmed through FTIR characterization, and the oxirane conversion is subsequently evaluated to determine the efficiency of the epoxidation process.

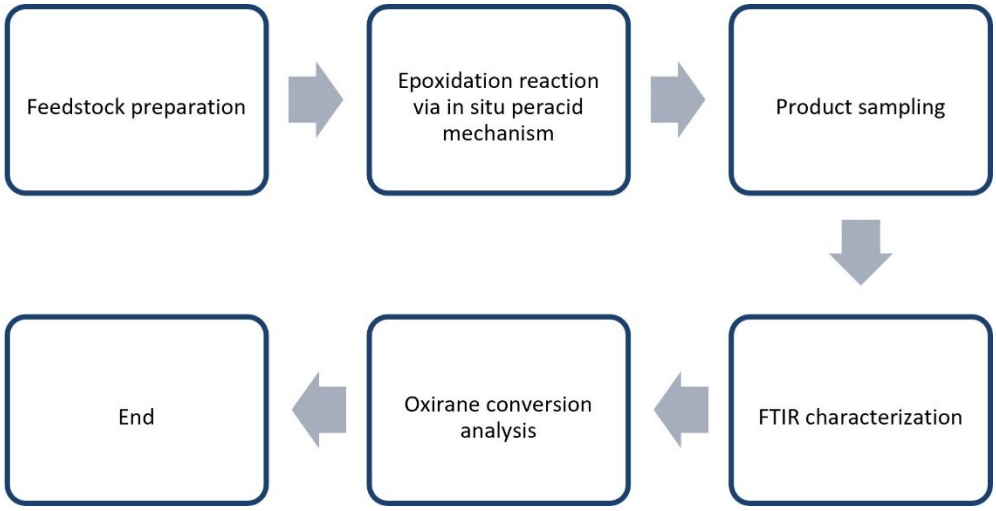

Figure 1. Flowchart of overall methodology.

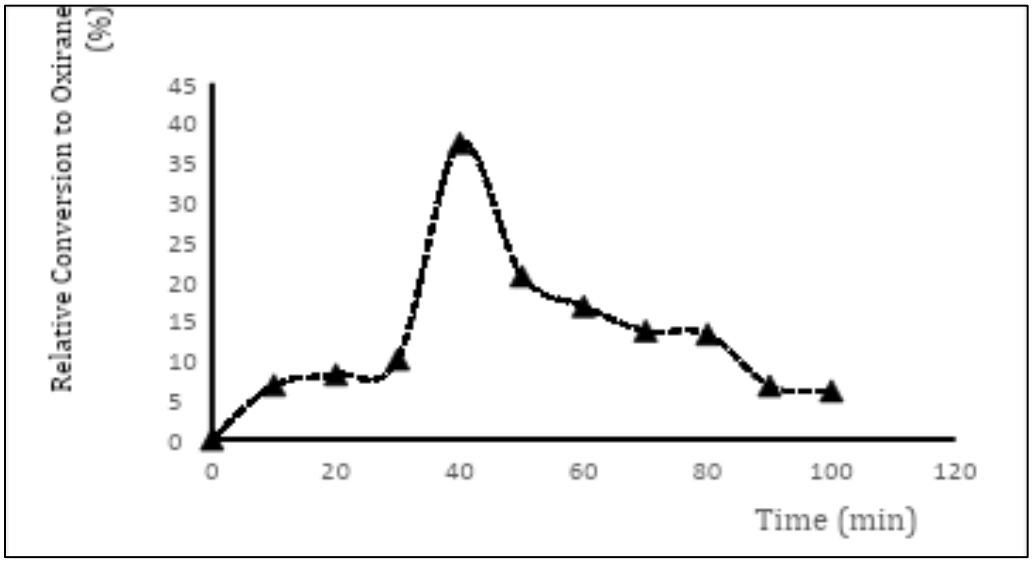

Figure 2. Relative conversion to oxirane for epoxidation of WCO.

Figure 2 shows the relative conversion to oxirane (RCO%) during the epoxidation of waste cooking oil over time. The oxirane conversion gradually increases in the early stage of the reaction and reaches a maximum value of approximately 38% at 40 minutes, indicating efficient formation of epoxide groups. This enhanced conversion is attributed to the synergistic catalytic effect of sulfuric acid and tartaric acid, which promotes efficient in-situ peracid formation and improves the epoxidation reaction rate. After the optimum reaction time, the oxirane conversion slightly decreases with prolonged reaction time, possibly due to side reactions such as oxirane ring opening or degradation. These findings highlight the effectiveness of the dual-acid catalytic system in enhancing oxirane formation from waste cooking oil. **Figure 3** shows the FTIR spectra of raw waste cooking oil (WCO) and epoxidized WCO. The spectrum of raw WCO exhibits a characteristic absorption band at around 1650 cm^{-1}, corresponding to the C=C stretching vibration of unsaturated fatty acids. After the epoxidation reaction, the intensity of these peaks decreases, indicating the consumption of double bonds during the epoxidation process. Simultaneously, the appearance of absorption bands in the range of 1100–1300 cm^{-1}, associated with C–O–C stretching, confirms the formation of epoxide groups. The main functional groups and their corresponding FTIR absorption ranges are summarized in **Table 1**. These results verify the successful conversion of unsaturated bonds in waste cooking oil into epoxide structures.

Table 1. Functional groups in FTIR.

Functional Group	FTIR Absorption (cm-1)
OH stretching	3000-4000
C=O stretching	1600-1800
C=C stretching	1650
C-O-C stretching	1100-1300
C-H stretching ($CH2$)	2500-3000

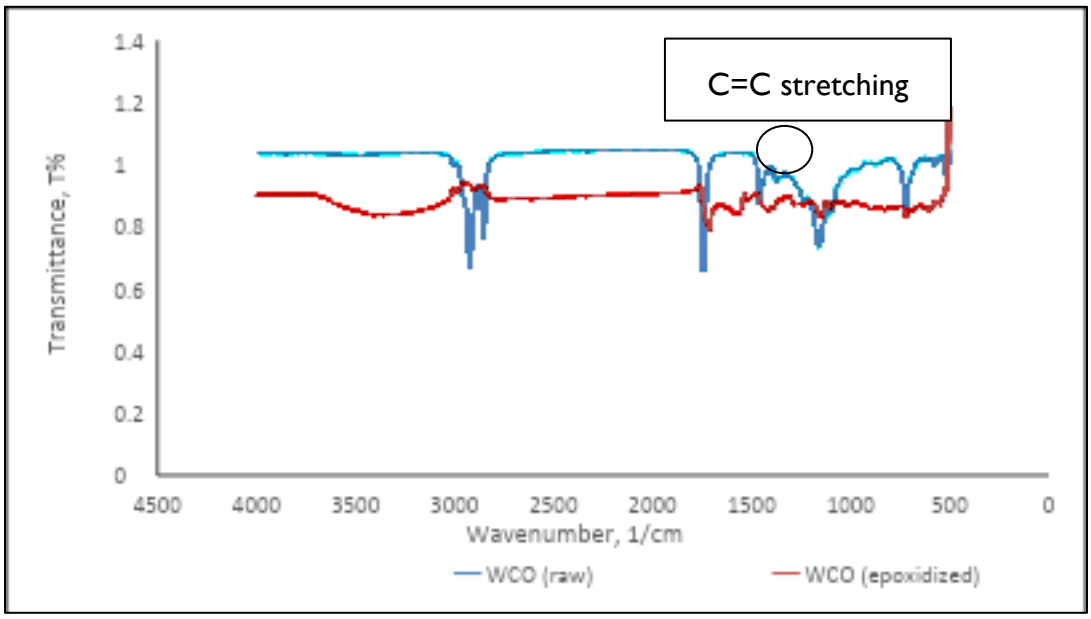

Figure 3. FTIR spectrum for WCO raw and WCO epoxide.

3. Novelty and uniqueness

This project stands out because it uses a unique combination of sulfuric acid and tartaric acid as a dual-acid catalyst for the epoxidation of waste cooking oil (WCO). Traditional methods often rely solely on sulfuric acid, while effective, is highly corrosive and can damage equipment or create safety concerns. By introducing tartaric acid as a co-catalyst, the process reduces the amount of sulfuric acid needed, making it safer, less corrosive, and more environmentally friendly, without compromising reaction efficiency. The synergy between sulfuric and tartaric acids enhances the formation of peracids in the reaction, while minimizing unwanted side reactions, such as epoxy ring opening. This creates a more controlled and efficient epoxidation process compared to conventional single-acid systems. Another unique aspect is the use of waste cooking oil as a low-cost, renewable feedstock, turning everyday waste into a valuable bio-based product and promoting circular economy practices. In short, this project combines safer chemistry, sustainable materials, and advanced modeling to create a novel, efficient, and environmentally friendly approach to producing epoxidized oil.

4. Benefit to mankind

This project tackles a pressing global challenge finding sustainable and environmentally friendly alternatives to petroleum-based chemicals. Traditional chemical products rely heavily on fossil fuels, which contribute to pollution, greenhouse gas emissions, and the depletion of non-renewable resources. At the same time, waste cooking oil (WCO) is produced in large amounts and often discarded improperly, causing environmental damage. By converting WCO into epoxidized oil (EWCO), this project provides a practical solution that addresses both issues. The process uses a safer dual-acid catalytic system of sulfuric acid and tartaric acid, combined with hydrogen peroxide as a green oxidant, minimizing chemical hazards and environmental impact. Beyond environmental benefits, the project creates economic opportunities by allowing communities and small businesses to collect and supply WCO. The resulting EWCO can replace petroleum-based products with plasticizers, lubricants, coatings, and polymers, supporting circular economy practices. Overall, it promotes sustainability, reduces waste, and provides greener, safer alternatives for industry and society.

5. Innovation and Entrepreneurial Impact

This project encourages innovation by introducing a unique dual-acid catalytic system that efficiently converts waste cooking oil (WCO) into epoxidized oil (EWCO). By combining sulfuric acid and tartaric acid with hydrogen peroxide, it creates a safer, more sustainable, and highly effective process. Beyond the laboratory, the project has strong entrepreneurial potential. WCO, which is usually discarded as waste, can now become a valuable raw material, creating opportunities for local communities and small businesses to collect and supply it. EWCO itself can be used in bio-based plasticizers, lubricants, coatings, and polymers, providing industries with environmentally friendly alternatives to petroleum-based products. By linking sustainable innovation with real-world economic opportunities, this project promotes a culture of creativity, problem-solving, and entrepreneurship, inspiring students, researchers, and businesses to develop greener, commercially viable solutions that benefit both society and the environment.

6. Potential commercialization

This project offers strong commercialization potential by turning waste cooking oil (WCO), usually discarded, into a high-value, bio-based product-epoxidized waste cooking oil (EWCO). EWCO can serve as a sustainable alternative to petroleum-based chemicals in industries such as plasticizers, lubricants, coatings, adhesives, and polymers. This opens opportunities for manufacturers to meet the growing demand for environmentally friendly products while reducing reliance on fossil fuels. The production process is scalable and cost-effective. By using a dual-acid catalytic system of sulfuric acid and tartaric acid alongside hydrogen peroxide as a green oxidant, the process is safer, efficient, and industrially feasible. Local communities and small businesses can participate by collecting and supplying WCO, creating new income streams and supporting circular economic practices. With increasing interest in sustainable and green materials, EWCO has strong potential for both local and international markets, offering economic, environmental, and industrial benefits while promoting a more sustainable future.

7. Acknowledgment

The authors would like to thank Universiti Teknologi MARA (UiTM), Johor Branch, for financial support for this research work.

8. Researchers' Biography

Ir. Dr. Intan Suhada Azmi is a chemical engineering lecturer at the Universiti Teknologi MARA, Malaysia. She is also a Chartered Chemical Engineer recognized by Institution of Chemical Engineers (IChemE). Her current work is focused on the conversion of sustainable vegetable oil into high added value products (eco-friendly polyol). Her work is also related to the application of catalysts, green chemistry, renewable energy, ionic liquids, biomass conversion, kinetics and optimization of chemical processes. She has published in several high-impact peer-reviewed journals, and she is also a reviewer for several reputable international journals.

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Khairun Nuhaa Binti Mohd Nasir is an Intern Student at Universiti Teknologi MARA, Pasir Gudang Campus, pursuing a Diploma in Chemical Engineering. As part of her academic curriculum, she is undergoing industrial and research training to strengthen her technical knowledge and practical skills in chemical process engineering. Her interests include epoxidation reaction, catalyst performance evaluation, reaction kinetics, and process parameter optimization for improved product selectivity and yield. During her internship, she assists in laboratory experiments, data collection, and report preparation while supporting ongoing research activities. She is committed to gaining valuable industry exposure to prepare for her future engineering career.

XTrackBully: Real-Time Web-Based Cyberbullying Detection on Twitter (X) Posts Using Machine Learning

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ABSTRACT

Cyberbullying, often exacerbated by the anonymity of social media, is on the rise and threatens the safety and well-being of internet users. The abundance and speed of online content make manual measures of content control tedious and imprecise, necessitating automated detection to filter text quickly and provide instant feedback. This study proposes XTrackBully, a web-based, real-time cyberbullying detection system to effectively filter Twitter (now X) posts with a Multi-Layer Perceptron (MLP) classifier. XTrackBully follows a supervised machine learning pipeline, with the post made on Twitter undergoing the common natural language processing (NLP) text processing. The processed texts are then projected using bag-of-words (BoW) and term frequency-inverse document frequency (TF-IDF) attributes, which are recognized by the MLP classifier to determine cyberbullying-related content. The proposed model focuses on low computational overhead and fast inference, which facilitates the lightweight system deployment. XTrackBully has the advantage of being an end-to-end, integrated preprocessing-feature extraction-classification workflow packaged as a web application to provide the instant screening. As the system allows identifying harmful content at an earlier stage, it contributes to healthier digital communities and can reduce moderation workload and costs. XTrackBully is commercially available as a hosted service or software-to-service web interface for small and medium sized enterprises (SMEs) and online community management in need of cost-effective cyber-safety solutions.

Keywords: Supervised machine learning, cyberbullying, Twitter (X), multi-layer perceptron, web application

1. Product Description

XTrackBully is a real-time, web-based cyberbullying detection system designed to screen Twitter posts and deliver immediate feedback to users and moderators. It addresses moderation challenges posed by the high volume and rapid dissemination of content on social media platforms, where manual review can be slow and inconsistent. To enable practical deployment, XTrackBully uses supervised machine learning optimized to achieve minimal computational cost and fast inference on small-scale system infrastructure. The user input is subjected to the common data

cleaning of NLP preprocessing, including tokenization, stop-word filtering, and lemmatization, to enhance the quality of the text and eliminate noises that characterize the text of social media. Subsequently, both BoW and TF-IDF translate the processed text into feature representations in numerical form, and the representation is then added in a MLP classification model to determine cyberbullying-related content. The system is packaged as an end-to-end web application that integrates preprocessing, feature extraction, and classification into a single workflow, providing clear, easy-to-understand results through a simple interface. XTrackBully helps to protect online communities by facilitating the detection of harmful content, reducing reliance on human moderators and contributing to lower the operational expenses. Commercially, it can be offered as an affordable software-as-a-service (SaaS) solution or an API (application programming interface)-based moderation module for schools, SMEs, and online community administrators seeking scalable cyber-safety solutions.

2. Methodology and System Interface

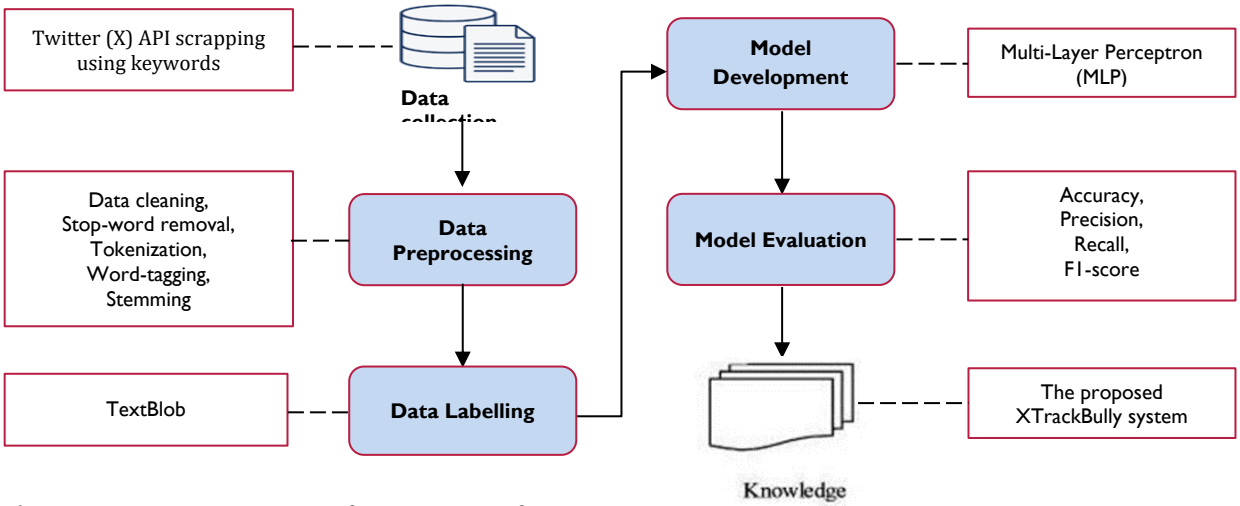

Figure 1. Methodological framework of the proposed XTrackBully system.

Figure 1 illustrates the methodological framework of this study. The API Twitter was used to collect tweets with 34 English-language cyberbullying-related **keywords** (see **Table 1**) between 1 January 2022 and 30 September 2023 resulting in 22,837 tweets. The tweets were subsequently preprocessed with conventional NLP methods, such as text cleaning (removing URLs, hashtags, user IDs, retweet marks, emojis, symbols, and punctuation); lowercasing; removing stop words; tokenization; word and part-of-speech (POS) tagging; and stemming.

Table 1. Summary of the employed cyberbullying-related search **keywords**.

Keywords				
stupid	*idiot*	*LGBTQ*	*whore*	*threat*
pussy	*faggot*	*shit*	*sucker*	*racism*
slut	*donkey*	*live*	*afraid*	*black*
moron	*poser*	*rape*	*fuck*	*muslim*
fucking	*ugly*	*bitch*	*ass*	*islam*
whale	*ban*	*kill*	*die*	*islamic*
evil	*hate*	*attack*	*terrorist*	

The dataset was then labelled using TextBlob, which assigns polarity scores from -1 to 1. Tweets with scores below 0 were labelled negative, scores of 0 were neutral, and scores above 0 were positive. **Figure 2** illustrates a bar chart depicting the sentiment polarity of TextBlob. The results show that negative sentiment had the highest count with 8,812 tweets. Neutral sentiment followed closely with 8,210 tweets, indicating many tweets expressed mixed or neutral emotions. Positive sentiment had the lowest count, with 4,543 tweets. After labelling, all neutral tweets were removed from the dataset. The remaining labels were mapped so that positive = 0 (non-cyberbullying) and negative = 1 (cyberbullying).

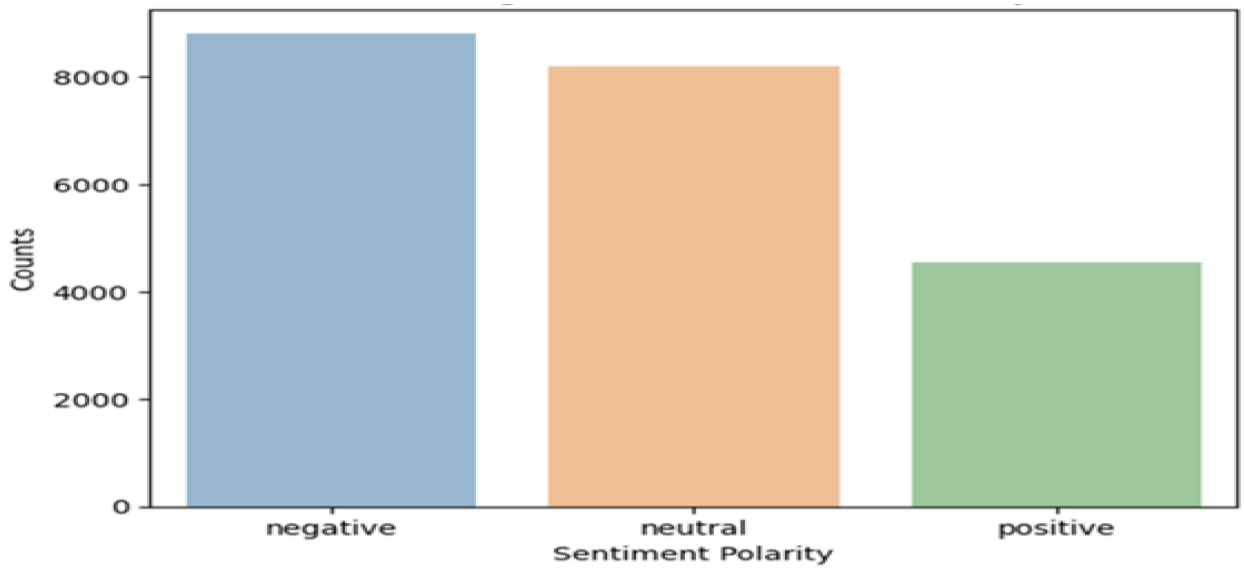

Figure 2. The TextBlob sentiment polarity.

A cyberbullying detection model was created in this study based on the MLP classifier and its performance was evaluated using an 80:20 train–test split and standard metrics (accuracy, precision, recall, and F1-score). As shown in **Table 2**, the MLP achieved 0.94 accuracy, with 0.95 precision, 0.96 recall, and an F1-score of 0.95. Finally, the trained model and findings informed the proposed XTrackBully web-based system, implemented using the Python programming language.

Table 2. Performance summary of MLP classifier for a 80:20 percentage split.

Accuracy	Precision	Recall	F1-Score
0.94	0.95	0.96	0.95

Figure 3 shows the main input interface of the proposed XTrackBully: Cyberbullying Detector system, where users can paste or type a tweet into the text field for analysis. The interface provides simple and user-friendly controls, allowing users to submit the tweet for detection, with pressing Enter and clearing the input by clicking Reset, making the screening process fast and convenient. Meanwhile, **Figure 4** presents the detection-result interface that is seen after the tweet is sent to XTrackBully for analysis. The system flags the entered message as a cyberbullying tweet and displays a clear visual indicator, represented by an angry icon, to emphasize the harmful classification. **Figure 5** illustrates the output screen when a neutral or positive tweet is analyzed

by XTrackBully. The system classifies the message as non-cyberbullying and conveys this information by displaying a friendly visual indicator, represented by a smiley-label icon, to indicate that the message does not contain harmful information.

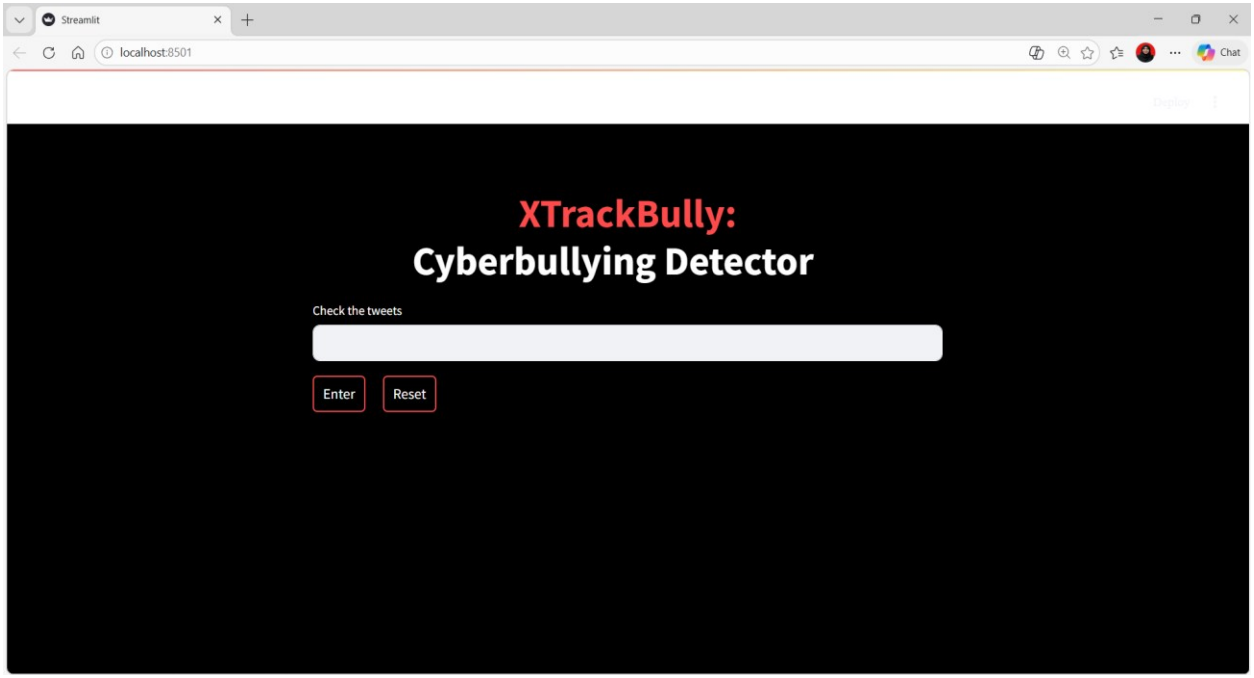

Figure 3. Main tweet input interface of the proposed XTrackBully system.

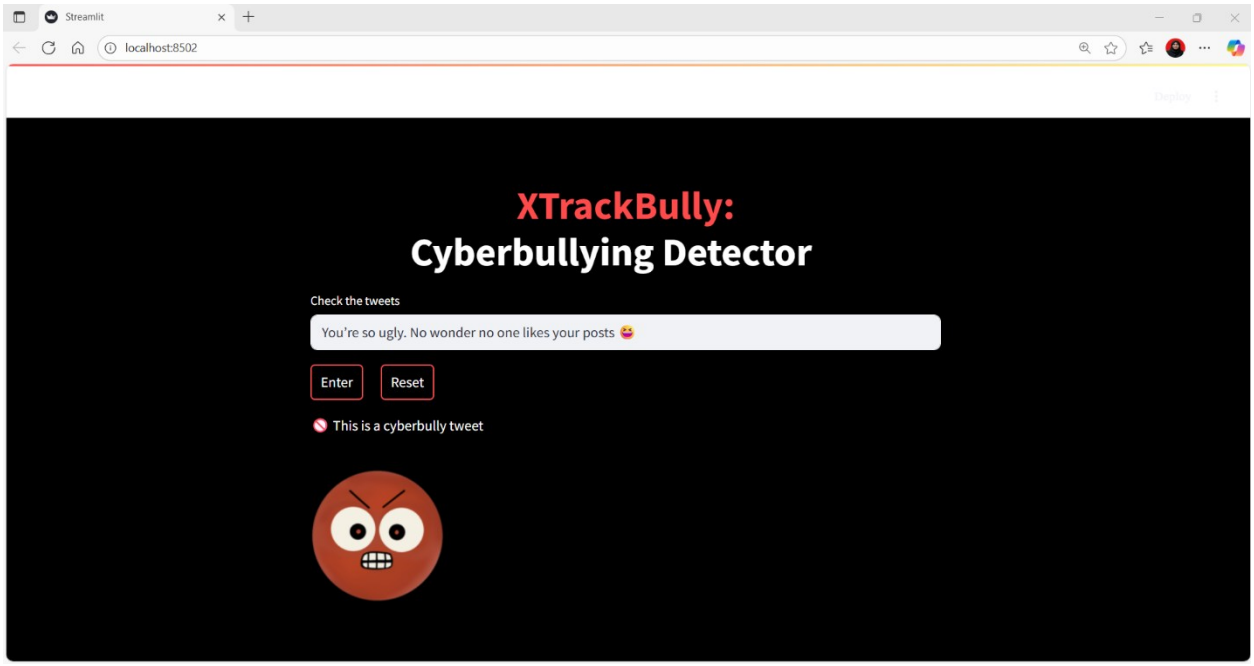

Figure 4. Example cyberbullying tweet detection result interface.

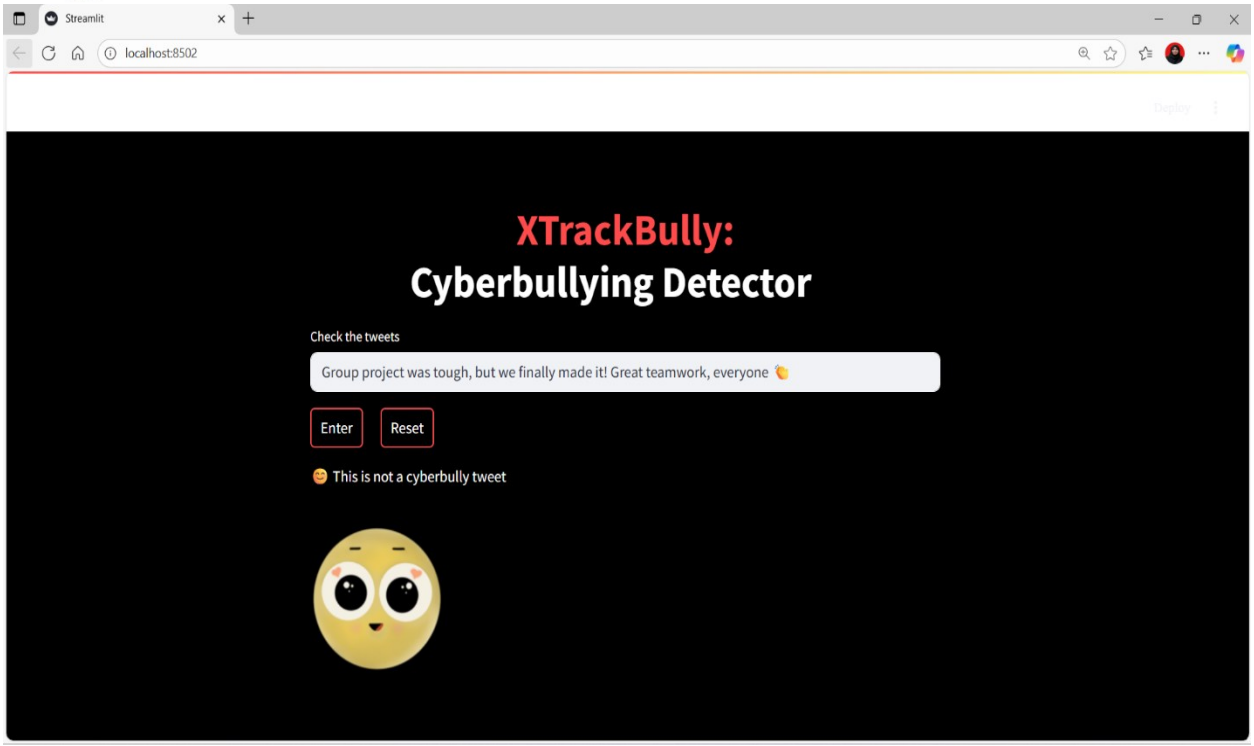

Figure 5. Example non-cyberbullying tweet detection result interface.

3. Novelty and uniqueness

The novelty of XTrackBully lies in its development as a practical real-time web application for cyberbullying detection using lightweight supervised machine learning instead of computationally expensive deep learning methods. Unlike many existing studies that focus mainly on model performance, this study presents an end-to-end and deployable system that can perform instant text screening with minimal infrastructure. This makes it suitable for real-world environments where computing resources and large labelled datasets are limited. The uniqueness of XTrackBully is reflected in its fully integrated NLP-to-classification workflow within a single web-based platform. To reduce the noisy nature of social-media text, e.g. the use of slang, abbreviations, and informal grammatical structures, the system uses specialized NLP preprocessing, including text cleaning, tokenization, stop-word removal and lemmatization. The format of the tokenized output is then captured as the output of statistical methods, which are BoW and TF-IDF. The outputs are then classified using a MLP classifier model which the user is then provided with the output as predictions through an interface that is not only easy to understand but also responds instantly to user query. In addition, the XTrackBully architecture enables easier review, update, and retrain in accordance with the changing online linguistic patterns and trends in cyberbullying. It is also capable of being expanded with additional labels or policy rules when needed. XTrackBully provides the solution of early intervention and reduces the volume of manual moderation, as well as increases the safety of online settings by providing timely and understandable feedback.

4. Benefit to mankind

XTrackBully benefits mankind as it contributes to establishing safer and healthier online spaces where people can share information without experiencing harassment. By promptly identifying cyberbullying, the system can support early intervention before negative messages grow to prolonged abuse, which in turn will limit emotional distress, anxiety and reputational damage, especially on those who are vulnerable like students and young adults. This system is also useful as it helps to reduce time and labor expenses by screening a large quantity of textual information automatically, which facilitates faster and more uniform responses from teachers, school counsellors, community moderators, and platform administrators. Its low cost, lightweight design makes the use of protective technology more accessible to smaller organizations and communities that may lack the financial resources to invest in costly moderation tools or infrastructure. XTrackBully may help achieve both improved well-being of online communities, strengthen websites the community trusts, and become more accountable in digital behavior both in the short-term and long-term by deterring toxic interactions and enabling proactive content regulation on social sites, discussion groups and in schools.

5. Innovation and Entrepreneurial Impact

The innovative feature of XTrackBully is its ability to provide real-time cyberbullying screening through a lightweight and deployable web-based application that can operate efficiently in fast-paced social media environments. Unlike a laboratory prototype, the proposed system is a functional and practical solution designed for real-world use. Its fast inference speed, low computational requirements, and user-friendly workflow interface enable users and moderators to make timely decisions. From an entrepreneurial perspective, XTrackBully creates value in three main ways. First, the system aids in minimizing the adoption difficulties as it is easy to install and implement thereby improving cyber-safety to those organizations with fewer resources. Second, by enabling intervention before harmful content, it helps reduce the reputational risk and maintain healthy communities, enhance digital trust and user well-being. Third, it prepares a platform to expand a larger trust-and-safety portfolio, including managed toxicity monitoring, policy enforcement procedures, and reporting and insights generation. This, in turn, supports scalable business models and foster collaboration with other key stakeholders in managing online harm, such as educational institutions, community ties and platform operators.

6. Potential commercialization

XTrackBully has a high commercialization potential, being an affordable cyber-safety option to the organizations, running online interaction and user-generated content. This can be provided as a SaaS web-based application where both the schools, SMEs, and community administrators can screen posts, comments, or chat messages in real time through a dashboard. Different levels of subscription may be based on the number of messages processed, the number of users or accounts of moderators, and the access to the advanced features like the alerting features, audit logs, and reporting. Alternatively, XTrackBully can be deployed as a REST API (Representational State Transfer API) or a plug-in, which can be embedded into the architecture of other systems such as learning systems, forums, and messaging apps. This allows flexible pricing options, such as monthly subscriptions or pay-per-use plans, while enabling developers to add moderator tools into their systems without major system modifications. Moreover, XTrackBully can also be used to create revenue, e.g. in education, gaming and workplace communities, analytics dashboards to monitor toxicity trends over time, and enterprise service packages that include support and

maintenance contracts. Since the system is lightweight, its operating costs remain low, making it easier to offer the service at an affordable price and attract cost-sensitive customers.

7. Acknowledgment

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8. Researchers' Biography

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Agrothink: An AI Powered Mobile Platform for Crop Disease Detection and Smart Household Farming

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ABSTRACT

The agricultural sector faces persistent challenges including delayed crop disease detection, limited access to agricultural advisory services for smallholder farmers, and the absence of structured farming guidance that often results in inefficient farming practices. To address these challenges, this project introduces AGROTHINK, an AI powered mobile application that provides accessible digital farming assistance through an integrated smart farming platform. Unlike many agricultural applications that offer isolated tools, AGROTHINK integrates crop diagnosis, AI advisory services, crop monitoring, and a digital agricultural marketplace within a single mobile environment. The application is developed using the Flutter framework with Firebase cloud infrastructure and Google Gemini AI integration. It provides five core functionalities: an AI agricultural chatbot for real time farming guidance, a computer vision-based crop disease detection module using smartphone images, an AI generated planting guide based on location and weather data, a crop health monitoring module, and an AI assisted task management system for organizing daily farming activities. A key innovation of AGROTHINK is its unbiased recommendation mechanism that suggests fertilizers and treatment solutions without affiliation to agrochemical companies. Recommended products can be purchased through the AGROTHINK digital marketplace using a 10 percent commission model that supports sustainable commercialization while maintaining objective agricultural recommendations.

Keywords: Artificial Intelligence, Mobile Application, Crop Disease Detection, Smart Farming, Agri-Marketplace

1. Product Description

AGROTHINK is an AI powered mobile application designed as a digital farming assistant for household farmers. The application is developed using the Flutter framework with Firebase cloud infrastructure and Google Gemini AI integration, providing five core functionalities within a single platform. The AGROX chatbot delivers real time agricultural guidance on planting techniques, pest management, fertilizer usage, and soil health. The AI based crop disease detection module allows farmers to capture crop images and receive instant diagnoses with appropriate treatment recommendations. These recommendations are generated independently without affiliation to agrochemical brands, ensuring objective and unbiased decision support. The AI generated planting guide produces personalized farming plans by combining crop information, GPS location, and weather data. These plans are converted into structured farming activities through an AI assisted task management system that organizes daily farming schedules. A crop health monitoring module enables continuous crop observation through periodic image analysis. Following diagnosis and

treatment recommendations, farmers may purchase suggested inputs through the AGROTHINK digital marketplace, which operates with a 10 percent commission model. AGROTHINK has also received mentorship and recognition from Universiti Teknologi Malaysia, Sunway iLabs, and Iskandar Investment Berhad, highlighting its technical credibility and commercialization potential.

2. System Architecture, Application Features, and Business Model

Figure 1 presents the layered system architecture of the AGROTHINK mobile application. The architecture consists of four layers: presentation layer, business logic layer, data services layer, and external cloud services layer.

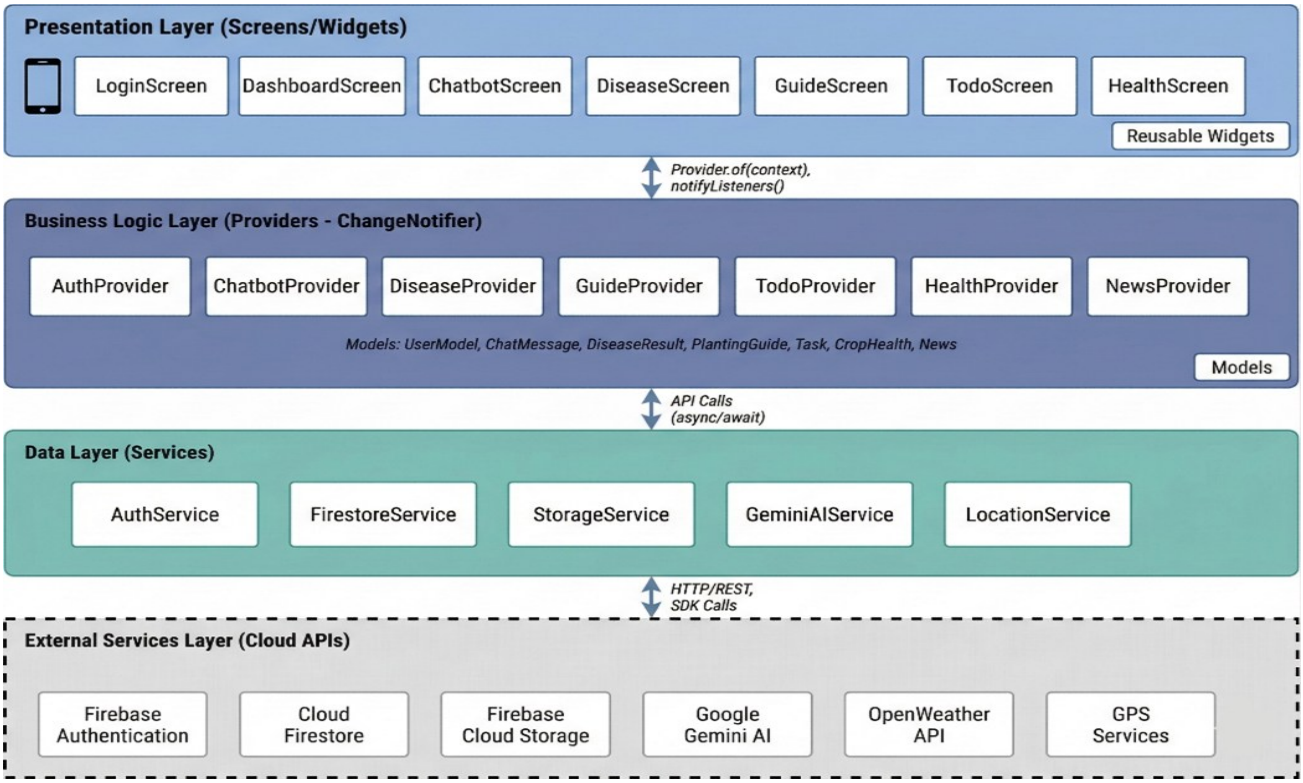

Figure 1. AGROTHINK layered system architecture.

The presentation layer contains the user interface components including login, dashboard, chatbot, disease detection, planting guide, task management, and crop health monitoring screens. The business logic layer implements application state management using the Provider pattern, coordinating modules such as authentication, chatbot interaction, disease analysis, task management, and health monitoring. The data layer provides service integration including authentication, database operations, file storage, AI processing, and location services. These services communicate with external cloud platforms including Firebase Authentication, Cloud Firestore, Firebase Cloud Storage, Google Gemini AI, OpenWeather API, and GPS services.

Figure 2 illustrates the AGROTHINK digital agricultural ecosystem and business model. The platform connects farmers, retailers, and producers within a data driven agri-ecosystem. Farmers use the application to diagnose crop diseases and receive AI powered recommendations. Based on these recommendations, farmers may purchase appropriate agricultural inputs through the

integrated marketplace. This model ensures efficient data flow between stakeholders while enabling transparent product recommendations and efficient product distribution.

Figure 2. AGROTHINK digital agricultural ecosystem and marketplace model.

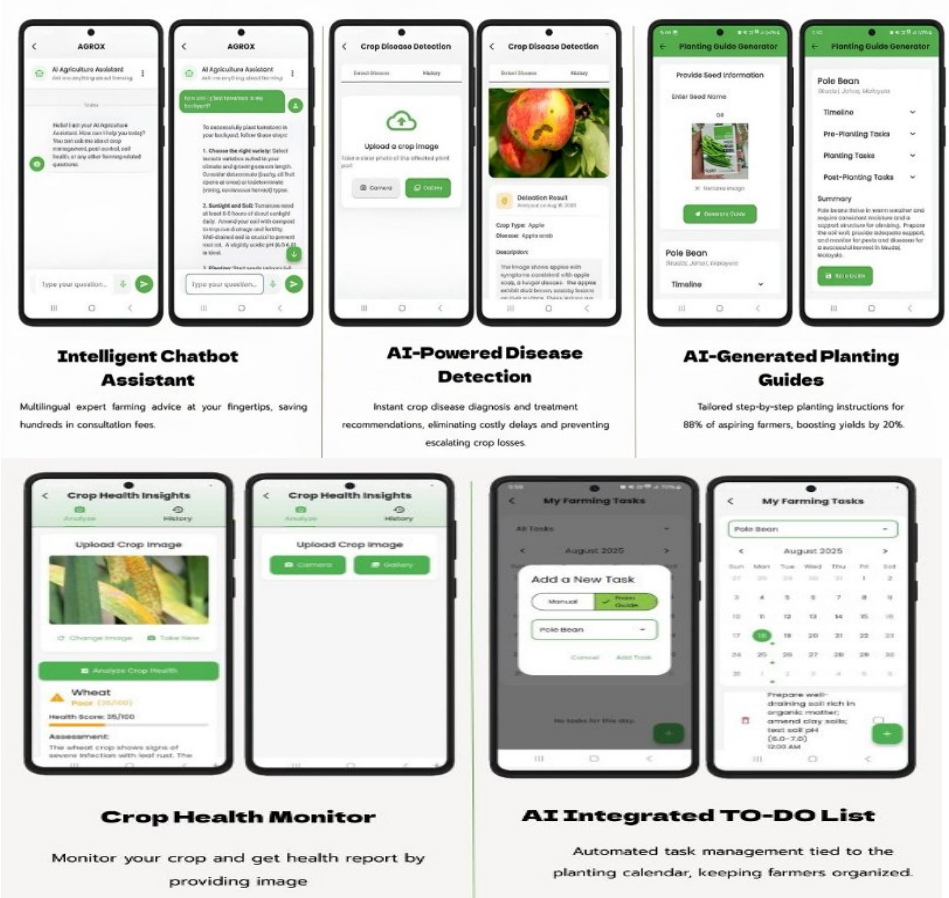

Figure 3. Core artificial intelligence features of the AGROTHINK mobile farming application.

Figure 3 presents the core intelligent modules integrated within the AGROTHINK mobile application. The platform provides an AI based chatbot assistant called AGROX that delivers conversational farming guidance and answers agricultural queries in real time. The crop disease detection module enables farmers to upload plant images and receive automated disease diagnosis together with recommended treatments using computer vision analysis. The application also includes an AI generated planting guide that produces structured farming instructions based on crop type and environmental conditions. In addition, the system provides a crop health monitoring feature that allows farmers to evaluate plant conditions through image-based analysis and obtain crop health reports. An AI integrated task management module automatically organizes farming activities based on planting schedules and recommended actions. Together, these modules allow AGROTHINK to function as a comprehensive digital farming assistant that supports informed agricultural decision making for household farmers. **Table 1** compares the intelligent farming features offered by AGROTHINK with several existing agricultural applications including Plantix, FarmRise, and commonly used communication platforms such as WhatsApp. The comparison focuses on key capabilities such as AI based crop disease detection, agricultural chatbot support, planting guide generation, crop health monitoring, and task management. The analysis shows that many existing platforms provide only limited or paid access to advanced features. In contrast, AGROTHINK integrates multiple artificial intelligence driven tools within a single platform while offering core services free of charge for farmers. This integrated functionality highlights the platform's potential to provide a more comprehensive digital farming assistant.

Table 1. Feature comparison between AGROTHINK and existing agricultural applications.

Feature	AGROTHINK	Plantix (10M+ DL)	FarmRise (5M+ DL)	WhatsApp
Agricultural AI Chatbot	✓ (FREE)	✗	✗	Partial
AI Disease Detection	✓ (FREE)	✓ (Paid)	✓ (Paid)	✗
AI Planting Guide Generator	✓ (FREE)	✗	Partial	✗
24/7 Expert Advice	✓ (FREE)	Partial	✗	Partial
AI To-Do / Task Manager	✓ (FREE)	✗	✗	✗
AI Crop Health Monitor	✓ (FREE)	✗	✗	✗
Unbiased Product Recommendations	✓	✗ (Biased)	✗ (Biased)	✗
Farmer Marketplace (10% fee)	✓ (Planned)	✗	✗	✗

Table 2 presents the projected financial performance of the AGROTHINK platform over a three-year commercialization period. The projection estimates growth in registered users, monthly active users, and revenue generated through the platform's agricultural marketplace. Revenue is primarily derived from commission fees applied to product transactions within the marketplace, while additional income is projected from API licensing services that allow external platforms to access AGROTHINK artificial intelligence capabilities. The financial model also considers operational costs associated with cloud infrastructure, system maintenance, and

platform operations. The projection indicates gradual adoption during the initial stage followed by significant revenue growth as the user base expands and marketplace activity increases. These projections demonstrate the potential commercial viability and long-term sustainability of the AGROTHINK platform.

Table 2. Three-year financial projection of the AGROTHINK platform.

Metric	2025/2026	2026/2027	2027/2028
Total Registered Users	390	1,950	4,875
Monthly Active Users	156	975	2,925
Marketplace Commission (RM)	8,415	93,600	447,525
API Licensing Revenue (RM)	0	4,776	21,492
Total Revenue (RM)	8,415	98,376	469,017
Operating Costs (RM)	8,450	27,600	50,900
Net Profit/ Loss (RM)	(35)	70,776	418,117

3. Novelty and uniqueness

AGROTHINK introduces an integrated AI powered mobile platform that combines crop disease diagnosis, conversational agricultural guidance, personalized planting planning, crop monitoring, and farming task management within a single application designed for household farmers. Unlike many existing agricultural applications that offer isolated tools or limited advisory functions, AGROTHINK integrates multiple intelligent farming services into a unified digital assistant that supports the entire farming workflow from crop diagnosis to farm activity management. A key innovation of AGROTHINK lies in its unbiased recommendation mechanism.After detecting crop diseases through image-based analysis, the platform recommends appropriate fertilizers and treatment solutions without affiliation to agrochemical companies. This approach ensures that farmers receive objective and transparent recommendations, addressing a common limitation in many agricultural platforms that promote products associated with specific commercial partners. Another distinctive aspect of AGROTHINK is the integration of multimodal artificial intelligence capabilities through Google Gemini AI. The platform supports both conversational interaction through an AI powered agricultural chatbot and image-based crop analysis within a single mobile interface. This combination allows farmers to access agricultural expertise through natural language communication while simultaneously benefiting from automated crop disease detection and personalized farming guidance.

4. Benefit to mankind

AGROTHINK contributes to improving agricultural productivity and knowledge accessibility for household farmers by providing AI assisted decision support through a mobile platform. By enabling early crop disease detection, structured planting guidance, and continuous crop monitoring, the platform helps farmers make informed farming decisions that can reduce crop losses and improve agricultural efficiency. This digital assistance is particularly valuable for smallholder farmers who have limited access to agricultural advisory services. The platform

supports several United Nations Sustainable Development Goals including SDG 1 (No Poverty) by improving farmer income potential, SDG 2 (Zero Hunger) by supporting sustainable food production, and SDG 8 (Decent Work and Economic Growth) by promoting digital innovation in the agricultural sector. In addition, AGROTHINK contributes to SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action) by encouraging more efficient use of agricultural inputs and supporting environmentally responsible farming practices.

5. Innovation and Entrepreneurial Impact

AGROTHINK demonstrates the integration of artificial intelligence innovation with entrepreneurial development in the agricultural technology sector. The platform combines crop disease diagnosis, AI powered advisory services, personalized planting guidance, crop monitoring, and digital marketplace integration within a single mobile application designed for household farmers. The project has received mentorship and startup development support from Universiti Teknologi Malaysia, Sunway iLabs, and Iskandar Investment Berhad, highlighting its potential to evolve from an academic innovation into a scalable agritech startup. AGROTHINK adopts a sustainable digital business model in which core AI driven farming assistance remains freely accessible to farmers, while revenue is generated through a commission based agricultural marketplace and potential AI service licensing. This approach supports technological innovation, entrepreneurial growth, and the digital transformation of agriculture.

6. Potential commercialization

AGROTHINK has strong commercialization potential within the rapidly growing agricultural technology market. The primary revenue stream is generated through the integrated digital marketplace, where agricultural inputs recommended by the platform can be purchased by farmers. The platform adopts a 10 percent commission model on marketplace transactions, offering competitive pricing compared to traditional agricultural retail margins. In addition to marketplace revenue, AGROTHINK also offers potential for AI service licensing through Application Programming Interface (API) integration, allowing third party agricultural platforms or digital farming services to access its crop diagnosis and advisory capabilities. The commercialization strategy begins with deployment among household farmers in Malaysia, followed by expansion into other Southeast Asian agricultural markets. With scalable cloud infrastructure and mobile based accessibility, AGROTHINK is positioned to support large scale adoption while contributing to the digital transformation of the agricultural sector.

7. Researchers' Biography

Dr. Ruhaidah Samsudin is an academician at the Faculty of Computing, Universiti Teknologi Malaysia (UTM). Her research focuses on Artificial Intelligence, Machine Learning, Computational Intelligence, and Predictive Modelling. Her publications explore hybrid intelligent models and optimization techniques for data analysis and forecasting tasks. Through her journal and conference publications, she contributes to advancing data-driven prediction methods and intelligent computational approaches.

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StudyPal: An AI-Driven Multi-Agent Platform for Adaptive Mastery-Based Learning in Higher Education

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ABSTRACT

Higher education institutions increasingly rely on digital learning platforms; however, most Learning Management Systems (LMS) prioritise course completion rather than ensuring that students achieve mastery of intended learning outcomes. This limitation often results in unresolved knowledge gaps, weak conceptual understanding, and poor knowledge retention among students. To address this challenge, this project introduces StudyPal, an AI-driven mastery-based learning platform that ensures students achieve verifiable competency before progressing to subsequent learning stages. The platform integrates a multi-agent AI architecture consisting of an Assessment Agent, Learning Path Agent, Adaptive Mentor Agent, Progress Monitoring Agent, and Regenerative Assessment Agent. These intelligent agents collaboratively diagnose learning gaps, generate personalised learning pathways, and continuously verify mastery through adaptive assessments aligned with Bloom's taxonomy levels. Unlike conventional LMS platforms, StudyPal enforces mastery-based progression through regenerative assessments and real-time AI mentoring. By transforming digital learning from completion-based delivery into a mastery-driven learning ecosystem, StudyPal aims to enhance knowledge retention, improve student engagement, and strengthen learning effectiveness at scale. This innovation supports the United Nations Sustainable Development Goal (SDG) 4: Quality Education and contributes to SDG 9: Industry, Innovation and Infrastructure through the development of scalable AI technologies for next-generation digital education.

Keywords: AI-driven learning, mastery-based learning, multi-agent AI architecture, adaptive tutoring, personalised learning

1. Product Description

StudyPal is an AI-powered mastery-based learning platform designed to support personalised education in higher education environments. The system addresses a critical gap in conventional LMS, which typically measure student progress based on course completion rather than mastery of learning outcomes. The platform operates using multi-agent AI architecture that coordinates several intelligent agents to deliver adaptive learning experiences. The Assessment Agent maps instructor-generated questions to learning outcomes and Bloom's taxonomy levels, ensuring accurate cognitive alignment. The Learning Path Agent dynamically adapts content sequencing according to student performance and prerequisite knowledge. The Adaptive Mentor Agen tutor. In addition, the Progress Monitoring Agent continuously tracks mastery levels across different topics, while the Regenerative Assessment Agent automatically generates new assessment items to reinforce learning until mastery thresholds are achieved. The system integrates knowledge

tracing, learning analytics, and retrieval-augmented generation (RAG) to provide contextual learning support. StudyPal can be deployed as a standalone platform or integrated with existing LMS systems, enabling scalable implementation across universities and training institutions. It provides real-time explanations, hints, and personalised learning guidance similar to a virtual

2. System Architecture and Feature Comparison

StudyPal is an AI-driven mastery-based learning platform developed to support personalised and adaptive education in higher education environments. The system architecture, illustrated in **Figure 1**, demonstrates how a coordinated multi-agent ecosystem supports continuous mastery verification, personalised tutoring, and adaptive learning pathways.

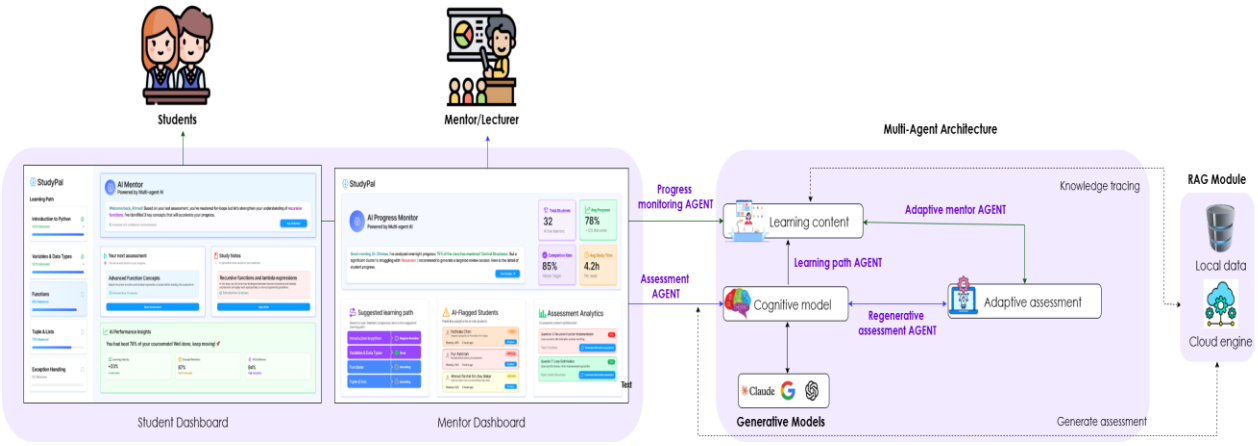

Figure 1. AI-Driven Multi-Agent Platform for Mastery-Based Learning.

At the core of the platform is a Cognitive Model, which acts as the central intelligence that interprets student performance data and learning analytics. This model coordinates five specialised AI agents that collaboratively manage the learning process. The Assessment Agent maps instructor-provided questions to defined learning outcomes and Bloom's taxonomy levels, ensuring cognitive alignment. The Learning Path Agent dynamically sequences learning materials according to each student's progress and prerequisite mastery. Meanwhile, the Adaptive Mentor Agent functions as an AI tutor that provides contextual explanations, personalised feedback, and targeted learning support. To ensure continuous learning improvement, the Progress Monitoring Agent tracks mastery levels across topics using knowledge tracing models, while the Regenerative Assessment Agent generates new adaptive assessments until mastery thresholds are achieved. These agents interact with generative AI models and a cloud-based data infrastructure to deliver scalable, real-time learning support. As shown in **Figure 1**, students interact with the platform through a Student Dashboard, while educators access analytics and performance insights through a Mentor Dashboard. This dual-interface design ensures both personalised learning and effective academic monitoring. While **Table 1** presents a comparative analysis of conventional LMS, AI tutoring systems, and the developed StudyPal platform. The comparison highlights the key differences in learning models, personalisation capabilities, feedback mechanisms and mastery verification approaches across these systems. Unlike traditional LMS platforms that focus primarily on course completion, StudyPal ensures continuous mastery verification through adaptive learning paths, regenerative assessments, and real-time personalised mentoring. Compared with conventional LMS and existing AI tutoring systems, StudyPal provided a more

comprehensive and scalable solution for adaptive mastery learning in higher education environments.

Table 1. Comparative Analysis of Conventional LMS, AI Tutoring Systems, and the StudyPal AI-Driven Mastery-Based Learning Platform.

Feature	Traditional LMS	AI Tutoring Systems	StudyPal Platform
Learning Model	Completion-based learning	Personalised tutoring	Mastery-based adaptive learning
Learning Path	Fixed course sequence	Semi-adaptive sequencing	Fully dynamic adaptive learning path
Feedback Mechanism	Static or delayed feedback	AI responses to questions	Real-time personalised AI mentoring
Assessment Strategy	Single or limited attempts	AI-generated exercises	Regenerative adaptive assessments until mastery
Personalisation Level	Minimal personalisation	Moderate personalisation	Multi-agent AI personalisation engine
Mastery Verification	Not enforced	Limited tracking	Continuous mastery verification using knowledge tracing
Instructor Support	Basic grade monitoring	Limited analytics dashboard	Advanced mentor dashboard with learning analytics
Scalability	Limited lecturer capacity	Scalable tutoring support	Scalable AI mentoring for large student cohorts
Learning Outcome	Course completion	Skill assistance	Verified competency and improved knowledge retention

3. Novelty and uniqueness

StudyPal introduces a disruptive shift in digital education by transforming conventional completion-based learning into an AI-driven mastery learning ecosystem. Unlike traditional LMS and existing AI tutoring tools that primarily deliver instructional content or respond to student queries, StudyPal integrates a multi-agent AI architecture that actively diagnoses learning gaps, adapts learning pathways, and verifies mastery in real time. The platform's novelty lies in its orchestrated multi-agent intelligence, where specialised agents collaborate to manage different stages of the learning cycle. The Assessment Agent aligns instructor-provided questions with learning outcomes and Bloom's taxonomy cognitive levels, while the Learning Path Agent dynamically sequences learning materials based on prerequisite mastery. The Adaptive Mentor Agent provides contextual explanations and personalised learning guidance identical to an intelligent AI tutor. Meanwhile, the Progress Monitoring Agent continuously tracks knowledge acquisition using knowledge tracing models, and the Regenerative Assessment Agent generates targeted assessments until predefined mastery thresholds are achieved. This closed-loop mastery verification mechanism distinguishes StudyPal from existing educational technologies. By integrating generative AI, learning analytics, and adaptive assessments within a unified architecture, StudyPal establishes a scalable AI-powered learning infrastructure capable of supporting large student cohorts while ensuring personalised learning experiences and measurable competency development.

4. Benefit to mankind

StudyPal enhances the quality and effectiveness of higher education by ensuring that students achieve genuine mastery of knowledge rather than merely completing course requirements. Through AI-driven mentoring, adaptive learning pathways, and continuous mastery verification, the platform helps students to develop deeper conceptual understanding, improve knowledge retention, and enhance higher-order thinking skills. By providing personalised learning support and adaptive assessments, StudyPal assists students' progress according to their individual learning pace and mastery levels. The platform empowers educators by providing automated learning analytics and intelligent monitoring tools (real-time insights into student learning progress), enabling lecturers to manage large student cohorts while maintaining personalised academic and learning support. The development of StudyPal directly supports the United Nations Sustainable Development Goal (SDG) 4: Quality Education by promoting inclusive, equitable, and technology-enhanced learning environments that improve learning outcomes. In addition, the platform contributes to SDG 9: Industry, Innovation and Infrastructure through the development of scalable AI technologies that strengthen digital education infrastructure and support innovation in the global knowledge economy.

5. Innovation and Entrepreneurial Impact

StudyPal demonstrates how academic research can be translated into a practical digital innovation for modern education systems. By integrating multi-agent AI architecture, learning analytics, and regenerative adaptive assessments, the platform introduces a novel AI-powered mastery learning infrastructure for higher education institutions. From an entrepreneurial perspective, StudyPal creates opportunities for the development of scalable AI-based education technologies that can be adopted by universities, online learning providers, and professional training institutions. The project also encourages collaboration between researchers, students, and industry partners to develop deployable digital learning solutions. By transforming research innovation into a functional AI-enabled learning platform, StudyPal supports the growth of innovation-driven education technologies and digital learning ecosystems.

6. Potential commercialization

StudyPal has strong commercialization potential as a scalable AI-powered learning platform for higher education institutions. The platform can be commercialised through institutional licensing, subscription-based services, or integration with existing LMS. Initial deployment targets universities seeking to improve learning outcomes, monitor student mastery and learning progress, and enhance teaching effectiveness. As a pilot implementation, the platform can be introducted within the Faculty of Computing at Universiti Teknologi Malaysia (UTM) before expanding to other faculties and higher education institutions. With further development and strategic industry collaborations, StudyPal can be extended to support professional training platforms, online learning ecosystems, and corporate workforce development programs.

7. Researchers' Biography

Lizawati Mi Yusuf is a Senior Lecturer at the Faculty of Computing, Universiti Teknologi Malaysia (UTM). She received her B.Sc. in Computer Science from UTM and her M.Sc. in Information Technology from Universiti Kebangsaan Malaysia (UKM). Her research focuses on artificial intelligence, optimization, machine learning, and intelligent data analytics. She is actively involved in AI-driven education innovation, particularly in applying intelligent computing techniques to enhance digital learning environments and data-driven decision support systems. Her work integrates computational intelligence with real-world applications to support scalable, technology-enabled education and institutional digital transformation initiatives.

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Tan Zheng Yu is an Undergraduate Researcher at Universiti Teknologi Malaysia (UTM), specializing in Multi-Agent Systems (MAS) and agentic AI architectures. Through his research and technical leadership, he has utilised methods for intelligent orchestration and adaptive learning, notably developing the StudyPal platform and the AI Travel Buddy system developed in collaboration with government stakeholders. His work seamlessly bridges academia and industry, demonstrated by his optimizations of scalable enterprise AI pipelines and multiple academic accolades, including the Silver Award at NALI 2025, recognizing his significant contributions to deploying reliable and innovative intelligent systems.

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BPSPro Application: Augmented Reality-Based Digital Pattern Design for Fashion TVET Education and Industry

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ABSTRACT

The rapid advancement of digital technologies has transformed learning approaches in Technical and Vocational Education and Training (TVET), particularly in skill-based disciplines requiring strong visualization and practical understanding. In fashion design education, clothing pattern construction requires accurate body measurements and spatial visualization, yet conventional pattern drafting methods remain largely manual, time-consuming, and prone to measurement errors. This study introduces BPSPro (Buat Pola Sendiri Profesional), a mobile-based application that integrates Augmented Reality (AR) to support digital clothing pattern design and learning. The application enables AR-based body measurement scanning, automated pattern parameter generation, and interactive garment visualization within a single platform. A quantitative survey was conducted involving 20 Diploma in Fashion and Clothing Design students at Politeknik Ibrahim Sultan, Malaysia. A 20-item questionnaire measuring application usability, learning understanding, measurement accuracy, and learning motivation was administered using a five-point Likert scale. Descriptive statistics and reliability analysis were applied. The findings indicate a high overall mean score of 4.42, with learning motivation recording the highest mean (4.46), followed by application usability (4.45), learning understanding (4.40), and measurement accuracy (4.38). The instrument demonstrated strong reliability (Cronbach's Alpha = 0.91). Overall, BPSPro enhances students' understanding of clothing pattern construction while reducing measurement errors and increasing learning motivation, supporting digital transformation in TVET fashion education and small-scale fashion industry practices.

Keywords: Augmented Reality, TVET Education, Digital Fashion Technology, Clothing Pattern Construction, Innovation in Learning.

1. Product Description

BPSPro (Buat Pola Sendiri Profesional) is an innovative mobile application designed to digitalize the clothing pattern-making process for fashion students, designers, and small-scale clothing entrepreneurs. The application integrates Augmented Reality (AR) technology to perform automatic body measurement scanning using a mobile device camera, enabling users to obtain accurate body dimensions quickly and efficiently. Based on the captured measurements, the system generates suitable clothing pattern parameters and supports visualization of garment structures before the actual pattern drafting process. By simplifying complex pattern construction procedures, BPSPro reduces measurement errors, improves design accuracy, and enhances learning experiences in Technical and Vocational Education and Training (TVET). The application supports the digital transformation of the fashion industry by providing an affordable and user-friendly digital platform with strong potential for commercialization among fashion designers, tailoring businesses, and fashion education institutions.

2. BPSPro System Architecture and Application Interface

The system architecture and application interface of BPSPro are designed to support an integrated digital workflow for clothing pattern development through mobile technology. As illustrated in **Figure 1**, the system architecture presents the interaction design flow of the BPSPro application, beginning from the introductory interface and language selection to user authentication and the main system functions. The architecture integrates several core modules including user registration and login, body measurement scanning, measurement data processing, template exploration, and dashboard management. This structured workflow allows users to access the main features of the application such as scanning body measurements, exploring pattern templates, viewing measurement data, and managing their user profiles within a unified mobile platform. The application interface design shown in **Figure 2** demonstrates the sequential interaction flow experienced by users when operating the BPSPro application. The interface includes several key screens such as the intro screen, welcome page, registration interface, home dashboard, scanning interface, camera-based measurement capture, measurement results display, and dashboard management. These interfaces are developed using a user-centered interaction design approach to ensure usability, accessibility, and ease of navigation for users with varying levels of technical expertise. To further evaluate the effectiveness of the application, a user perception study was conducted among students in the Diploma in Fashion and Clothing Design programme. The evaluation results are presented in **Figure 3**, which compares the mean scores across four constructs: measurement accuracy, learning understanding, application usability, and learning motivation. The findings indicate strong positive perceptions towards the BPSPro application, with learning motivation recording the highest mean score. This suggests that the integration of AR-based measurement features and interactive interface design enhances both learning engagement and user experience. Overall, the integration of automated measurement capture, intuitive interface design, and structured data management provides a scalable digital platform that improves efficiency and accuracy in clothing pattern construction within TVET fashion education and small-scale fashion production environments.

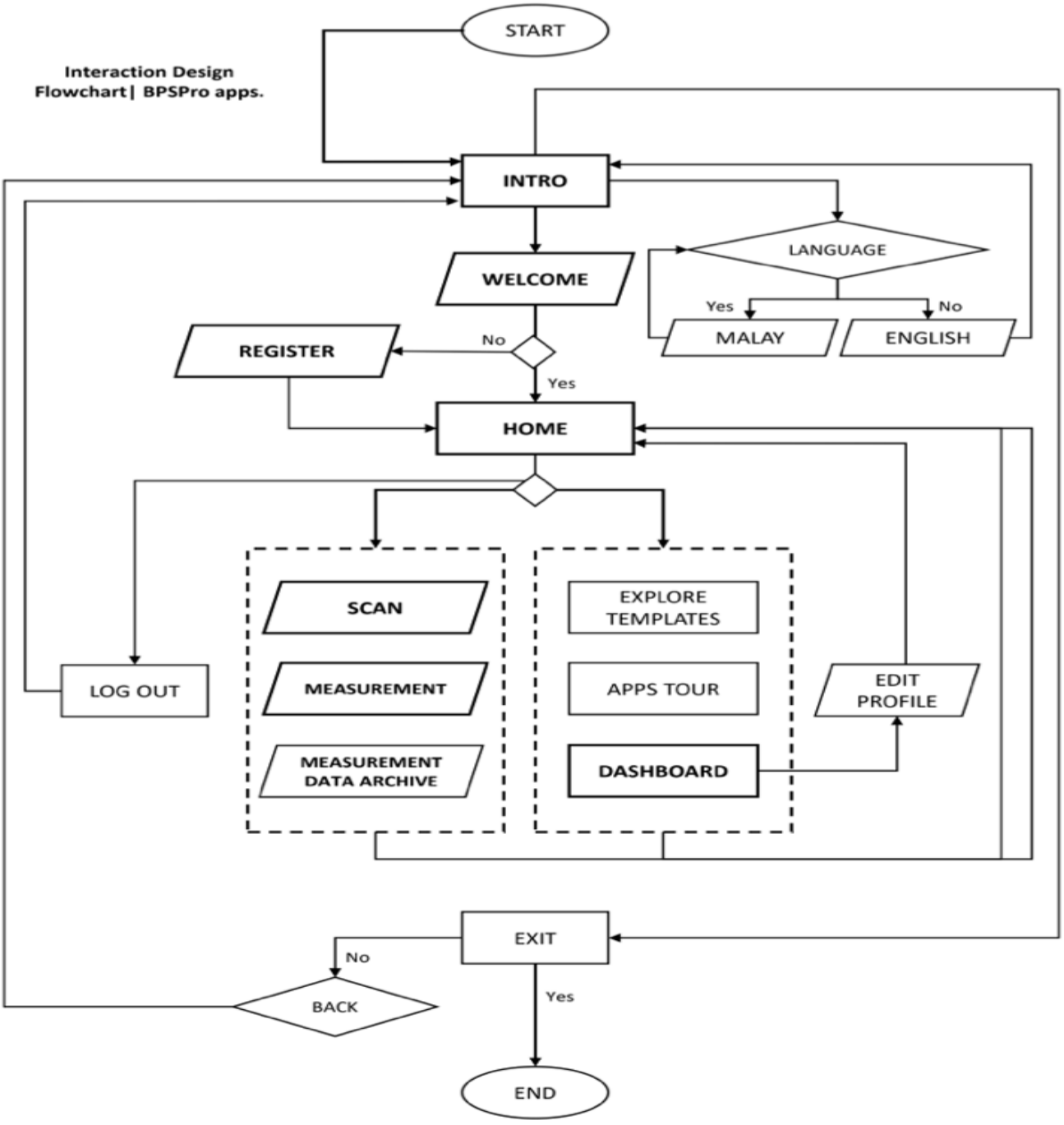

Figure 1. BPSPro Application System Architecture.

Figure 2. BPSPro Application Interface.

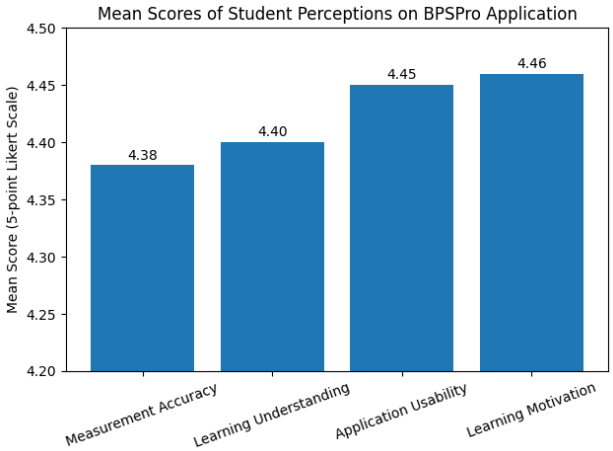

Figure 3. Mean Scores of Student Perceptions on BPSPro Application.

The figure presents the comparison of mean scores across four evaluation constructs: measurement accuracy (4.38), learning understanding (4.40), application usability (4.45), and learning motivation (4.46). The results indicate strong positive perceptions among students, with learning motivation recording the highest mean score.

3. Novelty and uniqueness

BPSPro introduces a novel approach to clothing pattern construction by integrating Augmented Reality body measurement scanning and digital pattern parameter generation within a mobile application environment. Unlike conventional fashion pattern drafting methods that rely on manual measurement and paper-based processes, BPSPro digitalizes the workflow into an interactive and efficient system. The innovation allows users to capture body dimensions using a smartphone camera and convert the captured measurements into clothing pattern parameters. This capability reduces measurement errors and improves pattern accuracy compared to traditional techniques. The application also provides digital visualization features that support better spatial understanding of garment structures, particularly for fashion students and beginner designers. Another unique aspect of BPSPro is its emphasis on accessible and affordable digital technology tailored for the TVET fashion sector and small-scale clothing entrepreneurs.

4. Benefit to mankind

BPSPro contributes to society by improving access to digital technology in fashion education and small-scale clothing production. The application simplifies clothing pattern construction processes, allowing students, fashion designers, and tailoring entrepreneurs to create accurate patterns more efficiently. In education, BPSPro enhances learning experiences in TVET by providing interactive digital visualization and automated body measurement tools that support practical skill development. Students can better understand garment structures through digital interfaces that improve engagement and reduce errors during practical activities. For the fashion industry, particularly small and medium-sized enterprises (SMEs), BPSPro offers a cost-effective digital solution that improves productivity, reduces measurement inaccuracies, and accelerates the design process.

5. Innovation and Entrepreneurial Impact

BPSPro promotes innovation by integrating emerging digital technologies such as Augmented Reality and mobile computing into fashion education and industry practices. The application demonstrates how digital technology can enhance traditional skill-based learning and production processes within the fashion sector. Within the educational context, BPSPro encourages students to explore digital innovation in fashion design, fostering creativity and technological awareness among future designers. By exposing students to digital tools aligned with Industry 4.0 technologies, the project contributes to building a technology-oriented mindset within TVET education. From an entrepreneurial perspective, the application empowers small-scale clothing entrepreneurs and tailoring businesses to adopt digital solutions that improve pattern accuracy and production efficiency, thereby increasing competitiveness in the fashion market.

6. Potential commercialization

BPSPro demonstrates strong commercialization potential as a digital fashion technology platform designed for fashion students, designers, tailoring businesses, and small-scale clothing entrepreneurs. The application can be distributed globally through mobile marketplaces such as

the Google Play Store and Apple App Store, enabling broad market accessibility. The platform can support various business models including subscription-based services, premium pattern templates, and advanced digital pattern generation features. In addition, BPSPro provides opportunities for collaboration with fashion education institutions and TVET training centres as a digital teaching and learning tool. The innovation is currently protected under Malaysian Utility Innovation Application (MYIPO: UI 2025008390), strengthening its readiness for commercialization and industry adoption.

7. Acknowledgment

The authors acknowledge Politeknik Ibrahim Sultan and the Department of Polytechnic and Community College Education (JPPKK), Ministry of Higher Education Malaysia, for supporting this project through the TVET Applied Innovation Grant Scheme (T-AIGS) 2025. The authors also acknowledge the students of the Diploma in Fashion and Clothing Design programme who participated in the testing and evaluation of the application prototype.

8. Researchers' Biography

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Nor Afian Bin Yusof is a lecturer at the Centre for Citra University Studies, Universiti Kebangsaan Malaysia (UKM), Malaysia. He holds a PhD from Universiti Kebangsaan Malaysia (UKM) and obtained his Master's and Bachelor's degrees from Universiti Teknologi MARA (UiTM). His research interests include Graphic Design, Visual Arts, Creative Media, digital media innovation, and visual communication within the field of Arts and Applied Arts.

CVT Motorcycle Edutrainer: A Hands-on Transmission Learning Innovation

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ABSTRACT
The operation of the Continuously Variable Transmission (CVT) system in scooters often presents learning challenges for automotive engineering students because the gear ratio changes continuously and cannot be easily observed through conventional teaching methods. Therefore, the CVT Motorcycle Edutrainer was developed as an experiential learning teaching aid to help students understand the operating principles of CVT through visual and practical interaction. This innovation was designed using a design-and-development approach that involved user-need analysis, literature review, and the development of a functional model integrating actual CVT transmission components, a speed-adjustment mechanism, and safety features. The main uniqueness of this edutrainer lies in its ability to demonstrate the dynamic movement of pulleys and belts, allowing students to observe real-time transmission ratio changes through interactive simulation. In addition, a robust frame structure and protective covers for moving components ensure safe operation in workshop and laboratory environments. From a socio-economic perspective, this innovation has the potential to enhance technical skills, safety awareness, and the employability of graduates in the automotive field. The product also has potential for commercialization as a modular training kit for TVET institutions, polytechnics, and technical training centres. Future improvements may include the integration of digital sensors and interactive display systems to strengthen modern engineering learning experiences.

Keywords: Continuously Variable Transmission (CVT), teaching aid, automotive engineering.

1. Product Description
The CVT Motorcycle Edutrainer is an innovative teaching aid designed to support the learning of Continuously Variable Transmission (CVT) concepts in the Automotive Workshop Practice 3 (DJA40052) syllabus for Semester 3. The edutrainer measures 74 cm × 63 cm × 63 cm with a height of 97.5 cm and serves as a compact, portable training kit that integrates authentic CVT components, including a primary pulley (variator), secondary pulley (clutch assembly), V-belt, pulley system, and a scrapped scooter engine. All components are systematically arranged for user-friendliness, incorporating wire mesh, locking wheels, speed adjusters, additional metal supports, screws and nuts, fuses, and protective paint for durability. The sturdy frame and moving part guards ensure safe use in workshops. Its dynamic mechanism allows students to observe

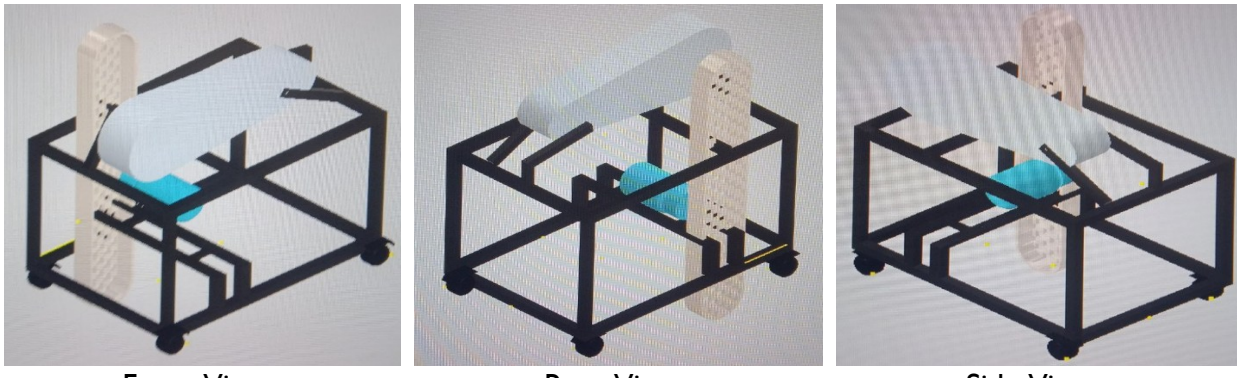
pulley and belt movements, delivering a practical, visual learning experience without requiring access to an actual vehicle. This teaching aid supports experiential learning, improves technical skills, promotes safety awareness, and enhances graduate employability. The CVT Motorcycle Edutrainer stands out as a structured, safe, and innovative practical training solution, offering an effective approach to understanding automotive transmission systems for polytechnics and TVET training centers.

2. Brief Introduction

Continuously Variable Transmission (CVT) in scooters allows the gear ratio to change continuously, enhancing vehicle efficiency and performance. However, the dynamic movement of pulleys and drive belts makes it challenging for automotive engineering students to grasp the concept through traditional teaching methods. Aligned with experiential learning pedagogy, the CVT Motorcycle Edutrainer was developed as a practical and safe teaching aid that visualizes the operation of CVT in real time. This innovation enables students to observe gear ratio changes, understand CVT mechanisms in a hands-on manner, and improve technical skills. Its modular design also allows potential integration of digital technologies to enhance interactive learning experiences. To support comprehension of CVT operation practically, a visual representation of the teaching aid plays a key role. The following sections present illustrations, models, development flowcharts, and diagrams of the CVT Motorcycle Edutrainer, helping students link theoretical concepts with practical application interactively.

Edutrainer Design

The CVT Motorcycle Edutrainer is depicted from three main perspectives: front, rear, and side. **Figure 1**-CVT Motorcycle Edutrainer Design showing views for front, rear and side view. The front view emphasizes critical components such as the primary pulley (variator), secondary pulley (clutch assembly), drive belt, and speed adjustment mechanism, alongside safety features like protective wire mesh. The rear view highlights frame support components, including locking wheels, fuses, and additional protective elements to ensure stability during use. The side view illustrates the dynamic movement of pulleys and belt, allowing students to visualize gear ratio changes in a practical way without requiring access to a real scooter.



Front View Rear View Side View

Figure 1. CVT Motorcycle Edutrainer Design.

Edutrainer Model

The CVT Motorcycle Edutrainer demonstrates the real interaction among CVT components, including the scrapped scooter engine, pulleys, belt, and speed-adjustment system. Positional for each part shown in **Figure 2**- CVT Edutrainer Model below Each component is represented in operational condition, allowing students to observe mechanical motion and understand CVT principles.

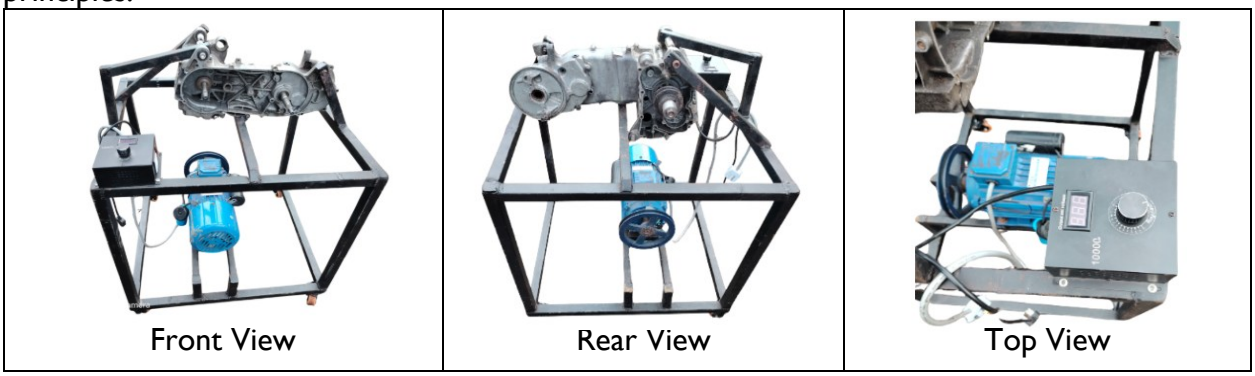


Figure 2. CVT Motorcycle Edutrainer Model.

Development Flowchart of the Edutrainer

The CVT Motorcycle Edutrainer development process is illustrated through a systematic flowchart in **Figure 3 -** CVT Motorcycle Model Development Flowchart. The process begin with user needs analysis, followed by literature review, conceptual design, component selection, and frame construction with module assembly. Subsequent steps include functionality and safety testing, integration of additional digital technologies, and preparation of the final operational edutrainer. The flowchart provides a comprehensive overview of the innovation journey from initial concept to fully functional prototype.

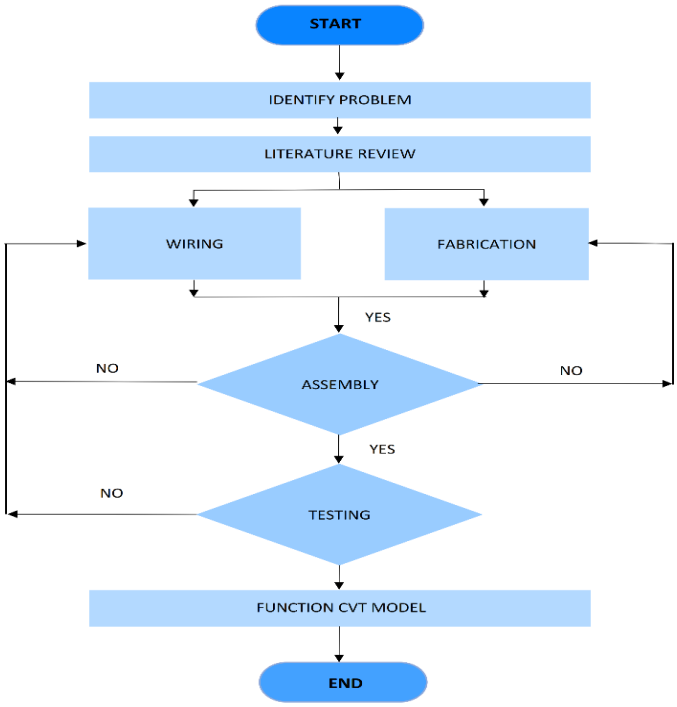


Figure 3. CVT Motorcycle Model Development Flowchart.

Principle of Operation

Figure 4 - CVT Motorcycle Main Component shows the component of a Continuously Variable Transmission (CVT) in a scooter. It presents the primary pulley (variator) and secondary pulley (clutch assembly) connected by a drive belt, with arrows indicating engine rotation and power transfer to the rear wheel. The diagram shows all component for student to assembe and dismentle CVT Edutrainer Model This practical task helps students to understand the real component and sequence of parts through visual observation and practical interaction without requiring access to an actual vehicle.

Figure 4. CVT Motorcycle Main Component.

3. Novelty and Uniqueness

The CVT Motorcycle Edutrainer stands out by combining authentic CVT components with a modular design that allows students to observe the dynamic movement of pulleys and drive belt in real time. Its primary novelty lies in its ability to visually demonstrate continuously changing gear ratios, which is not achievable through conventional teaching methods such as theoretical lectures or vehicle demonstrations. The edutrainer features a dynamic, safe mechanism, including protective covers for moving parts, a robust frame, and additional safety elements, enabling hands-on learning without risk. Its modular design also allows integration of digital technologies, including sensors and interactive displays, to enrich the learning experience. Another unique aspect is its compact and portable kit design, facilitating teaching in laboratories, workshops, or TVET training sessions. Overall, this innovation unites experiential learning, safety, and functional modularity, making the CVT Motorcycle Edutrainer a distinctive and practical solution for automotive education.

4. Benefit to Mankind

The CVT Motorcycle Edutrainer provides direct benefits to students, educators, and the automotive industry. Refer to **Figure 5 -** CVT Motorcycle Edutrainer Model used in automotive workshop, thus students gain a practical understanding of CVT principles, enhancing technical skills, safety awareness, and employability. While based on **Figure 6 -** CVT Motorcycle Edutrainer Model were used for educators training. For educators and institutions, it offers a safe, structured, and interactive teaching medium, reducing reliance on costly or high-risk real vehicles. From a socio-economic perspective, the CVT Motorcycle Edutrainer contributes to the

development of a skilled workforce, preparing young people to meet the demands of modern automotive industries. Experiential learning with the edutrainer also improves student motivation and conceptual understanding, supporting higher-quality technical and vocational education (TVET) and fostering a generation capable of applying mechanical and engineering knowledge effectively.

Figure 5. CVT Motorcycle Edutrainer Model Used in Automotive Workshop.

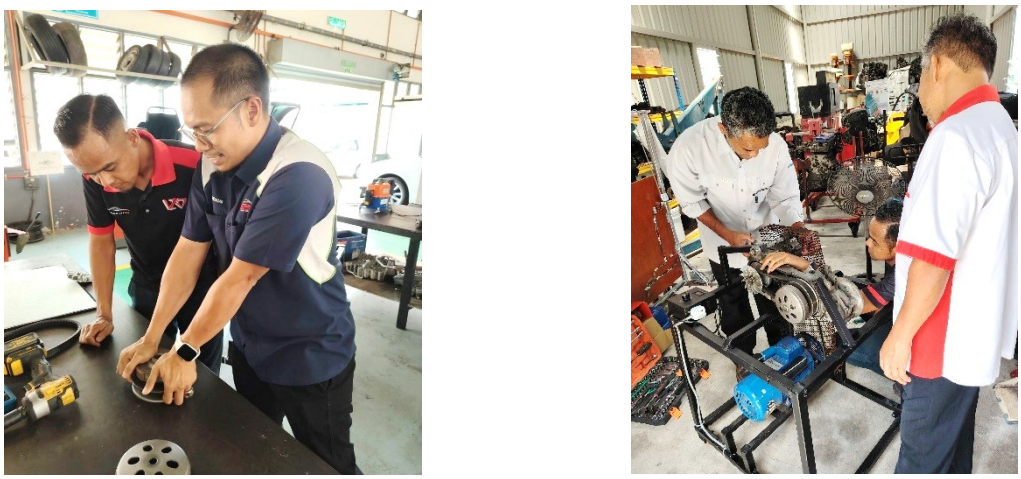


Figure 6. CVT Motorcycle Edutrainer Model Used for Educators Training.

5. Innovation and Entrepreneurial Impact

The CVT Motorcycle Edutrainer promotes a culture of innovation and entrepreneurship by providing a platform that can be developed into modular CVT training products. Educational institutions can use it for research and development projects, while students gain practical experience in mechanical design, CVT operation, and digital integration. The innovation also creates opportunities for students and local communities to produce commercial versions, such as training kits for TVET centers, polytechnics, or technical workshops. The project fosters creative and innovative thinking, builds entrepreneurial skills, and instills a technical entrepreneurial mindset among students and staff, supporting a competitive educational and industrial ecosystem.

6. Potential Commercialization

The CVT Motorcycle Edutrainer has strong potential for commercialization as a modular training kit for TVET institutions, polytechnics, and automotive skill centers. Its compact and modular design allows scalable production, easy transportation, and convenient storage. Educational institutions can adopt the edutrainer as a safe and interactive teaching tool, while workshops or technical training providers can use it for hands-on student and employee training. With potential digital integration, such as sensors and interactive displays, the product can be marketed as an innovative tool for modern technical education. Its fully functional and modular design increases commercial value, creating business opportunities and fostering partnerships between institutions, training equipment manufacturers, and the automotive industry.

7. Acknowledgment

The project is financially supported by the Department of Mechanical Engineering, Politeknik Port Dickson, Port Dickson, Negeri Sembilan.

8. Researchers' Biography

Shaifatulna'im Binti Shamsuddin is a Senior Lecturer at the Department of Mechanical Engineering, Politeknik Port Dickson, with 20 years of teaching experience. She specializes in Thermodynamics and Workshop Technology, delivering strong theoretical foundations alongside practical skills essential for engineering applications. Her extensive experience supports effective hands-on training, workshop safety practices, and technical competency development, helping students build the practical expertise required for industrial environments.

Helly Suhailla binti Solaiman is a Principal Lecturer at the Department of Mechanical Engineering, Politeknik Port Dickson, with over 20 years of experience. She specializes in Occupational Safety and Health (OSH) auditing, Electrical and Electronic Technology, and Materials Science and Engineering. She possesses extensive expertise in developing practical teaching tools, safety-focused learning modules, and applied research initiatives. Throughout her career, she has contributed to curriculum development and hands-on technical training programs that bridge academic knowledge with industry requirements. Her work emphasizes interactive learning, technical competence, and safety awareness, enhancing students' skills and employability in engineering fields.

Mohd Fikri Bin Mohd Soffian is a Lecturer in Automotive Technology at the Department of Mechanical Engineering (Automotive), Politeknik Port Dickson, with 16 years of teaching experience. He specializes in automotive systems, diagnostics, and vehicle performance, with a strong emphasis on practical and industry-aligned training. He holds several professional certifications, including IMI Hybrid Level 3, Basic Diagnosis & Troubleshooting HINO Engine, and Degree Wheel Motorcycle, reflecting his technical competency in hybrid vehicle systems, engine diagnostics, and motorcycle tuning. His expertise supports hands-on learning approaches and strengthens students' technical proficiency in line with current automotive industry standards.

Electrically Powered System for Real-Time Water Quality Monitoring and Stabilization in Fish Tanks

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ABSTRACT

This project introduces a solar-powered automated system designed to monitor and stabilize pH levels in freshwater fish tanks. Utilizing an Arduino Uno R4 and a pH sensor, the system provides real-time monitoring and automatically activates corrective measures such as releasing stabilizing solutions via a servo motor when water conditions fall outside the ideal range. This innovation addresses the challenges of manual water quality management and potential power dependencies by integrating a sustainable solar-powered battery system. The prototype features a 16x2 I2C LCD for real-time status updates on pH value, battery level, and fish type, alongside a buzzer for low-power alerts. Results demonstrate high reliability in maintaining optimum water conditions, offering a cost-effective and eco- friendly solution for small-scale fish owners. By reducing manual labor and preventing fish stress or mortality due to water instability, the system holds significant potential for commercialization in the home-scale aquaculture market.

Keywords: Water Quality, Solar Energy, pH Stabilization, Arduino Uno R4, Aquaculture Automation

1. Product Description

The product is an automated, energy-independent water quality management system tailored for freshwater fish tanks. It employs an Arduino Uno R4 as the central controller to process data from a pH sensor. When the system detects "Danger" pH levels (below 5.1 or above 9.0), it triggers peristaltic pumps or a servo motor to inject acidic or basic solutions until the water reaches "Optimum" status (pH 7.0–8.0). A 16x2 LCD provides a user interface displaying vital parameters. The device is powered by a 12V lead-acid battery charged by a 5W solar panel via an MPPT controller, ensuring 24-hour operation even in remote locations.

2. Flow Charts, Graph and Schematic Diagram.

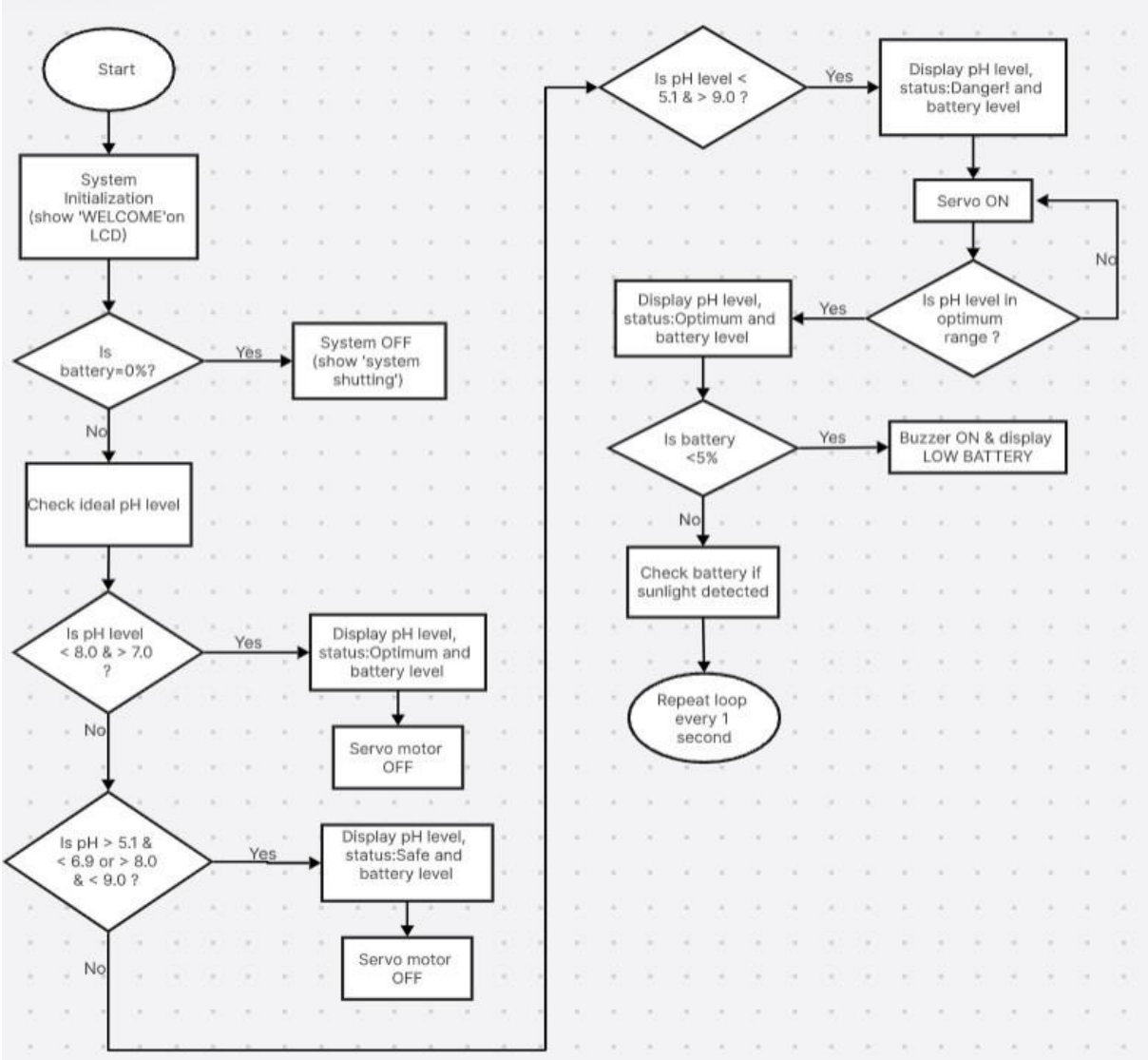

Figure 1. Flow chart model.

Figure 1 illustrates system flow chart for Electrically Powered System for Real-Time Water Quality Monitoring and Stabilization which designed to automate the maintenance of freshwater fish tanks. By integrating an Arduino Uno R4 with a high-precision pH sensor, the system continuously monitors water acidity and provides real-time data on an LCD screen. Its primary innovation is an active stabilization mechanism; when the pH level falls outside the safe range (below 5.1 or above 9.0), the controller automatically triggers a servo-motor or peristaltic pump to dispense neutralizing solutions. This ensures a stable environment for aquatic life without human intervention. To ensure complete energy independence, the device is powered by a 12V battery recharged via a 5W solar panel and MPPT controller. This combination of autonomous chemical balancing and renewable energy makes it a sustainable and cost-effective tool for preventing fish mortality in small-scale aquaculture.

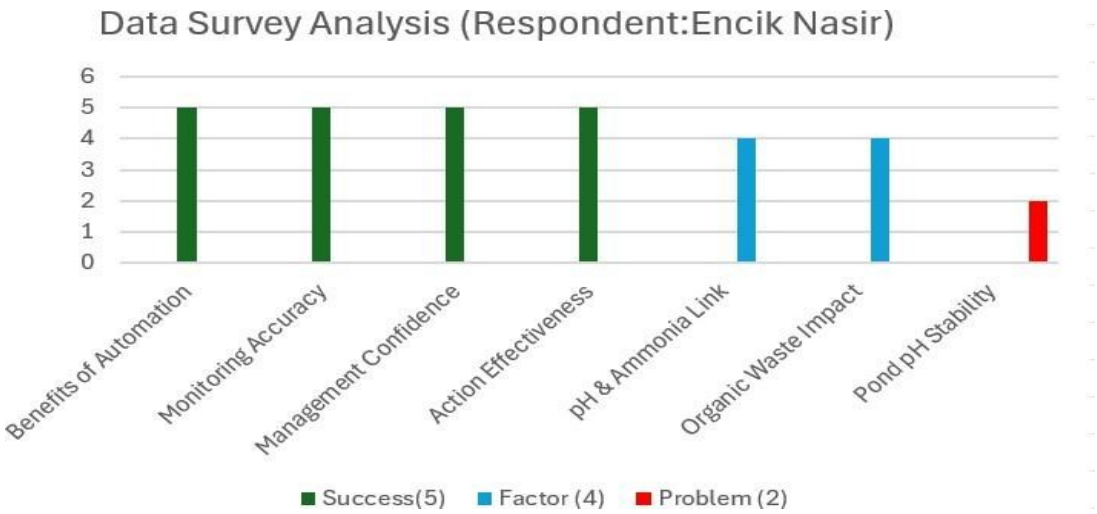

Figure 2. Data Survey Analysis.

Figure 2 shows the survey results where the automated system is highly successful in its core functions, with maximum scores of 5 (Success) recorded for monitoring accuracy, action effectiveness, and benefits of automation. This indicates the respondent strongly agrees that the system reliably measures pH levels and makes confident, effective decisions during automated pond management. Other factors like organic waste impact and the link between pH and ammonia were rated slightly lower with a score of 4 (Factor), suggesting they are influential but could benefit from further study. However, pond pH stability received the lowest score of 2 (Problem), highlighting that maintaining a perfectly stable pH remains a challenge due to external factors like waste accumulation or environmental changes, which provides a clear area for future system improvement.

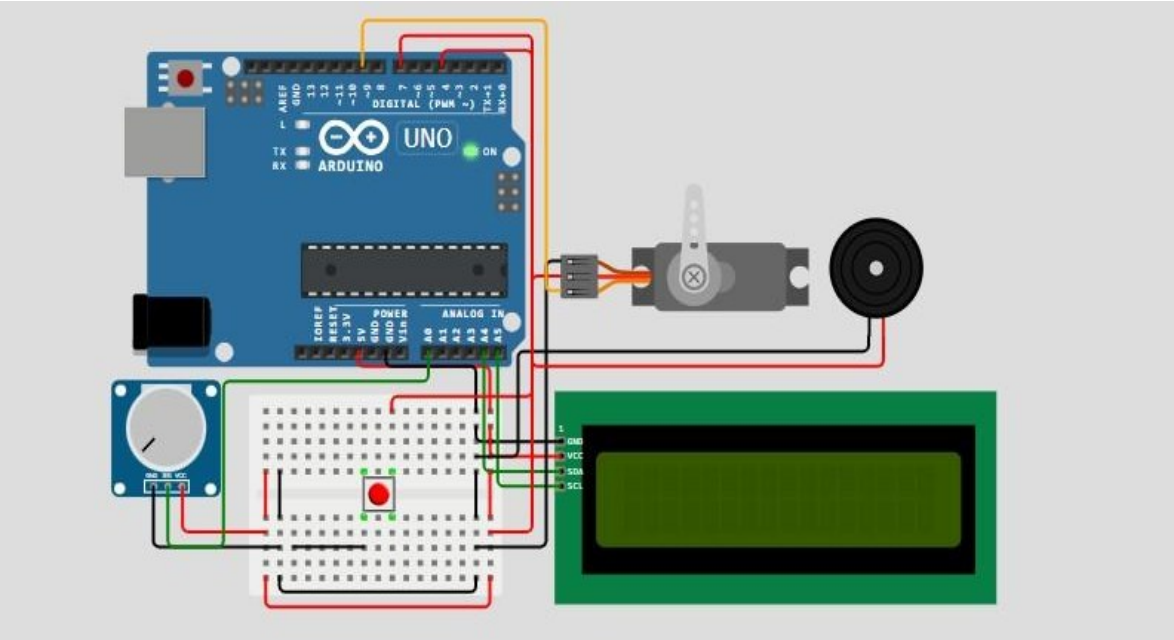

Figure 3. Schematic Diagram.

Figure 3 represents a solar-powered control system centered around an Arduino Uno R4. It connects a pH sensor and water level sensor to analog pins for environmental monitoring, while a voltage sensor tracks the 12V battery health. Outputs include an I2C LCD for data display, a buzzer for alerts, and a servo motor on pin D9 to automate water stabilization. Energy is managed through a 5W solar panel and MPPT controller, providing a fully autonomous, 24/7 power solution

3. Novelty and uniqueness

The novelty of this project lies in its transition from passive monitoring to an active, autonomous intervention system specifically optimized for small-scale aquaculture. While many existing solutions focus solely on data logging or remote alerts via IoT, this system introduces an integrated feedback loop that detects and corrects pH imbalances in real-time without human interference. By utilizing an Arduino Uno R4 to control a precise servo-motor dispensing mechanism, the prototype provides immediate chemical stabilization, which is critical for preventing fish fatalities during rapid water quality shifts. A significant unique feature is the project's complete energy independence through a dedicated solar-powered infrastructure. Unlike conventional aquarium systems that rely on grid electricity, this design incorporates a 5W solar panel and an MPPT charge controller to manage a 12V battery. This allows the system to operate reliably in outdoor environments or regions with unstable power grids. Furthermore, the integration of a multi-parameter display showing pH status, battery health, and fish-specific safety thresholds within a low-cost, portable framework offers a sophisticated level of automation previously inaccessible to hobbyists and small-scale farmers. This combination of autonomous stabilization and renewable energy integration sets it apart as a sustainable, "all-in-one" aquatic life support system.

4. Benefit to mankind

The implementation of this automated water quality system offers significant advantages to both individual hobbyists and the broader aquaculture industry. By providing real- time pH stabilization and solar-powered reliability, the system ensures a consistent and healthy environment for aquatic life, drastically reducing fish mortality rates caused by sudden chemical imbalances. This promotes animal welfare and protects the financial investments of small-scale farmers. Furthermore, the project democratizes "smart farming" technology by offering an affordable, low-maintenance alternative to expensive industrial equipment. Its reliance on solar energy encourages the adoption of green technology, reducing the carbon footprint of home-scale food production. By automating the labor-intensive task of water monitoring, the system saves users significant time and effort, making sustainable fish farming more accessible to the general public. Ultimately, it supports food security and economic resilience by empowering communities to maintain productive and efficient small-scale aquaculture systems

5. Innovation and Entrepreneurial Impact

This project promotes a culture of innovation by applying accessible microcontroller technology to solve critical challenges in the aquaculture sector. It demonstrates how low-cost components like the Arduino Uno R4 can be transformed into high-value industrial solutions, encouraging local students and entrepreneurs to develop indigenous technology rather than relying on expensive imports. By focusing on solar energy, the project aligns with global sustainability trends, fostering an entrepreneurial mindset centered on "Green Tech." It provides a scalable blueprint

for small-to-medium enterprises (SMEs) to produce localized, smart farming tools, thereby contributing to the modernizing of the local agricultural economy and supporting the digital transformation of traditional fish farming practices.

6. Potential commercialization

The system holds significant commercial potential within the ornamental fish hobbyist market and the small-scale aquaculture industry. With a prototype cost of approximately RM 341.90, it is positioned as an affordable entry-level "Smart Tank" solution. The target market includes home aquarium owners, local fish breeders (e.g., Catfish or Tilapia), and urban farmers. Commercial viability is further enhanced by its modular design, allowing for future add-ons like IoT-based mobile monitoring or automated feeding modules. By offering an all-in-one "plug-and-play" device that works off-grid, the product fills a gap in the market for remote or outdoor farming applications where power infrastructure is limited, presenting a strong opportunity for a startup or licensing to aquarium equipment manufacturers.

7. Acknowledgment

I would like to express my deepest and most sincere appreciation to my project supervisor, Ts. Muhammad Muzamil B. Mustam, for his continuous guidance, patience, and unwavering support throughout the entire duration of this research. His valuable technical insights, constructive feedback, and encouragement played a vital role in shaping the direction of this project and in refining the safety mechanisms of the system. His dedication and commitment greatly motivated me to complete this work with confidence and determination. I would also like to extend my sincere gratitude to the Faculty of Electrical Engineering, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, for providing the necessary laboratory facilities, equipment, and a conducive learning environment that made the development and testing of this project possible. The support and resources provided by the university were absolutely essential to the successful completion of this research and the final prototype.

8. Researchers' Biography

A final-year student pursuing a Diploma in Electrical Engineering (Power) at Universiti Teknologi MARA (UiTM), Johor Branch. His academic focus lies in power systems, renewable energy integration, and automated control systems. Through his Final Year Project, he has demonstrated proficiency in microcontroller programming and hardware prototyping, specifically in developing sustainable solutions for water quality management. He is passionate about leveraging green technology to solve real-world environmental challenges and aims to contribute to the advancement of smart agricultural tools in Malaysia.

Ts. Dr. Muhammad Muzamil bin Mustam is a Senior Lecturer at UiTM Pasir Gudang, specializing in high-voltage engineering. His academic journey includes a Bachelor's and Master's in Electrical Engineering from UTM, followed by a PhD from UPM. As a Professional Technologist (Ts.), his research focuses on sustainable power systems, exemplified by his study in the *Indonesian Journal of Electrical Engineering and Computer Science* regarding the impact of moisture and acid on the thermal ageing of palm oil insulation. Beyond power systems, he bridges technology and culture through innovative projects like "E-CONGKAK," while actively contributing to engineering education and peer-reviewed research.

Norlina Mohd Zain is a lecturer at Universiti Teknologi MARA (UiTM) Pasir Gudang, where she has spent over a decade specializing in Electrical Engineering. She holds an M.Sc from UiTM and is an expert in flexible materials for microwave applications, specifically focusing on the design and optimization of flexible antennas. A dedicated academic and researcher, Norlina has a proven track record of excellence. She is deeply committed to advancing microwave technologies and continues to contribute significantly to the development of specialized flexible materials within the engineering field.

Associate Professor Ts. Dr. Nor Diyana binti Md Sin earned her PhD and First Class Honours in Electrical Engineering from UiTM. As a Professional Technologist and Associate Professor, her academic foundation supports high-impact research in nanotechnology. One key research project focuses on lead-free piezoelectric energy harvesting. Funded by the FRGS-RACER grant, she investigates using nanostructured materials to convert mechanical vibrations from human movement into electricity. This research aims to provide sustainable, eco- friendly power solutions for portable devices, moving away from toxic materials towards greener alternatives like zinc oxide thin films.

A Technology-Integrated Inquiry-Based Learning Framework for Enhancing Technological Literacy

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ABSTRACT
This paper presents a Technology-Integrated Inquiry-Based Learning framework designed to enhance technological literacy among students in Technical and Vocational Education and Training (TVET), particularly within Final Year Project implementation. The framework was developed in response to the growing demands of Industry 4.0, where graduates are expected to demonstrate not only technical competence but also the ability to inquire, evaluate, and apply digital technologies meaningfully. Current vocational practices remain largely lecturer-centred and output-focused, resulting in uneven technology integration and limited learner confidence. To address this gap, the proposed framework integrates the stages of Inquiry-Based Learning with key constructs from the Technology Acceptance Model, positioning technology as a cognitive and investigative tool that supports structured inquiry processes. The main novelty of this framework lies in its explicit alignment between pedagogical inquiry structure and learner readiness toward technology use, offering clear guidance for both educators and students. The framework has the potential to improve students' problem-solving abilities, digital competence, and workforce readiness, thereby contributing to socio-economic development through a more skilled and adaptable TVET graduate population. In addition, the framework demonstrates strong commercialisation prospects as a scalable teaching and training model suitable for adoption by TVET institutions, teacher training bodies, and educational technology platforms.

Keywords: *Technology-Integrated Inquiry-Based Learning, Technological Literacy, TVET Education, Technology Acceptance Model, Final Year Projects.*

1. Product Description
The Technology-Integrated Inquiry-Based Learning framework is a structured pedagogical model designed to guide the meaningful integration of digital technology within inquiry-driven learning, particularly in Technical and Vocational Education and Training (TVET) Final Year Projects. The framework systematically combines the phases of Inquiry-Based Learning orientation, conceptualisation, investigation, conclusion and reflection with constructs from the Technology

Acceptance Model, namely perceived usefulness and perceived ease of use. This integration enables technology to function as a cognitive and investigative tool that supports learners throughout the inquiry process rather than as a peripheral instructional aid. The framework provides clear guidance for educators in designing learning activities, selecting appropriate digital tools, and scaffolding student inquiry while simultaneously addressing learner readiness and confidence in technology use. Recent studies highlight that technological literacy in vocational education requires purposeful engagement with digital tools within authentic learning contexts rather than isolated skill training Fallon, (2020). Developed through a synthesis of constructivist learning theory, empirical studies, and national TVET policy directions, the TI-IBL framework addresses existing gaps in lecturer-centred and output-oriented practices. It is designed to be adaptable across disciplines and institutional contexts, offering a systematic approach for enhancing technological literacy, problem-solving skills, and reflective learning in project-based environments. Furthermore, recent evidence demonstrates that well-designed technology-enhanced inquiry frameworks significantly enhance learners' technological literacy and higher-order thinking skills (Zhai et al., 2025).

2. Results and Methods

Figure 1 illustrates the conceptual foundation of the proposed Technology-Integrated Inquiry-Based Learning framework, which systematically integrates the Inquiry-Based Learning (IBL) model with the Technology Acceptance Model (TAM) to enhance technological literacy among TVET students undertaking Final Year Projects. The inquiry dimension is adapted from the IBL cycle proposed by Pedaste et al. (2015), comprising four core phases: orientation, conceptualisation, investigation, and conclusion. These phases are complemented by continuous discussion and reflection, which function as iterative mechanisms that support deeper cognitive engagement and knowledge construction throughout the inquiry process. To address learners' readiness and sustained engagement with digital tools, the framework incorporates key TAM constructs introduced by Davis (1989), namely perceived usefulness (PU) and perceived ease of use (PEOU). These constructs act as mediating factors that influence students' willingness to adopt and meaningfully apply technology during inquiry activities. By embedding PU and PEOU within the inquiry cycle, technology is positioned not as a supplementary instructional aid but as a cognitive and investigative tool that actively supports problem exploration, data analysis, and solution development. The integration of IBL and TAM culminates in an enhanced inquiry-based learning framework tailored specifically for TVET Final Year Projects. This integrated approach ensures alignment between pedagogical structure and learner technology acceptance, thereby addressing gaps in current output-oriented and lecturer-centred practices while fostering technological literacy, reflective inquiry, and workforce-relevant competencies.

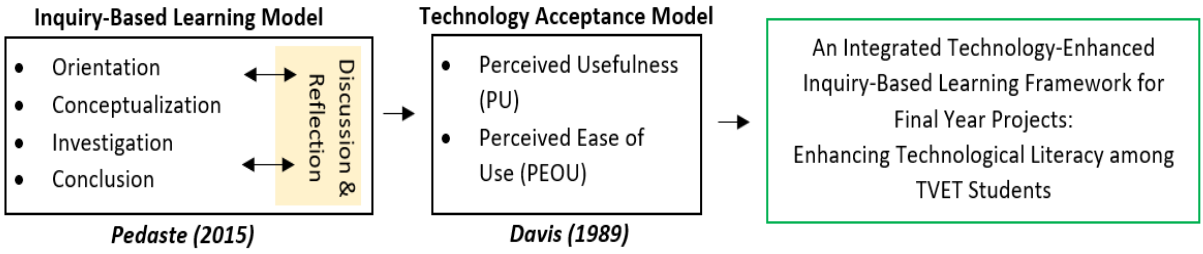

Figure 1. Conceptual framework.

Inquiry-Based Learning Phases

The **orientation phase** initiates the inquiry process by engaging students with authentic problems or project contexts. At this stage, technology supports problem scoping, information searching, and contextual understanding through digital resources and exploratory tools. During the conceptualisation phase, students formulate inquiry questions, hypotheses, or project objectives. Digital tools such as concept-mapping software, simulation platforms, or collaborative applications facilitate idea generation and conceptual clarity. The investigation phase represents the core of inquiry, where students collect data, conduct experiments, test solutions, and analyse findings. Technology functions as a cognitive instrument that enables data processing, modelling, documentation, and iterative testing, thereby supporting higher-order thinking and problem-solving skills. In the conclusion phase, students synthesise findings, evaluate outcomes, and generate solutions or project artefacts. Digital presentation tools, reporting software, and reflective platforms support knowledge consolidation and evidence-based justification. Across all phases, discussion and reflection act as continuous mechanisms that promote metacognition, critical evaluation, and iterative improvement of both inquiry processes and technological practices.

Technology Acceptance Model Integration

The integration of TAM ensures that students' engagement with technology is both intentional and sustainable. Perceived usefulness (PU) influences students' belief that digital tools enhance inquiry effectiveness and project outcomes, while perceived ease of use (PEOU) affects their confidence and willingness to engage with technology throughout the inquiry cycle. By embedding PU and PEOU within each inquiry phase, the framework addresses learner readiness and reduces resistance to technology adoption.

3. Novelty and uniqueness

The primary novelty of the TI-IBL framework lies in its explicit integration of Inquiry-Based Learning and the Technology Acceptance Model within a unified pedagogical structure tailored for vocational education. Unlike existing approaches that treat technology integration as an auxiliary component, this framework positions digital tools as central cognitive instruments that actively mediate inquiry processes. While previous studies have explored inquiry-based approaches or technology integration independently, few frameworks explicitly address learner readiness and acceptance alongside structured inquiry processes Bekbayeva et al., (2021). The framework uniquely addresses both pedagogical structure and learner readiness by embedding technology acceptance considerations directly into the inquiry cycle. This dual focus ensures that students are not only guided through systematic inquiry stages but are also supported in developing confidence and intentionality in technology use. Additionally, the framework shifts the emphasis of Final Year Projects from product-oriented outcomes to process-oriented learning, fostering deeper engagement, reflection, and problem-solving. Its design is grounded in constructivist theory while remaining responsive to Industry 4.0 demands, making it contextually relevant for TVET institutions. The adaptability of the framework across disciplines and project types further enhances its uniqueness, as it provides a transferable model that can be applied beyond a single institutional or technological context.

4. Benefit to mankind

The Technology-Integrated Inquiry-Based Learning framework contributes to societal development by enhancing technological literacy and inquiry competence among future workforce entrants. By equipping students with the ability to critically select, evaluate, and apply digital technologies in problem-solving contexts, the framework supports the development of adaptable and industry-ready graduates. Improved technological literacy enhances employability, productivity, and lifelong learning capacity, which are essential for socio-economic sustainability in an increasingly digital economy. For educators, the framework provides structured guidance that reduces instructional uncertainty and promotes more effective teaching practices. Technological literacy is increasingly recognised as a critical socio-economic capability that enables individuals to adapt to technological change, participate productively in the workforce, and engage in lifelong learning World Economic Forum, (2022). At a broader level, the framework supports national education and workforce development agendas by aligning TVET outcomes with Industry 4.0 expectations, thereby contributing to a more competent, resilient, and innovation-driven society.

5. Innovation and Entrepreneurial Impact

The proposed framework promotes innovation by encouraging inquiry-driven learning environments where students actively explore problems, test solutions, and leverage digital technologies creatively. By embedding technology as a core component of inquiry, the framework cultivates a mindset of experimentation, adaptability, and continuous improvement key attributes of entrepreneurial thinking. Within institutions, the framework encourages educators to adopt innovative pedagogical practices and rethink conventional supervision models for Final Year Projects. At the industry level, graduates trained under this framework are better prepared to engage with digital transformation initiatives, contribute innovative solutions, and participate in technology-driven enterprises. The framework also supports the development of entrepreneurial culture by fostering autonomy, critical thinking, and digital competence, which are essential for start-ups, innovation ecosystems, and future-oriented industries

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6. Potential commercialization

The Technology-Integrated Inquiry-Based Learning framework demonstrates strong commercialisation potential as a scalable teaching and training solution for TVET institutions, teacher education programmes, and professional development providers. It can be packaged as a structured instructional model, implementation guide, or digital toolkit to support inquiry-based project learning. The framework also offers integration opportunities with educational technology platforms, learning management systems, and digital assessment tools. Commercial deployment may include licensing to institutions, customised training modules for educators, and consultancy services for curriculum redesign. Its adaptability across disciplines and institutional contexts enhances market viability, positioning the framework as a practical solution for institutions seeking to align pedagogy with Industry 4.0 and digital education priorities.

7. Acknowledgment

The authors would like to acknowledge the support of Kolej Vokasional Batu Lanchang and Universiti Teknologi Malaysia for their academic guidance and institutional support. Appreciation is also extended to the educators and students who contributed insights during the conceptual development of the framework.

8. Researchers' Biography

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iMEDBT: AI-Driven Microcalcification Enhancement for Breast Cancer Diagnosis in Digital Breast Tomosynthesis

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ABSTRACT

Breast cancer remains one of the leading causes of cancer-related mortality among women worldwide, where early detection plays a critical role in improving survival rates. Digital Breast Tomosynthesis (DBT) has enhanced breast imaging by providing quasi-three-dimensional views; however, image blur and low contrast, especially in dense breast tissue, continue to obscure microcalcifications, which are key early indicators of malignancy. To address this challenge, iMEDBT is introduced as an AI-driven solution for microcalcification enhancement in DBT images. iMEDBT integrates a hybrid deep learning framework that automatically detects and filters blurry DBT slices using a hybrid CNNSVM model, followed by targeted image enhancement using a deep CNN and a newly proposed Microcalcification Contrast Enhancement (McCE) algorithm. This design ensures that only diagnostically reliable images are enhanced, significantly improving the visibility of microcalcifications without distorting anatomical structures. The key advantages of iMEDBT include improved diagnostic reliability, reduced radiologist workload, and increased confidence in lesion interpretation, particularly in dense breast cases. From a socio-economic perspective, earlier and more accurate breast cancer detection can reduce treatment costs, improve patient outcomes, and lower long-term healthcare burdens. iMEDBT has strong commercialization potential as a software-based add-on for existing DBT and CAD systems, making it scalable, cost-effective, and suitable for adoption in hospitals, screening centres, and AI-assisted radiology platforms.

Keywords: AI-Based Medical Imaging, Microcalcification Enhancement, Breast Cancer Detection

1. Product Description

iMEDBT is an AI-driven medical imaging solution designed to enhance the detection of microcalcifications in DBT images, addressing one of the key challenges in early breast cancer diagnosis. Although DBT provides quasi-three-dimensional breast imaging, its clinical effectiveness is often limited by image blur and low contrast caused by limited-angle acquisition, particularly in women with dense breast tissue. These limitations obscure subtle microcalcifications, increase radiologist workload, and reduce the reliability of computer-aided diagnosis (CAD) systems. To overcome these challenges, iMEDBT integrates a hybrid artificial intelligence framework that automatically improves DBT image quality before diagnosis. The system first employs a CNN–

SVM-based blur detection module that accurately identifies and filters out low-quality, blurry slices, ensuring that only diagnostically reliable images are processed further. This mirrors real-world radiologist practice and reduces unnecessary computational load. Subsequently, iMEDBT applies a deep learning-based enhancement pipeline using a Very Deep Super Resolution (VDSR) network to improve global image clarity. A novel McCE algorithm is then applied to selectively enhance regions of interest containing microcalcifications while preserving surrounding anatomical structures. As a result, iMEDBT delivers clearer images, improved lesion visibility, and higher diagnostic confidence, supporting more accurate and efficient breast cancer diagnosis in clinical workflows.

2. Diagrams

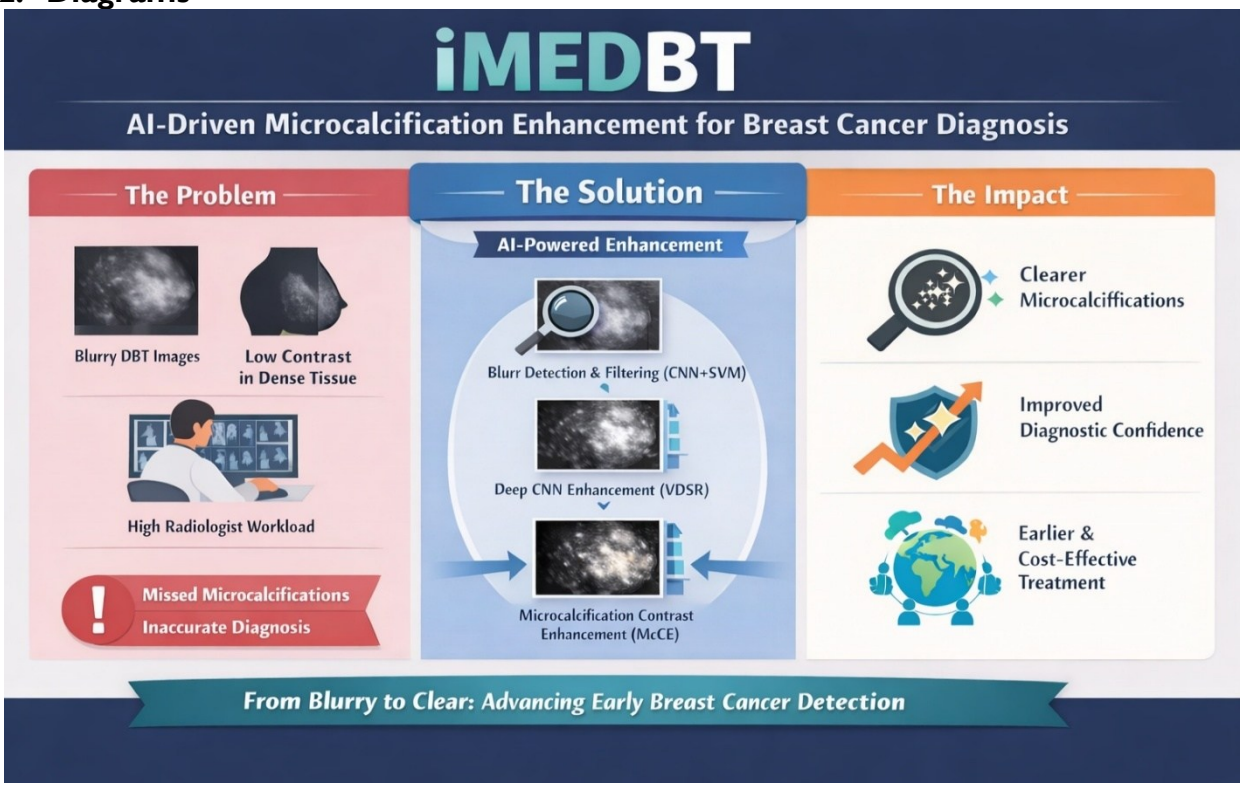

Figure 1. iMEDBT framework demonstrating the transformation from blurred, low-contrast DBT images to enhanced microcalcification visibility and improved diagnostic confidence using AI.

The diagram in **Figure 1** presents the problem, solution, and impact framework of the proposed iMEDBT system for AI-enhanced breast cancer diagnosis using DBT images. The left section highlights the primary challenges in DBT imaging, including blurring caused by limited-angle acquisition, reduced contrast in dense breast tissue, and increased radiologist workload, all of which contribute to missed microcalcifications and decreased diagnostic accuracy. The central section illustrates the proposed AI-based solution, where a hybrid CNN–SVM model is employed to automatically detect and filter blurry DBT slices, ensuring that only diagnostically reliable images are processed. The selected high-quality slices are subsequently enhanced using a deep CNN-based VDSR network, followed by a novel McCE algorithm that selectively amplifies microcalcification regions while preserving anatomical integrity. The right section depicts the

clinical and socio-economic impact of the system, demonstrating improved microcalcification visibility, enhanced diagnostic confidence, earlier breast cancer detection, and more cost-effective patient management. In addition, **Figure 2** contrasts the conventional DBT diagnostic workflow with the proposed AI-assisted pipeline. The traditional approach relies heavily on manual visual inspection and slice selection by radiologists after image reconstruction, increasing workload and the risk of missed findings, particularly in dense breast tissue. In contrast, the proposed framework introduces automated image quality classification and targeted enhancement before diagnosis, reducing dependence on manual interpretation and improving the reliability and efficiency of DBT-based breast cancer detection. **Figure 3** further demonstrates the effectiveness of this approach through a qualitative comparison between expert-annotated ground truth regions and the predicted microcalcification detections on four randomly selected DBT images. The predicted regions, indicated by yellow bounding boxes with associated confidence scores, show strong correspondence with ground truth annotations,

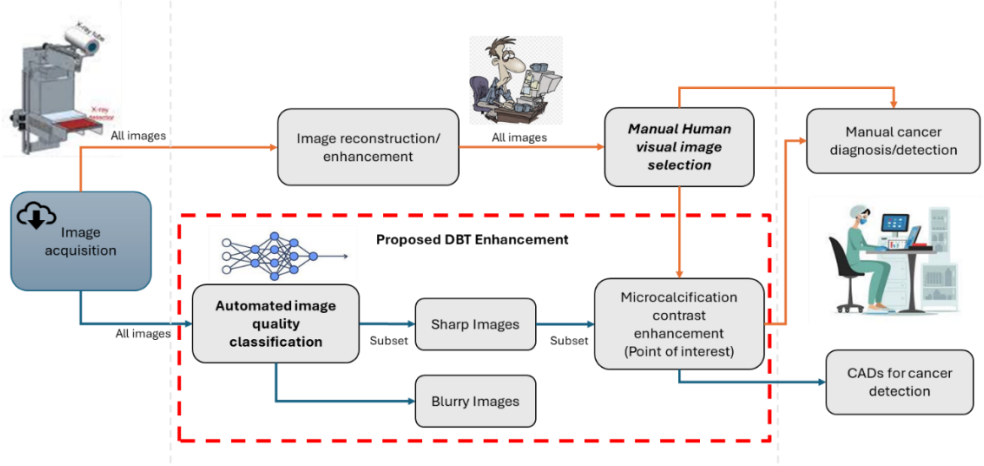

Figure 2. Comparison between the conventional DBT diagnostic workflow and the proposed AI-assisted framework. The blue arrows show the flow of automated processing steps for the proposed DBT enhancement, and the orange arrows show the flow of manual processing practice by the human expert. even in dense breast tissue. The presence of high-confidence detections highlights the robustness of the proposed method in distinguishing true microcalcifications from surrounding anatomical structures, supporting its effectiveness in improving microcalcification visibility and detection accuracy in DBT images.

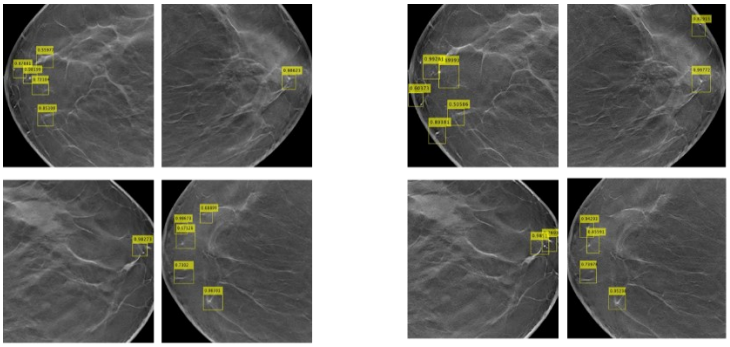

Figure 3. Microcalcification detection on four random DBT images and comparison with ground truth. Yellow labels indicate confidence level annotations for that area. (a) Ground truth regions marked with microcalcifications. (b) Predicted microcalcification areas.

3. Novelty and uniqueness

Three key innovations distinguish the proposed approach. First, it introduces a hybrid blur detection strategy that fuses deep features from a lightweight CNN with Laplacian-based blur descriptors, eliminating the need for conventional blur kernel estimation and improving robustness under varying imaging conditions. Second, a novel McCE algorithm is developed to selectively enhance microcalcification regions while preserving surrounding anatomical structures. Third, the framework is implemented as a sequential AI pipeline aligned with radiologist workflows, enabling automatic filtering of low-quality slices before enhancement and analysis. The system is specifically optimized for extremely dense breast tissue, addressing a critical challenge in DBT-based breast cancer diagnosis.

4. Benefit to mankind

iMEDBT directly benefits mankind by improving the early detection of breast cancer, a disease that affects millions of women worldwide and remains a leading cause of cancer-related mortality. By enhancing the visibility of microcalcifications, often the earliest signs of cancer and the system enables more accurate and timely diagnosis, particularly in women with dense breast tissue who are at higher risk of missed findings. Earlier detection leads to less invasive treatment, higher survival rates, reduced emotional burden on patients and families, and lower long-term healthcare costs. Additionally, by reducing radiologists workload and diagnostic uncertainty, iMEDBT supports safer, more efficient healthcare delivery. As a scalable, software-based solution, it can be deployed widely across healthcare systems, including resource-limited settings, contributing to more equitable access to high-quality cancer screening and ultimately improving quality of life for patients and society.

5. Innovation and Entrepreneurial Impact

The proposed iMEDBT system delivers significant innovation and entrepreneurial value by addressing critical clinical and operational challenges in breast cancer diagnosis. iMEDBT is a scalable, AI-driven imaging solution that enhances microcalcification visibility in Digital Breast Tomosynthesis, enabling earlier and more reliable breast cancer diagnosis. By automating blur detection and targeted image enhancement, iMEDBT reduces radiologist workload and improves diagnostic confidence, particularly in dense breast cases. As a software-based platform, it integrates seamlessly into existing DBT and CAD systems without additional hardware costs, offering strong commercialization potential through licensing or SaaS models. The innovation supports SDG 3 (Good Health and Well-Being) by improving early cancer detection and SDG 9 (Industry, Innovation, and Infrastructure) through advanced AI-driven healthcare technology.

6. Potential commercialization

iMEDBT has strong commercialization potential as a software-based, AI-driven solution that can be integrated into existing DBT machines, PACS, or CAD platforms without additional hardware investment. By lowering downstream treatment costs and reducing patient burden through early diagnosis, the system offers tangible economic value to healthcare providers, insurers, and patients alike. This combination of clinical impact, workflow efficiency, and scalable deployment positions iMEDBT as a high-impact innovation with strong market readiness in the medical imaging and digital health sectors.

7. Acknowledgement

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8. Researchers' Biography

Nur Athiqah Harron is a senior lecturer at the Universiti Teknologi MARA Cawangan Pulau Pinang. Nur Athiqah obtained her Bachelor of Electrical Engineering (Computer) from Universiti Teknologi Malaysia in 2007 and MSc in Electronic System Design Engineering from Universiti Sains Malaysia in 2011. She is currently doing her PhD at Universiti Teknologi MARA Cawangan Pulau Pinang. Her research focuses on the image processing of medical images, specifically in analyzing DBT image enhancement using deep learning.

Siti Noraini Sulaiman received her PhD in image processing in 2012 from the School of Electrical and Electronics Engineering at Universiti Sains Malaysia. She is currently a Professor at the Centre for Electrical Engineering Studies, Universiti Teknologi MARA, Penang Branch in Permatang Pauh, Penang, Malaysia. Her primary research interest is biomedical engineering, specifically in image filtering, image clustering, image processing algorithms and intelligent diagnostic systems.

Noor Khairiah A. Karim received her bachelor's degree in medicine, bachelor's degree in surgery (MBBS), and Master of Radiology (MRad) from the University of Malaya, Malaysia. She then obtained her Fellowship in Cardiac Imaging from the National Heart Centre Singapore. She is currently an Associate Professor at the Regenerative Medicine Cluster and a Consultant Radiologist at the Advanced Medical and Dental Institute, Universiti Sains Malaysia. Her current research areas include medical image processing and analysis with a special interest in cardiac, breast and brain imaging.

Noor Fadzilah binti Razali received her Doctoral degree in Electrical Engineering from Universiti Teknologi MARA (UiTM) in 2025, an MSc in Biomedical Engineering in 2014 and a Bachelor's Degree in Biomedical Engineering in 2010 from the University of Malaya (UM), Malaysia. She is currently a lecturer at Electrical Engineering Studies, Universiti Teknologi MARA (UiTM), Malaysia. Her main research interests include biomedical engineering, signal and image processing, Internet of Things (IoT) and machine and deep learning applications.

Gas Leakage Detector with Automated Ventilation System

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ABSTRACT

The Gas Leakage Detector with Automated Ventilation System is an innovative safety device designed to monitor and mitigate Liquefied Petroleum Gas (LPG) hazards in residential settings. Developed to address the fire risks and health hazards associated with LPG use, the system utilizes a Raspberry Pi Pico W to process data from MQ-6 gas sensors and a BMP280 temperature sensor. Its uniqueness lies in its integrated automated response. When gas levels exceed 50%, it triggers a warning and medium-speed ventilation, while at levels above 80%, it activates a buzzer, high-speed exhaust fan and a servo motor to physically shut off the gas valve. Local monitoring is provided via an OLED screen, while a Wi-Fi module enables remote IoT alerts through Adafruit IO. This system improves socio-economic safety by reducing human intervention during emergencies and minimizing environmental gas release. Given its modular, cost-effective design, the prototype offers significant commercialization prospects as an entry level smart safety tool for residential markets, provided it undergoes further refinement and safety compliance testing.

Keywords: Smart gas leak system, Automated safety response, IoT-enabled monitoring, Household energy safety, Gas leak mitigation

1. Product Description

The Gas Leakage Detector with Automated Ventilation System is an innovative safety device designed to protect homes from LPG gas hazards. Powered by the Raspberry Pi Pico W, the system serves as the central controller, processing inputs from MQ-6 gas sensors and the BMP280 temperature sensor. Gas concentrations are measured, converted into percentages, and compared to preset thresholds, while temperature monitoring detects sudden spikes that may indicate potential dangers. Real-time data, including gas levels and temperature, is displayed on an OLED screen, allowing users to monitor conditions locally. For automatic safety response, the system uses a servo motor and exhaust fan to regulate ventilation when harmful gas levels are detected. Visual and audible alerts, including a red warning indicator, buzzer, and LEDs, notify occupants immediately. Users can also monitor the system remotely and manage ventilation through a Wi-Fi connection, sending data to an IoT platform such as Adafruit IO. Combining DC-powered operation with IoT-enabled monitoring and local safety measures, this system ensures fast detection and response to gas leaks. Its automated ventilation, real-time alerts, and remote accessibility provide a reliable, user-friendly solution that enhances household safety, minimizes environmental risks, and promotes awareness, making it an ideal tool for safer LPG usage in residential settings.

2. Block Diagram, Circuit Diagram and Flow Chart for Gas Leakage Detector with Automated Ventilation System

Figure 1 and **Figure 2** demonstrate the block diagram and circuit diagram of the overall system. The system consists of two sensors, namely the MQ-6 gas sensor and the BMP280 temperature sensor. These sensors are connected to the main controller, which processes the input data and controls six output components. The outputs include an LED and a buzzer that function as visual and audible alerts to indicate the presence of gas in the surrounding area. When a gas leak is detected, the servo motor is activated and rotates 180 degrees to shut off the gas valve, preventing further leakage. At the same time, the exhaust fan operates at high speed to provide ventilation and disperse the leaked gas. The OLED display serves as an additional output, presenting real-time system information and sensor readings. In addition, a Wi-Fi connection enables the transmission of data to an IoT platform, such as Adafruit IO, for remote monitoring.

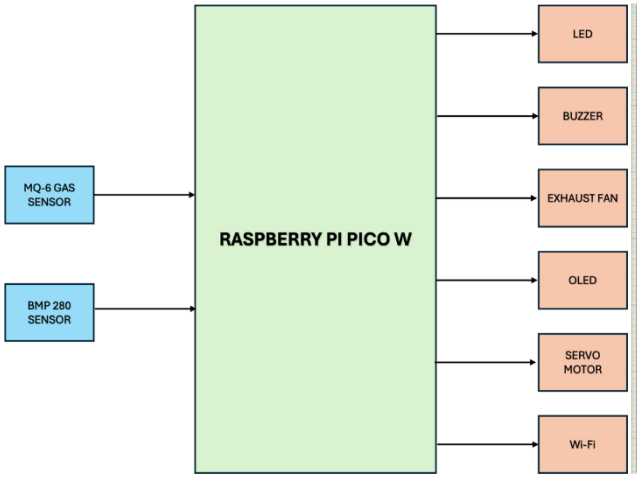


Figure 1. Block Diagram.

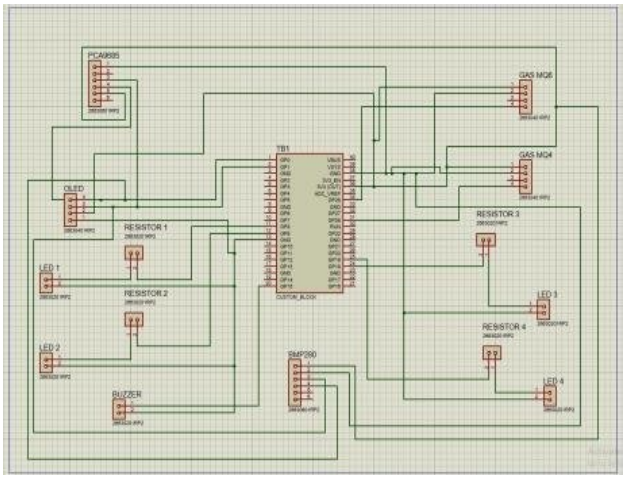


Figure 2. Circuit Diagram.

Figure 3 illustrates the operational flow of the system. The process begins with monitoring the gas concentration (%) using MQ-6 gas sensors placed both inside and outside the house. When the detected gas concentration exceeds 50%, the yellow LED is activated, a WARNING message is displayed on the OLED screen, and the ventilation fan operates at medium speed. The system continuously monitors the gas concentration to detect any changes. If the gas concentration increases further and exceeds 80%, the red LED is turned on, a GAS DETECTED message is displayed on the OLED screen, and the buzzer is activated to alert the user of a gas leakage. Upon gas detection, the servo motor is triggered and rotates 180 degrees to shut off the gas valve, preventing further leakage, while the ventilation system operates at high speed. The displayed messages on the OLED screen are tabulated in **Table 1**. In addition, system data is transmitted to an IoT platform to further notify the user. As a secondary safety measure, the BMP280 temperature sensor is incorporated to detect abnormal temperature spikes in the event of sensor malfunction. When the temperature exceeds 50 °C, the buzzer is activated to alert the user. The final prototype of the developed system is shown in **Figure 4**(a) to **Figure 4**(c).

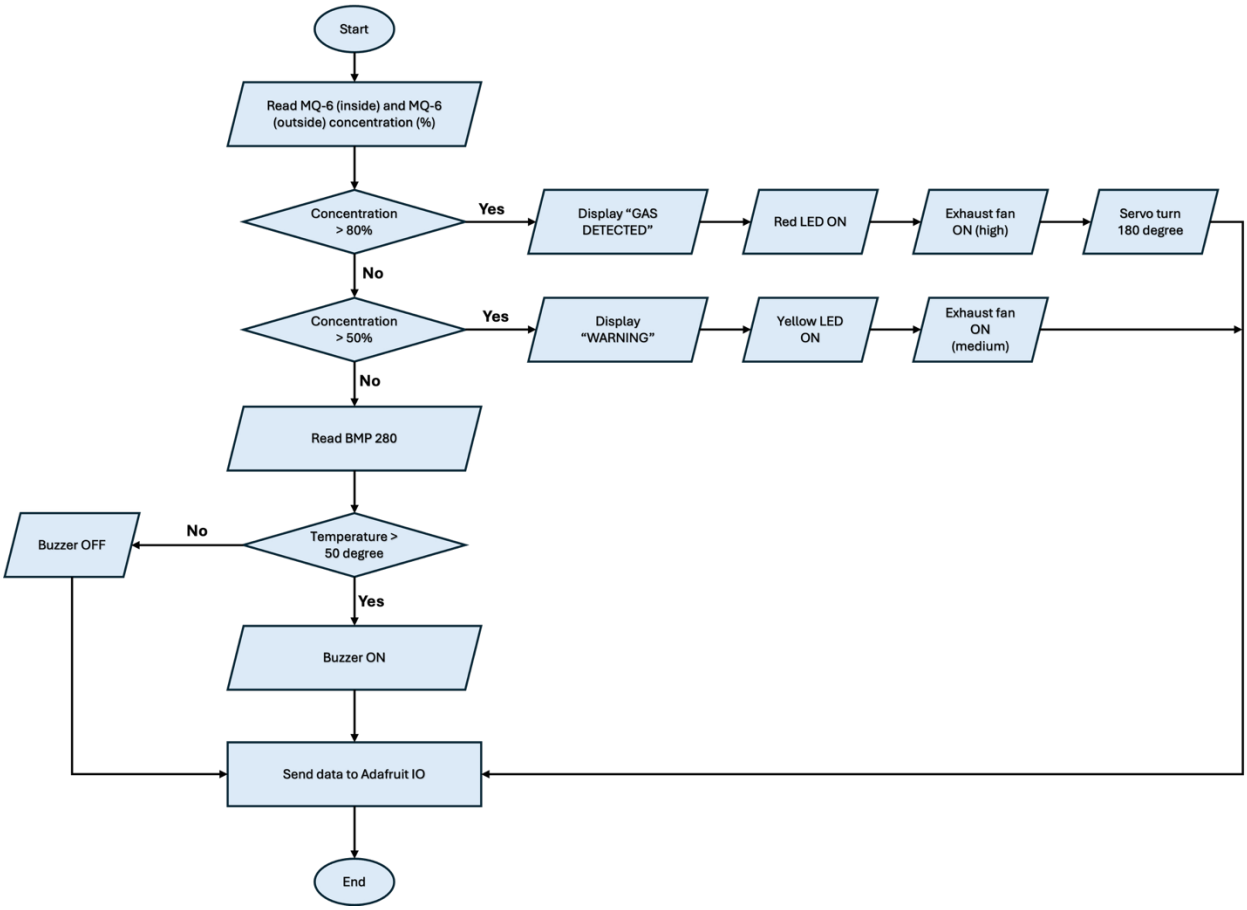
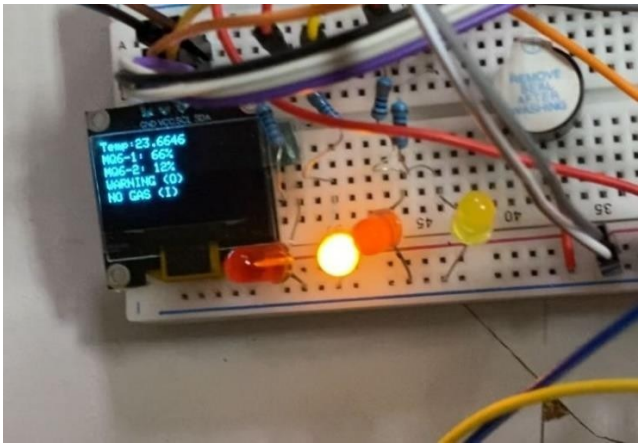
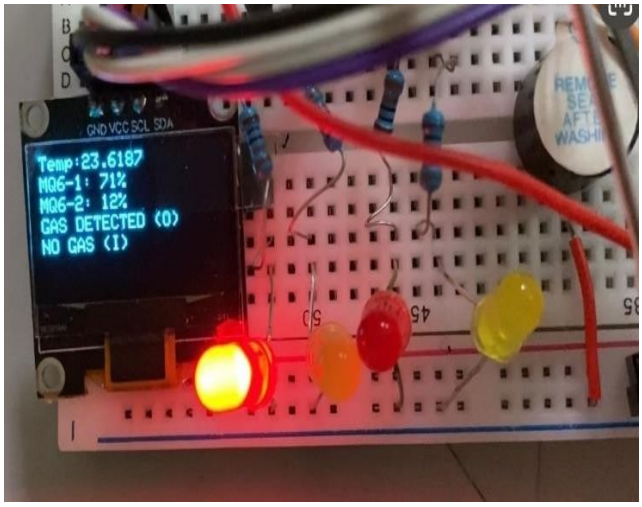
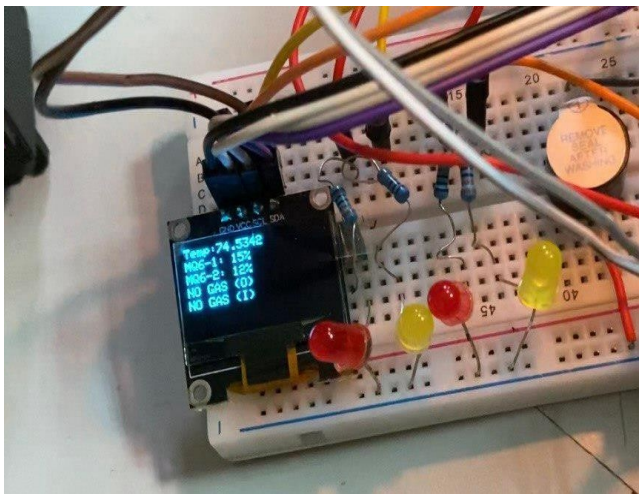


Figure 3. Operational Flowchart.

Table 1. OLED Screen Result Display.

Gas Concentration/Temperature	OLED Display
GAS CONCENTRATION >50%	

Gas Concentration/Temperature	OLED Display
GAS CONCENTRATION >80%	
TEMPERATURE >50°C	

3. Novelty and uniqueness

The novelty of this project lies in the integration of LPG gas leak detection with automated ventilation and gas valve shut off in a single residential safety system. Unlike conventional gas detectors that mainly provide alarms, this system is designed to take immediate action by controlling ventilation and stopping gas flow when a leak is detected. The combination of MQ-6 gas sensors, a BMP280 temperature sensor, local display, and IoT monitoring enhances functionality while maintaining a simple and practical design suitable for home use.

4. Benefit to mankind

This system improves household safety by reducing the risks associated with LPG gas leaks, such as fire and health hazards. Automated alerts, ventilation, and gas shut-off help minimize human intervention during emergencies. Remote monitoring also increases user awareness, especially when occupants are not at home. Overall, the system supports safer living environments and helps reduce unnecessary gas release.

5. Innovation and Entrepreneurial Impact

The project demonstrates practical innovation by applying embedded systems and IoT technology to address a real household safety issue. It shows how affordable components can be integrated into a functional safety product. From an entrepreneurial perspective, the system has potential as a basic smart safety device, particularly for cost-sensitive markets, although further refinement is required for robustness and scalability.

6. Potential commercialization

The prototype shows potential for commercialization as an entry-level smart gas safety system for residential use. Its modular design allows future improvements and customization. However, additional testing, product casing design, and compliance with safety standards are necessary before large-scale market deployment.

(a) Overall View. **(b) Front View** **(c) Side View**

Figure 4. Final Prototype.

7. Acknowledgment

The author would like to express sincere appreciation to the supervisors and lecturers of the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM) Cawangan Sarawak, for their guidance, support, and valuable advice throughout the completion of this project. Gratitude is also extended to UiTM for providing the facilities and resources required for this project.

8. Researchers' Biography

Nicole Uni Anak Valentine is currently a student at the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM) Shah Alam, pursuing her Bachelor's degree in Electrical Engineering. She graduated with a Diploma in Electrical Engineering (Electronic) from UiTM Cawangan Sarawak in 2025. Her final year project, titled "Gas Leakage Detector with Automated Ventilation System," focuses on the development of a microcontroller-based safety system for residential LPG leakage detection, incorporating automated ventilation, gas valve control, and IoT-based monitoring.

Muhd Firdaus Muhd Yusoff obtained his B. Eng. in Microelectronics and M.Eng. Computer and Microelectronics in electrical engineering from Universiti Teknologi Malaysia (UTM), Johor, Malaysia, in 2011 and 2015, respectively. He has been working as a lecturer at UiTM since 2015. His research interests include IC design and image processing applications

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Bingo Hati: Reimagining Emotional Expression Through Digital Counseling Innovation

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ABSTRACT

Emotional expression represents a foundational dimension of psychological wellbeing and constitutes a critical prerequisite for effective counseling engagement. Within Technical and Vocational Education and Training (TVET) institutions, however, students frequently encounter difficulties in expressing emotions due to shyness, limited emotional awareness, and discomfort with direct emotional disclosure. These challenges often constrain the effectiveness of conventional counseling approaches that rely predominantly on verbal interaction. In response, this study reports a qualitative descriptive case study examining the design, implementation, and perceived impact of Bingo Hati, a digital counseling tool developed using the myViewBoard platform to facilitate emotional communication among vocational college students. The study involved eighteen students who participated in structured counseling sessions incorporating Bingo Hati as an emotionally mediated stimulus. Student perceptions were collected using a structured five-point Likert scale feedback instrument complemented by reflective responses. Descriptive analysis revealed consistently positive perceptions across key constructs, including emotional awareness, emotional comfort, engagement in counseling interactions, social emotional understanding, and overall acceptance of the tool. The interactive and structured bingo format supported psychological safety, reduced emotional resistance, and enhanced students' willingness to communicate during counseling sessions. This study contributes practical insights into technology-enhanced counseling practices in vocational education and highlights the potential of structured digital tools to support emotional expression in TVET contexts.

Keywords: Digital Counseling, Emotional Expression, Vocational College Students, myViewBoard, Case Study

1. Product Description

Bingo Hati is an innovative digital counseling tool designed to enhance emotional expression and wellbeing among students. It transforms traditional counseling approaches by integrating a gamified, bingo-style selection system that allows students to identify and share their emotions in a structured yet engaging manner. By prioritizing psychological safety over competition or

assessment, the platform provides a supportive environment where students feel comfortable expressing their feelings without fear of judgment. The tool is compatible with digital applications such as MyViewBoard, enabling interactive sessions that combine technology with guided reflection. *Bingo Hati* not only facilitates more focused and meaningful emotional dialogues between counselors and students but also promotes self-awareness, emotional resilience, and holistic wellbeing. Empirical research indicates that emotional inhibition and limited emotional literacy significantly reduce students' willingness to engage in counseling processes and constrain the effectiveness of emotional support interventions (Wang et al., 2025). Its adaptable design makes it suitable for schools, colleges, and counseling centers, as well as programs in Social and Emotional Learning (SEL), mental health, and youth development. With opportunities for licensing, collaboration with EdTech companies, and professional customization, *Bingo Hati* offers a scalable, innovative, and marketable solution that bridges traditional counseling with contemporary digital engagement, fostering both educational and entrepreneurial impact.

2. Methods and Results

Figure 1 illustrates the counseling process implemented in this study. In conventional counseling sessions, students frequently encounter difficulties in expressing their emotions due to factors such as shyness, limited emotional awareness, and discomfort with direct emotional disclosure. These challenges often limit the effectiveness of traditional counseling approaches that rely predominantly on verbal interaction. As a result, counseling sessions may be prematurely terminated without sufficient exploration of students' emotional experiences. The integration of a counseling tool, namely *Bingo Hati*, was found to enhance students' willingness to communicate during counseling sessions.

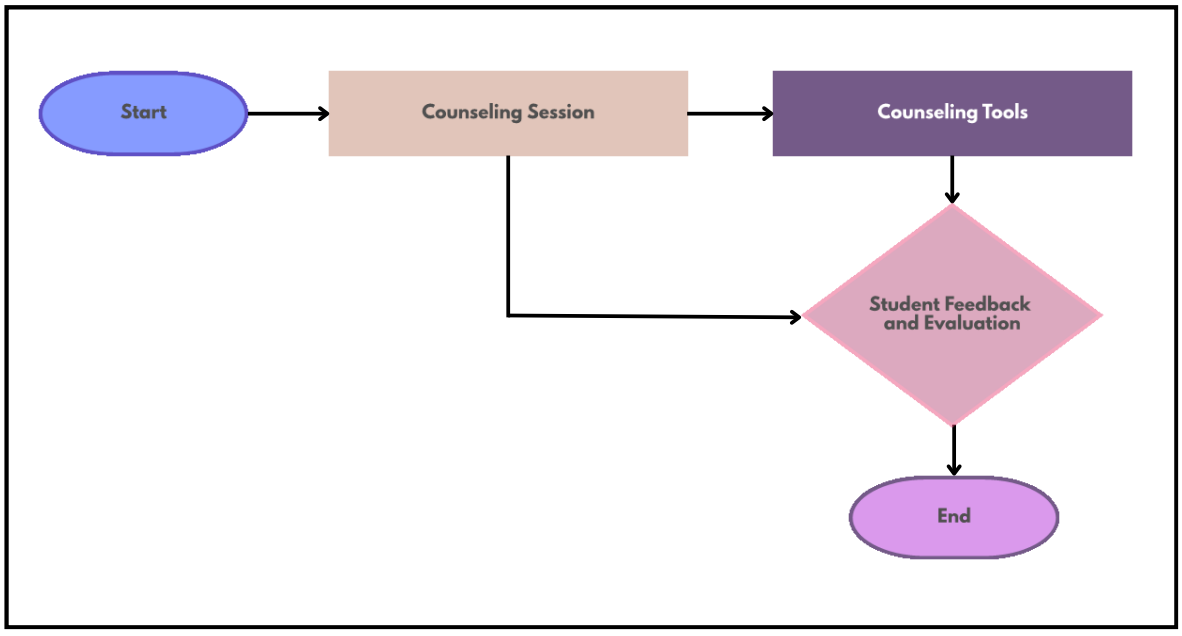

Figure 1. The Counseling Process using Bingo Hati.

This is evidenced in **Table 1**, which demonstrates consistently positive student perceptions regarding the use of Bingo Hati as a digital counseling support tool. Specifically, students reported

improved recognition and awareness of their own emotions after participating in the Bingo Hati activity, suggesting that its structured and visually supported format facilitated emotional reflection. High mean scores related to emotional comfort further indicate that students felt safe and at ease expressing emotions through the digital bingo mechanism, with reduced feelings of embarrassment or self-consciousness. Additionally, strong agreement on engagement-related items suggests that Bingo Hati increased students' motivation to communicate and actively participate during counseling sessions. Qualitative reflections and counselor observations further reinforced these findings. Students reported that selecting emotionally resonant statements helped them organise their thoughts, clarify feelings, and articulate emotional experiences more coherently. Counselors similarly observed increased student responsiveness, longer engagement durations, and deeper emotional dialogue compared to conventional counseling interactions. Collectively, these findings indicate that Bingo Hati functioned as an effective emotional mediation tool, supporting both individual emotional awareness and meaningful counselor–student interaction within the vocational counseling context.

Table 1. Student Feedback on the Use of Bingo Hati in Counseling Sessions (N = 18).

Construct	Item	Mean	SD
Emotional Awareness	Bingo Hati helps me recognise my emotions more clearly	4.39	0.61
Emotional Awareness	I am more aware of my feelings after the session	4.50	0.62
Emotional Comfort	I feel comfortable expressing emotions using Bingo Hati	4.44	0.51
Emotional Comfort	Bingo Hati reduces embarrassment when sharing emotions	4.33	0.59
Engagement	The activity makes counseling more engaging	4.39	0.50
Engagement	I am more willing to communicate during counseling	4.28	0.57
Social Understanding	I better understand others' emotions	4.22	0.55
Overall Acceptance	Bingo Hati is suitable for counseling sessions	4.44	0.51

3. Novelty and uniqueness

The Bingo Hati innovation demonstrates strong novelty and uniqueness by transforming emotional disclosure into a structured digital activity that moves beyond traditional verbal-centric counseling practices. Instead of relying on direct verbal expression, this approach employs a bingo-style selection mechanism that allows students to identify and express emotions in a mediated, non-threatening manner. By prioritising psychological safety over competition or assessment, Bingo Hati creates a supportive environment where students feel secure to engage emotionally without fear of judgment. Bingo Hati avoids competitive or socially evaluative elements, aligning with evidence cautioning against complex social gamification designs when emotional safety is the primary objective (Coelho et al., 2026; Hong et al., 2025). The integration of gamification serves to reduce anxiety and emotional resistance, particularly among students who may struggle with conventional counseling approaches. Furthermore, this innovation repositions counseling as a collaborative, engaging, and student-centred process, aligning emotional expression with interactive digital engagement. Through its gamified yet psychologically safe design, Bingo Hati offers a distinctive and contemporary counseling approach that effectively bridges emotional development with digital innovation.

4. Benefit to mankind

The implementation of *Bingo Hati* enables students to express their emotions with greater comfort and confidence, particularly within a supportive and non-judgmental counseling environment. The structured and interactive design reduces emotional barriers, allowing students to articulate feelings more openly without the pressure of direct verbal disclosure. From a technological perspective, the use of the myViewBoard platform aligns with research demonstrating that interactive smart board technologies enhance engagement, motivation, and participation by creating collaborative and psychologically supportive environments (Alsaied et al., 2025). As a result, counselors are able to facilitate deeper and more focused emotional dialogue, as students' responses provide clearer emotional cues and themes for exploration. This enhanced interaction supports more meaningful counseling sessions and strengthens counselor–student engagement. Furthermore, *Bingo Hati* contributes to holistic student wellbeing in vocational education by addressing emotional, psychological, and social dimensions alongside academic and career development. By integrating emotional expression with digital innovation, this approach aligns counseling practices with the needs of vocational students, promoting emotional resilience, self-awareness, and overall wellbeing in a contemporary educational context.

5. Innovation and Entrepreneurial Impact

Bingo Hati promotes innovation by introducing a gamified and digitally mediated approach to emotional expression and counseling, moving beyond traditional verbal-centric methods. By integrating technology such as MyViewBoard and interactive bingo-style activities, the project exemplifies how creative solutions can enhance educational and psychological support services. Its design encourages experimentation, problem-solving, and the use of digital tools, fostering a mindset of innovation among educators, counselors, and students alike. In addition, the project contributes to a culture of entrepreneurship by demonstrating the potential for scalable, marketable solutions in education and mental health. Through licensing opportunities, collaborations with EdTech and wellbeing providers, and adaptation for schools, colleges, and counseling centers, *Bingo Hati* inspires stakeholders to explore new business models, digital solutions, and social ventures, cultivating entrepreneurial thinking and proactive innovation within the community, institution, and industry.

6. Potential commercialization

Bingo Hati demonstrates strong potential for commercialization through a flexible licensing model tailored for schools, colleges, and counseling centres. This innovation can be offered as a licensed digital counseling tool, enabling educational and support institutions to integrate it seamlessly into existing guidance, Social and Emotional Learning (SEL), mental health, and youth development programs. Its adaptable design allows for customization across diverse age groups and institutional contexts, increasing its market viability. Furthermore, *Bingo Hati* presents opportunities for strategic collaboration with EdTech companies and wellbeing service providers to enhance digital platforms, expand content development, and scale implementation. Such partnerships could support broader dissemination, professional training, and sustainable adoption. With the growing emphasis on digital wellbeing and preventive mental health interventions in education, *Bingo Hati* holds strong commercial value as an innovative, scalable, and impactful counseling solution.

7. Acknowledgment

I extend my sincere appreciation to my team for their unwavering commitment, substantial time investment, and valuable contributions that made the successful completion of this manuscript possible.

8. Researchers' Biography

Tuan Noor Hazariani Binti Tuan Zakaria is a Counseling Officer at the Psychology and Career Unit, Batu Lanchang Vocational College, serving since March 2023. She is a Registered Counselor with the Malaysian Board of Counselors since 2021 and a Volunteer Counselor with Talian Kasih 15999. She also serves as a coordination panel member for compliance in student selection and support services under the Code of Practice for Programme Accreditation (COPPA) for Vocational Colleges, Ministry of Education Malaysia. Her professional interests include the digitalization of counseling materials using MyViewBoard and research on enhancing digital competencies in guidance and counseling services.

Zi Jian Oh is a lecturer in the Business Department at Batu Lanchang Vocational College, Penang, Malaysia. He has over nine years of teaching experience in the Diploma in Business Management program. He earned his Doctor of Philosophy in Educational Management from Universiti Pendidikan Sultan Idris in 2023. His research interests include mobile leadership, blue ocean leadership, employee engagement, team performance, and motivation. His ORCID iD is https://orcid.org/0000-0001-6152-7437, and he can be contacted via email at ohzijian@gmail.com.

Muhammad Afif Ammar bin Muhammad Hijaz is an Automotive Lecturer at Batu Lanchang Vocational College, Penang, Malaysia. His expertise includes Technical and Vocational Education and Training (TVET), automotive technology, and technology-integrated pedagogy. His academic interests focus on Inquiry-Based Learning, technological literacy, and the integration of digital tools in Final Year Projects to enhance students' problem-solving skills and industry readiness. He is actively involved in curriculum development, student supervision, and applied educational research aligned with Industry 4.0 and national TVET priorities.

Noor Shaliha binti Abdul Halim is an experienced educator from Tangkak, Johor. She holds a Master's Degree in Technical and Vocational Education and a Bachelor's Degree in Electronic Engineering. She has teaching experience as an Electronics Lecturer, having served one year at Megatech International College and seven years at Batu Lanchang Vocational College in the Electronic Technology program. Her professional focus includes practical-based teaching and learning, curriculum implementation, and the enhancement of technical and vocational education aligned with current industrial and technological demands.

Integration Packaging Design Education via iDPAC (Intelligence Digital Packaging) Mobile Application

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ABSTRACT

Intelligence Digital Packaging (iDPAC) is the integration of Artificial Intelligence (AI) in mobile learning applications to enhance packaging design teaching and learning through accessible, interactive and learner-centered by digital experiences. The lack of conventional packaging design instructions often relies heavily on studio practice and printed references, leading to limiting flexibility, consistency progression and student engagement. iDPAC addresses this gap by incorporation AI as an assistant tools' guidance in packaging design course. This supports students through digital learning strategies more directly. The iDPAC provides structured learning modules and visual references with intelligent design assistance that enable self-paced experiential learning. Design Developmental Research (DDR) employed Design Thinking (DT) and was applied in IDPAC mobile application. DDR is a systematic, iterative, and human-centered approach to solve complex problems in three phases; need analysis, design and development, and evaluation. Meanwhile, DT involves five stages: empathize, define, ideate, prototype and test. Combination of both frameworks leads to more comprehensive and innovative solutions. Therefore, a quantitative approach involving 30 students of Diploma of Graphic Design at Politeknik Ibrahim Sultan to reflect the effectiveness of iDPAC in teaching and learning. The findings demonstrate that iDPAC has a strong potential as an innovative digital learning tool with promising opportunities for educational adoption and commercialization in the future. Furthermore, the study suggests that integrating iDPAC will greatly improve engagement of students and enhance the outcomes.

Keywords: Artificial Intelligence, Packaging Design, Mobile Application, Digital Learning, Mobile Learning.

1. Product Description

iDPAC is mobile application-based learning for an educational platform developed to support students, educators and creative industry designers in learning packaging design more effectively. iDPAC combines integration of AI in developing these mobile apps with instructional video guidance for structural visualization of packaging design. The active navigation interaction in modules enhances conceptual understanding, improves creativity and makes the technical proficiency of packaging design more impactful. iDPAC also offers real-time feedback and assessment tools to track progress and identify areas for improvement, leading to higher levels of student engagement with better learning outcomes. The user-friendly interface and customizable user navigation features in iDPAC allow to cater to the diverse needs of learners in packaging design courses. Furthermore, iDPAC with the real-time collaboration capabilities

allows for direct communication and feedback between students and instructors to enhance the learning experience. Lastly, iDPAC provides access to a wide range of resources and tools that support learners in developing skills and creativity in packaging design.

2. Project Innovation Functional

iDPAC provides users with guidance through the six main section pages inside iDPAC mobile apps: Packaging Design, Design Research, Design Process, Package Structure, Package Design, and Final Design including the About iDPAC, Verify Me (Assignment Submission), and Contact Me (Author Information). This section describes the key features and functionalities of each component in packaging design to help users navigate through the apps effectively and maximize their learning experiences (**Figure 1**). Meanwhile, **Figure 2** shows the flowchart of the functional iDPAC mobile application. Learners can adapt the AI integration in developing the unique package structure to meet their specific needs and preferences. Additionally, users can access a variety of templates, video tutorials and design examples to be inspired and improve the packaging design project. Moreover, iDPAC offers and allows approach mobile application-based to take place anytime and anywhere independently self-learning contexts outside classroom. Users can easily explore new design techniques and experiment with different styles through the convenience of their own mobile devices. This flexibility enables the users to continue improving skills and understanding with stay up-to-date latest trends in packaging design. iDPAC has been registered in the Intellectual Property Corporation of Malaysia (myIPO) with the number CRAR2025J00267 to protect its innovative technologies and user interface (UI). As for widening the usage of iDPAC, it was published in Google Play for android users and the Play Store for apple users, making it easily accessible to a wider audience of students and professionals interested in strengthening their packaging design skills. Additionally, iDPAC offers regular updates and new features to enable users to learn with the latest tools and techniques in the industry.

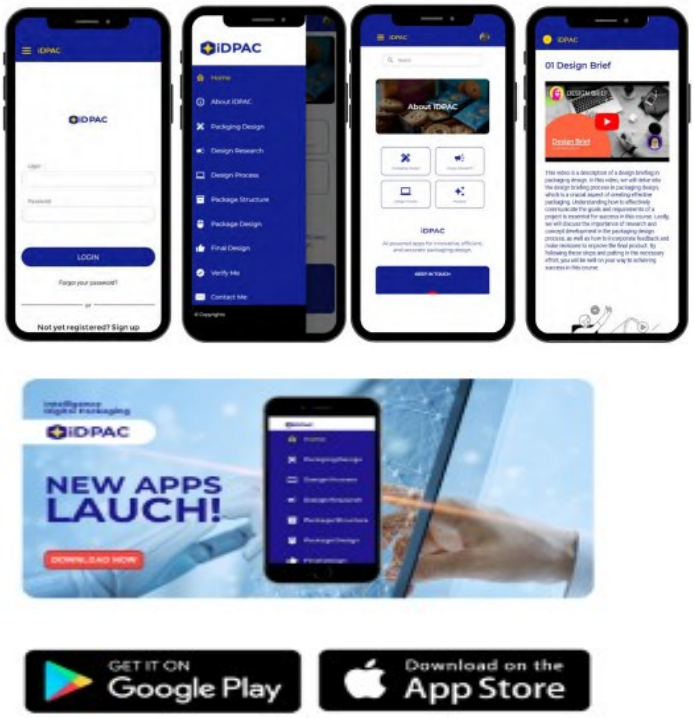
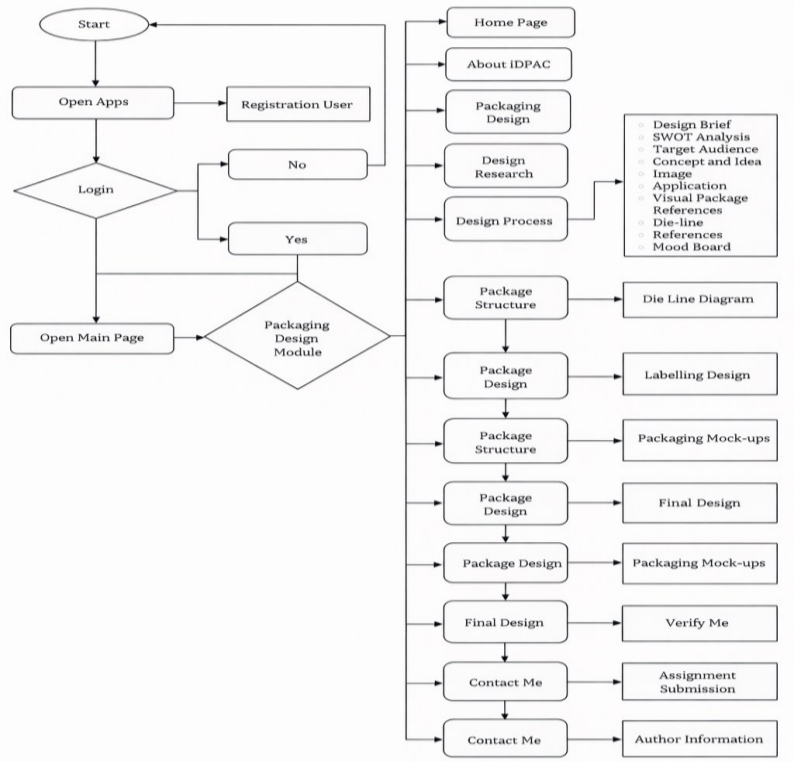


Figure 1. iDPAC App AI-powered for Packaging Design Solution.



The iDPAC novelty is in its specialized integration of AI learning support within a mobile application tailored for packaging design education. The conventional learning gives a static content, iDPAC offers a contextual guidance and intelligent visual and interactive instructional video in one application mobilization to support visual assistance learners through the packaging design process. The iDPAC system bridges the gap between theory and practice by providing real-time feedback and guidance visual references aligned with the latest trend industry packaging design standard. This unique approach enhances learners to develop practical skills that are directly applicable in the employment industry. iDPAC lead to AI technology setting the apart in cutting-edge tools that inspire packaging learners, educators and designers.

4. Benefit to mankind

iDPAC enhances access to quality design education by enabling flexible, inclusive, and self-learning directly. It supports learners from diverse backgrounds by reducing dependency on physical studio resources and face-to-face instruction. By incorporating real-world case studies and interactive simulation, IDPAC ensures that users are well-equipped to tackle the challenges pd the packaging design field. This dynamics platform empowers individuals to enhance their craft at their own pace, develop creativity and innovation in the process. The digital literacy and creative problem-solving skills can be more effective by utilizing its components. iDPAC offers a comprehensive and engaging learning experience that prepares learners for success in packaging design industry. Though its innovative approach, iDPAC equips individuals with the knowledge and skills needed excel in a competitive market in shaping the future of design innovation.

5. Innovation and Entrepreneurial Impact

The project promotes innovation by merging artificial intelligence with mobile education in a creative discipline. iDPAC encourages a culture of innovation and entrepreneurship by demonstrating how emerging technologies can be transformed into scalable educational solutions. The application provides a platform for future expansion, including integration with industry partners, content monetization, and customization for institutional use.

6. Potential commercialization

iDPAC demonstrates strong commercialization potential through institutional licensing, subscription-based access for students, and strategic collaborations with educational institutions and training providers. Additional revenue streams may include premium features, industry-sponsored content, and customization services for academic and professional users. The growing demand for digital and mobile learning solutions further enhances the market potential of iDPAC.

7. Acknowledgment

I gratefully acknowledge the support and cooperation of Politeknik Ibrahim Sultan in facilitating the development of this innovation. Appreciation is also extended to my Professor (Associate) Dr Zainuddin bin Ibrahim as supervisor, all individuals who provided insights, feedback, and assistance during the research and development process. Thanks, the organizers of the International Tinker Innovation & Entrepreneurship Challenge (I-TIEC) for the opportunity in this innovation.

8. Researchers' Biography

Nurulkusuma binti Adnan is a Malaysian researcher and educator specializing in graphic design technology, new media, digital media, and visual communication since 2010 of experience in higher education, focusing on creative thinking, design principles, and emerging technologies in design pedagogy. Currently a senior lecturer in the Department of Design and Visual Communication at Politeknik Ibrahim Sultan, she is actively involved in curriculum development and skills training. Her research interests include digital and new media design, artificial intelligence in creative practice, and education design innovation. She also contributes as a national coach and technical committee member for WorldSkills graphic design technology competitions.

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Laser-RTS: A Smart Laser-Based Distance Measurement System for Return-to-Sport Functional Assessment

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ABSTRACT
Return-to-sport (RTS) assessment is a critical component in sports rehabilitation to determine an athlete's readiness to safely resume sporting activities. Hop and jump tests such as the single hop, triple hop, crossover hop and horizontal jump are commonly used, yet their measurements are still largely dependent on manual tape measures, visual estimation and physical marking, which are time-consuming, prone to human error and inconsistent. LASER-RTS introduces a smart laser-based distance measurement system designed to automatically detect and calculate jump distance in real time. The system utilises a laser emitter and sensor module to identify the landing point and instantly compute the distance without the need for manual marking or measurement. Key features include automated measurement, digital data recording, and potential integration with mobile applications for performance tracking. This innovation improves accuracy, efficiency and standardisation of RTS assessment while supporting sustainable practices through reduced paper usage and material waste. The system has strong potential for commercialisation in physiotherapy clinics, sports academies, universities and rehabilitation centres, contributing to enhanced clinical decision-making and safer return-to-sport outcomes.

Keywords: Return to Sport, Laser Measurement, Hop Test, Sports Rehabilitation, Digital Assessment

1. Product Description
LASER-RTS is a portable, laser-based distance detection system specifically developed for hop and jump assessments in return-to-sport evaluation. The device consists of a laser emitter positioned at the starting line and a sensor module that detects the athlete's landing point. Once the landing point is detected, the system automatically calculates the jump distance and displays the result on a digital interface. The system eliminates the need for manual tape measurement, floor markings or visual estimation. LASER-RTS is designed to be lightweight, easy to set up and user-friendly, making it suitable for clinical, educational and field-based environments. The system can be used for various functional tests including horizontal jump, single hop, triple hop, crossover hop and vertical jump. Data can be stored digitally for performance monitoring, progress tracking and clinical documentation. By automating the measurement process, LASER-RTS enhances assessment efficiency, reduces human error and improves the reliability of return-to-sport decision making.

2. System Architecture and Measurement Workflow

Figure 1 illustrates the overall system architecture of LASER-RTS, highlighting the laser emitter, sensor module, processing unit and display interface. The laser emitter projects a beam along the testing area while the sensor detects interruption at the landing point. The processing unit then calculates the distance and displays the output digitally.

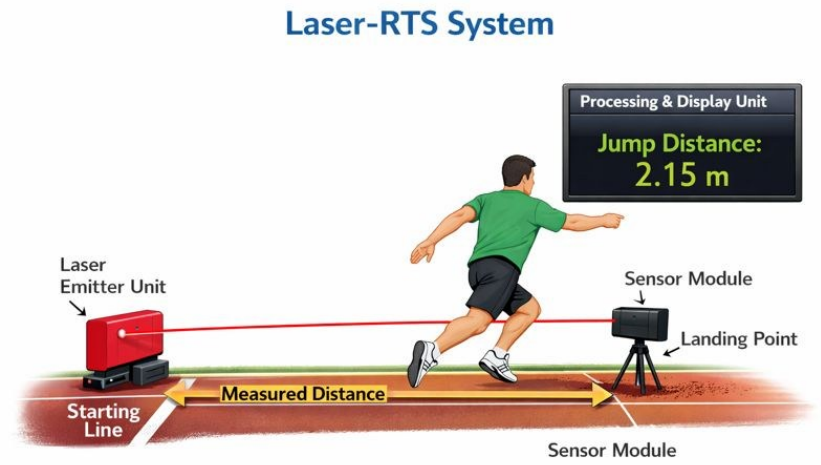

Figure 1. System architecture of LASER-RTS.

Figure 2 shows the operational workflow of the LASER-RTS during a horizontal jump assessment, starting from system calibration, athlete take-off, landing detection, distance calculation and data display.

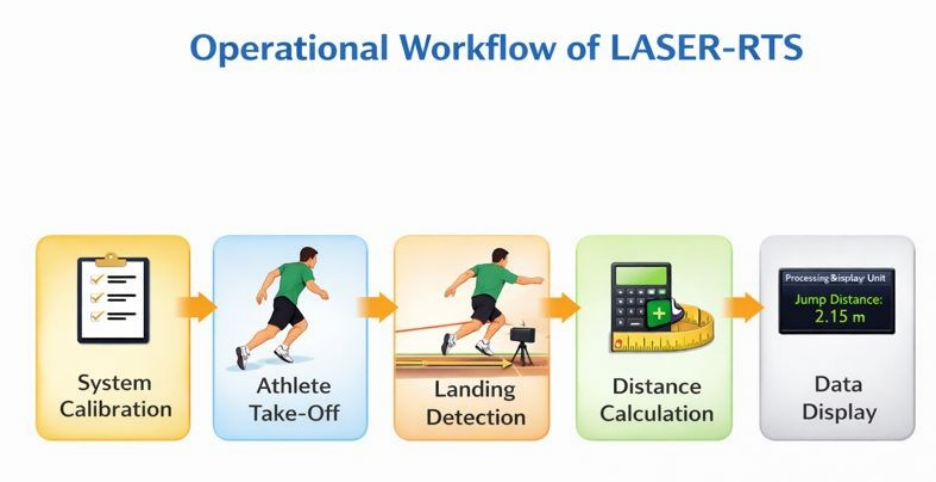

Figure 2. Operational workflow of the LASER-RTS.

3. Novelty and uniqueness

LASER-RTS is novel in its application of laser-based distance detection technology specifically tailored for return-to-sport functional assessment. Unlike conventional systems that rely on manual tape measurement and floor markings, LASER-RTS provides automated, real-time measurement of hop and jump distances without physical contact or manual intervention. The uniqueness of this innovation lies in its combination of simplicity, portability and clinical relevance. It bridges the gap between engineering technology and physiotherapy practice by translating

advanced sensing technology into a practical clinical tool. The system also supports digital data recording, enabling long-term performance tracking and objective clinical decision making. To the best of our knowledge, there is no existing low-cost, portable laser-based system
dedicated specifically to hop and jump assessment in physiotherapy and sports rehabilitation settings. This makes LASER-RTS a distinctive and impactful innovation in the field of sports injury rehabilitation.

4. Benefit to mankind

LASER-RTS benefits patients, clinicians and the wider community by improving the accuracy and reliability of return-to-sport assessments. Athletes and patients receive safer and more objective evaluation before returning to sport, reducing the risk of re-injury. Clinicians benefit from faster assessment time and standardised measurements, allowing more efficient patient management. Educational institutions can utilise the system for teaching and training purposes, enhancing learning experiences for physiotherapy and sports science students. From a sustainability perspective, the system reduces paper usage and material waste by enabling digital documentation. Overall, LASER-RTS contributes to safer rehabilitation practices, improved healthcare quality and more sustainable clinical operations.

5. Innovation and Entrepreneurial Impact

LASER-RTS promotes innovation by integrating engineering technology with clinical rehabilitation practice, fostering interdisciplinary collaboration and problem-solving culture. It encourages students and professionals to explore technology-driven solutions in healthcare, aligning with the vision of empowering innovation for a sustainable future. From an entrepreneurial perspective, the project has strong potential to be developed into a commercial product for physiotherapy clinics, sports academies, universities and rehabilitation centres. It opens opportunities for start-up development, product licensing and industry collaboration. By addressing a real clinical need with a practical solution, LASER-RTS contributes to the growth of health technology entrepreneurship and supports the development of innovative, impact-driven enterprises.

6. Potential commercialization

LASER-RTS has high commercialisation potential in the healthcare and sports industry. Target markets include physiotherapy clinics, sports rehabilitation centres, universities, sports academies and professional sports teams. The product can be commercialised through direct device sales, bundled packages with software applications, and training workshops for users. Partnerships with medical device distributors and sports equipment suppliers can further expand market reach. With increasing emphasis on objective assessment and digital health solutions, LASER-RTS aligns well with current market trends. Its portable design and cost-effective production make it suitable for both local and international markets.

7. Acknowledgment

The authors would like to express their sincere appreciation to all team members for their invaluable contributions, dedication and continuous support in the development of this innovative project.

8. Researchers' Biography

Mohamad Hafiz Abu Seman is a Physiotherapy Lecturer at Universiti Teknologi MARA (UiTM) Cawangan Pulau Pinang, Kampus Bertam. He specialises in clinical exercise testing and exercise prescription for clinical populations. He has actively contributed to innovation in education and healthcare, receiving multiple awards at national and international levels. His achievements include Gold Awards for Physio Expert Learning 1.0 & 2.0 and LET'S BREATHE: Everything at Your Fingertips, Silver Award for Tourist Detective and Infographic Solat, and Bronze Awards for Grammar Quest, Stop Urinary Incontinence; Keep Squeeze!, and Physiotherapy Assessment Made Easy. His work focuses on enhancing learning, rehabilitation outcomes and digital health innovation.

Nurshazana Akmal Jamaludin is a Physiotherapy Lecturer at UiTM Cawangan Pulau Pinang, Bertam Campus. She possesses extensive experience in both the healthcare industry and academia, allowing her to bridge the gap between clinical practice and teaching. A dedicated researcher, she has won multiple innovation awards for her creative contributions to the field and has been featured in numerous academic publications. She is committed to advancing physiotherapy through research-driven solutions and high-quality education.

Aslinda Che Mood is a physiotherapy professional with over 30 years of experience in the field and more than 20 years of academic experience as a lecturer in physiotherapy. She is currently serving at Universiti Teknologi MARA (UiTM) Bertam Campus and has dedicated her career to advancing physiotherapy practice and education, particularly within higher education institutions. As an academic, she is actively involved in teaching, curriculum development, student supervision, and assessment, and has contributed to the training of diploma and undergraduate physiotherapy students. In addition, she has been involved in educational innovation, teaching and learning enhancement, and professional development activities, reflecting her commitment to lifelong learning and excellence in physiotherapy education.

Nur Ainah Mohd Shipah is a Physiotherapy Lecturer at Universiti Teknologi MARA (UiTM), Cawangan Pulau Pinang, Bertam Campus. She has nine years of experience in the physiotherapy profession, with a strong foundation in musculoskeletal physiotherapy. Her academic and clinical interests focus on the assessment, management, and rehabilitation of musculoskeletal conditions. As an educator, she is actively involved in teaching, clinical supervision, and the development of future physiotherapists through evidence-based practice.

FuelGuard: Intelligent Security System for RON95 Subsidised Fuel Distribution

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ABSTRACT
This project presents the development of FuelGuard as an intelligent security and identification system. It is designed to enhance Malaysia's RON95 fuel subsidy system under the BUDI MADANI initiative. The proposed system integrates with vehicle License Plate Recognition (LPR) and RFID verification. The embedded automatic system uses a Raspberry Pi 4 Model B and a Raspberry Pi Pico 2 W. Fuel dispensing is regulated by a motor-driven submersible pump, ensuring that subsidized RON95 is supplied only to eligible vehicles. A camera captures vehicle license plates, which are classified as Malaysian-registered, foreign, unregistered, or blacklisted. Meanwhile, RFID authentication provides an additional layer of verification. The feedback and system status are presented using LCD and OLED displays, with visual indicators and an audible buzzer for alerts and notifications. The system used Artificial Intelligence (AI) and Internet of Things (IoT) technologies to reduce manual checks, prevent subsidy misuse and improve transparency at fuel stations, particularly in border-sensitive areas. Although implemented as a prototype without direct integration to government databases, the system demonstrates a scalable and practical framework that complements existing MyKad-based subsidy mechanisms while supporting national goals of operational efficiency, security, and digital transformation.

Keywords: Vehicle Identification, License Plate Recognition (LPR), RON95 Fuel Subsidy, Intelligent Security System, Internet of Things (IoT)

1. Product Description
FuelGuard is an intelligent security and identification system designed to improve enforcement of RON95 subsidized fuel distribution at petrol stations. The system functions as a modular add-on integrated into existing fuel station operations without major infrastructure changes. A Raspberry Pi 4 Model B performs high-level processing, including camera-based vehicle license plate recognition and RFID verification, while a Raspberry Pi Pico 2 W manages real-time control tasks such as keypad input, display operation and fuel dispensing. Based on vehicle eligibility and authentication results, the system controls a motor driver and submersible pump to allow or restrict fuel flow accordingly. Visual and audio feedback is provided through LCD and OLED displays, LEDs, and a buzzer to inform users of access status. FuleGuard reduces manual intervention and enhances enforcement consistency. It offers a practical, scalable approach to protecting fuel subsidies, especially in high-risk border regions.

2. Methods and Results

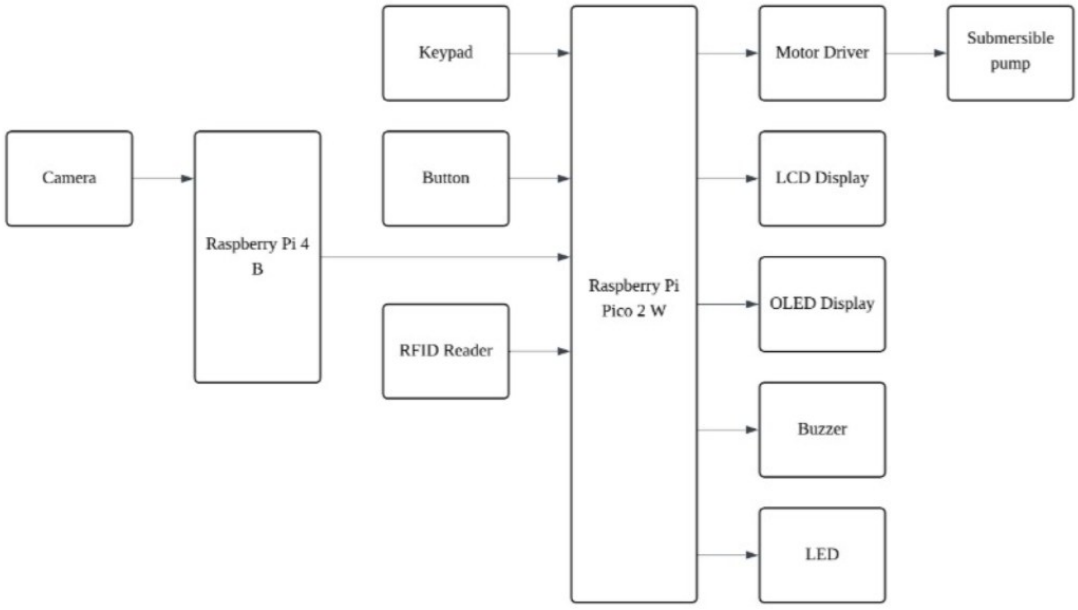

Figure 1. Block Diagram of FuelGuard system.

Figure 1 illustrates the operation of the FuelGuard through a block diagram, providing an overview of how the hardware components interact to implement an intelligent security and identification system for RON95 subsidized fuel distribution. This block diagram representation simplifies understanding of the system architecture by clearly illustrating the flow of information and control between input devices, processing units, and output components. The system begins with high-level input acquisition, where a camera and RFID reader connected to the Raspberry Pi 4 Model B capture vehicle license plate information and user credentials for eligibility verification. Once vehicle and identity validation are completed, control signals are transmitted to the Raspberry Pi Pico 2 W, which functions as the real-time control unit. User interaction is enabled through a keypad and push button connected to the Pico, allowing authorized access only after successful verification. Based on the received commands, the Pico controls output devices, including the motor driver and submersible pump, to regulate fuel dispensing, while visual and auditory feedback is provided through the LCD, OLED display, LEDs, and buzzer. The motor driver modules ensure safe isolation between the controller and the pump during operation. Throughout the process, the system continuously updates the user on access status and system conditions, ensuring controlled, automated and secure fuel distribution.

3. Novelty and uniqueness

The novelty of FuelGuard lies in its automated vehicle-based verification using License Plate Recognition (LPR) and in enforcing fuel access before dispensing. This vehicle-centric and preventive approach differentiates the system from existing products and services by adding an additional security layer that enhances subsidy protection without altering current payment or identity verification mechanisms. In comparison with existing fuel subsidy enforcement methods and commercial fuel station systems, current solutions primarily focus on identity-based verification, such as MyKad tapping, e-wallet authentication, or manual staff inspection. These

approaches verify the eligibility of the individual. However, it does not automatically verify that the vehicle being refueled is valid. Therefore, it allows loopholes such as card borrowing and human intervention.

4. Benefit to mankind

FuelGuard benefits society by promoting fair and responsible use of government-funded fuel subsidies while reducing misuse and financial leakage. By automating vehicle-based identification and fuel access control, the system ensures that subsidized RON95 fuel is accessed only by eligible users, protecting public resources and supporting national subsidy objectives. The reduction of manual enforcement improves consistency and transparency at fuel stations, particularly in border areas where misuse is more prevalent. Additionally, the system enhances operational efficiency and safety by providing real-time user feedback and controlled fuel dispensing. The project also demonstrates how AI and IoT technologies can be applied responsibly to address real-world infrastructure challenges, contributing to long-term societal and technological advancement.

5. Innovation and Entrepreneurial Impact

FuelGuard demonstrates innovation by transforming a traditionally manual subsidy enforcement process into an intelligent, automated security solution. By integrating vehicle identification, embedded control, and logical decision-making, the system introduces a new service layer that can be offered as a modular add-on to existing petrol station infrastructure. From an entrepreneurial perspective, the system has potential as a compliance and security solution for fuel station operators and regulatory stakeholders. The design supports future expansion into cloud-based monitoring, analytics, and reporting services, creating opportunities for subscription-based deployment. By aligning technological innovation with national policy needs, the FuelGuard highlights the commercial viability of smart infrastructure solutions that deliver both economic value and social impact.

6. Potential commercialization

Importantly, the FuelGuard is designed to operate as a complementary solution to the existing BUDI MADANI subsidy framework, rather than as a replacement. It enhances current MyKad-based verification by introducing an additional vehicle-level validation layer, strengthening enforcement while maintaining compatibility with existing policies and workflows. By functioning alongside BUDI MADANI, the system supports gradual adoption and integration without disrupting established subsidy mechanisms, making it suitable for real-world deployment and regulatory acceptance.

7. Acknowledgment

The author expresses gratitude to Universiti Teknologi MARA, Sarawak, for providing the resources and laboratory facilities for this research. The author extends sincere thanks to all the staff and fellow students at the Faculty of Electrical Engineering, Sarawak, for their assistance and guidance.

8. Researchers' Biography

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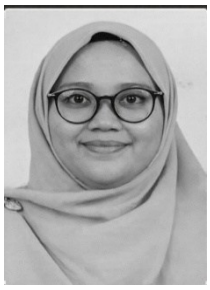
Bibi Sarpinah bt Sheikh Naimullah received a Bachelor of Engineering (Electrical) from Universiti Teknologi MARA, Shah Alam and a Master of Science (Communications and Networking Engineering) from Universiti Putra Malaysia (UPM). She is currently senior lecturer at Universiti Teknologi MARA, UiTM Sarawak.



Fatimatul Anis Bakri obtained her Bachelor degree in Electrical Engineering (Control and Instrumentation) from Universiti Malaysia Pahang (UMP) and Master of Science in Mechatronic Engineering from Universiti Malaysia Perlis (UNIMAP), Perlis, Malaysia, in 2008 and 2014, respectively. She has been working as a lecturer at UiTM since 2014. Her research interests Artificial Intelligence and satellite applications.

Nur Atiqah Abdul Rahman received a Bachelor degree in Electrical Engineering in 2011 and Master of Science in Electrical Engineering in 2014 from Universiti Teknologi MARA Malaysia. Currently she is working as a lecturer in Universiti Teknologi MARA Cawangan Sarawak and doing part time PhD in Electrical Engineering at Universiti Teknologi MARA Malaysia. Her current research interests are optimization technique, distributed generation and Power System.

Compost Biopore: A Sustainable Environmental Alternative Solution

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ABSTRACT

Biopore Compost is an environmentally friendly innovation that integrates biopore infiltration technology with organic composting processes. This product is designed to address increasing organic waste accumulation, declining soil fertility, and reduced water infiltration caused by land degradation. Compost is produced through the natural decomposition of organic waste, such as household and agricultural residues, inside vertical biopore holes that function simultaneously as water infiltration systems. This method enhances microbial activity, increases soil organic matter content, and improves soil structure and porosity. The final product is a safe, eco-friendly organic compost that is easy to apply and supports sustainable agriculture while contributing to carbon emission reduction. Biopore Compost not only offers ecological benefits but also provides economic value by transforming organic waste into a marketable, value-added product suitable for household, community, and commercial-scale applications.

Keywords: Biopore Compost, Environmental Technology, Organic Waste, Sustainable Agriculture; Soil and Water Conservation

1. Product Description

Biopore Compost is a solid organic fertilizer produced through the utilization of biopore infiltration holes as an active composting medium. Vertical biopore holes are constructed in the soil and filled with organic waste such as kitchen scraps, dry leaves, and agricultural residues. The waste undergoes natural decomposition facilitated by soil microorganisms, moisture, and optimal aeration. Direct interaction between organic materials, soil organisms, and soil structure accelerates the composting process. The resulting compost is applied directly to agricultural land, home gardens, and green spaces to enhance soil fertility, water-holding capacity, and biological activity. Biopore Compost is simple to produce, cost-effective, and environmentally sustainable, making it suitable for farmers, households, and urban green area management. **Figure 1**

Figure 1. Biopore Compost.

2. Pictures Compost Biopore: A Sustainable Environmental Alternative Solution

The schematic diagram illustrates the biopore compost production process through a vertical soil-based system. The upper section presents a cross-sectional view of a biopore hole constructed with a diameter of approximately 10–15 cm and a depth of 80–100 cm. Organic waste, including kitchen residues, dry leaves, and agricultural by-products, is placed at the surface and gradually deposited into the biopore hole. Rainwater infiltration is facilitated through the biopore structure, enhancing soil aeration and reducing surface runoff. The lower section depicts the biological decomposition process occurring inside the biopore hole. Organic materials are decomposed naturally by soil microorganisms, fungi, insects, and earthworms. This biological activity accelerates the breakdown of organic matter, leading to the formation of nutrient-rich compost within the soil profile. Throughout the process, soil porosity, microbial activity, and water infiltration capacity are improved. The diagram demonstrates the dual function of the biopore system, which simultaneously produces organic compost and enhances soil physical and biological properties. As a result, biopore compost production contributes to sustainable waste management, soil fertility improvement, and environmental conservation

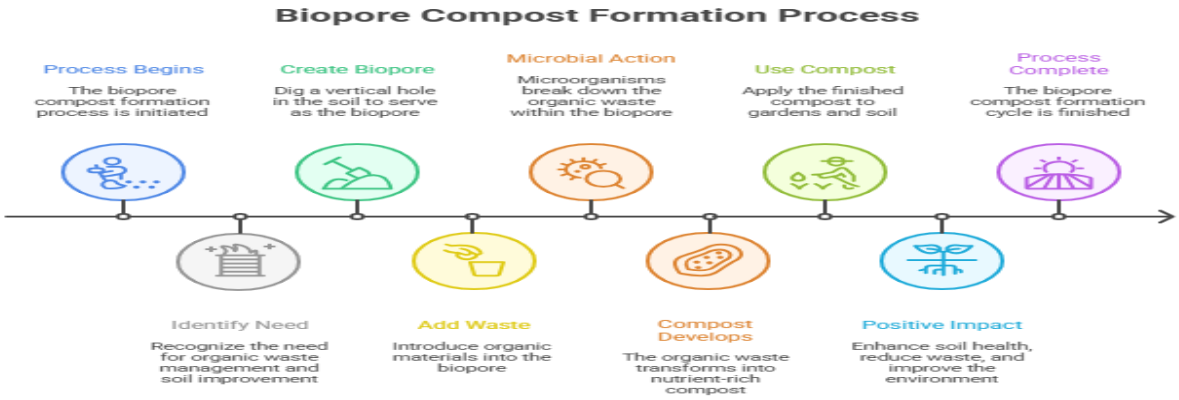

Figure 2. Flow Chart Biopore Compost.

The concept of a "Compost Biopore" integrates sustainable waste management with soil and water conservation techniques. Biopore infiltration holes, typically created using simple soil augers, are vertical holes in the ground designed to enhance water absorption, reduce surface runoff, and facilitate organic waste decomposition. When filled with organic compost, these structures transform into productive "Compost Biopores," serving as a dual-purpose solution for organic waste processing and environmental remediation.

The environmental efficacy of biopore technology is well-documented. Research indicates that biopore infiltration holes significantly increase soil infiltration capacity. As noted by Arifin et al. (2020), biopore holes can increase infiltration rates by up to 600% compared to untreated soil, directly mitigating urban flooding by reducing surface runoff volume and peak discharge. This aligns with the sustainable water management goals highlighted in the provided image notes regarding positive environmental impact. Furthermore, the integration of composting within these structures addresses solid organic waste challenges. Kitchen and garden waste placed inside biopores decomposes in situ, creating nutrient-rich compost that improves surrounding soil fertility. This process mirrors principles of the circular economy, turning waste into a resource. A study by Hakim et al. (2021) demonstrated that compost from biopores significantly increased

soil organic carbon, nitrogen, phosphorus, and potassium levels, enhancing soil quality for plant growth without chemical fertilizers. This material action transforming waste into valuable compost echoes the "Material Action" and "Add Value" concepts from the Elopore process description, where unique, valuable materials are created from base components. The combined system also promotes biodiversity and soil ecosystem health. The moist, organic-rich environment within compost biopores attracts soil macrofauna, such as earthworms and other decomposers, which naturally aerate the soil and accelerate decomposition. Research by Surbakti et al. (2019) confirms that biopore holes enhance soil fauna activity and diversity, leading to improved soil structure and porosity a natural form of "Process Control" that maintains consistent biological processing of organic matter. In conclusion, the Compost Biopore system embodies a sustainable, low-tech, and scalable environmental solution. It effectively manages organic waste, enhances soil and water conservation, and supports urban green infrastructure, directly contributing to several Sustainable Development Goals (SDGs), including Clean Water and Sanitation (SDG 6), Sustainable Cities and Communities (SDG 11), and Responsible Consumption and Production (SDG 12). As a community-based technology, it empowers local stakeholders to participate directly in environmental stewardship, creating a tangible "Positive Impact on society through sustainable materials and processes. **Figure 2**.

Figure 3. Biopore Compost Products.

The schematic diagram illustrates the structural design and biochemical process of a Compost Biopore, a simple yet highly effective bioremediation and soil conservation technology. As depicted, the system consists of a vertical cylindrical hole, typically 10–15 cm in diameter and 80–100 cm deep, drilled into the ground and filled with layered organic waste. This design facilitates

a multi-functional process that integrates enhanced hydrology, waste valorization, and soil ecosystem engineering. The specified dimensions are critical for optimal performance. The depth of 80–100 cm allows the biopore to bypass compacted surface layers or hardpans, creating a direct conduit for surface water to infiltrate into deeper soil strata or groundwater aquifers. This significantly reduces surface runoff and erosion. Research by Septyandy et al. (2021) confirms that biopores with depths exceeding 80 cm are markedly more effective in reducing runoff volume and peak flow rates in urban areas compared to shallower variants. The diameter of 10–15 cm provides sufficient volume for organic waste storage and microbial activity while maintaining structural stability against collapse. The core function of the Compost Biopore is the in-situ decomposition of organic waste, as shown in the process diagram.

The addition of fruit peels, vegetable scraps, dry leaves, and agricultural residue provides a carbon-rich substrate. This initiates a complex decomposition ecosystem involving soil engineers like earthworms and diverse microbial consortia. Earthworms (e.g., Lumbricus terrestris) play a crucial role by fragmenting and aerating the waste, enhancing its accessibility to fungi and bacteria. A study by Setyowati et al. (2020) demonstrated that biopore holes containing organic waste and active earthworm populations showed a 40% faster decomposition rate and produced compost with higher humic acid content than static compost piles. This symbiotic process directly "Enhances Microbial Activity" and "Improves Soil Aeration," leading to the formation of high-quality compost. This internal composting process yields significant agronomic and environmental benefits. The resulting compost gradually enriches the surrounding soil matrix with essential nutrients and organic matter. As noted in the diagram, this "Resists Soil Erosion" by improving soil aggregate stability. Furthermore, the activities of earthworms and insects create a network of micro-channels around the main biopore, further increasing the soil's macroporosity and hydraulic conductivity.

This is supported by the findings of Hakim et al. (2019), who reported that the area within a 20-cm radius of active compost biopores exhibited a 25% increase in soil porosity and a significant rise in populations of beneficial nematodes and bacteria compared to control soil. In conclusion, the Compost Biopore system, as detailed in the schematic, is a quintessential example of biomimicry and circular economy applied to environmental management. It technically functions as a small-scale, vertically oriented bioreactor that simultaneously addresses organic waste disposal, improves soil physical and biological health, and mitigates urban hydrological problems. Its scalable and community-friendly nature makes it a potent tool for decentralized sustainable development, effectively transforming waste into a resource for ecosystem restoration.**Figure 3**

3. Novelty and uniqueness

The novelty of Biopore Compost lies in the integration of biopore infiltration systems as an active composting mechanism rather than solely a water absorption structure. This dual-function approach simultaneously produces organic fertilizer while enhancing soil hydrological function and biological quality, distinguishing it from conventional composting methods.

4. Benefit to mankind

Biopore Compost provides multiple benefits, including reduction of organic waste volume, improvement of soil resilience against degradation, enhancement of local water infiltration, and promotion of environmentally sustainable agricultural practices. It supports food security and ecological balance while encouraging responsible waste management.

5. Innovation and Entrepreneurial Impact

This product offers strong social and economic innovation potential through community-based green entrepreneurship. Biopore Compost production can generate employment opportunities, empower local communities, and promote circular economy principles by converting waste into profitable agricultural inputs.

6. Potential commercialization

Biopore Compost can be commercialized as packaged organic fertilizer, biopore installation kits, and training or consultancy services related to organic waste management. Potential markets include farmers, urban gardeners, educational institutions, landscaping companies, and environmental organizations.

7. Acknowledgment

Gratitude to the Chancellor of Universitas Labuhanbatu, Head of the Agrotechnology Study Program, Faculty of Science and Technology, Universitas Labuhanbatu

8. Researchers' Biography

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Convolutional Neural Network (CNN)-Based Fake Image Detection System

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ABSTRACT
This project presents a Convolutional Neural Network (CNN)-based Fake Image Detection System designed to identify manipulated and generated images amid rising digital misinformation. The system was developed to address the growing threat of visual forgeries such as copy-move, splicing, and inpainting that influence public opinion, elections, and cybersecurity. A custom CNN architecture automatically extracts pixel-level features through convolutional layers, max-pooling, ReLU activation, and fully connected classification, achieving 94.90% accuracy. Key uniqueness lies in its lightweight, efficient design without heavy pre-trained models, combined with data augmentation and an intuitive GUI for accessible real-time verification. The system promotes socio-economic benefits by curbing disinformation, enhancing trust in digital media, reducing scam impacts, and supporting informed decision-making across society. Its high performance and user-friendliness make it ideal for journalists, forensic experts, and platforms combating misinformation. With strong commercialization prospects, the tool can be deployed as a standalone application, browser plugin, API, or integrated into social media and content moderation services, offering subscription models, enterprise licensing, and scalable solutions to meet the increasing demand for reliable image authenticity verification.

Keywords: Convolutional Neural Network, Fake Image Detection, Image Forgery, Fake Image, Detection System

1. Product Description
The CNN-based Fake Image Detection System is an advanced deep learning-based tool designed to address the spread of manipulated and generated images. Leveraging a custom CNN architecture, the system automatically extracts hierarchical features to identify subtle artifacts from manipulations such as copy-move, splicing, and inpainting. The pipeline includes image preprocessing such as resizing, normalization, and augmentation with feature extraction through convolutional and max-pooling layers with ReLU activation, fully connected integration, and binary classification using Softmax. Trained on a balanced dataset of real and fake images, the model achieves 94.90% accuracy, 94.00% precision, 95.92% recall, and 94.95% F1-score. A user-friendly GUI enables easy image upload and real-time results, making it accessible for journalists, forensic experts, and social media moderators. This system effectively distinguishes authentic visuals from deceptive content, addressing misinformation threats in digital ecosystems.

2. Flow Charts of CNN-based Fake Image Detection System

The overall workflow of the proposed CNN-based fake image detection system is illustrated in **Figure 1** below. The process begins with image input from the user, followed by preprocessing steps such as resizing and normalization to ensure compatibility with the trained CNN model. The preprocessed image is then passed through the convolutional neural network, where hierarchical feature extraction and classification are performed. Finally, the system outputs the prediction result, indicating whether the uploaded image is genuine or fake. This flowchart highlights the sequential stages of data handling, model inference, and result generation within the system.

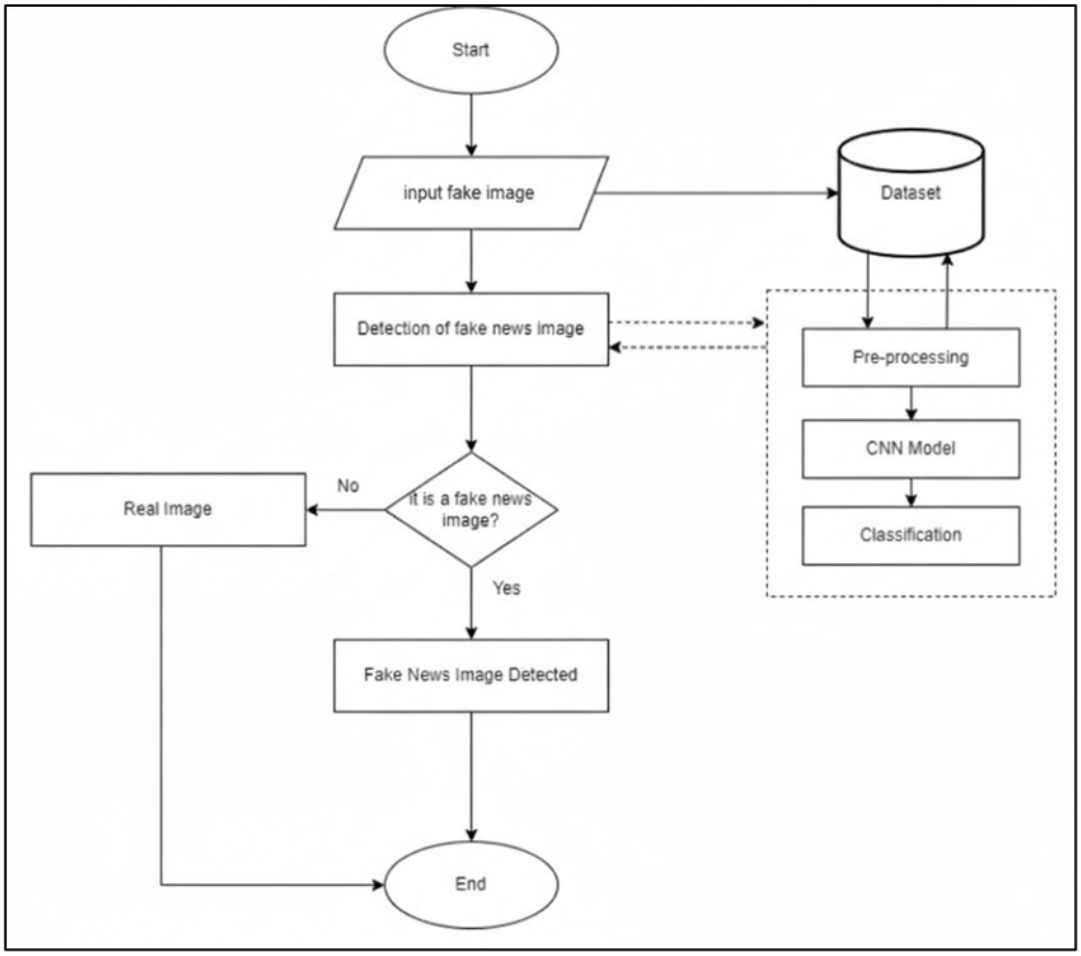

Figure 1. Flowchart for CNN-based Fake Image Detection System.

The performance of the proposed system is summarized in evaluation metrics include accuracy, precision, recall, and F1-score, which are standard measures for classification performance. As shown in **Table 1**, the system achieved an accuracy of 94.90%, precision of 94.00%, recall of 95.92%, and F1-score of 94.95%. These results indicate that the CNN model provides balanced and reliable performance in detecting fake images, with particularly strong recall, demonstrating its effectiveness in correctly identifying manipulated images.

3. Novelty and uniqueness

This system introduces a lightweight yet highly effective CNN architecture tailored for detecting common image forgeries like copy-move, splicing, and inpainting, achieving 94.90% accuracy on a compact dataset without relying on resource-intensive pre-trained models like VGG or ResNet. Unlike many existing methods focused solely on deepfakes or face manipulations, this approach targets general digital tampering artifacts through pixel-level feature learning. The integration of data augmentation and a user-friendly GUI enhance accessibility for non-experts. The model's emphasis on binary classification with balanced precision-recall trade-offs provides robust performance in real-world scenarios with limited training data. By prioritizing efficient convolutional layers and avoiding complex ensembles, the system offers a novel balance of accuracy, computational efficiency, and distinguishing it from heavier deep learning solutions.

4. Benefit to mankind

This CNN-based Fake Image Detection System safeguards society by reducing the spread of visual misinformation, which influences elections, incites unrest, and erodes public trust. It empowers individuals, journalists, and institutions to verify image authenticity swiftly, reducing the impact of scams, phishing, and disinformation campaigns. By flagging manipulated content early, it promotes informed decision-making, enhances cybersecurity, and preserves the integrity of digital media. Ultimately, it fosters greater trust in online information sources, protecting vulnerable populations from deception and contributing to a more truthful and stable digital ecosystem.

5. Innovation and Entrepreneurial Impact

The project drives innovation by applying deep learning to a pressing societal challenge, demonstrating how accessible CNN techniques can yield high-performance tools with minimal resources. It cultivates an entrepreneurial mindset by transforming academic research into a practical, user-centric prototype with a GUI, ready for real-world deployment. This encourages students and developers to pursue AI-driven solutions for social good, inspiring startups in digital forensics and content verification. By showcasing scalability and commercialization potential, it promotes a culture of entrepreneurship within academic institutions and the tech industry, bridging research with market-ready applications to address global misinformation.

6. Potential commercialization

The system holds strong commercialization potential as a standalone software tool, browser plugin, or API integrable into social media platforms, news aggregators, and forensic services. Monetization options include subscription-based access for professionals such as journalists and law enforcement, freemium models for general users, or licensing to content moderation firms. Its lightweight design enables deployment on mobile devices or cloud services with low latency. Partnerships with tech companies could embed it in verification workflows, while open-source elements could attract community contributions for broader adoption. With rising demand for anti-misinformation tools, the product offers scalable revenue through enterprise solutions, ensuring sustainability and widespread impact against evolving digital threats.

7. Acknowledgment

The authors would like to express their sincere gratitude to Universiti Teknologi MARA (UiTM) for the support and facilities provided throughout this project.

8. Researchers' Biography

Noor Hazriena Afizah Awang is a recent graduate from Universiti Teknologi MARA (UiTM), Kuala Terengganu Campus of Bachelor of Computer Science (Hons.). As a dedicated student in the field of computer science, she focused her studies on machine learning and image processing applications. Her capstone work explored innovative approaches to detecting manipulated visual content in digital media, contributing to broader efforts in addressing misinformation challenges on social platforms. She demonstrated strong technical skills and a keen interest in applying artificial intelligence to real-world problems in information integrity and computing.

Siti 'Aisyah Sa'dan is a Lecturer at Universiti Teknologi MARA (UiTM), affiliated with the Faculty of Computer and Mathematical Sciences. With over 10 years of academic and research experience in signal and image processing, she specializes in image classification and retrieval, as well as soft computing. Her work focuses on the application of intelligent systems, including artificial immune systems, fuzzy inference systems, and deep learning, for image classification, image retrieval, and multimedia e-learning tools. She has authored numerous publications, including conference papers and journal articles, and has contributed to practical computing education and system development projects.

DeT-BIS

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ABSTRACT

Business Intelligence (BI) tools such as Microsoft Power BI and Looker Studio are increasingly used in educational settings to visualize student performance and support data-informed teaching practices. However, most existing BI dashboards focus primarily on presenting analytic and trends, while the teaching decisions made based on these insights are rarely documented, traced, or evaluated systematically. As a result, valuable pedagogical decisions and their impacts on learning outcomes often remain informal, limiting opportunities for reflective teaching, continuous improvement, and institutional knowledge sharing. This project introduces the Decision Traceability Business Intelligence System (DeT-BIS), an innovative enhancement layer designed to bridge the gap between performance analytics and teaching decision-making. DeT-BIS enables educators to systematically capture instructional decisions triggered by performance dashboards, including the decision context, intervention strategy, expected outcome, and actual learning outcome. These decisions are then linked to subsequent assessment results, allowing educators to evaluate the effectiveness of pedagogical interventions across academic sessions. The key uniqueness of DeT-BIS lies in integrating performance visualization, decision traceability, and outcome evaluation within a single analytics environment. By transforming conventional dashboards into reflective teaching support systems, DeT-BIS enables educators to monitor assessment trends, identify learning challenges, document improvement strategies, and evaluate their impact over time. The system promotes evidence-based teaching, pedagogical accountability, and institutional learning. To demonstrate its applicability, DeT-BIS is implemented using continuous assessment data from a Business Intelligence course, where multiple assessments across academic sessions provide opportunities to analyze performance trends and evaluate the effectiveness of instructional interventions. The framework illustrates how educational dashboards can evolve beyond descriptive analytics toward actionable and traceable teaching decision support systems.

Keywords: Decision Traceability, Learning Analytics, Teaching Decision Support, Business Intelligence, Data-Driven Education

1. Product Description

The Decision Traceability Business Intelligence System (DeT-BIS) is a modular analytical framework designed to extend traditional learning analytic dashboards by embedding structured mechanisms for capturing, tracking, and evaluating teaching decisions. Unlike conventional BI dashboards that only display performance indicators, DeT-BIS connects performance insights with the pedagogical decisions made by educators in response to those insights.

The system operates on top of existing data visualization platforms such as Looker Studio or Power BI and consists of two main analytical environments: a performance analytics dashboard

and a decision traceability dashboard. The Performance Dashboard presents key learning indicators derived from continuous assessment data, including average assessment scores, performance trends across academic sessions, and comparisons among different assessment types. These indicators help educators identify assessments with low performance and recognize patterns in student learning outcomes. When performance issues are detected, educators document improvement strategies through a structured decision log. Each decision record includes the session in which the issue occurred, the assessment type, the intervention strategy implemented, the expected learning outcome, and the actual outcome observed in subsequent sessions. All decisions are stored in a structured decision repository, forming a traceable record of instructional interventions and their impacts on student performance. A separate decision analytic dashboard then visualizes decision patterns, intervention frequency, and success rates, allowing educators to review the effectiveness of different teaching strategies. By transforming traditional dashboards into traceable decision-support environments, DeT-BIS enables educators to move beyond passive data monitoring toward evidence-based teaching improvement. The system supports reflective teaching practices, promotes transparency in pedagogical decision-making, and contributes to continuous improvement in teaching and learning processes.

2. Conceptual Framework of DeT-BIS

Framework Overview

DeT-BIS is structured around a Teaching Decision Feedback Loop Framework that extends conventional learning analytics dashboards into reflective teaching environments. The framework connects assessment performance data, teaching decisions, and learning outcomes through a structured cycle of monitoring, intervention, and evaluation. The framework consists of five interconnected layers that collectively bridge the gap between performance analytics and pedagogical decision-making. Although implemented using Business Intelligence technologies, the framework is designed to support educational environments where instructors continuously evaluate and improve teaching strategies based on assessment evidence.

- Layer 1: Learning Data and Visualization Layer

This layer represents the existing learning analytics environment, where student performance data from continuous assessments are visualized through dashboards. These dashboards display key indicators such as average assessment scores, performance trends across sessions, and comparisons among different assessment types. The visualizations act as triggers that help educators identify learning gaps and performance issues.

- Layer 2: Teaching Decision Capture Layer (Core Innovation)

The Teaching Decision Capture Layer represents the core innovation of DeT-BIS. It enables educators to record pedagogical interventions in response to performance insights. Each decision entry includes the assessment context, improvement strategy implemented, expected learning outcome, and the academic session in which the intervention will be applied. This structured documentation ensures that instructional decisions are systematically recorded rather than remaining informal teaching adjustments.

- Layer 3: Decision Repository Layer

All recorded teaching decisions are stored in a centralized Decision Repository, which functions as an institutional memory of instructional interventions. The repository allows educators to review past decisions, identify recurring learning challenges, and analyze intervention strategies across different academic sessions.

- Layer 4: Outcome Evaluation Layer

The Outcome Evaluation Layer links recorded interventions with subsequent assessment results. By comparing expected outcomes with actual assessment performance in the following session, DeT-BIS evaluates the effectiveness of each instructional intervention. This allows educators to determine whether specific strategies successfully improved student learning outcomes.

- Layer 5: Reflective Learning and Teaching Improvement Layer

The final layer supports reflective teaching and continuous pedagogical improvement. By analyzing decision outcomes and performance trends, educators can refine teaching strategies, avoid repeated instructional issues, and develop evidence-based approaches to course delivery. This layer promotes a culture of reflective practice and data-driven teaching improvement within educational institutions.

Figure 1 illustrates the DeT-BIS conceptual framework, highlighting the interaction between assessment analytics dashboards, the decision capture mechanism, the centralized decision repository, outcome evaluation processes, and the reflective teaching improvement layer. The directional flow represents the Teaching Decision Feedback Loop, which enables continuous improvement in teaching and learning practices.

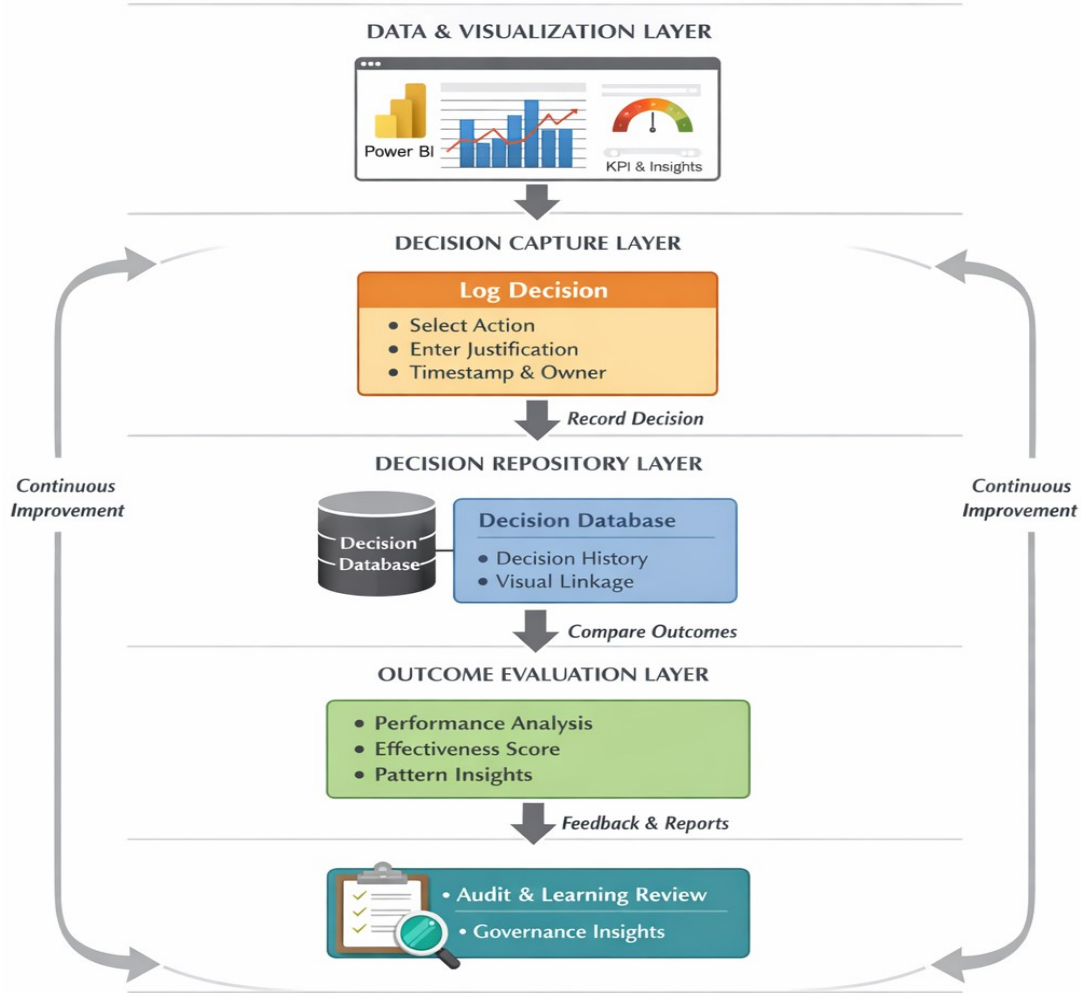

Figure 1. Conceptual Framework of DeT-BIS Decision Traceability Business Intelligence System.

3. Novelty and uniqueness

The novelty of DeT-BIS lies in its explicit integration of decision traceability within learning analytics dashboards. While existing Business Intelligence (BI) tools such as Microsoft Power BI and Looker Studio are widely used in educational contexts to visualize student performance, assessment trends, and learning analytics, these platforms primarily focus on data presentation and descriptive insights. They do not capture the teaching decisions made in response to these insights, nor do they provide mechanisms to evaluate whether such instructional interventions successfully improve student learning outcomes. DeT-BIS addresses this critical gap by embedding a structured teaching decision capture and evaluation mechanism directly within the analytics workflow. Unlike traditional decision support systems that are often complex, standalone, and disconnected from daily teaching practices, DeT-BIS is designed as a lightweight and modular enhancement layer that integrates seamlessly with existing BI dashboards. The system enables educators to systematically record instructional interventions triggered by assessment analytics, including the assessment context, improvement strategies implemented, expected learning outcomes, and actual outcomes observed in subsequent academic sessions. By connecting performance analytics with documented teaching decisions and their outcomes, DeT-BIS transforms conventional dashboards from passive monitoring tools into reflective teaching decision environments. This capability supports evidence-based teaching practices, encourages pedagogical accountability, and enables institutions to accumulate a structured knowledge base of instructional interventions and their effectiveness. To the best of our knowledge, current commercial BI platforms and learning analytics tools primarily emphasize data visualization and predictive insights, but they rarely operationalize decision traceability and intervention outcome evaluation within a unified analytics environment. DeT-BIS therefore, introduces a novel shift from performance-centric dashboards toward decision-aware and learning-oriented analytics systems, enabling continuous improvement in teaching and learning practices.

4. Benefit to mankind

DeT-BIS contributes to educational and institutional well-being by promoting transparent, accountable, and evidence-based teaching practices. By enabling educators to systematically document instructional decisions and evaluate their impact on student performance, the system supports reflective teaching and reduces repeated instructional issues that may hinder student learning outcomes. This structured approach encourages educators to move beyond intuition-based teaching adjustments toward data-informed pedagogical interventions.

In educational institutions, DeT-BIS strengthens academic quality assurance by providing traceable records of teaching interventions and their outcomes. Such traceability supports program evaluation, course improvement processes, and evidence-based curriculum development. By linking assessment analytics with documented teaching decisions, the system enables educators and administrators to better understand which instructional strategies contribute to improved student learning. In addition, DeT-BIS promotes teaching decision literacy by encouraging educators to critically reflect on the rationale, implementation, and effectiveness of their pedagogical interventions. Rather than focusing solely on performance metrics, the system highlights the decision processes behind teaching improvements and the resulting learning outcomes.

Ultimately, DeT-BIS fosters a culture of continuous teaching improvement, reflective practice, and responsible use of learning analytics. By transforming performance dashboards into traceable decision-support environments, the system contributes to improved teaching quality, enhanced student learning experiences, and stronger institutional capacity for data-driven educational improvement.

5. Innovation and Entrepreneurial Impact

The DeT-BIS promotes innovation by redefining how Business Intelligence is used beyond reporting and visualization toward accountable and learning-oriented decision practices. By embedding decision capture and outcome evaluation within standard BI workflows, the system encourages users to critically reflect on their decisions and continuously improve data-driven practices.From an entrepreneurial perspective, DeT-BIS lowers the barrier to innovation by leveraging existing BI infrastructures, enabling organizations, institutions, and startups to adopt the solution without extensive system redevelopment. The modular design supports rapid prototyping, customization, and scalability across different sectors, fostering an innovation mindset within organizations. In educational and professional environments, DeT-BIS nurtures entrepreneurial thinking by exposing users to real-world decision accountability, risk evaluation, and performance assessment. This approach supports the development of data-literate professionals who are capable of transforming analytical insights into responsible, value-driven decisions, thereby strengthening innovation capacity and entrepreneurial culture.

6. Potential commercialization

DeT-BIS promotes innovation in educational analytic by redefining how Business Intelligence tools are used beyond performance reporting and visualization toward traceable and reflective teaching decision practices. While conventional BI dashboards primarily present learning analytics and assessment results, DeT-BIS extends their functionality by embedding structured mechanisms for capturing teaching interventions and evaluating their impact on student performance. This integration encourages educators to critically reflect on their instructional decisions and continuously refine data-driven teaching practices. From an innovation and implementation perspective, DeT-BIS lowers the barrier to adoption by leveraging existing Business Intelligence infrastructures, such as Power BI or Looker Studio dashboards. Rather than requiring the development of new complex systems, the framework operates as a lightweight and modular enhancement layer that can be integrated into existing learning analytics environments. This modular design allows institutions to rapidly prototype, adapt, and scale the system across different courses and academic programs. In educational settings, DeT-BIS also supports the development of data-literate and reflective educators by promoting structured decision-making based on learning analytics evidence. By documenting instructional interventions, evaluating their outcomes, and reflecting on their effectiveness, educators develop stronger analytical thinking and pedagogical decision skills. Ultimately, this approach cultivates a culture of continuous teaching innovation, evidence-based improvement, and responsible use of educational data, strengthening institutional capacity for learning analytics–driven educational transformation.

7. Acknowledgment

The authors would like to acknowledge Politeknik Sultan Abdul Halim Muadzam Shah for supporting this innovation initiative.

8. Researchers' Biography

Mrs. Nor Hasimah binti Abd Rahman is a Senior Lecturer in Information Technology with over 14 years of teaching experience, specializing in Business Intelligence, data analytics, and educational innovation. Her work focuses on developing industry-relevant pedagogical frameworks that enhance decision-making competencies among diploma certificate students.

Mr. Mohd Zool Fazlee bin Basir is a Senior Lecturer in Civil Engineering with approximately 17 years of teaching experience and prior professional exposure in the construction industry. Before entering academia, he spent about two years in the construction field, where he was involved in construction-related decision-making and project execution. His interests include engineering project decision processes, construction management, and the application of data-driven and analytical approaches to enhance decision accountability across engineering domains.

Eril-Sustain – Transforming Eggshell Waste into Sustainable Long-Term Corrosion Protection

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ABSTRACT
Corrosion is a persistent problem affecting carbon steel, particularly in acidic environments encountered in oil and gas pipelines and industrial boilers. This study presents the development of an environmentally friendly corrosion inhibitor derived from kitchen waste for the protection of carbon steel in 1 M hydrochloric acid. The innovation addresses the growing demand for sustainable alternatives to conventional toxic corrosion inhibitors by utilizing waste materials with a low-cost formulation approach. The inhibitor was designed using processed kitchen waste and evaluated at different concentrations via weight-loss testing over immersion periods of 3 to 7 days. The results indicate that increasing inhibitor concentration significantly improves corrosion resistance, achieving a maximum inhibition efficiency of 99.74% after 7 days of exposure. The key advantages of this innovation include its non-toxic nature, biodegradability, low production cost, and ease of in-situ application without disrupting industrial operations. From a socio-environmental perspective, the utilization of kitchen waste promotes waste valorization, reduces environmental pollution, and enhances workplace safety by minimizing hazardous chemical exposure. Economically, the proposed inhibitor offers potential cost savings in corrosion management and maintenance. The commercialization prospects are promising due to abundant raw material availability, scalability of production, and adaptability for formulation into industrial-grade corrosion inhibitor products.

Keywords: Waste, Corrosion Inhibitor, Weight Loss, Acidic, Nature

1. Product Description
Corrosion is a critical degradation process that significantly affects carbon steel, particularly in acidic environments commonly found in oil and gas pipelines, boilers, and structural applications. Its impact includes surface deterioration, reduced mechanical performance, loss of flexural capacity, and weakened surface bonding, all of which pose serious economic and safety concerns. Various corrosion mitigation strategies have been employed, such as alloying, impurity reduction, surface coatings, and cathodic protection. Among these, corrosion inhibitors have gained considerable attention due to their cost-effectiveness, ease of application, and ability to provide in-situ protection without disrupting industrial processes. However, most conventional corrosion inhibitors are derived from toxic and hazardous chemicals, posing significant risks to human health and the environment. Prolonged exposure to inorganic inhibitors has been shown to adversely affect ecosystems, including plants, animals, and water quality. Consequently, there is growing interest in developing environmentally friendly and biodegradable alternatives. Natural materials,

particularly plant-based resources such as leaves, fruits, peels, and extracts, have emerged as promising green corrosion inhibitors due to their sustainability, availability, and high inhibition efficiency. Current research increasingly focuses on these eco-friendly inhibitors, aligning corrosion control strategies with green chemistry principles and global sustainability goals.

2. Schematic Representation of the Weight Loss Process

Figure 1 illustrates the weight loss process of kitchen waste as a natural corrosion inhibitor for carbon steel. The procedure consists of three main stages. First, sample preparation is performed, in which kitchen waste is processed and prepared into a suitable form for corrosion inhibition testing. This step ensures uniformity and consistency of the inhibitor material. Second, the prepared samples are immersed in a 1 M hydrochloric acid (HCl) solution containing different concentrations of the kitchen waste inhibitor. The immersion process allows interaction between the inhibitor molecules and the steel surface, promoting adsorption and the formation of a protective layer. Finally, corrosion performance is evaluated by measuring corrosion rate, typically using the weight-loss method. This step quantifies the effectiveness of the kitchen waste inhibitor by determining corrosion rate reduction and inhibition efficiency.

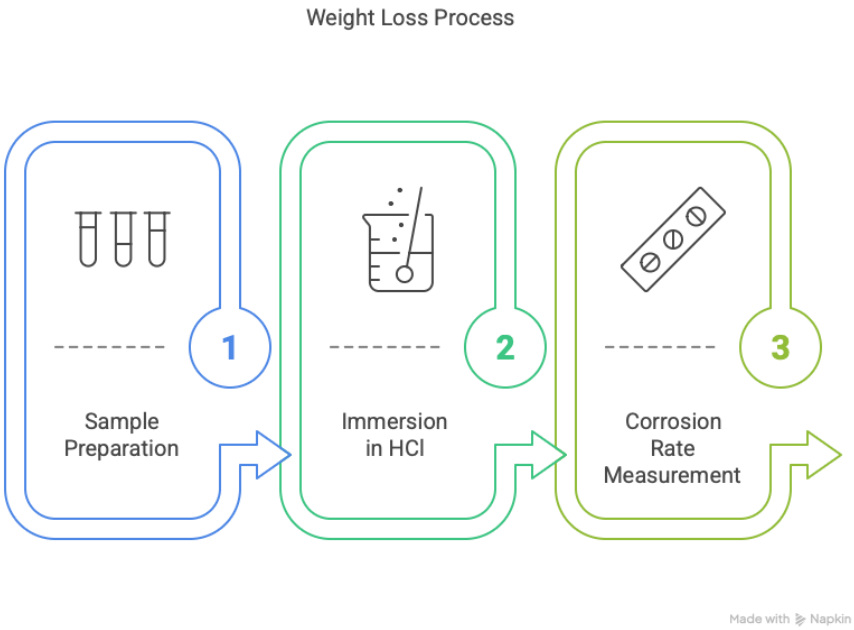

Figure 1. Weight loss process.

3. Novelty and uniqueness

The novelty of this project lies in using kitchen waste as a sustainable, eco-friendly corrosion inhibitor for carbon steel in acidic environments. Contrasting conventional green inhibitors that predominantly rely on plant extracts or chemically modified natural compounds, this study emphasizes waste-to-wealth innovation by valorizing discarded kitchen waste into a functional corrosion-protection material. The uniqueness of the proposed inhibitor is its dual role in corrosion mitigation and waste management, addressing both industrial and environmental challenges simultaneously. The formulation process is simple, low-cost, and does not require

complex chemical treatments, enhancing its practicality for industrial adoption. Furthermore, the inhibitor adsorbs to the surface, forming a protective layer that suppresses metal dissolution without altering the base material's properties.

4. Benefit to humanity

This project provides significant benefits to humanity by offering a safer, environmentally friendly alternative to conventional toxic corrosion inhibitors. By utilizing kitchen waste, the proposed inhibitor reduces reliance on hazardous chemicals that pose risks to human health, occupational safety, and environmental quality. Reducing corrosion-related failures enhances the safety and longevity of infrastructure such as pipelines, boilers, and industrial equipment, thereby minimizing accidents and maintenance costs. Additionally, the reuse of kitchen waste contributes to waste reduction and environmental conservation, supporting sustainable consumption and production practices. The project aligns with global sustainability goals by promoting green chemistry and responsible resource utilization.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by transforming low-value kitchen waste into a high-impact corrosion protection solution through applied materials engineering. It encourages an entrepreneurial mindset by demonstrating how everyday waste materials can be converted into commercially valuable products through simple, scalable processes. Within academic and research institutions, the project fosters interdisciplinary collaboration between engineering, sustainability, and entrepreneurship. For the community and industry, the innovation supports the development of green products that meet increasing regulatory and environmental demands. The formulation's simplicity allows small enterprises and start-ups to participate in the production of corrosion inhibitors without a heavy capital investment. By bridging research outcomes with real-world applications, the project contributes to a culture of innovation, problem-solving, and sustainable entrepreneurship.

6. Potential commercialization

The commercialization potential of this project is strong due to the abundance, low cost, and continuous availability of kitchen waste as raw material. The inhibitor can be formulated into liquid or powdered products suitable for industrial corrosion protection. applications, particularly in acidic cleaning, pickling, and oil-and-gas environments. Its eco-friendly nature provides a competitive advantage in markets increasingly driven by environmental regulations and sustainability requirements. The production process is simple and scalable, enabling cost-effective manufacturing at both small and large scales. Potential commercialization pathways include licensing to chemical suppliers, collaborating with industrial maintenance companies, or developing the product as a startup under green technology initiatives. This innovation has strong market potential as a sustainable alternative to conventional corrosion inhibitors.

7. Acknowledgment

The authors would like to thank Universiti Teknologi MARA (UiTM) Cawangan Johor, Malaysia, for approving the research grant, which enabled us to conduct this study. This study is supported by a grant from Universiti Teknologi MARA (UiTM) Cawangan Johor, Geran Penyelidikan Bestari Fasa 1/2023, Rujukan 600-TNCPI 5/3/DDN (01) (003/2023).

8. Researchers' Biography

Ts Hazriel Faizal Pahroraji is a Senior Lecturer and a PhD student Faculty of Mechanical Engineering at UiTM Pasir Gudang, specializing in corrosion protection. His current research area focuses on corrosion inhibitor, sustainable materials and optimization. He has several publications and awards highlighting his work in each related area of research.

Dr Siti Khadijah Alias is a Senior Lecturer Faculty of Mechanical Engineering at UiTM Pasir Gudang, specializing in alloy materials. Her current research area focuses on corrosion inhibitor, metal and alloy, mechanical properties and wear characterization microstructure. She has impact and journal publications and awards highlighting her work in each related area of research.

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A.D.L.I (Assistive Delivery for Life Integration)

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ABSTRACT
Providing timely physical assistance and health monitoring for elderly and mobility-impaired individuals remains a significant challenge, as current systems fail to integrate wearable health devices with assistive robots capable of capable of real-world actions. This work proposes A.D.L.I (Assistive Delivery for Life Integration), a mobile health-assisting robot designed to support independent living. The system employs a Raspberry Pi 5 running Ubuntu with ROS2 for SLAM navigation and a Raspberry Pi Pico 2W for low-level motor control via MDD10A drivers. A COROS Pace 3 smartwatch broadcasts heart rate and activity data via BLE, enabling the system to monitor health status and trigger autonomous responses. Upon detecting abnormal vitals or scheduled medication times, the robot navigates toward the user using LiDAR-based mapping and BLE signal strength for proximity guidance, while caregivers receive real-time updates via a Firebase-connected web application. Beyond its technical utility, A.D.L.I offers significant socio-economic and socio-environmental impact by reducing the financial and emotional burden on healthcare systems, promoting social dignity through prolonged domestic independence, and utilizing a low-power modular architecture to minimize energy consumption. A.D.L.I offers high commercialization potential through a scalable, tiered subscription model targeting the global "Silver Economy" and institutional care facilities.

Keywords: Assistive Robot, SLAM, Health Monitoring, Elderly Care, IoT, Silver Economy

1. Product Description
This project introduces the development of a mobile health-assisting robot named A.D.L.I (Assistive Delivery for Life Integration), specifically designed to aid elderly and individuals with physical impairments by providing health-related reminders and delivering essential items, including medication and hydration. A.D.L.I serves as a complementary tool for wearable smartwatches by integrating real-time health monitoring with basic delivery functionalities. The robot interfaces with a COROS Pace 3 smartwatch via BLE to collect vital health data, such as heart rate and activity levels. This information is processed using a Raspberry Pi 5 running Ubuntu with ROS2 for SLAM-based autonomous navigation, which also supports an application for caregivers to monitor users remotely. The robot's movement functions are managed by a Raspberry Pi Pico 2W through MDD10A motor drivers, while an LiDAR sensor enables mapping and obstacle avoidance. Wheel encoders provide accurate odometry for precise positioning. Upon detecting specific health triggers, such as an elevated heart rate, A.D.L.I issues alerts and autonomously navigates towards the user to deliver small items placed on its tray. Additionally, it sends notifications to a Firebase-connected caregiver application with live camera streaming, facilitating remote supervision. It is essential to note that this robot is not designed for physical

assistance such as lifting or guiding users, but rather a lightweight, delivery-oriented companion aimed at enhancing routine care and promoting greater independence for elderly individuals.

2. Methods and Results

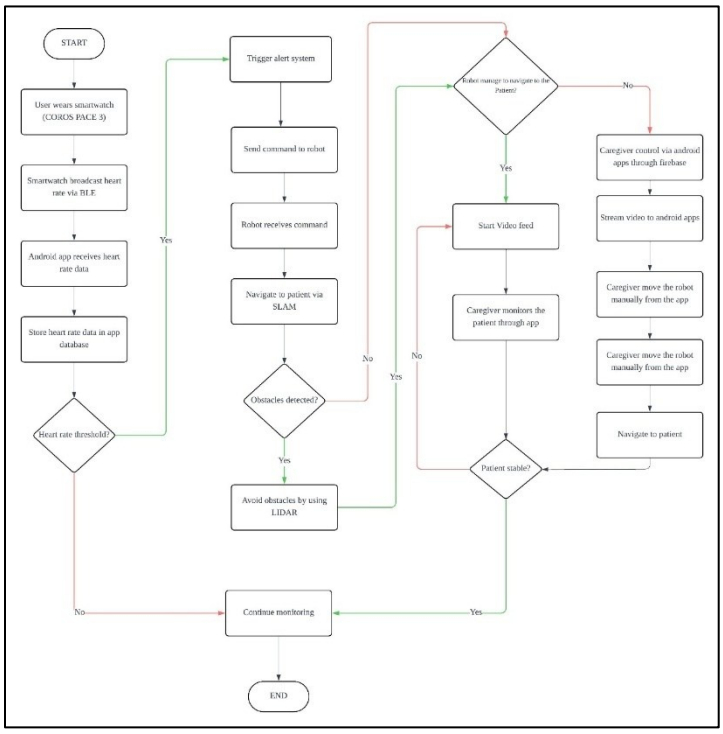


Figure 1. System Flowchart of A.D.L.I.

Figure 1 illustrates the complete operational flow of the A.D.L.I system from health monitoring to emergency response. The process begins when the user wears the Coros Pace 3 smartwatch, which broadcasts heart rate data via BLE to the Android application. The app receives and stores this data in its database while continuously checking against threshold values. When the heart rate exceeds normal limits, the alert system triggers and sends a command to the robot. The robot receives the command and navigates to the patient using SLAM technology. During navigation, the LiDAR sensor detects obstacles; if obstacles are avoidable, the robot calculates an alternative route, but if the path is completely blocked or the patient is not at their expected location, the system allows caregiver manual control via the Android app through Firebase. Once the robot successfully reaches the patient through autonomous navigation, it starts the video feed which streams to the Android application for caregiver monitoring. If the robot cannot navigate autonomously because the patient has moved from their usual bed or normal position, the caregiver immediately takes manual control and the video feed starts right away, providing real time visual feedback necessary for the caregiver to see where they are going. The caregiver then manually pilots the robot using the live video stream as their guide, searching through different rooms and areas to locate the patient. Once the patient is found through either autonomous or manual navigation, the caregiver monitors the patient's condition through the app interface and assesses stability. If the patient is stable with normalized heart rate, the system continues monitoring mode. If the patient remains unstable, the system loops back to continue active monitoring so that the caregiver can monitor the patient condition while they call for emergency

service or to monitor until condition improves. This integrated workflow ensures continuous health monitoring, autonomous or manual robot navigation with immediate video feedback, real time patient search capability, and appropriate caregiver intervention throughout the emergency response process.

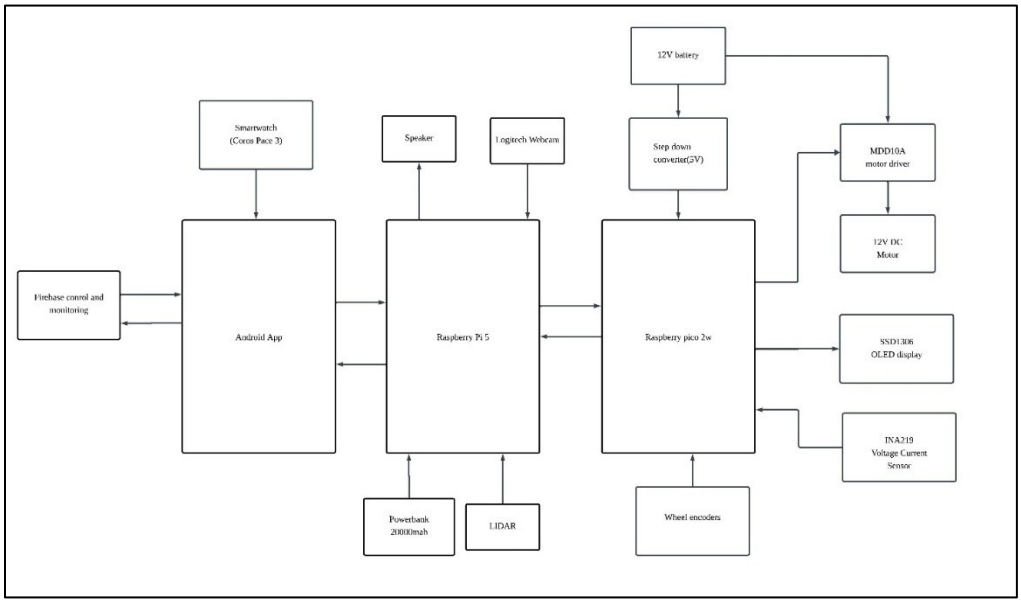


Figure 2. Block Diagram of A.D.L.I.

Figure 2 illustrates the complete system architecture of A.D.L.I through a block diagram. It provides an overview of how all hardware and software components work together, from health data collection to emergency response and robot navigation, making the integrated system easier to understand. The system operates with three main processing units: the Android application as the central control hub, the Raspberry Pi 5 for high level tasks, and the Raspberry Pi Pico 2W for motor control. Power is supplied by a 12V battery 1.2 ah with a step-down converter regulating voltage to 5V for microcontrollers and sensors. The 12V supply directly powers the MDD10A motor driver, which controls DC motors. Health monitoring begins when the Coros Pace 3 smartwatch continuously broadcasts heart rate data via Bluetooth Low Energy to the Android application, which analyses the data and triggers alerts when thresholds are exceeded. The Android app communicates bidirectionally with Firebase for cloud synchronization and caregiver notifications, while sending control commands to the Raspberry Pi 5 via Wi-Fi. The Raspberry Pi 5 serves as the main robot processor, managing the Logitech webcam for real time video streaming, processing LiDAR sensor data for obstacle detection and SLAM navigation, coordinating with the 20000mAh power bank for power and communicating movement commands to the Raspberry Pi Pico 2W. The Pico 2W translates these commands into motor control signals for the MDD10A driver, manages the SSD1306 OLED display showing heart rate and battery status information, reads the INA219 voltage and current sensor for power monitoring, and processes wheel encoder data for precise odometry and position tracking. The Speaker connected to the Pi 5 provides voice alerts and guidance to the patient, while the webcam streams H.264 encoded video to caregivers through the Android app for remote monitoring. This dual controller architecture ensures efficient task distribution: the Pi 5 handles computationally intensive processing like video encoding and SLAM algorithms, while the Pico

2W manages real time motor control and display updates with minimal latency. The integrated power system with main battery and power bank ensures extended operation during emergencies, while the comprehensive sensor array including smartwatch, LiDAR, webcam, encoders, and power monitor enables responsive and safe assistive care for elderly individuals in home environments.

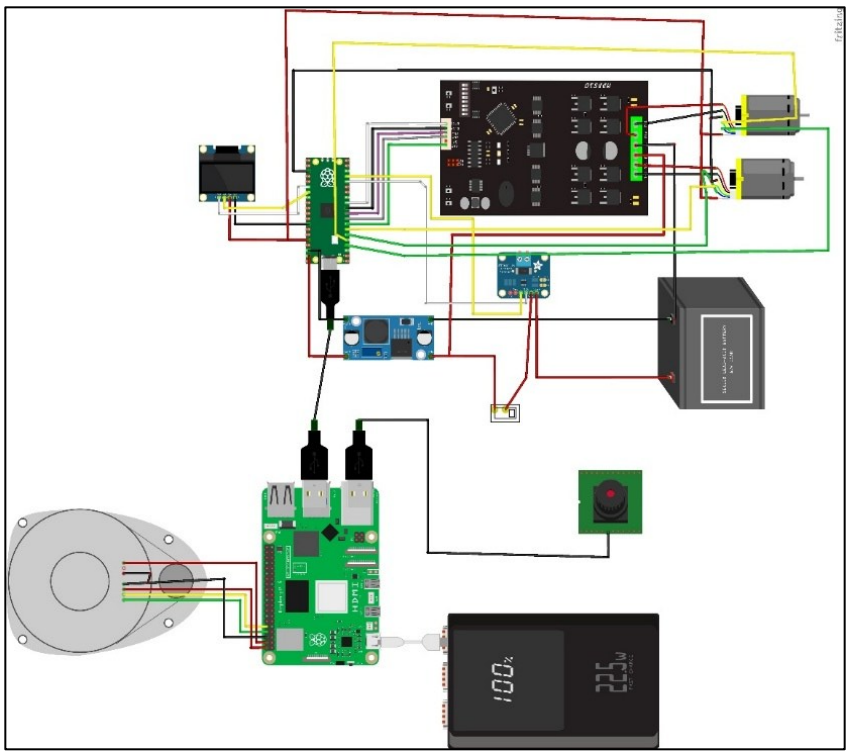
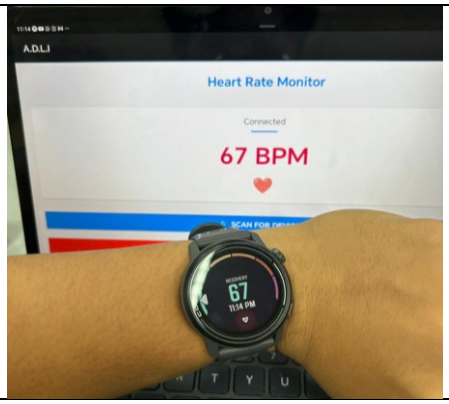
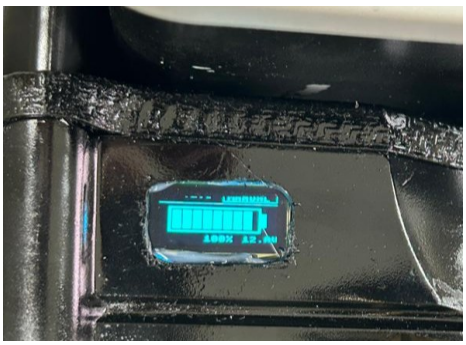
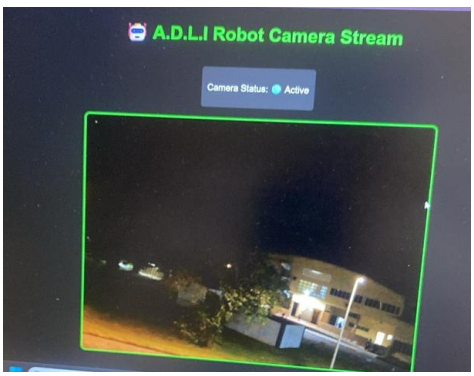


Figure 3. Schematic diagram of A.D.L.I.

Figure 3 illustrates system's design and functionality of A.D.L.I. The following circuit diagram shows the detailed circuit configuration for the A.D.L.I system. The diagram shows the connections between the Raspberry Pi 5, Raspberry Pi Pico 2W, SSD1306 OLED, MDD10A motor driver, INA219, LM2596 Step-down converter, Webcam and LIDAR, ensuring proper communication and smooth operation of the system. The 12V battery supplies power to both the step-down converter for 5V regulation and directly to the MDD10A motor driver for the DC motors. The Raspberry Pi 5 interfaces with the Logitech webcam via USB for video capture, connects to the LiDAR sensor for obstacle detection, and communicates with the Speaker for audio output. The Raspberry Pi Pico 2W receives movement commands from the Pi 5 and controls the MDD10A motor driver, manages the SSD1306 OLED display via I2C, reads the INA219 voltage current sensor for power monitoring, and processes wheel encoder signals for odometry data. The Android application communicates with the Raspberry Pi 5 through Wi-Fi and Firebase for bidirectional control and monitoring, while the Coros Pace 3 smartwatch broadcasts heart rate data via Bluetooth Low Energy to the Android app. This interconnected configuration enables seamless integration of health monitoring, autonomous navigation, video streaming, and caregiver communication throughout the A.D.L.I system.

Table 1. A.D.L.I Operating System.

Functionality	Result
Smartwatch connects to the A.D.L.I application	
Manual control Via Firebase	
Battery and mode status on SSD1306 OLED	
A.D.L.I camera feed	

3. Novelty and uniqueness

A.D.L.I distinguishes itself from existing assistive technologies through its seamless integration of commercial wearable health monitoring with autonomous robotic delivery capabilities. Unlike conventional assistive robots that rely solely on onboard sensors for health assessment, A.D.L.I leverage data from a COROS Pace 3 smartwatch via BLE, enabling accurate health monitoring without requiring users to interact directly with the robot. This approach reduces system complexity while utilizing the advanced sensing capabilities already present in consumer wearables. The implementation of ROS2 with SLAM-based navigation on Raspberry Pi 5 provides autonomous mapping and obstacle avoidance typically found in more expensive commercial platforms, making advanced robotics accessible for home care applications. The dual-microcontroller architecture, combining Raspberry Pi 5 for high-level processing with a Raspberry Pi Pico 2W for real-time motor control, ensures reliable performance while maintaining cost-effectiveness. Furthermore, the Firebase-connected web interface with live camera streaming enables caregivers to monitor and control the robot remotely from anywhere, bridging the gap between passive health monitoring and active physical intervention. This integrated approach of combining wearable technology, autonomous navigation, and remote caregiver connectivity in a single affordable platform represents a novel solution for elderly care that addresses limitations of existing isolated systems.

4. Benefit to mankind

A.D.L.I provides significant benefits to elderly individuals and their caregivers by promoting independent living while ensuring continuous health monitoring. The robot reduces caregiver burden by automating routine tasks such as medication delivery and hydration reminders, allowing caregivers to focus on more critical aspects of care. Through real-time health data integration from the COROS Pace 3 smartwatch, the system enables early detection of abnormal vital signs, facilitating timely interventions that can prevent medical emergencies. The Firebase-connected web dashboard empowers caregivers to monitor users remotely, reducing the necessity for constant physical presence while maintaining connectivity and peace of mind. For elderly users, A.D.L.I enhances safety and autonomy by delivering essential items directly to them, minimizing the risk of falls associated with mobility. The affordable and user-friendly design ensures accessibility for families across various economic backgrounds, democratizing advanced assistive technology for home care environments.

5. Innovation and Entrepreneurial Impact

A.D.L.I demonstrates that advanced assistive robotics can be developed using affordable, commercially available components, inspiring students and entrepreneurs to explore healthcare technology solutions. The project showcases the integration of open-source platforms including ROS2, Firebase, and Micro Python, lowering barriers for future developers to build upon this foundation. Within the academic institution, A.D.L.I serves as a practical example of interdisciplinary engineering, combining robotics, IoT, embedded systems, and healthcare applications, encouraging students to pursue innovative projects with real-world impact. The modular system architecture allows for scalable production and customization, presenting viable commercialization opportunities for local startups targeting the growing elderly care market. By addressing the increasing demand for affordable home care solutions in Malaysia and globally, A.D.L.I opens potential business avenues in healthcare robotics, remote monitoring services, and assistive technology manufacturing. This project cultivates an entrepreneurial mindset by

demonstrating how technical skills can be transformed into marketable solutions that address genuine societal needs.

6. Potential commercialization

A.D.L.I presents strong commercialization potential targeting the rapidly growing elderly care market. The system can be marketed as a complete home care package, bundling the robot with subscription-based caregiver monitoring services through the Firebase web platform. Healthcare facilities, nursing homes, and assisted living centers represent primary institutional customers seeking cost-effective automation solutions. The modular design allows for tiered product offerings, from basic delivery units to fully integrated SLAM-enabled autonomous systems, catering to different budget segments. Partnerships with smartwatch manufacturers like COROS could enable bundled health monitoring solutions. The use of readily available components such as Raspberry Pi, standard motors, and open-source software ensures manageable production costs and scalable manufacturing. Additional revenue streams include maintenance services, software updates, and customized features for specific medical conditions. With Malaysia's aging population projected to reach 15% by 2030, and similar global demographic trends, A.D.L.I addresses a timely market need with significant growth potential.

Front view

(b) Side view

(c) Top view

Figure 4. Final Prototype of A.D.L.I.

7. Acknowledgement

The author would like to express sincere appreciation to the supervisors and lecturers of the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM) Cawangan Sarawak, for their guidance, support, and valuable advice throughout the completion of this project. Gratitude is also extended to UiTM for providing the facilities and resources required for this project.

8. Researchers' Biography

Adli Rahman bin Saharrudin is a final year student pursuing a Diploma in Electrical Engineering (Electronics) at Universiti Teknologi MARA UiTM Sarawak Branch, Kota Samarahan Campus. Specializing in robotics and embedded systems, his final year project, "A.D.L.I (Assistive Delivery for Life Integration): Your Moving Health Mate," demonstrates his commitment to developing innovative healthcare solutions for elderly care. With strong interests in artificial intelligence, autonomous navigation, and IoT integration, Adli aims to create impactful technologies that improve quality of life. His work combines hardware design, software development, and user centered design principles to address real world challenges in assistive technology and remote health monitoring systems.

Nur Atiqah Abdul Rahman received a bachelor's degree in electrical engineering in 2011 and Master of Science in Electrical Engineering in 2014 from Universiti Teknologi MARA Malaysia. Currently she is working as a lecturer in Universiti Teknologi MARA Cawangan Sarawak and doing part time PhD in Electrical Engineering at Universiti Teknologi MARA Malaysia. Her current research interests are optimization technique, distributed generation and Power System.

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Hadi Jumaat received the B. Eng. in engineering electronics, M.Sc. degree in electrical engineering, and PhD degree in electrical engineering from the Universiti Teknologi MARA (UiTM), Selangor, Malaysia in 2012, 2015, and 2025. He is currently a member of Antenna Research Center (ARC) in Universiti Teknologi MARA. Since 2015, he joined UiTM as a young lecturer. His research interests are in communication antenna design, biomedical antenna and electromagnetic wave propagation.

Smart Sustainable Community-Based Agriculture System: Kebuniti Lestari Pintar

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ABSTRACT
Agricultural practices in small-scale and community-based farms frequently depend on manual fertilizer preparation and fixed application schedules, resulting in inefficient resource utilization, inconsistent nutrient delivery, and high labor dependency. Kebuniti Lestari Pintar is developed to overcome these limitations by introducing an Internet of Things (IoT) based smart and sustainable farming system that enables remote monitoring and automated fertilizer mixing through a web-based platform. The primary objective of this project is to enhance the efficiency, accuracy, and sustainability of fertilizer application by integrating real-time data acquisition, automated control of pumps and mixers, and programmable operation schedules. The novelty of this innovation lies in integration of automated fertilizer sequencing, flexible operation modes for both fertilization and irrigation, and real-time IoT-based control within a unified smart farming framework. The system is expected to increase crop yield by up to 30%, significantly reduce water and fertilizer consumption, and empower local communities with practical knowledge and skills in smart and sustainable agriculture. This initiative directly supports the United Nations Sustainable Development Goals, particularly SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action)

Keywords: Internet of Things, Smart agriculture, Irrigation, Fertigation

1. Product Description
Kebuniti Lestari Pintar is an integrated agricultural management solution designed to support community farming through intelligent automation, real-time monitoring, and sustainable resource utilization. The system replaces conventional manual fertilizer preparation and fixed scheduling practices with an Internet of Things (IoT)-based platform that facilitates real-time monitoring, automated fertilizer mixing, and remote system control. The system integrates environmental sensing and automated pump and mixer operations to ensure precise and consistent fertilizer and irrigation management. Real-time data acquisition enables automated fertilizer sequencing and flexible operation modes for both fertilization and irrigation, thereby ensuring accurate nutrient delivery while minimizing water and fertilizer wastage. All system operations are managed through a centralized web-based interface, allowing remote access, monitoring, and scheduling without the need for continuous on-site supervision.

The key innovation of Kebuniti Lestari Pintar lies in its unified smart farming framework, which combines automated fertilizer sequencing, multi-mode operational flexibility, and IoT-based real-time control within a single integrated system. By improving operational efficiency and reducing labor dependency, the system contributes to enhanced crop productivity, with projected yield improvements of up to 30%, while simultaneously supporting sustainable resource utilization. Designed for community deployment, the system promotes collective management and knowledge transfer, empowering local communities with practical exposure to smart and sustainable agricultural technologies.

2. Project Implementation and Operation

This project integrates mechanical, electrical, and IoT components in a cohesive design to develop an efficient and smart irrigation and fertigation system. The system is designed to automate water distribution and fertilizer mixing, enable precise control of nutrient delivery, and provide real-time monitoring through an IoT platform. **Figure 1** illustrates the configuration of the system. The mechanical subsystem consists of a main water tank, Fertilizer A and B storage tanks, two mixer tanks, pumps, and valves that facilitate controlled water and nutrient flow to the crop beds. The pumps and mixers are arranged to support accurate fertilizer sequencing and consistent mixing before the solution is distributed to the plants. On the electrical and control side, the controller box functions as the main control unit of the IoT liquid mixing system consists of ESP32 microcontroller and a Real-Time Clock (RTC) module. The ESP32 serves as the core processing unit, managing sensor data acquisition, control logic, and Wi-Fi communication, while the RTC provides accurate timekeeping for scheduled and repeatable irrigation and fertigation operations. Water level sensors, provide real-time feedback to ensure safe and efficient system operation. The controller box regulates the operation of the water pump, Fertilizer A and B pumps, and mixing units (Mixer 1 and Mixer 2), and controls the discharge of the mixed solution in either manual or automatic mode, supported by an on-site display screen and LED indicators. For user convenience, system status and operational parameters can be accessed remotely through a web-based dashboard and a mobile-friendly application, allowing efficient monitoring, scheduling, and control of the system.

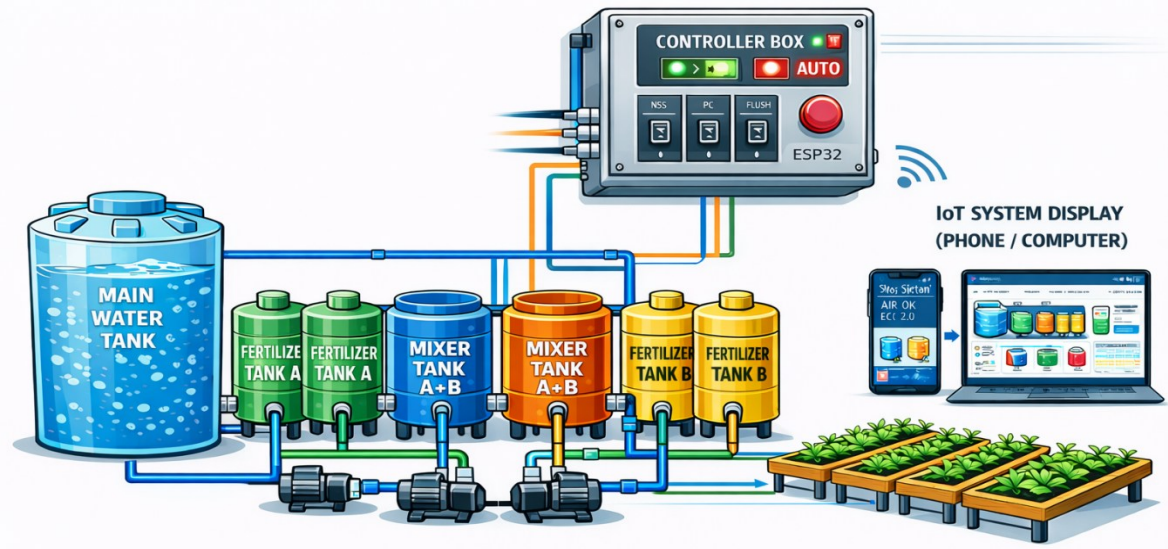

Figure 1. Configuration of IoT Kebuniti Lestari Pintar.

The operating system begins when the user configures the irrigation and fertilizer mixing schedule through the web-based dashboard. Once the schedule is activated, sensors continuously monitor the water level in the tanks to ensure sufficient supply and safe operation. Based on the predefined parameters, the system automatically mixes Fertilizer A and Fertilizer B according to the specified and precise ratio using the mixer units. The mixed solution, together with water, is then distributed automatically to the crops through the irrigation and fertigation system without manual intervention. Throughout the entire operation, the system status, sensor readings, and device activities are displayed in real time on the dashboard, **Figure 2** shows the dashboard of the web-based IoT control system developed for the Kebuniti Lestari Pintar project, which serves as the main interface for monitoring and controlling the irrigation and fertigation operations. Through this dashboard, control commands are transmitted from the web interface to the IoT controller to regulate the operation of water pumps, Fertilizer A and B pumps, and mixing units deployed in the field. The dashboard displays real-time system status, connection state, and operational mode, and allows users to start or stop Mixer 1 and Mixer 2 independently, update system settings, and activate an emergency "Stop All" function to immediately halt all operation.s For Real-Time Data, this interface displays sensor readings and device status information received in real time from the IoT controller, as shown in **Figure 3**. The interface provides up-to-date information on tank levels, mixer conditions, pump and mixer status, and system timing parameters.

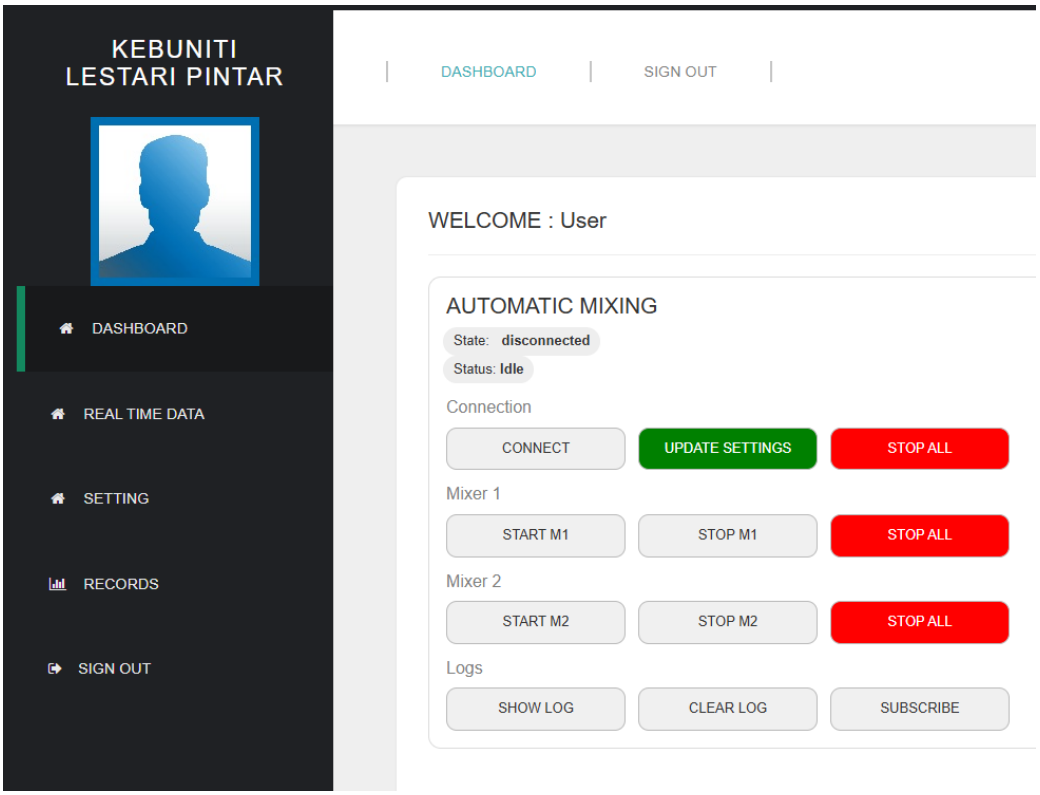

Figure 2. Dashboard of IoT System.

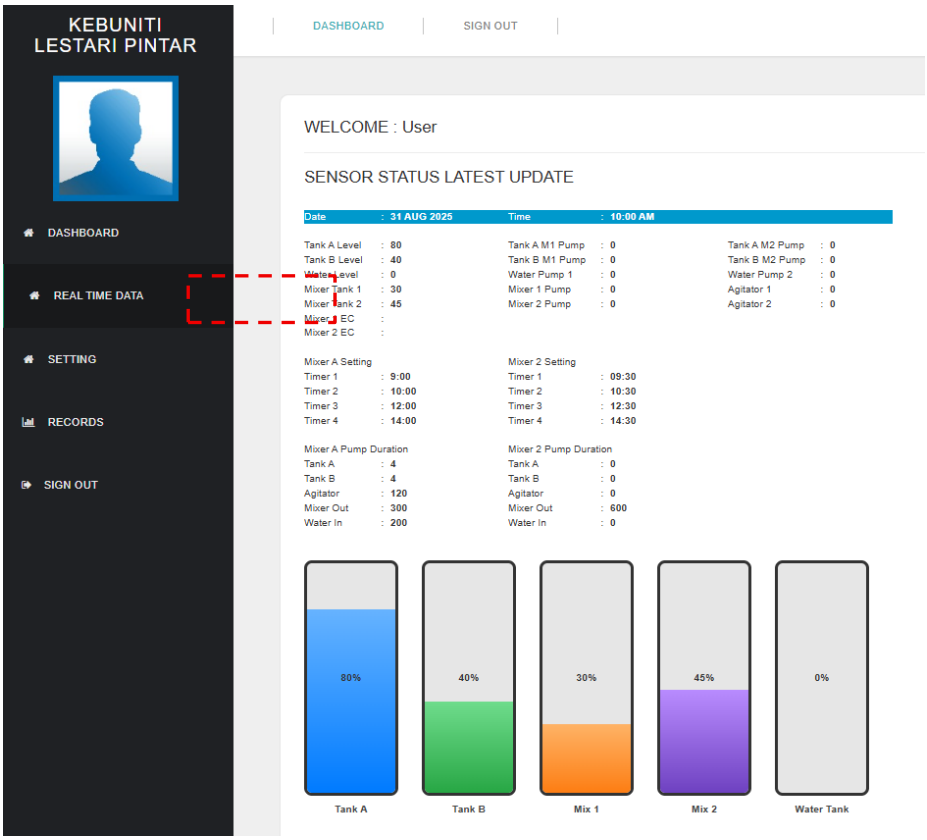

Figure 3. Real-time Data Interface.

The Settings interface is used to configure the automatic operational parameters of the IoT system, as shown in **Figure 4.** Through this interface, users can define pump operation durations, including the activation time for Fertilizer A, Fertilizer B, water input, mixer operation, and outlet discharge for both Mixer 1 and Mixer 2. In addition, the interface allows users to set multiple time schedules for automated operation, where each timer can be individually enabled or disabled according to operational requirements. The process setup section further enables users to select the type of mixing process, such as normal fertigation or water-only operation, for each scheduled cycle.

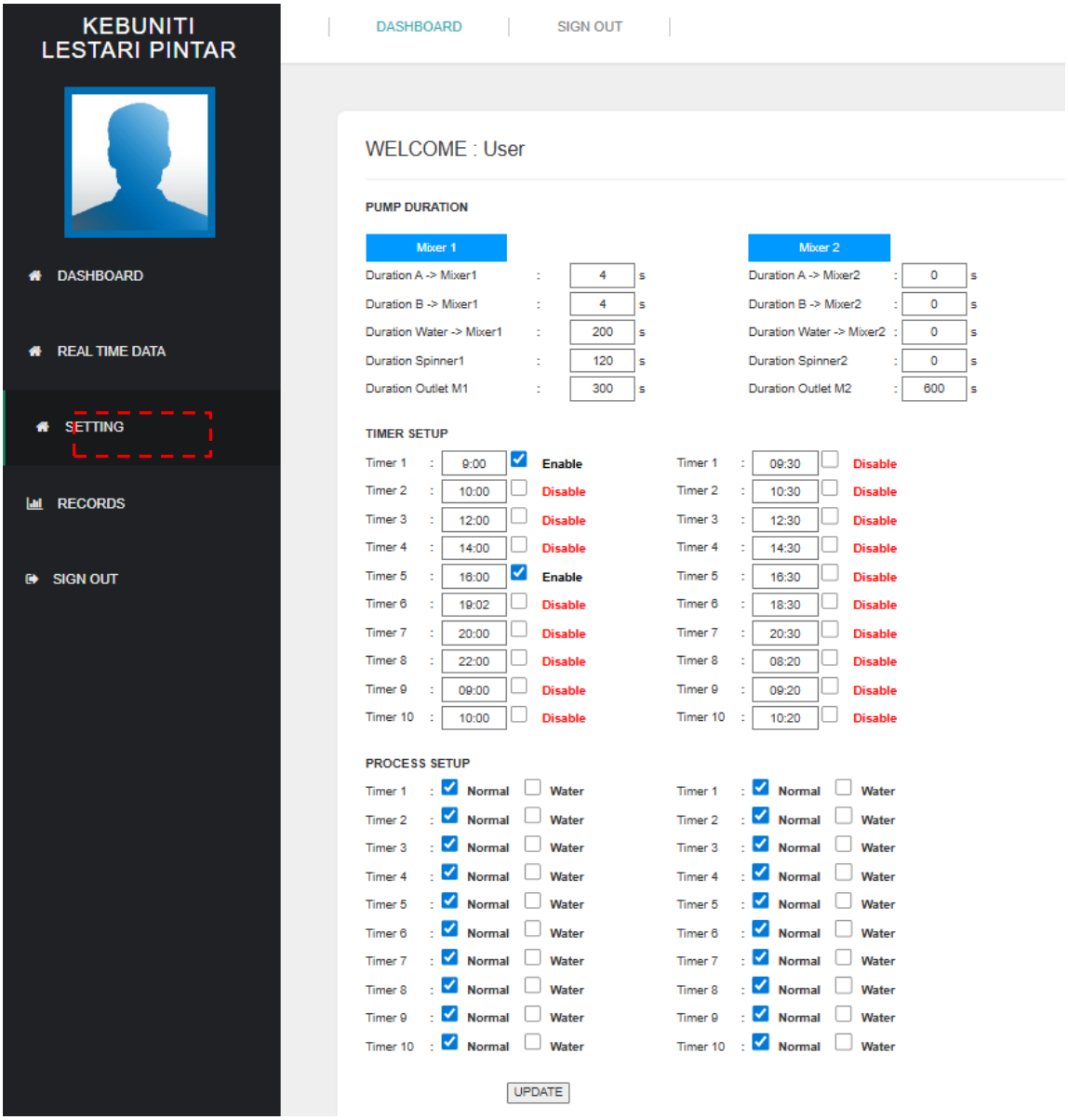

Figure 4. Setting Interface.

3. Novelty and uniqueness

This project introduces a novel approach in integrated IoT-based fertilizer mixing and irrigation control framework specifically designed for community-based agriculture. Unlike conventional irrigation systems that rely on fixed schedules and manual fertilizer preparation, the proposed system combines automated Fertilizer A and B mixing, dual mixer operation (Mixer 1 and Mixer 2), and time-based control using a RTC within a single unified platform. The system supports both manual and fully automated modes, allowing flexible operation based on user needs and field conditions. In addition, real-time sensor feedback, centralized web-based monitoring, and remote control capabilities enable precise nutrient delivery, reduced resource wastage, and improved operational efficiency. The inclusion of configurable pump durations, multiple programmable schedules, and process selection (normal fertigation or water-only operation) further

distinguishes the system from existing solutions, making it a cost-effective, scalable, and practical smart agriculture solution tailored for community and small-scale farming environments.

4. Benefit to mankind

Kebuniti Lestari Pintar delivers significant benefits to society and local communities by enabling smarter, more sustainable, and more efficient agricultural practices. Through automated fertilizer mixing and intelligent irrigation control, the system reduces excessive use of water and fertilizers, helping to lower operational costs while minimizing environmental impact. The web-based IoT platform empowers community farmers with real-time monitoring and remote-control capabilities, reducing dependence on manual labor and improving consistency in crop management. In addition, the project promotes knowledge transfer and digital literacy by introducing communities to smart farming technologies, enhancing their capacity to adopt modern and sustainable agricultural practices. By improving crop productivity, increasing food security, and supporting responsible resource management, Kebuniti Lestari Pintar contributes to resilient community farming systems and aligns with global sustainability goals

5. Innovation and Entrepreneurial Impact

This project fosters a culture of innovation by introducing a practical, IoT-enabled smart irrigation and fertigation solution that bridges the gap between traditional farming practices and modern digital agriculture. The system has strong potential for commercialization as a modular smart farming solution, service-based deployment, and customized installations for community farms, schools, urban agriculture projects, and smallholders. Its scalable and adaptable design allows entrepreneurs to expand the system for different farm sizes, crop types, and operational needs, creating opportunities for startups, local technology providers, and agritech businesses. In addition, the project encourages technology adoption, skill development, and innovation-driven entrepreneurship within the community, contributing to economic growth while supporting sustainable agricultural practices.

6. Potential commercialization

The modular and cost-effective design of the proposed system makes it highly suitable for commercialization across multiple sectors, particularly in education and smart agriculture. The system can be packaged as an educational and training toolkit for community agricultural training centers, addressing the gap created by conventional industrial-scale systems that are often too expensive and complex for instructional use. Its affordability, flexibility, and modular architecture allow the product to be offered as a DIY smart agriculture kit, complete with comprehensive instructional manuals, pre-configured software, and customizable hardware modules that can be adapted to different learning levels and applications. Beyond education, the system has strong potential for deployment in community farms, urban agriculture projects, and small-scale commercial farming operations.

7. Acknowledgment

The successful completion of this project was made possible through the financial support provided by the Geran Komuniti Iskandar Puteri Rendah Karbon 5.0 (GKIPRK5.0/BU1/A1.3). The authors gratefully acknowledge this support, which enabled the development, implementation, and evaluation of the proposed smart and sustainable community-based agriculture system

8. Researchers' Biography

Ezril Hisham Mat Saat received his Bachelor of Engineering (Hons.) in Electrical Engineering from Universiti Teknologi Malaysia and his Master of Science in Electrical Engineering from Universiti Putra Malaysia. He is currently a Senior Lecturer in the Department of Electrical Engineering at Universiti Teknologi MARA (UiTM), Cawangan Johor, Kampus Pasir Gudang. His primary research interests focus on Artificial Intelligence (AI), Robotics, and Internet of Things (IoT), with applications in Computer Engineering, intelligent systems, and automation technologies

Noor Hasliza Abdul Rahman received her B. Eng. (Hons) in electrical engineering from Universiti Putra Malaysia in 2006 and M.Sc in Electrical Engineering from Universiti Teknologi MARA in 2014. Since 2014, she has been a lecturer in the Department of Power, College of Engineering, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus. She is currently pursuing the PhD degree in electrical engineering, focusing on the photovoltaic system at the Universiti Teknologi MARA. Her field of interest includes artificial intelligence and its applications in renewable energy source systems.

Ts. Muhammad Imran Ismail is a Senior Lecturer at the Faculty of Chemical Engineering, Universiti Teknologi MARA (UiTM) Johor, Pasir Gudang Campus. He is actively involved in teaching, research, and community–industry engagement, with academic and professional interests spanning plant safety and occupational health, sustainable process engineering, palm oil and oleochemical applications, and green technology innovation. He has led and coordinated various innovation, research, and community-based projects, including smart fertigation systems, climate education gamification programmes, and sustainability-driven initiatives in collaboration with local authorities, industry partners, and communities. His work reflects a strong commitment to applied innovation, student development, and the translation of engineering knowledge into practical solutions that support sustainability and societal impact.

Mohd Zaki Sukor is a Senior Lecturer at the Faculty of Chemical Engineering, Universiti Teknologi MARA (UiTM) Johor, Pasir Gudang Campus. He is actively involved in teaching, research, and applied innovation, with expertise in chemical process engineering, sustainable technologies, and industry-relevant engineering applications. His academic work emphasizes practical problem-solving, student-centred learning, and the integration of engineering principles with real-world challenges. Mohd Zaki Sukor has also contributed to various research, innovation, and community engagement projects in collaboration with academic colleagues, industry partners, and local communities, demonstrating a strong commitment to knowledge transfer, innovation impact, and sustainable development.

Sedan Rear End Aero-Optima

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ABSTRACT
Aerodynamic drag significantly impacts fuel consumption and vehicle stability in sedans. This study addresses the limited systematic analysis of rear-end geometric parameters by employing Latin Hypercube Sampling (LHS) to explore a multiparametric design space. Seven key rear-end features were investigated: windshield angle, trunk angle, trunk length, trunk height, bumper height, bumper height off ground, and windshield length. Forty unique sedan configurations were generated using LHS in MATLAB, modeled in CATIA, and analyzed via CFD simulations in ANSYS Fluent. The Polynomial Response Surface Method (PRSM) was used to build a predictive model achieving R^2 = 0.9804 and RMSE = 0.0055, outperforming a reference CCD model with 100 samples (R^2 = 0.926, RMSE = 0.006986). The optimal configuration achieved Cd = 0.2010, while the worst recorded Cd = 0.3166. Windshield angle emerged as the most influential parameter, particularly when interacting with trunk angle and bumper height. Results validate LHS as a resource-efficient method for aerodynamic optimization, enabling precise modeling with fewer simulations and supporting drag-reducing vehicle designs without external add-ons.

Keywords: Sedan aerodynamics; Drag coefficient; Latin Hypercube Sampling; Computational Fluid Dynamics; Rear-end design

1. Product Description
This research product delivers a validated computational framework for optimizing sedan rear-end aerodynamics through advanced statistical sampling and predictive modeling. The methodology combines Latin Hypercube Sampling with Polynomial Response Surface Method to systematically analyze seven geometric parameters affecting drag coefficient. The framework includes:
(1) LHS-based design space exploration requiring only 40 simulations versus traditional methods needing 100+ samples.
(2) CATIA-based parametric CAD modeling enabling automated geometry generation.
(3) ANSYS Fluent CFD simulation protocols validated for automotive aerodynamics.
(4) MATLAB MBC toolbox implementation for PRSM predictive modeling.
The deliverable provides automotive designers with a resource-efficient tool achieving 98% prediction accuracy while reducing computational costs by 60%. The methodology successfully identified drag reductions of up to 36.5% through geometric optimization alone, demonstrating practical applicability for fuel-efficient vehicle development. This approach eliminates dependence on external aerodynamic add-ons, offering manufacturers a cost-effective path to meeting increasingly stringent emission standards.

Problem Statement

Aerodynamic drag significantly reduces fuel efficiency and vehicle stability in sedans, yet existing research predominantly focuses on external add-ons rather than intrinsic geometric optimization. Previous studies examined only one or two rear-end parameters using traditional sampling methods like Central Composite Design, requiring extensive simulations and design iterations. Furthermore, systematic analysis of multiparametric interactions among rear-end geometric features remains limited. This research gap necessitates an efficient computational approach to explore complex geometric relationships and achieve substantial drag reduction through intelligent rear-end design optimization alone.

Objectives

This study aims to develop a resource-efficient aerodynamic optimization framework using Latin Hypercube Sampling to systematically analyze seven rear-end geometric parameters of sedan vehicles. The objective is to quantify individual and interactive effects of windshield angle, trunk geometry, bumper height, and ground clearance on drag coefficient through CFD simulations. By constructing accurate predictive models using Polynomial Response Surface Method, the research seeks to identify optimal geometric configurations achieving significant drag reduction without external aerodynamic devices, thereby supporting fuel-efficient vehicle design.

2. Parameter selection and Optimized outcome

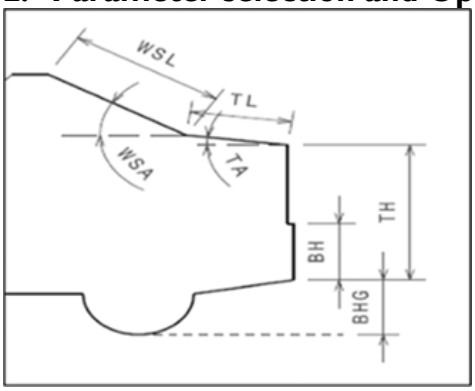

Figure 1. Rear-end vehicle profile for sedan car.

These parameters in **Figure 1** were chosen based on their aerodynamic importance and effectiveness in previously used optimization studies of sedan vehicle rear-ends.

Table 1. All seven parameters and their minimum and maximum value data.

Parameter	Definition of rear end shape	Minimum	Maximum
$x1$ (°)	wind shield length	520	740
$x2$ (mm)	trunk length	220	580
$x3$ (mm)	bumper height	220	380
$x4$ (mm)	trunk height	650	790
$x5$ (mm)	bumper height from ground	200	380
$x6$ (°)	wind shield angle	21	41
$x7$ (mm)	trunk angle	5	10

The study is focused on investigating the combined effects of these parameters in **Table I** to improve the aerodynamics and fuel consumption of modern sedan designs. The minimum and maximum values of the parameters listed in **Table I** indicates the lower and upper boundary for each parameter.

Optimized vehicle model

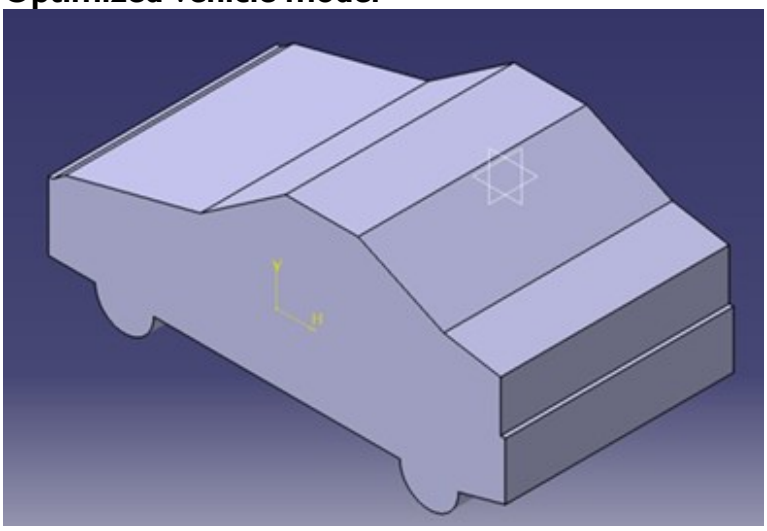

Figure 2. Model 30 (Best Model for Lowest Drag Coefficient).

Figure 2 displays model 30 which had the lowest drag coefficient at 0.2010, which occurred due to good configuration, such as the wind shield length (WSL) of 611.59 mm, and a low bumper height from the ground (BHG) of 233.89 mm which ensured a good flow of air beneath the vehicle.

Velocity contour

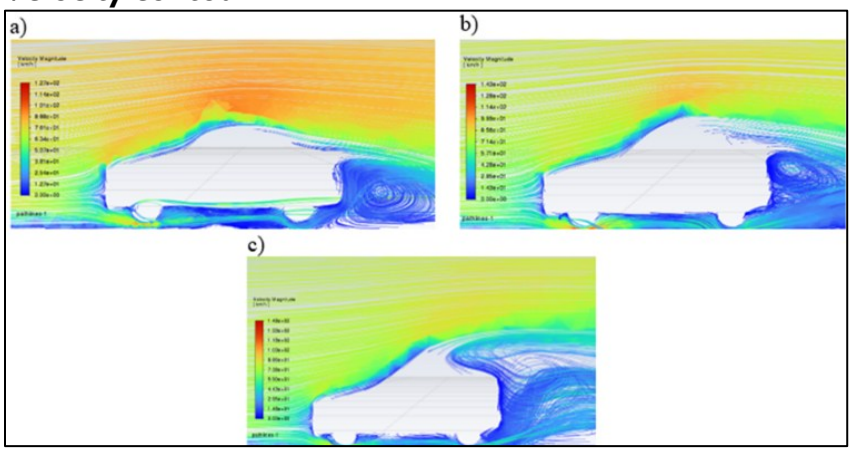

Figure 3. a) Model 30 b) Model 21 c) Model 22.

The contour plots of velocity for Models 30 (a), 21 (b), and 22 (c) in **Figure 3** indicate the aerodynamic performance of each model, from best to worst based on drag coefficient values (Cd).

Response Surface Graph

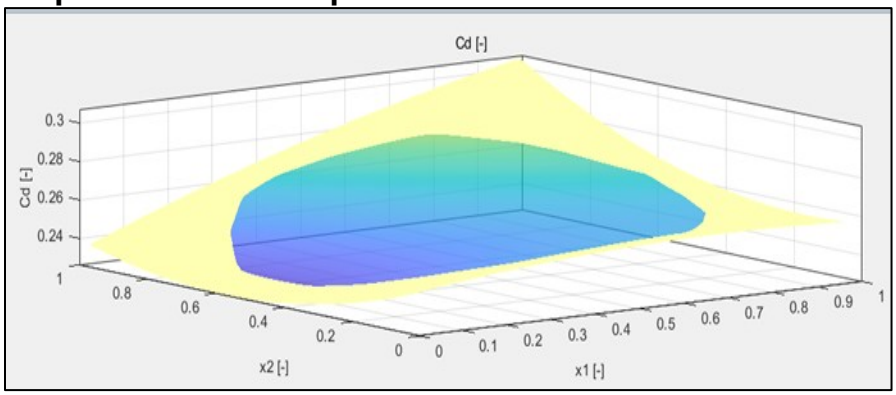

Figure 4. The interaction between parameters x1 and x2.

The response surface graph provided in **Figure 4** shows a great amount of clarity on how rear-end geometric parameters affect the drag coefficient (Cd) of a sedan vehicle. The 3D surface plot illustrates how windshield length ($x1$) and trunk angle ($x2$) interact with the drag coefficient (Cd). Out of all interaction pairs, windshield length ($x1$) plus trunk angle ($x2$) had the greatest positive interaction coefficient of +0.014954. This means that the total aerodynamic effect when those two parameters are both increased simultaneously is an exaggeration of how much Cd is raised, beyond what their individual influences have raised the drag coefficient.

3. Novelty and uniqueness

This research introduces three distinctive innovations to automotive aerodynamic optimization.

1. It represents the pioneering application of Latin Hypercube Sampling for multiparametric sedan rear-end analysis, achieving superior predictive accuracy (R^2 = 0.9804) with 60% fewer simulations than conventional Central Composite Design methods. Unlike previous studies focusing on one or two parameters, this work simultaneously analyzes seven geometric variables and their complex interactions without external add-ons.
2. The study provides comprehensive interaction analysis revealing that windshield angle serves as the dominant parameter in coupled effects with trunk geometry and bumper positioning insights previously undocumented in sedan aerodynamics literature.
3. The methodology achieves exceptional computational efficiency by demonstrating that geometric tuning alone can reduce drag coefficient from 0.3166 to 0.2010, representing a 36.5% improvement solely through intelligent parameter optimization. This eliminates the traditional reliance on spoilers, diffusers, or vortex generators, offering a paradigm shift toward intrinsic aerodynamic design rather than corrective add-ons.

4. Benefit to mankind

This research contributes significantly to global environmental sustainability and economic welfare, directly supporting five UN Sustainable Development Goals (SDGs 7, 9, 11, 12, 13). The demonstrated 36.5% drag coefficient improvement reduces fossil fuel dependency and greenhouse gas emissions, advancing SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action). For consumers, enhanced fuel economy reduces operational costs, making transportation more affordable. The methodology democratizes advanced optimization tools for developing nations and smaller manufacturers, promoting equitable technological advancement under SDG 9 (Industry, Innovation and Infrastructure). By supporting electric vehicle

development through extended battery range, the framework accelerates clean energy transportation. Eliminating reliance on external add-ons reduces manufacturing complexity and material waste, contributing to SDG 12 (Responsible Consumption and Production). Reduced vehicular emissions improve urban air quality, supporting SDG 11 (Sustainable Cities). Ultimately, this work advances sustainable mobility benefiting society through cleaner air, reduced energy consumption, and improved quality of life for future generations.

5. Innovation and Entrepreneurial Impact

The LHS-PRSM framework presents significant commercial opportunities for automotive manufacturers and engineering consultancies. By reducing simulation requirements by 60% while maintaining 98% accuracy, the methodology dramatically accelerates the design-to-production timeline and reduces R&D costs. For mid-sized automotive companies lacking extensive wind tunnel facilities, this computational approach provides enterprise-level optimization capabilities at substantially lower capital investment. The framework's ability to achieve 36.5% drag reduction through geometry alone enables manufacturers to meet stringent fuel efficiency regulations without costly add-on components, directly improving profit margins. Additionally, the technology supports the growing electric vehicle sector where aerodynamic efficiency directly translates to extended battery range—a critical competitive advantage. The standardized MATLAB-CATIA-ANSYS workflow facilitates technology transfer and licensing opportunities, while the predictive models enable rapid prototyping and virtual testing scenarios valuable for both established automakers and emerging mobility startups.

6. Potential commercialization

Commercialization pathways include software-as-a-service (SaaS) platforms offering cloud-based aerodynamic optimization for automotive designers, with subscription pricing based on simulation volume. The methodology can be licensed to CAE software vendors for integration into existing design tools, creating recurring revenue streams. Consulting services targeting automotive OEMs and Tier-1 suppliers represent immediate market entry, particularly in developing economies where manufacturers seek cost-effective alternatives to wind tunnel testing. The technology addresses the $50 billion global automotive aerodynamics market, with specific applications in electric vehicle development where every 10% drag reduction translates to approximately 5-7% range improvement. Partnership opportunities exist with CATIA/ANSYS resellers for bundled optimization packages, while the validated framework supports grant funding for collaborative industry-academia research projects. The methodology's applicability extends beyond sedans to SUVs, crossovers, and commercial vehicles, expanding the total addressable market substantially.

7. Acknowledgment

This research was self-funded by the main author.

8. Researchers' Biography

Ir. Ts. Dr. Kausalyah Venkatason is a Senior Lecturer in the Faculty of Mechanical Engineering at Universiti Teknologi MARA (UiTM), Malaysia. With over 20 years of academic and research experience, she specializes in structural dynamics, finite element analysis, and engineering optimization. Dr. Kausalyah has led numerous industrial and academic projects, focusing on vehicle crash dynamics and pedestrian safety. Her expertise extends to CAD/CAM/CAE applications, statistical methods, ergonomics and engineering education. A prolific researcher, she has published widely in Scopus-indexed journals and conferences, earning recognition through awards such as Best Presenter and Best Paper at international events.

Syamir Rafiq bin Farid Zamri is a Mechanical Engineer at Duriane Professionals Sdn Bhd, Malaysia, and a graduate of Mechanical Engineering from Universiti Teknologi MARA (UiTM). He specializes in mechanical and building services engineering (M&E), computational analysis, and product development. His research work focuses on CFD-based aerodynamic optimization using Latin Hypercube Sampling and response surface modelling techniques to enhance vehicle performance. In professional practice, he is involved in M&E consultancy works including HVAC system design coordination, technical documentation, drawing preparation, and site coordination. Syamir has also contributed to academic and industrial projects related to smart automation systems, CNC manufacturing, and mechanical system design. His technical expertise includes CAD/CAM/CAE applications, finite element analysis, MATLAB modelling, and building services engineering tools.

Ergo-Floor Analytics – Low Seating Workstation Analysis

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ABSTRACT
This study investigates ergonomic implications of low-seating workstations, specifically foldable floor tables (25-30 cm height), on adults sitting with extended legs. Using a 50th-percentile Japanese manikin in CATIA V5 to approximate Malaysian anthropometry, forty digital configurations were generated via Latin Hypercube Sampling, varying eleven body-and-workstation parameters including lumbar flexion, trunk position, head angles, shoulder and elbow positions, wrist extension, and table height. RULA analysis quantified musculoskeletal risk for each configuration. MATLAB multivariable curve-fitting tools correlated RULA scores with input parameters, revealing trunk flexion and table height as primary risk contributors. Results showed Final RULA Scores of 4-7 (moderate to high risk). This integrated approach of multiparametric sampling, CATIA-based RULA assessment, and MATLAB regression analysis addresses critical gaps in floor-seated work environment studies, providing data-driven recommendations for improving musculoskeletal comfort and informing ergonomic design of low-seating workstations.

Keywords: Ergonomics, RULA, CATIA V5, MATLAB Curve-Fitting, Latin Hypercube Sampling

1. Product Description
Ergo-Floor Analytics is a comprehensive computational ergonomic assessment system specifically designed for low-seating workstation evaluation. The system integrates three core components:
(1) Digital Human Modeling using CATIA V5 with anthropometrically-accurate 50th-percentile manikins;
(2) Latin Hypercube Sampling methodology for generating statistically representative postural configurations across eleven critical parameters (lumbar flexion/twist, head positioning, trunk alignment, shoulder-elbow-wrist angles, and table height); and
(3) Automated RULA analysis coupled with MATLAB multivariable curve-fitting for predictive modeling.

The system evaluates foldable floor tables (60×40 cm tabletop, 32 cm leg spacing, 25-30 cm height) for users sitting with extended legs. It produces quantitative risk assessments (RULA scores 1-7), identifies high-impact parameters through regression analysis (R^2 0.66-0.94), and generates actionable design recommendations. The methodology is scalable, repeatable, and applicable to various anthropometric populations and workstation configurations.

Problem Statement

Low-seating workstations, particularly foldable floor tables (25-30 cm), are prevalent in home and student environments yet remain inadequately studied. Extended static positions in unconventional floor-level seating lead to musculoskeletal pain and injury risk, especially in neck, trunk, and upper limbs. While ergonomic guidelines exist for conventional desk-chair setups, detailed assessments for floor-level furniture are notably absent. This gap necessitates systematic investigation of how table height and upper-body posture variations influence musculoskeletal strain in floor-seated work environments.

Objectives

To computationally simulate and assess ergonomic impacts of low-seating workstation designs on musculoskeletal strain; to identify which joint angles and table heights significantly influence RULA scores through multiparametric analysis; to quantify relationships between postural parameters and ergonomic risk using MATLAB curve-fitting; and to develop data-driven design recommendations for low-seating workstations that minimize strain, enhance user comfort, and reduce musculoskeletal disorder risks in floor-based seating arrangements.

2. Workstation Set-up and Optimized Outcome

The workstation environment was digitally modelled in CATIA V5 to simulate a standard low-seating floor workstation common in home and educational settings. The setup featured a foldable table with a 60 x 40 cm surface area and a 32 cm leg clearance. To ensure the results were applicable to the target demographic, a 50th-percentile Japanese manikin was utilized as a proxy for Malaysian adult anthropometry. The experimental design employed a multiparametric approach, varying eleven simultaneous parameters (including joint angles and table height) to capture the complexity of human stature in floor-seated positions. To ensure statistical coverage of the vast postural range, Latin Hypercube Sampling (LHS) was used to generate 40 unique digital configurations. These configurations were systematically assessed using the Rapid Upper Limb Assessment (RULA) module. The analysis identified Model 4 as the optimized configuration, yielding the lowest calculated musculoskeletal risk within the experimental range.

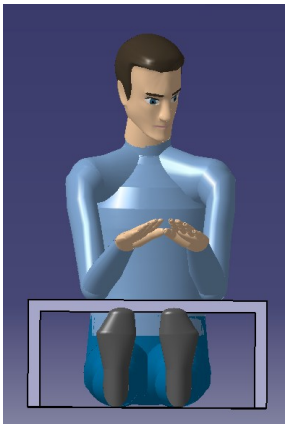

Figure 1. Optimized Low-Seating Workstation (Model #4).

Figure 1 demonstrates the digital prototype in its optimized state. In this configuration, a minimal trunk flexion of 3.27° and a table height of **269.87 mm** were maintained. The visual

confirmation shows the manikin achieving a neutral Neck Score of 1, which significantly contributes to the reduction of the final RULA score compared to more aggressive leaning postures.

Table 1 RULA score results for optimized vs. high-risk configurations

Configuration	Trunk Flexion (°)	Table Height (mm)	Neck Score	Trunk Score	Final RULA Score
Model 4 (Optimized)	**3.27**	**269.87**	**1**	**3**	**4**
Model 20 (High Risk)	6.04	260.51	3	4	7
Model 40 (Typical)	8.84	251.00	3	4	6

As detailed in **Table 2**, the optimized model achieves a Final RULA Score of 4, which represents a "Moderate Risk" level requiring further investigation. By comparison, configurations with lower table heights (e.g., Model 40 at 251 mm) or higher trunk flexion (Model 20) quickly escalate to a score of 7, indicating an immediate need for postural or design intervention.

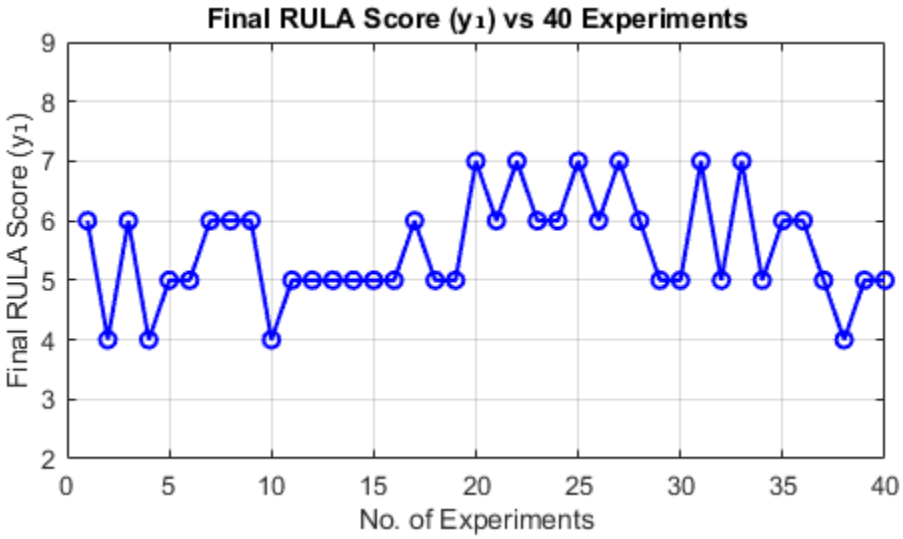

Figure 2. Final RULA Score across the 40 experimental configurations.

The distribution graph in **Figure 2** illustrates the overall ergonomic risk profile of the study. It reveals that only 10% of the configurations achieved the minimum score of 4, while the vast majority (over 85%) fell within the high-risk category (scores 5-7). This high frequency of elevated risk scores underscores the critical importance of this research in establishing ergonomic standards for the commercial production of low-seating furniture.

3. Novelty and uniqueness

This research represents the first comprehensive multiparametric ergonomic analysis specifically targeting floor-level workstations with extended-leg sitting postures. Unlike conventional ergonomic studies focused on standard desk-chair configurations, this work addresses an underserved user population prevalent in Asian, student, and home-office environments. The integration of Latin Hypercube Sampling for systematic postural variation, CATIA V5 digital human modeling for precise biomechanical simulation, and MATLAB regression analysis for predictive modeling creates a unique methodology absent in current literature. The approach identifies previously unquantified relationships between multiple simultaneous postural

parameters and ergonomic outcomes, moving beyond single-variable analyses. Furthermore, the development of simplified polynomial models (coefficient threshold 0.01) enables practical implementation for ergonomic interventions. This computational framework establishes a replicable protocol for ergonomic assessment of non-traditional workstations, filling critical gaps in occupational health research.

4. Benefit to mankind

This research directly supports SDG 3 (Good Health and Well-being) by reducing musculoskeletal disorder risks affecting millions of floor-seated workers and students globally. The data-driven design recommendations promote healthier work practices, preventing chronic pain and disability. Supporting SDG 8 (Decent Work and Economic Growth), improved ergonomic workstation designs enhance productivity and reduce healthcare costs associated with work-related injuries. The methodology aligns with SDG 9 (Industry, Innovation, and Infrastructure) by establishing innovative computational frameworks for ergonomic assessment applicable to furniture manufacturing and workplace design industries. By addressing underserved populations in developing regions where floor-seating is culturally prevalent, this work promotes SDG 10 (Reduced Inequalities), ensuring ergonomic safety standards extend beyond conventional office environments to benefit diverse global communities.

5. Innovation and Entrepreneurial Impact

The Ergo-Floor Analytics system creates significant entrepreneurial opportunities in ergonomic consulting, furniture design, and occupational health sectors. The methodology enables development of evidence-based ergonomic certification programs for low-seating furniture manufacturers, creating new market differentiators. Furniture companies can leverage the predictive models to optimize product designs, reducing prototyping costs while improving market competitiveness. The computational framework supports development of SaaS platforms for ergonomic assessment services targeting SMEs, educational institutions, and home-office markets. Integration with CAD software creates licensing opportunities for furniture design tools. The research establishes intellectual property foundations for patent applications in ergonomic assessment methodologies and adjustable workstation designs. Additionally, the system facilitates workplace ergonomic auditing services, addressing growing demand for occupational health compliance and employee wellness programs in emerging markets.

6. Potential commercialization

Commercialization pathways include:
(1) Software licensing of the Ergo-Floor Analytics platform to furniture manufacturers, interior designers, and occupational health consultants;
(2) Development of ergonomically-optimized adjustable floor table product lines incorporating research findings, targeting education, home-office, and cultural markets;
(3) Consulting services offering customized ergonomic assessments for corporate wellness programs and institutional procurement;
(4) White-label solutions for furniture retailers seeking ergonomic certification;
(5) Integration with existing CAD/CAM systems as plugin modules for design firms;
(6) Educational licensing for universities and vocational training programs in industrial design and occupational health; and

(7) Partnerships with healthcare providers for preventive ergonomic intervention programs. The global ergonomic furniture market, valued at over $7 billion and growing 6-8% annually, presents substantial commercialization potential, particularly in underserved Asian and Middle Eastern markets.

7. Acknowledgment

This research was funded by a grant from Universiti Teknologi MARA's MYRA Research Grant (600-RMC RD/70/002/2024).

8. Researchers' Biography

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Muhammad Fahim Bin Mazelan is a Mechanical Engineering (Honours) graduate from Universiti Teknologi MARA (UiTM) Shah Alam. With a strong foundation in Computer-Aided Design (CATIA, AutoCAD) and MATLAB programming, he specializes in digital human modeling and ergonomic risk assessment. During his academic career, he received multiple Dean's List awards and demonstrated leadership in various technical projects, including solar PV system design and mechanical simulations. As the lead researcher for this project, he spearheaded the multiparametric RULA analysis and predictive modeling. Fahim is currently advancing his professional career as a PROTÉGÉ at SD Guthrie, where he continues to apply engineering innovation to industrial challenges.

EcoCan Bin - a Smart Recycling System with Gamified User Interaction

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ABSTRACT

EcoCan Bin is a smart recycling system developed to increase aluminium can recycling through interactive gamification. EcoCan Bin integrates sensor-based material detection, automated in-bin separation, and a touchscreen-based reward interface that transforms recycling into an engaging, measurable activity. Each aluminium can is detected and recorded in a database for usage monitoring and impact analysis. The system is currently installed and operating at Sutera Mall, Johor, and is funded by Majlis Bandaraya Iskandar Puteri (MBIP) under the Geran Komuniti Iskandar Puteri Rendah Karbon. EcoCan Bin employs a Raspberry Pi as the main embedded controller, interfaced with a metal detection sensor and a Python-based touchscreen graphical user interface. Each detected can generates reward opportunities through a digital lucky draw system, enabling users to redeem e-wallet credits, vouchers, or donate to charity, while also participating in educational gamified activities such as eco-quizzes, riddles, and mini-games. The project is implemented through collaboration between Universiti Teknologi MARA (UiTM) as the system developer, Sutera Mall as the industry deployment partner, and Kiwanis CareHeart Centre as the community and charity beneficiary. EcoCan Bin promotes positive recycling behaviour, reduces landfill waste and carbon emissions, and demonstrates strong commercialization potential through scalable deployment, sponsorship, and data-driven service models.

Keywords: Smart Recycling System, Gamification, Embedded System, Raspberry-pi, Arduino

1. Product Description

EcoCan Bin is a smart recycling system that integrates embedded hardware, mechanical separation, and interactive software to promote aluminium can recycling in public environments. The system is built around a Raspberry Pi serving as the main controller, interfaced with a metal detection sensor to identify aluminium can insertion events. Based on the sensor output, a motorized rotating holder (diverter mechanism) controlled by Arduino, is actuated to direct the inserted item to different internal compartments, enabling automatic separation between metal and non-metal materials. User interaction is facilitated through a touchscreen graphical user interface (GUI) developed in Python using the Tkinter framework. The software implements a session-based workflow comprising recycling initiation, can insertion, reward gameplay, and redemption selection. Each detected aluminium can generates a reward opportunity through a probability-based lucky draw mechanism. Additional gamified activities, including eco-quizzes, riddles, jokes, and embedded mini-games such as Snake, Memory, Reaction, and Catch, are provided to sustain user engagement. All system operations are recorded in a local SQLite database, including session IDs, timestamped detection events, material classification outcomes, reward values, and redemption decisions. The system is currently deployed at Sutera Mall,

demonstrating a modular, cashless, and scalable solution for sustainable waste management and smart recycling infrastructure.

2. System Diagrams, Flow Charts and Results

Figure 1 illustrates the overall system architecture of the EcoCan Bin, which adopts a dual-independent control design consisting of two parallel subsystems operating without direct communication. The Raspberry Pi subsystem is equipped with its own metal sensor and serves as the high-level application controller. It manages all user-facing and data-processing functions through a touchscreen graphical user interface (GUI) developed using the Tkinter framework. Upon metal detection, the Raspberry Pi initiates a session-based interaction flow within the GUI. This includes updating the display to reflect can insertion, incrementing the internal can count, and allocating reward chances based on the number of detected cans. The system then launches a probability-based lucky draw game, where each valid can corresponds to one reward opportunity. Users interact with the GUI to reveal rewards, engage in optional bonus activities (such as eco-quizzes, riddles, jokes, and mini-games), and select their preferred redemption method. The GUI further supports user input for certificate generation, voucher display, e-wallet information, and optional email delivery. All session data, including timestamps, can counts, reward values, game outcomes, and redemption selections, are stored in a local SQLite database for analysis and reporting. In parallel, the Arduino subsystem is equipped with a separate metal sensor and proximity sensor dedicated to real-time material classification and mechanical actuation. Based on sensor input, the Arduino directly controls the motor that drives the rotating holder, directing objects to either the aluminium can storage or the non-metal storage compartment. This architecture eliminates inter-controller dependency, improves fault isolation, and ensures continuous mechanical operation even if one subsystem experiences a failure, thereby enhancing system robustness for long-term public deployment.

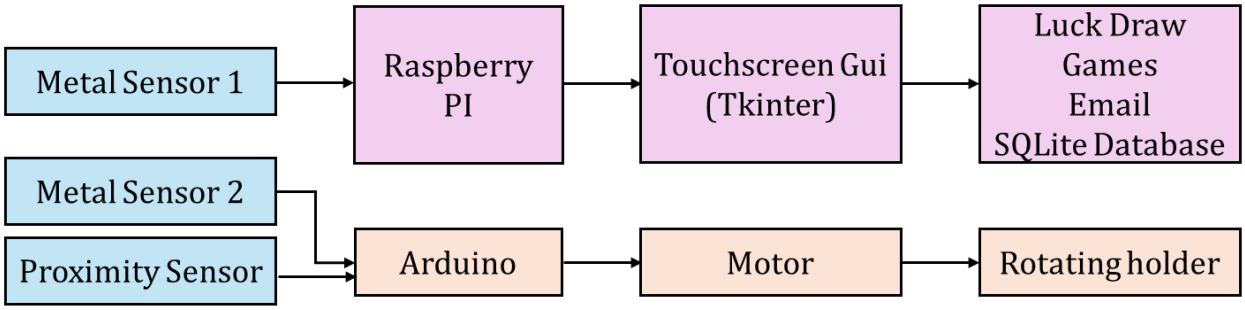

Figure 1. System diagram of EcoCan Bin.

Figure 2 illustrates the operational workflow of the EcoCan Bin system, highlighting the parallel execution of mechanical separation and user interaction processes. The workflow begins when an object is inserted into the bin. On the Raspberry Pi side, when an aluminium can is detected, a software event is initiated within the Tkinter-based graphical user interface on the touchscreen display. The system increases the can count and provides the user with chances to participate in a digital lucky draw based on the number of cans recycled.nThe user then interacts with the touchscreen by selecting virtual gift boxes to reveal rewards. In addition to the lucky draw, users may choose to engage in simple educational and entertainment activities such as eco-quizzes, riddles, jokes, or mini-games. After completing the interaction, the user selects how to use the reward, either by donating it, receiving a digital voucher, or entering e-wallet information via

email. Finally, the system saves the recycling record and reward details in the database. The session ends automatically, and the touchscreen returns to the starting screen, ready for the next user. Simultaneously, on the Arduino side, metal detection triggers immediate mechanical action. If a metal object is detected, the Arduino commands the motor to rotate the holder toward the aluminium can storage compartment. If no metal is detected but other object detected by proximity sensor, the holder is rotated toward the non-metal storage compartment. This decision and actuation occur in real time to ensure reliable material separation regardless of the state of the user interface. If no object is detected, the system remains in an idle state while continuously monitoring the sensors until an insertion event occurs.

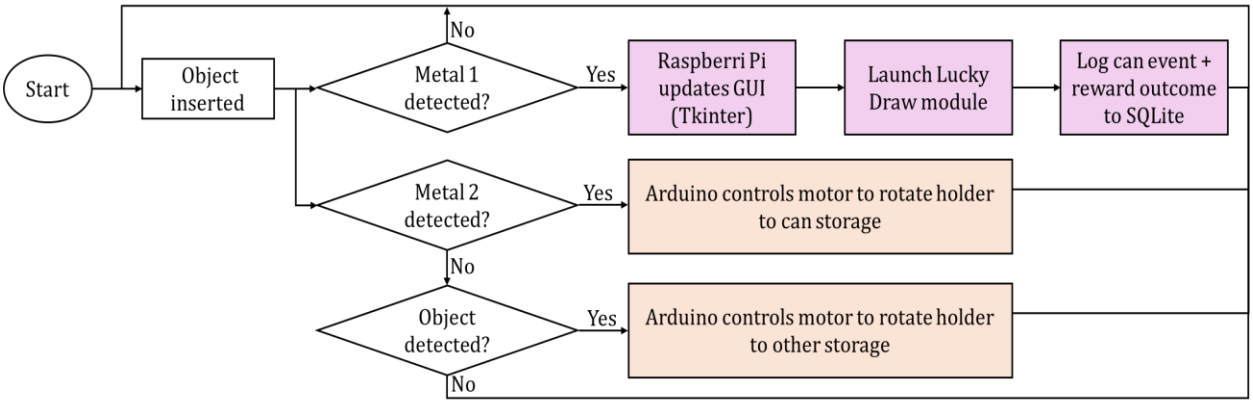

Figure 2. EcoCan Bin flowchart.

Figure 3. Deployed EcoCan Bin System and User Interface Screens.

Figure 3 shows the actual implementation of the EcoCan Bin system installed at Sutera Mall, together with some of key touchscreen interfaces used during user interaction. The image on the left presents the physical EcoCan Bin unit, featuring the aluminium can insertion slot, instructional signage, and an integrated touchscreen display mounted on the front panel. This unit houses the

sensing, control, and mechanical separation components described in the system architecture. The top-right image illustrates the Lucky Draw interface, where users are invited to select virtual gift boxes after successfully recycling aluminium cans. The interface displays the remaining number of chances and accumulated reward value, reflecting the real-time session state managed by the Raspberry Pi application. The bottom-right image shows the Bonus Fun interface, which provides optional educational and entertainment activities such as eco-quizzes, riddles, jokes, and interactive mini-games (e.g., Snake, Catch, Memory, and Reaction). These activities are time-limited based on the number of cans recycled and are designed to enhance user engagement beyond the recycling action. Additional GUI displays, including individual game screens, donation and reward selection pages, certificate generation screens, voucher displays, and e-wallet information interfaces, are implemented as separate classes within the Tkinter-based application. Together, these interfaces demonstrate the complete user journey, from physical can insertion to digital interaction, highlighting the practical deployment, interactive design, and gamified reward features of the EcoCan Bin system.

3. Novelty and uniqueness

EcoCan Bin introduces a novel smart recycling approach by combining a dual-independent control architecture, automated material separation, and session-based gamified user interaction in a single deployed system. Unlike conventional recycling bins that function as passive collection points or rely on simple incentive mechanisms, EcoCan Bin actively integrates mechanical control with structured digital interaction to influence recycling behaviour. A key novelty of the system is its dual-independent architecture, in which an Arduino-based subsystem performs real-time metal detection and mechanical separation, while a Raspberry Pi–based subsystem manages user interaction, reward processing, and data storage. This architectural separation improves system reliability, simplifies maintenance, and supports long-term operation in public environments. The interface incorporates lucky draw rewards, optional educational and entertainment activities (eco-quizzes, riddles, jokes, and mini-games), and flexible reward redemption options such as donations, vouchers, and e-wallet credits. Recycling events and user interactions are recorded in a local database, enabling structured analysis of system usage. Furthermore, EcoCan Bin is not a conceptual prototype but a fully deployed system, with real-time data logging to an SQLite database for monitoring recycling behaviour and system performance. This combination of mechanical automation, gamified interaction, and deployment-ready robustness distinguishes EcoCan Bin from existing recycling solutions.

4. Benefit to mankind

EcoCan Bin benefits society by encouraging responsible recycling behaviour through a practical and engaging system that integrates technology with environmental awareness. By providing immediate feedback and incentives, the system motivates users to recycle aluminium cans more consistently, contributing to reduced landfill waste and lower carbon emissions associated with aluminium production. The automated separation mechanism improves recycling efficiency and minimizes contamination of recyclable materials. Beyond environmental impact, EcoCan Bin supports social responsibility through its integrated donation feature, which allows users to contribute their rewards to charitable organisations. This feature promotes community engagement and enables recycling activities to directly support social causes. Additionally, the system serves an educational role by incorporating eco-themed quizzes and interactive activities that raise awareness of sustainable practices among users of different age groups. Through its

public deployment, EcoCan Bin demonstrates how technology-driven recycling solutions can simultaneously address environmental sustainability, social contribution, and community awareness in an accessible and inclusive manner.

5. Innovation and Entrepreneurial Impact

EcoCan Bin demonstrates innovation through the translation of academic research into a functioning public system. The project illustrates how academia can lead applied innovation by integrating sensing, mechanical control, and interactive software within a real-world recycling application, while maintaining practical operability in public spaces. From an entrepreneurial perspective, the project establishes a foundation for sustainable technology adoption through collaboration between academia, industry, and the community. The technical robustness and practical relevance of the system enabled it to gain the confidence and support of external stakeholders, including Majlis Bandaraya Iskandar Puteri (MBIP) as the funding authority, Sutera Mall as the industry deployment partner, and Kiwanis CareHeart Centre as the community beneficiary. The modular system design and proven public deployment support scalable implementation, service-based deployment models, and long-term partnerships across commercial, institutional, and community settings. By aligning environmental responsibility with practical business potential, EcoCan Bin contributes to fostering a culture of sustainable entrepreneurship and innovation.

6. Potential commercialization

EcoCan Bin demonstrates strong commercialization potential as a smart recycling solution for shopping malls, public facilities, educational institutions, and community spaces. The system's modular hardware and software architecture enables flexible deployment through direct sales, leasing, or service-based models that include installation, maintenance, and performance monitoring. Revenue opportunities may be supported through partnerships with facility operators, sponsored reward programmes, touchscreen-based advertising, and corporate social responsibility (CSR) initiatives. The successful deployment at Sutera Mall and funding support from Majlis Bandaraya Iskandar Puteri (MBIP) provide validation of system feasibility and market readiness. In addition, the system's data logging capability enables value-added services such as recycling analytics and sustainability reporting for local authorities and commercial partners. With increasing demand for smart city and low-carbon solutions, EcoCan Bin is well positioned for scalable adoption and long-term commercialization through collaboration between academia, industry, and community stakeholders.

7. Acknowledgment

The authors would like to express their sincere appreciation to Majlis Bandaraya Iskandar Puteri (MBIP) for the financial support provided through the Geran Komuniti Iskandar Puteri Rendah Karbon. Special thanks are extended to Sutera Mall for granting permission and support for the system deployment, and to Kiwanis CareHeart Centre for their collaboration as the community and charity partner. The authors also acknowledge Universiti Teknologi MARA (UiTM) for institutional support and facilities that enabled the development and implementation of the EcoCan Bin system.

8. Researchers' Biography

Dr. Siti Musliha Ajmal Binti Mokhtar is a Senior Lecturer at Universiti Teknologi MARA (UiTM) Pasir Gudang Campus under the Kolej Pengajian Kejuruteraan. She holds a Doctor of Philosophy (PhD) from the University of South Australia, a Master of Science in Electrical Engineering from Universiti Teknologi MARA Shah Alam, a Bachelor of Engineering in Electronics and Electrical Engineering from Keio University, and a Diploma in Electrical and Electronic Engineering from Universiti Industri Selangor. Her expertise lies in circuit design, thin film coating, electrochemical applications, and microneedle technologies, focusing on engineering science and industrial technology.

Ezril Hisham Mat Saat obtained his B. Eng. (Hons) in electrical engineering from University Teknologi Malaysia, M.Sc. in electrical engineering from Universiti Putra Malaysia. He is currently working as senior lecturer in Department of Computers, College of Engineering, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus. His main research interests are Computer Engineering, Embedded System Robotics, Artificial Intelligent, and IoT field.

Ts. Rozi Rifin earned a Bachelor of Engineering in Electronic from USM in 2005 and a Master of Science in MicroElectronics from UKM in 2013. Currently, he serves as a lecturer at UiTM Cawangan Johor Kampus Pasir Gudang in Electronics Department. Prior to joined UiTM, he served 9 years of experience as an engineer, working in different local and multinational companies that focused on various aspects such as Manufacturing, Process and Equipment Engineering, Quality Control, and Cost Reduction within the Integrated Circuit and Photovoltaic Solar Cells Fabrication industry. His main research interests are in Microelectronics, IC and VLSI design, solar cells fabrication, embedded systems and IoT.

Kamaru Adzha Bin Kadiran obtained his Bachelor of Engineering (Electrical - Telecommunications) (Hons) and Master of Engineering (Electrical - Electronics & Telecommunications) from Universiti Teknologi Malaysia (UTM). Currently, he serves as a lecturer at UiTM Cawangan Johor Kampus Pasir Gudang in Electronics Department. His main research interests are e-learning and machine learning.

Planet Care Kids Tales An SDG-Aligned Children's Storybook for Sustainable Education

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ABSTRACT
Planet Care Kids Tales is a story-driven educational project under the Alam Lestari Si Cilik series designed to cultivate sustainability awareness and global responsibility among children aged six to nine years. The project consists of a curated collection of digital children's storybooks aligned with the United Nations Sustainable Development Goals (SDGs), particularly Quality Education, Climate Action, Responsible Consumption and Production, Life Below Water, and Life on Land. Through engaging narratives, relatable child protagonists, and the personification of natural elements, complex global challenges such as climate change, plastic pollution, renewable energy use, biodiversity loss, and waste management are presented in an age-appropriate and emotionally resonant manner. By integrating literacy development with values-based education, Planet Care Kids Tales transforms reading into a meaningful learning experience that encourages reflection, discussion, and sustainable action. The project is designed for use in schools, homes, and community programmes, with strong potential for scalability and broader social impact.

Keywords: Sustainable Education, Children's Storybooks, Climate Action, SDG-aligned learning, Early Childhood Literacy

1. Product Description
Planet Care Kids Tales is a curated digital children's storybook collection developed under the Alam Lestari Si Cilik series, designed to introduce sustainability concepts to children in an engaging and age-appropriate manner. For this competition, the project features four selected storybooks that collectively address key sustainability themes aligned with the United Nations Sustainable Development Goals (SDGs), including climate change, environmental protection, renewable energy, biodiversity conservation, and responsible waste management.
The stories are written in clear, simple language suitable for children aged six to nine years and are complemented by vibrant illustrations that support comprehension, imagination,

and sustained engagement. Each storybook integrates narrative storytelling with moral reflection, sustainability-related keywords, and guided prompts to encourage discussion and reflection with parents, teachers, or caregivers.

Delivered in a digital format, PlanetCare Kids Tales ensures wide accessibility and cost-effective distribution while maintaining affordability for families and educational institutions. The format also allows flexibility for use in classrooms, home-based learning, community programmes, and environmental education initiatives, making the product adaptable to diverse educational contexts and learning needs.

2. PlanetCare Kids Tales : Alam Lestari Si Cilik series

The PlanetCare Kids Tales storybooks are made available in digital format to ensure wide accessibility and ease of distribution. The digital interface of PlanetCare Kids Tales is organized through a centralized Linktree platform that aggregates all published eBook titles within a structured and user-friendly navigation layout. Readers, educators, and stakeholders may access the eBook collection through the project's official link at https://linktr.ee/PlanetCareKidsTales, which serves as a central access point for the published titles and related learning resources.

Figure 1 presents the digital platform and eBook layout, displaying the available storybooks through vertically arranged access buttons integrated with thumbnail visuals. The platform provides structured navigation that enables direct redirection to external reading and purchasing page. Furthermore, the platform is designed using responsive web architecture to ensure cross-device compatibility. **Figure 2** illustrates the adaptive interface display across PC, tablet and mobile devices, demonstrating consistent layout rendering, readability and navigation across different screen sizes.

Figure 1. The PlanetCare Kids Tales : Alam Lestari Si Cilik series eBook online layout and readers' interphase.

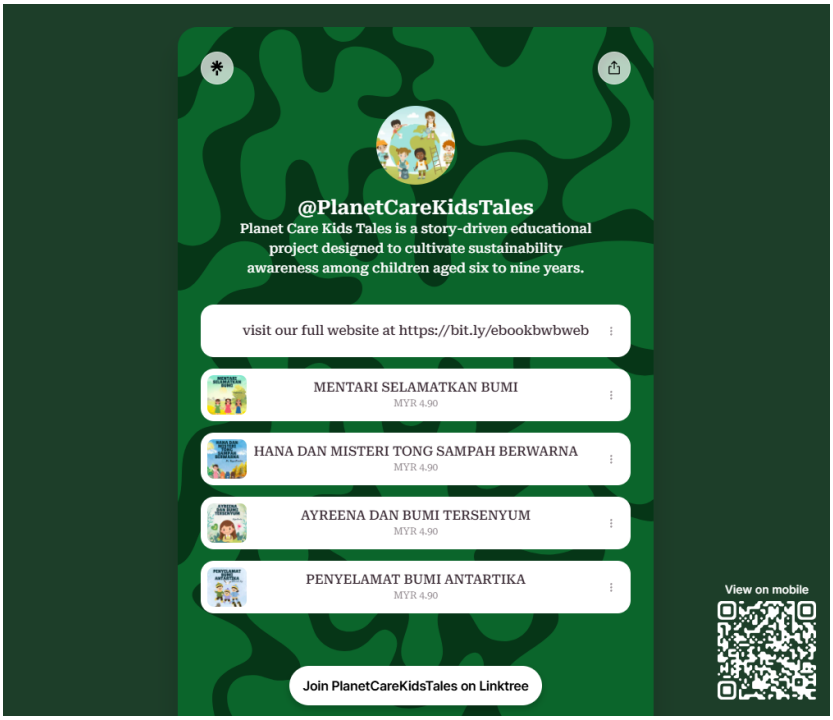

Figure 2. Readers' interphase on PC, tablet and mobile phone.

3. Novelty and uniqueness

The novelty of PlanetCare Kids Tales lies in its use of narrative-based learning as the core mechanism for sustainability education. Instead of presenting environmental concepts through instructional or technical explanations, the project humanises global challenges by allowing elements of nature, animals, and ecosystems to "speak" within the stories. This approach fosters empathy, emotional engagement, and deeper understanding among young readers. The content is developmentally appropriate, culturally adaptable, and academically grounded, having been developed by an experienced academic team. The deliberate integration of SDG themes into storytelling rather than didactic teaching distinguishes PlanetCare Kids Tales as a unique and impactful educational innovation.

4. Benefit to mankind

PlanetCare Kids Tales delivers significant benefits at multiple levels of society. For children, the project enhances reading literacy, critical thinking, emotional intelligence, and environmental awareness while nurturing positive values and responsible habits. For parents and educators, it provides a structured, accessible, and user-friendly resource for introducing sustainability concepts without the need for specialised training. At the societal level, the project contributes to the formation of environmentally responsible citizens by embedding sustainability mindsets early in life, supporting global efforts to address climate change, pollution, and ecological degradation through education.

5. Innovation and Entrepreneurial Impact

PlanetCare Kids Tales represents an innovative shift in sustainability education by positioning storytelling as a transformative learning tool rather than a supplementary activity. From an entrepreneurial perspective, the project offers a low-cost, high-impact educational solution with

strong market relevance. It aligns closely with global education trends, environmental, social and governance (ESG) priorities, and SDG-driven agendas, making it attractive to schools, non-governmental organisations, government agencies, and Corporate Social Responsibility (CSR) programmes. The ecosystem model also enables future expansion into digital education technologies, interactive learning platforms, and multimedia adaptations.

6. Potential commercialization

PlanetCare Kids Tales demonstrates strong commercialization potential through multiple channels. The digital storybook ecosystem can be distributed through subscription-based platforms for families and educators, licensed to schools and early childhood education centres, or packaged as sustainability education modules for corporate social responsibility and community outreach initiatives. Additional growth opportunities include translation into multiple languages for regional and international markets, adaptation into animated or audio storytelling formats, and integration with interactive educational technologies. The project's digital scalability, educational relevance, and global sustainability focus position PlanetCare Kids Tales as a viable and sustainable long-term educational venture.

7. Acknowledgment

The authors would like to express their sincere gratitude to all individuals and institutions who contributed to the development of *PlanetCare Kids Tales*. Special appreciation is extended to the educators, parents, and children whose support and feedback made this project possible. This work is dedicated to nurturing a generation that cares for the planet and contributes towards a more sustainable future.

8. Researchers' Biography

Nur Atharah Kamarzaman obtained her PhD in photovoltaic system optimization from Universiti Teknologi MARA (UiTM), Shah Alam, with research focus on photovoltaic system optimization. Her areas of expertise include renewable energy, system optimization, and artificial intelligence. Her work contributes to the advancement of intelligent and efficient renewable energy systems.

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Sabarina binti Abdul Hamid is an accomplished Lecturer in the Avionics Section at Universiti Kuala Lumpur Malaysian Institute of Aviation Technology (UniKL MIAT), specializing in electronics, electrical fundamentals, and unmanned systems. She holds a Master of Engineering from Universiti Tenaga Nasional (UNITEN) and recently completed her PhD in Electrical and Electronics Engineering at Universiti Kuala Lumpur.

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Effects of Temperature and pH Levels on Aquaculture Using Sensor-Based Monitoring

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ABSTRACT
In aquaculture ponds, water quality is a critical factor affecting the survival and growth of aquatic organisms. Fish production, water temperature, and pH level are key parameters that must be properly monitored and optimized. The objective of this project is to monitor pH and temperature levels in a fishpond to support an increase in fish population. An Arduino board was used to interface with pH and temperature sensors, and the system was programmed using the C language due to its compatibility and ease of implementation. The pH and temperature sensors employed in this project are fully submersible, allowing accurate data collection directly from the fishpond. Experimental results indicate that the sensors can measure the parameters accurately with minimal noise. The data collected were plotted in graphical form to analyze the relationship between temperature and pH levels. The results show that when the temperature reaches its maximum value of 32 °C at 2:00 pm, the pH level decreases to its minimum value of 6.9. Conversely, when the temperature drops to its minimum value of 24 °C at 4:00 am, the pH level increases to its maximum value of 7.06.

Keywords: Fishpond, Sensors, pH level, temperature, Arduino

1. Product Description
This project presents a fishpond water quality monitoring system designed to assist fish farmers in maintaining optimal pond conditions. The system uses an Arduino-based microcontroller integrated with temperature and pH sensors to continuously monitor key water parameters. The sensors are fully submersible and provide real-time measurements of water temperature and pH level, which are critical to fish health and survival. Data collected by the system can be displayed and analyzed to help farmers detect harmful conditions early, prevent fish mortality, and improve overall fish production. The system is cost-effective, easy to use, and suitable for small- to medium-scale aquaculture applications.

2. Project Methodology and Results
The flowchart of the research is show in **Figure 1**. Arduino Integrated Environment Development (IDE) was used to run the programming for the system by using Arduino board as the microcontroller and the input are water temperature and pH value that were obtained by temperature sensor and pH sensor that can be submerged in water to get a precise reading of the water conditions. This input is then received by microcontroller to process the data before

the outputs are displayed on laptop. C programming language was used to construct the whole system and library for microcontroller were utilized. PH sensor was calibrated using hardware calibrated by dipping the pH probe into a buffer and adjust the potentiometer until it reaches the same value with buffer. For temperature sensor, there no need to calibrate because only depend on programming code. To get the precise reading, each sensor will be tested by comparing to thermometer and pH meter provided by the laboratory. The functionality of all the sensor is proven with the construct of a model. The deviations of the resistance value from the sensors and algorithm in programming code, will produce a reading and displayed on the laptop to be plotted into a graph. Graph constructed can be used because of the project and see the relationship between temperature and pH value against time.

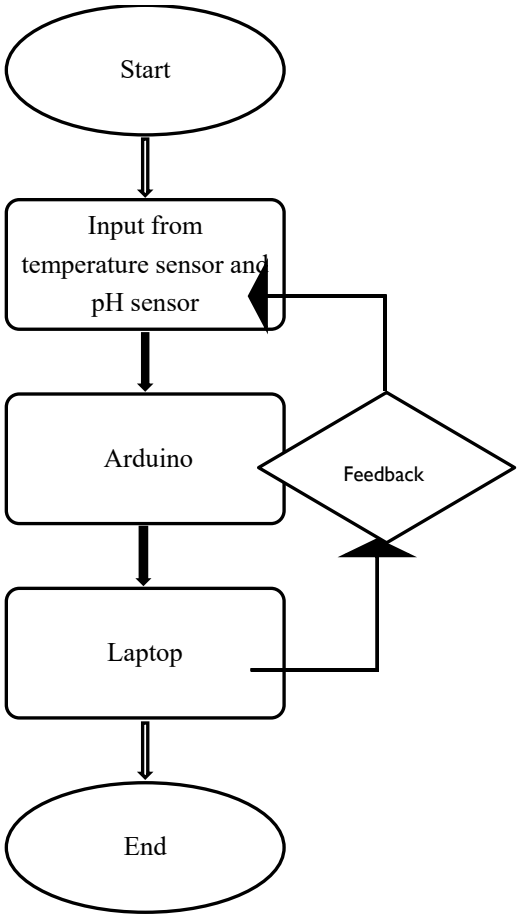

Figure 1. Flowchart of the project.

Figure 2 shows the hardware design of the system. Temperature sensor used is DS18B20 that and pH sensor SKU: SEN0169 that can be submerged in water to get a precise reading. Pin used is analog pin because the input is in an analog form. A specification for temperature sensor is between -55 °C to +125 °C with Accuracy of ±0.5 °C. For pH sensor specification measuring Range between 0 to 14 pH with measuring temperature of 0 to 60 °C and having an accuracy of ± 0.1 pH with response time less than 1 minute.

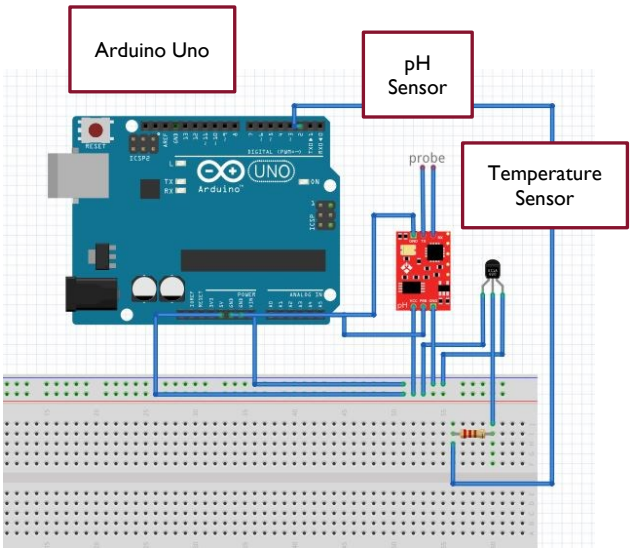

Figure 2. Hardware of the project.

Figure 3 shows the relationship between temperature and pH level in a time interval of 24 hours. Data taken from temperature and pH level are compared to see how pH level reacts when the temperature varies from time to time. In this graph, the result from this project can be seen because the outcome of this project same with the finding in the literature review. When the temperature at maximum peak, which are 32°C at 2 pm, pH level decreases to a minimum peak of 6.9 pH value. The high temperature will slightly decrease the hydrogen ion inside of fishpond that cause the pH level lower than optimum value. When the temperature reaches its lowest peak of 24 °C at 4 am, pH level achieved its peak value of 7.06 pH. This shows that low temperature is slightly influenced the pH value compared to high temperature. When temperature reaches 25°C, pH value reaches its optimum value [10]. This result shows that for an optimum water quality, water temperature must remain at 25°C. For the range of temperature and pH level shown, the fishpond is suitable for fish farming and living organism inside fishpond will grow healthy.

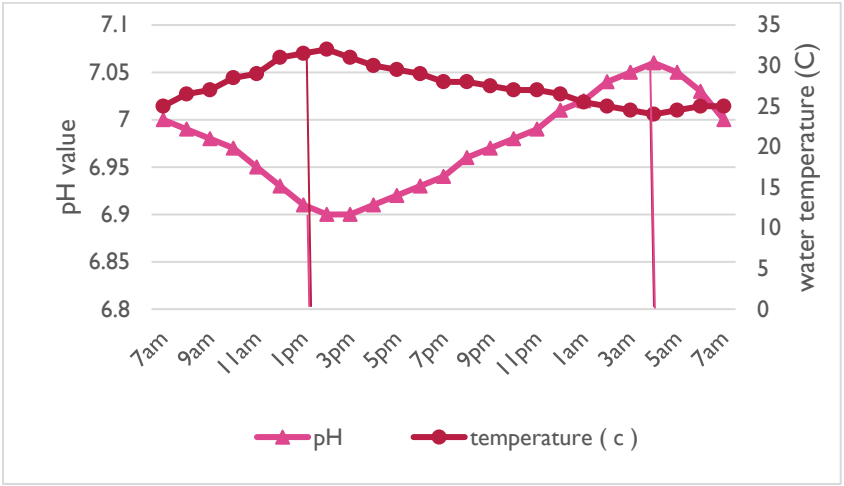

Figure 3. Plot of temperature and pH versus time.

3. Novelty and uniqueness

This study is considered novel because it uses commercially available sensors to continuously monitor temperature and pH in aquaculture systems under real operating conditions. Unlike traditional studies that rely on laboratory instruments or periodic manual measurements, this research applies real-time sensor data to observe how these two critical water quality parameters interact in actual aquaculture environments. By combining temperature and pH analysis, the study provides a more realistic understanding of water quality dynamics that affect aquatic health and productivity. The approach bridges the gap between controlled laboratory research and field-based application, demonstrating that affordable, off-the-shelf sensor technology can be effectively used for scalable and practical aquaculture monitoring and management solutions.

4. Benefit to mankind

This research benefits mankind by enhancing food security, promoting sustainable aquaculture practices, improving seafood safety, and providing affordable monitoring solutions that support both environmental protection and economic stability.

5. Innovation and Entrepreneurial Impact

The project promotes innovation by highlighting the practical use of commercially available sensor technology in aquaculture systems. It encourages the application of existing technologies in new, data-driven ways, shifting traditional aquaculture practices toward real-time monitoring and evidence-based management. By focusing on measurable environmental parameters, the study demonstrates how research can be transformed into practical solutions for industry challenges. The emphasis on commercial sensors signals strong market relevance, inspiring researchers, students, and practitioners to explore product development, service innovation, and technology-based enterprises. This approach lowers barriers to entry for small-scale farmers and local entrepreneurs, making innovation more accessible. Within institutions and communities, the study fosters interdisciplinary collaboration and strengthens links between research and industry. Overall, the title supports a culture of entrepreneurship by promoting scalable, affordable, and sustainable smart aquaculture solutions that generate both economic and social value.

6. Potential commercialization

The study enables commercialization of a low-cost, sensor-based aquaculture monitoring solution that improves productivity, reduces losses, and supports data-driven farm management through scalable hardware and software offerings.

7. Acknowledgment

The authors would like to thank the Faculty of Electrical Engineering, Universiti Teknologi MARA, for providing the laboratory facilities and financial support.

8. Researchers' Biography

She is a senior lecturer at the Faculty of Electrical Engineering, Universiti Teknologi MARA since 2005. She graduated from the Universiti Tenaga Nasional (UNITEN), Kajang with Bachelor of Electrical and Electronics Engineering in 2000. She started her first job as a process engineer at Seagate (M) Sdn. Bhd., Penang before furthering her study in master's degree in the field of microelectronic at the Universiti Kebangsaan Malaysia (UKM). Then she worked as a process engineer at MIMOS Berhad. She received PhD from the La Trobe University, Australia in the field of Electronic Engineering in 2013.

Zambri Harun is a professor in turbulence and renewable energy. He is the Chairman of the Department of Mechanical and Manufacturing Engineering at the Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia (UKM). Before joining UKM, he worked as a process engineer at Motorola (M) Sdn. Bhd. and as a mechanical and electrical design manager for the Gerbang Selatan Bersepadu (GSB) project in Johor Bahru. He is a principal consulting engineer, contributed to engineering programme accreditation, and examined professional engineers. He holds a BSc and MEng in Mechanical Engineering from Rensselaer Polytechnic Institute, New York, and a PhD in turbulence and wall-bounded flows from the University of Melbourne.

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She is a Senior Lecturer at the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM) Shah Alam. She received her PhD in Electrical Engineering from Universiti Teknologi MARA in 2015, MSc. in Microelectronics in 2003 and BEng (Hons) in Micorelectronics 2002. She specializes in semiconductor devices, microelectronics education, and thin-film materials, with research focused on ZnO-based thin films on flexible substrates using sol-gel and immersion techniques. Her work also extends to sensor development and organic optoelectronic devices, including OLED-related studies. She can be contacted via email: sobihana@uitm.edu.my.

Smart PV Performance Maximization Using Resistance Modeling and IoT-Enabled MPPT

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ABSTRACT

Conventional photovoltaic (PV) monitoring often ignores internal resistive losses, particularly series resistance (Rs) and shunt resistance (Rsh), which significantly limit energy harvesting. This innovation was developed to address this gap by creating a smart, resistance-aware solar optimization system that integrates double-diode modeling, MATLAB simulation, Maximum Power Point Tracking (MPPT), and real-time IoT monitoring. The system analyzes how Rs and Rsh influence key parameters such as short-circuit current (Isc), open-circuit voltage (Voc), fill factor (FF), and maximum power (Pmax), across different PV cell types. These insights are embedded into a Perturb and Observe (P&O) MPPT algorithm implemented on an ESP32 microcontroller, with live data acquisition via Blynk and Telegram. By combining analytical results with real-time measurements, the system optimizes PV output based on resistance behavior rather than relying solely on voltage and current. Its uniqueness lies in the resistance-aware MPPT strategy, low-cost IoT architecture, and integration of simulation with experimental validation. The approach detects performance degradation due to resistive losses and enhances power extraction dynamically. This innovation offers socio-economic and environmental benefits through improved efficiency, reduced energy waste, and lower operational costs. It has strong commercialization potential as a scalable smart PV monitoring and optimization kit for residential, educational, and small industrial applications.

Keywords: Double-diode photovoltaic model; Series and shunt resistance; Maximum power point tracking (MPPT); MATLAB simulation; IoT-based monitoring

1. Product Description

This project introduces a smart approach to improving solar panel performance. It focuses on a problem that is often overlooked in many photovoltaic systems, namely energy losses caused by internal resistance such as series resistance (Rs) and shunt resistance (Rsh). Instead of monitoring only voltage and current like conventional systems, this solution studies how these hidden resistive effects reduce power output and use that insight to improve performance.

Using a double-diode model in MATLAB, the system analyzes how Rs and Rsh influence key parameters such as current, voltage, fill factor, and maximum power. These findings are applied to a resistance-aware MPPT algorithm running on an ESP32 microcontroller. With IoT integration through Blynk and Telegram, users can monitor solar performance in real time, receive updates, and track efficiency from anywhere. The system is compact, low-cost, and easy to integrate with existing solar installations or use as a standalone monitoring kit. It helps detect performance degradation early and enhances energy extraction dynamically. By combining intelligent simulation

with real-time hardware monitoring, this innovation turns ordinary solar panels into smarter, more efficient energy systems suitable for homes, labs, educational use and small industries.

2. Methods and Results

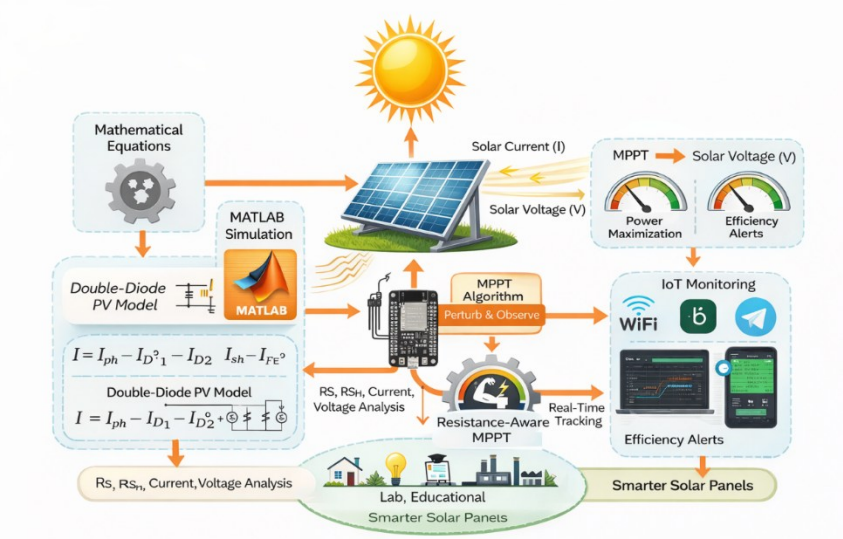

Figure 1. Overall Process of MATLAB–MPPT–IoT Integrated Solar Optimization.

Figure 1 illustrates the complete workflow of the smart solar optimization system, starting from mathematical modeling of the double-diode PV equations and MATLAB simulation. The system analyzes Rs, Rsh , current, and voltage to understand their impact on solar cell performance. A resistance-aware MPPT algorithm using the Perturb and Observe (P&O) method is then implemented on an ESP32 microcontroller for real-time tracking. Finally, IoT platforms enable live monitoring, efficiency alerts, and practical application in laboratory, educational, and smart solar panel environments. Simulation results using MATLAB integrated with the P&O MPPT algorithm demonstrated that the High-Efficiency Lab Cell with series resistance (Rs = 1.7 Ω) and shunt resistance (Rsh = 5000 Ω) achieve the highest performance among all tested cells, reaching an efficiency of 93.23% and a maximum power output (Pmax) of 3.9155 W (as shown in **Table 1** and **Figure 2**).

Real-time validation using an ESP32 microcontroller under natural sunlight conditions confirmed this trend. The same High-Efficiency Lab Cell recorded an efficiency of 75.89% and a maximum power output of 7.59 W, outperforming both the Typical Lab Cell and General Commercial Lab Cell (as shown in **Table 2** and **Figure 3**). Further time-based analysis revealed that at peak solar irradiance (12:30 PM), the system achieved its highest recorded performance with an efficiency of 91.65% and a maximum power output of 22.91 W. This daytime performance trend is clearly illustrated in **Table 3**. These findings strongly validate the importance of low series resistance and high shunt resistance in enhancing the effectiveness of MPPT and highlight the practical value of integrating IoT-based real-time monitoring for photovoltaic system optimization.

Table 1. Simulation Parameters Comparison Between the Lab Cells.

Cell / Parameter	Typical	High-Efficiency	General Commercial
Isc (A)	5	7	3
Voc (V)	0.69	0.70	0.68
Pmax (W)	2.7148	3.9155	1.5104
η (%)	90.49	93.23	84.76

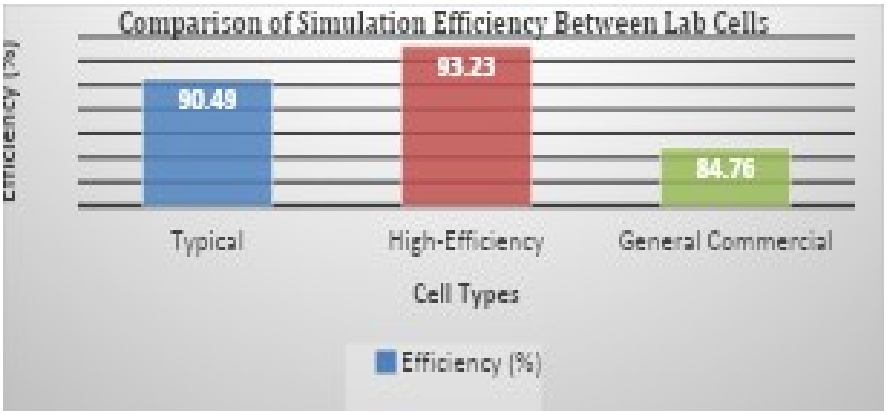

Figure 2. Comparison of Simulation Efficiency (%) Between Typical, High-Efficiency, and General Commercial Lab Cells.

Table 2. Real-Time Performance Parameters Comparison Between the Lab Cells Using ESP32 IoT Monitoring.

Cell / Parameter	Typical	High-Efficiency	General Commercial
Isc (A)	0.782	0.794	0.745
Voc (V)	12.45	12.75	12.30
Pmax (W)	7.30	7.59	6.87
η (%)	73.00	75.89	68.68

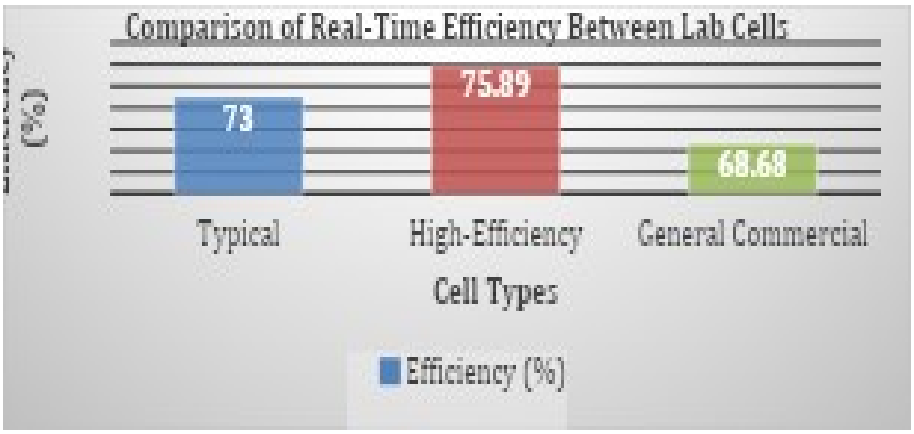

Figure 3. Comparison of Real-Time Efficiency (%) Between Typical, High-Efficiency, and General Commercial Lab Cells.

Table 3. Data Analysis of Isc(A), Voc(V), Pmax(W) and efficiency (%) for 3 phases times.

Cell / Time	9.30 a.m	12.30 p.m	3.30 p.m
Isc (A)	1.34	1.66	0.16
Voc (V)	13.43	10.98	27.18
Pmax (W)	21.05	22.91	4.39
η (%)	84.19	91.65	17.57

3. Novelty and uniqueness

This work introduces a resistance-aware solar optimization system where Rs and Rsh are used as intelligent indicators for MPPT control and real-time PV performance enhancement, validated through MATLAB simulation and IoT-based hardware monitoring.

4. Benefit to mankind

This innovation enables solar panels to generate more energy, last longer, and waste less power by intelligently monitoring and optimizing hidden resistive losses, making renewable energy more affordable, efficient, and sustainable for society.

5. Innovation and Entrepreneurial Impact

This project introduces a smarter approach to solar optimization by using Rs and Rsh as key indicators for improving photovoltaic performance. Unlike conventional systems that rely only on voltage and current, this resistance-aware method enables more accurate MPPT control, validated through MATLAB simulation and real-time IoT monitoring. It transforms PV monitoring into a diagnostic-driven, intelligent energy management system. Built with low-cost components such as ESP32, sensors, and IoT platforms, the solution can be developed into a practical smart PV monitoring and optimization kit. It can be retrofitted into existing solar installations and applied in homes, schools, laboratories, and small industries. The system also serves as a valuable educational tool for renewable energy training. With growing demand for efficient solar solutions, this innovation offers strong commercialization potential for startups and green technology providers, supporting scalable, IoT-based products for smarter and more sustainable solar energy systems.

6. Potential commercialization

This innovation can be commercialized as a Smart PV Monitoring and Optimization Kit that improves solar panel performance by detecting internal resistive losses (Rs and Rsh) and applying resistance-aware MPPT in real time. The product may include compact hardware unit (ESP32 with sensors and preloaded firmware), an IoT dashboard for live monitoring, and alert features for performance tracking. Target users include homeowners with rooftop solar, schools and universities, small industries, and solar installation or maintenance companies. The system can be retrofitted into existing PV setups, making it attractive for upgrading current installations without replacing panels. Revenue opportunities include device sales, subscription-based cloud monitoring, installation services, and licensing to solar service providers. With the rapid growth of solar adoption and demand for smarter energy management, this low-cost, scalable solution fits well into the expanding IoT and renewable energy market, offering practical value for efficient solar optimization.

7. Acknowledgment

The authors would like to express their sincere appreciation to the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM), Shah Alam, for providing the facilities and resources necessary to carry out this project.

8. Researchers' Biography

Muhammad Izham Bin Ismail is an undergraduate student at the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM), Shah Alam, Malaysia. His interests include renewable energy systems, photovoltaic modeling, and Internet of Things (IoT) applications for smart energy monitoring. His final year project focuses on optimizing solar cell performance using the double-diode model, MATLAB simulation, MPPT techniques, and real-time monitoring with ESP32 and cloud platforms. Through this work, he aims to develop intelligent solutions that improve solar energy efficiency and support practical, low-cost implementations for smarter renewable energy systems.

Puteri Sarah Mohamad Saad is a Senior Lecturer at the Center for Electronic Engineering Studies, Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM), Shah Alam. She earned a PhD in Electrical Engineering from UiTM and a Master of Science in Microelectronics from Universiti Kebangsaan Malaysia (UKM). Her research focuses on nanocomposites, nanostructure synthesis, thin-film devices, sensors, and IoT. She has published over 30 papers in indexed journals and IEEE conferences and contributed to grants including FRGS and e-Science. Her awards reflect dedication to research excellence, innovation, and advancing electronic materials.

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Shafinaz Sobihana Shariffudin is a Senior Lecturer at the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM) Shah Alam. She received her PhD in Electrical Engineering from Universiti Teknologi MARA in 2015, MSc. in Microelectronics in 2003 and BEng (Hons) in Micorelectronics 2002. She specializes in semiconductor devices, microelectronics education, and thin-film materials, with research focused on ZnO-based thin films on flexible substrates using sol-gel and immersion techniques. Her work also extends to sensor development and organic optoelectronic devices, including OLED-related studies.

Smart Padi: Solar-Powered IoT System for Intelligent Paddy Field Monitoring

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ABSTRACT
Rice farming plays a crucial role in ensuring rice supply for millions of people around the world, but many paddy farmers still depend on manual observation and traditional practices to manage their fields. This often leads to over-watering, water shortages, and delayed responses to changing field conditions, which can reduce crop yield and increase costs. To overcome this problem, our project introduces Smart Padi, a solar-powered IoT monitoring system designed to help farmers manage their paddy fields more easily and efficiently. The system uses sensors to monitor important conditions such as water level, temperature, and soil pH in real time. The data is sent wirelessly, allowing farmers to check field conditions and receive early warnings when action is needed. Powered by solar energy, Smart Padi works well even in remote areas without stable electricity. By giving farmers timely and reliable information, the system reduces guesswork, saves water, and supports healthier crop growth. This innovation not only helps farmers improve productivity and reduce labor but also supports sustainable farming and national food security. Smart Padi represents a simple yet impactful step toward smarter and greener rice farming for the future.

Keywords: IoT monitoring, Smart paddy farming, Solar-powered irrigation, Precision agriculture, Sustainable farming

1. Product Description
Smart Padi is a solar-powered IoT monitoring system designed to help paddy farmers manage their fields more efficiently and sustainably. Traditional paddy farming often depends on manual observation, which can lead to overwatering, water shortages, and delayed responses to changing conditions. Smart Padi solves this by providing real-time field information that farmers can rely on. The system uses sensors to monitor key parameters such as water level, soil pH, and temperature. These readings are sent wirelessly to a monitoring platform, allowing farmers to check their field conditions anytime. When abnormal conditions are detected, the system sends early alerts so farmers can take quick action before crops are affected. Powered by solar energy, Smart Padi works well in remote areas without stable electricity, making it cost-effective and environmentally friendly. The system is also designed to be simple and user-friendly so that farmers can use it without technical expertise. By reducing guesswork and improving water management, Smart Padi helps farmers save resources, protect crop health, and increase productivity. This innovation supports smarter farming, sustainability, and stronger food security for the future.

2. Project Methodology and Result

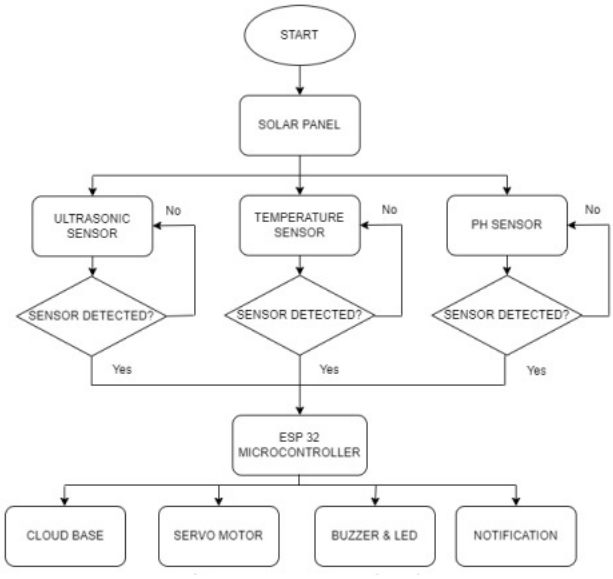

Figure 1. Flowchart of Methodology.

Table 1. pH and Temperature measured by Smart Padi at different conditions.

Case	Condition	pH	Temperature (°C)
Tap Water	Surface	6.83	28.37
		6.82	29.20
		6.83	28.37
	In Soil	6.63	27.81
		6.63	27.32
		6.61	26.78
Hot Water	Surface	8.30	77.80
		8.46	75.35
		8.60	72.00
	In Soil	7.43	76.33
		6.98	72.99
		7.83	69.40
Acidic Water (Orange juice)	Surface	3.83	15.23
		3.83	16.00
		4.21	17.56
	In Soil	4.21	21.14
		4.56	22.71
		4.81	24.12

3. Novelty and uniqueness

The novelty of this IoT-based paddy monitoring system lies in its combination of practicality, sustainability, and farmer-centered design**,** tailored specifically for Malaysian paddy field conditions. Unlike many existing systems that focus only on irrigation control, this system integrates multi-parameter monitoring**,** including water level, soil pH, and temperature. This provides a more complete understanding of field conditions, allowing farmers to make better decisions rather than relying on a single parameter. Another key uniqueness is the use of solar power as the primary energy source**,** making the system suitable for remote paddy fields where electricity access is limited. This reduces operating costs and supports environmentally friendly farming. The system is also designed to be simple, low-cost, and user-friendly**,** ensuring that small-scale farmers can adopt it without requiring advanced technical knowledge. Many high-tech solutions remain inaccessible due to cost and complexity, but this system focuses on affordability and ease of use.

4. Benefit to mankind

Smart Padi benefits mankind by helping to protect one of the world's most important food sources, rice by supporting farmers to produce more stable and healthier yields. When farmers can monitor their fields accurately, they can respond quickly to problems and reduce crop losses, which contributes to better food security. The system also encourages responsible water use, helping to reduce wastage in a crop that typically requires large amounts of water. This not only protects the environment but also preserves resources for future generations. Powered by solar energy, Smart Padi reduces reliance on electricity and promotes cleaner energy use. At the same time, it supports small farmers by providing simple and practical technology to improve their productivity and income. Overall, smarter and more sustainable farming leads to a more reliable food supply, better environmental protection, and improved well-being for communities.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by showing how simple and affordable technology can solve real farming problems. Instead of relying on expensive or complex systems, Smart Padi uses practical IoT and solar solutions that can be realistically adopted by local farmers. This encourages a mindset that innovation does not always mean high cost, but smart and useful design. From an entrepreneurial perspective, Smart Padi creates opportunities for local businesses, students, and startups to develop, install, and maintain smart farming systems. It can inspire young entrepreneurs to explore agri-tech solutions and turn ideas into real products or services. Within institutions, it also encourages collaboration between researchers, engineers, and the agricultural community. By linking technology with agriculture, this project helps build a culture where innovation is seen as a tool to improve livelihoods. It opens pathways for small-scale enterprises and supports the growth of a modern, technology-driven farming industry.

6. Potential commercialization

Smart Padi has good commercialization potential because it solves a real problem faced by many farmers, which is water management and monitoring crops effectively. The system can be offered as an affordable product or service to paddy farmers, cooperatives, and agricultural agencies, either as a one-time purchase, rental, or subscription for monitoring support. There is also room to work with government programs and agri-tech companies that promote smart farming. Local entrepreneurs and technicians could be involved in installation and maintenance, creating business

opportunities within the community. Since the system is scalable and can be adapted for other crops, its market is not limited to paddy farming alone. With the growing demand for sustainable and digital agriculture, Smart Padi has the potential to reach wider markets, including other rice-producing regions, making it a practical and promising commercial solution.

7. Acknowledgment

The authors would like to sincerely thank Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM) Shah Alam for their support throughout this project. The facilities, resources, and guidance provided by the faculty made it possible for this work to be carried out smoothly.

8. Researchers' Biography

Shafinaz Sobihana Shariffudin is a Senior Lecturer at the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM) Shah Alam. She received her PhD in Electrical Engineering from UiTM Shah Alam in 2016. She graduated MSc. in Microelectronics and BEng. Microelectronics from Universiti Kebangsan Malaysia (UKM). She specializes in semiconductor devices, microelectronics education, and thin-film materials, with research focused on ZnO-based piezoelectric energy harvesters on flexible substrates using sol-gel and immersion techniques. She has published more than 40 papers in IEEE and Scopus-indexed journals and conferences.

Muhammad Zarul Ikmal bin Nordin is a graduate in Electrical Engineering from Universiti Teknologi MARA (UiTM) Shah Alam, having completed his Bachelor of Engineering (B.Eng.) in March 2023. He was trained in key areas of electrical engineering such as electrical systems, electronics, and control technologies, and gained hands-on experience through laboratory and project-based work. His academic background has equipped him with solid technical knowledge, analytical skills, and problem-solving abilities.

Puteri Sarah Mohamad Saad is a Senior Lecturer at the Center for Electronic Engineering Studies, Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM), Shah Alam. She earned a PhD in Electrical Engineering from UiTM and a Master of Science in Microelectronics from Universiti Kebangsaan Malaysia (UKM). Her research focuses on nanocomposites, nanostructure synthesis, thin-film devices, sensors, and IoT. She has published over 30 papers in indexed journals and IEEE conferences and contributed to grants including FRGS and e-Science. Her awards reflect dedication to research excellence, innovation, and advancing electronic materials.

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A Bio-Based Corrosion Inhibitor for Steel in Halide and Thermal Variations

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ABSTRACT

This innovative approach explores the use of mango peel extract (MPE) in combination with potassium iodide (KI) as a sustainable corrosion inhibitor for mild steel under acidic conditions and varying temperatures. The project was performed to reduce corrosion issues in metal industry. The corrosion inhibition performance was evaluated using the weight loss method in 0.5 M HCl at temperatures range 25°C to 60°C. The findings show that adding KI greatly improved the effectiveness with the highest inhibition efficiency reaching 99.83% at 350 ppm MPE with KI, even the lowest efficiency remaining above 80%. Most of the inhibition efficiencies were above 90% at higher temperatures, showing good thermal stability. Micro surface analysis verified that the protected steel surface exhibited a smoother appearance with reduced corrosion defects. Overall, the inhibitor system demonstrates excellent efficiency and thermal resistance, with additive-assisted performance enhancement. This formulation has the potential to be commercialized due to its excellent prospect in metal troubleshooter for corrosive medium, cost-effective and eco-friendly invention. Eventually, the innovative plant residue usage was capable to reach the market demand in corrosion inhibitors production establishing it as an environmentally benign and sustainable corrosion inhibitor for industrial applications.

Keywords: Mango Peel Extract (MPE), Corrosion Inhibition, Mild Steel, Potassium Iodide (KI), Thermal Stability

1. Product Description

The product benefits from mango peel extract (MPE), an environmentally sustainable agricultural by-product, as the main active component in a green corrosion inhibitor for mild steel exposed to acidic and halide-rich environments. Mango peel contains abundant bioactive phytochemicals, such as polyphenols, flavanoids, and tannins which showed significant adsorption properties and provide a protective layer on metal surfaces, hence reducing metal dissolution and corrosion. This formulation synergistically combines MPE with KI, improving surface coverage, adsorption strength, and thermal stability, thus preserving high inhibition efficiency at increased temperatures. Transforming mango peel waste into a value-added bioresource minimizes environmental impact while providing a cost-effective, non-toxic, and sustainable alternative to conventional synthetic inhibitors. It demonstrates potential as an alternative for large-scale corrosion protection due to its high efficiency, environmental sustainability, and applicability in industrial applications, which highlights its innovative potential and strong commercialization prospects.

2. Methods and Results

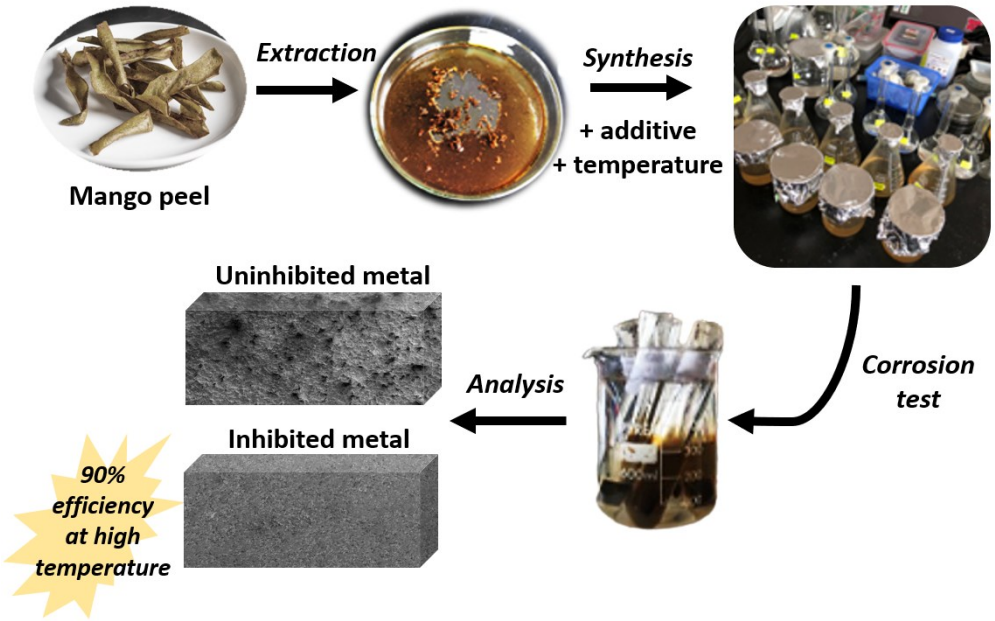

Figure 1. Flow chart of Experimental Procedure.

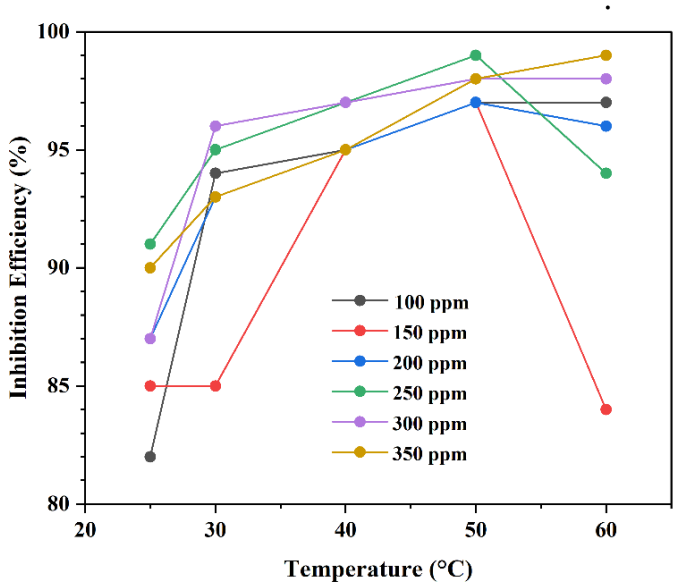

Figure 2 Effect of temperature on inhibition efficiency.

The experimental work has been successfully carried out starting with extraction and synthesis, followed by the corrosion test, then surface analysis **(Figure 1)**. The findings indicate that the combination of MPE and KI significantly enhances the corrosion inhibition efficiency of mild steel across all tested concentration and temperatures. The combination of MPE and KI achieved inhibition efficiency between 82% and 99.8% **(Figure 2)**, with most values over 90%, indicating steady and consistent protection even at elevated temperatures. This enhancement indicates that iodide ions facilitate the adsorption of MPE molecules onto the mild steel surface. Microstructure

images complement these findings, demonstrating that mild steel immersed in 0.5M HCl at 60°C as shown in **Figure 3** has a rough surface characterized by deep corrosion pits resulting from extensive corrosion. In comparison, the mild steel sample immersed in 350 ppm MPE in the presence of KI **(Figure 4)** exhibits a much smoother surface with minimal corrosion degradation. This suggests the development of a protective layer on the steel surface, resulting in a high inhibition efficiency of 99.83% at 60°C.

Figure 3 Microstructure images of mild steel after 3h in 0.5M HCl at 60°C

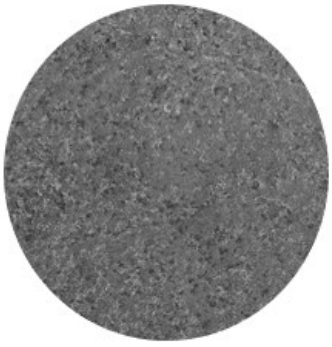

Figure 4 Microstructure images of mild steel after 3h in 0.5M HCl + KI + 350 ppm MPE at 60°C.

3. Novelty and uniqueness

This study presents a sustainable method for controlling mild steel corrosion in halide-rich acidic conditions by using mango peel extract (MPE) as an eco-friendly corrosion inhibitor. The novelty of the study is investigating the capability and effectiveness of both MPE and KI as corrosion inhibitor for mild steel. This innovative work was initially performed by synthesizing the plant waste containing additive in acidic environment. Further, a systematic analysis in measuring the inhibition efficiency under elevated temperature combined additives was executed, where fewer studies have focused on the thermal behavior of green inhibitors. The uniqueness of this work is the incorporation of MPE and halide ion. The examination on the synergistic effect of MPE and halide ions, namely iodide ions, on corrosion inhibition performance revealed the high performance. The variations in inhibition efficiency are reviewed concerning potential synergistic interactions and competitive co-adsorption on the mild steel surface. This diversify usage of agro-waste materials enhance the functionality of chemical compounds in the byproduct.

4. Benefit to mankind

This study contributes to society and the environment by examining the use of mango peel extract, an agricultural byproduct, as an eco-friendly corrosion inhibitor for mild steel. Utilizing biodegradable and low toxicity materials minimizes the dependence on potentially harmful synthetic chemicals that can be harmful to human health and the environment. Moreover, using waste materials like mango peels promotes sustainable waste management and supports a more effective utilization of natural resources. Enhanced corrosion control for mild steel could improve the durability of industrial materials, including pipelines, storage tanks, and building structural parts. This minimizes maintenance expenses, material waste, and the potential of equipment malfunction. Overall, the study supports safer industrial practices and encourages ecologically sustainable solutions, delivering long-term societal benefits.

5. Innovation and Entrepreneurial Impact

This study fosters innovation by using mango peel, an agricultural byproduct, as an eco-friendly corrosion inhibitor, providing a more sustainable alternative to conventional chemical inhibitors. It promotes innovative solutions to industrial issues while maintaining environmental sustainability. The study emphasized prospects for entrepreneurial ventures in sustainable chemical products, demonstrating how waste materials may be transformed into valuable and cost-effective solutions. It illustrates the potential to reduce expenses and environmental effects via the use of eco-friendly corrosion control approaches. This initiative has the potential to inspire academicians and researchers at various institutions to raise innovative and sustainable solutions. This study also encourages a culture of creativity and entrepreneurship by connecting research to practical and sustainable applications.

6. Potential commercialization

This study demonstrates the opportunity for commercialization by promoting the mango peel extract as an environmentally sustainable corrosion inhibitor for mild steel. Industries using steel equipment, pipelines, or storage tanks may use this eco-friendly solution as a safer and more sustainable alternative for conventional chemical inhibitors, therefore minimizing environmental impact and operating expenses. The inhibitor containing additive and mango peel extract may be formulated in several types, including a liquid additive for industrial cleaning or acid treatment, or as a protective coating for long-term protection. The use of abundant and inexpensive waste material like mango peel makes a large-scale production possible. This initiative may also encourage small enterprises or startups to change agricultural waste into value-added corrosion protection products, therefore supporting sustainable industrial practices and delivering economic and environmental benefits.

7. Acknowledgment

The authors wish to acknowledge the financial support provided by the Ministry of Higher Education (MOHE) Malaysia through the Fundamental Research Grant Scheme (FRGS-EC/1/2024/STG04/UITM/02/22) and Universiti Teknologi MARA.

8. Researchers' Biography

Nurul Ain Syasya Binti Muhamad Rizal is a student at Universiti Teknologi MARA (UiTM) Perlis, majoring in Chemistry. For her final year project, she is investigating sustainable corrosion control using plant-based inhibitors, focusing on the potential of mango peel extract, with the aid of halide ions, as an eco-friendly solution for protecting mild steel. Through this project, she is gaining hands-on experience in experimental design, surface analysis, and data interpretation, while applying her knowledge of chemistry and management to develop practical and environmentally responsible solutions.

Dr. Solhan Yahya is a Senior Lecturer at Universiti Teknologi MARA (UiTM) Perlis, specializing in the field of Chemistry. She received her PhD in Materials Science from Universiti Kebangsaan Malaysia. Her research expertise lies in corrosion prevention and control, with particular emphasis on the study of corrosion inhibitors. Her research interests also encompass electrochemistry, surface science, advanced materials and polymer chemistry.

Assoc. Prof. Dr. Razif Bin Muhammed Nordin is a polymer chemist with expertise in polymer science and materials engineering at Universiti Teknologi MARA (UiTM) Perlis. He earned his Ph.D. in Polymer Blends from Universiti Sains Malaysia in 2011. His research spans polymer composites, bio-based materials, and high-performance thermosets, with 70+ publications, including 18 indexed journals (3 Q1, 5 Q2) and a cumulative impact factor of ~34.9. Passionate about teaching, innovation, and sustainability, he actively mentors' students, contributes to professional societies, and advances research in sustainable materials.

Dr. Wan Nur Atikah Haji Wan Nafi is a Senior Lecturer at Faculty of Applied Sciences, Universiti Teknologi MARA (UiTM) Perlis. She graduated from University of New South Wales (Canberra) with a PhD in Chemistry. Her research interests include surface chemistry, solution chemistry, physical chemistry, water treatment and advanced materials.

Design and Implementation of an IoT-Integrated PLC System for Real-Time Power Monitoring and Automatic Power Factor Correction

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ABSTRACT
The common use of inductive loads in industrial and commercial single-phase electrical installations leads to poor power factor problems which result in energy waste and higher electricity expenses and utility penalty charges. This paper presents the design and implementation of a novel IoT-integrated Programmable Logic Controller (PLC) system for real-time power monitoring and automatic power factor correction in single-phase 230V AC networks. The system consists of five functional modules which include a power supply unit, a control and processing core, a measurement and sensing interface, a switching and compensation stage, and a load management section. The control core uses a FATEK FBs-14MAT2-AC PLC to run the compensation algorithm which handles actual data from current and potential transformers that link to an energy analyzer. The system achieves reactive power compensation through the controlled operation of four 1μF 230V AC capacitor banks which the PLC manages using optically isolated 5V DC relay modules. An ESP32-S1 microcontroller enables IoT functionality by sending critical parameters which include voltage current active power reactive power and power factor to the ThingSpeak cloud platform for remote monitoring and data storage while a local I2C LCD provides on-site display. The system underwent thorough testing using an experimental setup which included an AC induction motor and a resistive lamp bank. The experimental results show that the power factor increased from 0.65 to 0.95 which resulted in a 44.6% power factor improvement and a 75% reduction of reactive power demand together with the complete removal of power factor penalties. This integrated PLC-IoT solution requires about RM 850 to implement which makes it both affordable and expandable. The study develops an advanced system which uses artificial intelligence to enhance power quality control in small and medium-sized enterprises, resulting in major energy conservation and improved business performance.

Keywords: Power Factor Correction, Programmable Logic Controller, Internet of Things, Single-Phase System, Reactive Power Compensation, Energy Management.

1. Product Description
The system provides a complete solution that combines hardware and software components to enable automatic power factor correction for single-phase 230V AC systems. The system divides its functions into five separate modules. The Power Supply Module uses a 230V AC single-phase input to supply power to a Switch-Mode Power Supply (SMPS) which produces a constant 5V DC output that operates all low-voltage control electronics. The Control & Processing Module

functions as the system's brain because it uses a FATEK FBs-14MAT2-AC Programmable Logic Controller (PLC) to control its operations. The PLC uses a proprietary ladder logic program to assess power quality while deciding the appropriate compensation needs. The system establishes a connection with an ESP32-S1 microcontroller which manages IoT communication. The Measurement & Sensing Module uses a Current Transformer (CT) and a Potential Transformer (PT) to measure electrical parameters with high accuracy. The energy analyzer receives their outputs to compute real-time voltage and current and active power and reactive power and power factor measurements. The Switching & Correction Module executes physical compensation operations. The system contains four separate capacitor banks which each provide 1µF capacitance at 230V AC. The PLC's relay outputs activate the 5V DC single-pole relay (R1-R4) which connects each capacitor in parallel to the main line. The Interface & Load Module creates two functions which allow users to interact with the system and perform testing activities. The system shows all measured parameters through a 20x4 I2C LCD display which shows measurements at the local site. The system uses an AC induction motor (inductive) and a resistive lamp bank as validation load to test its performance. The system transmits all information through Wi-Fi directly to the ThingSpeak cloud platform which allows users to monitor data in real time and access past data through a specially designed web dashboard.

2. Block Diagrams

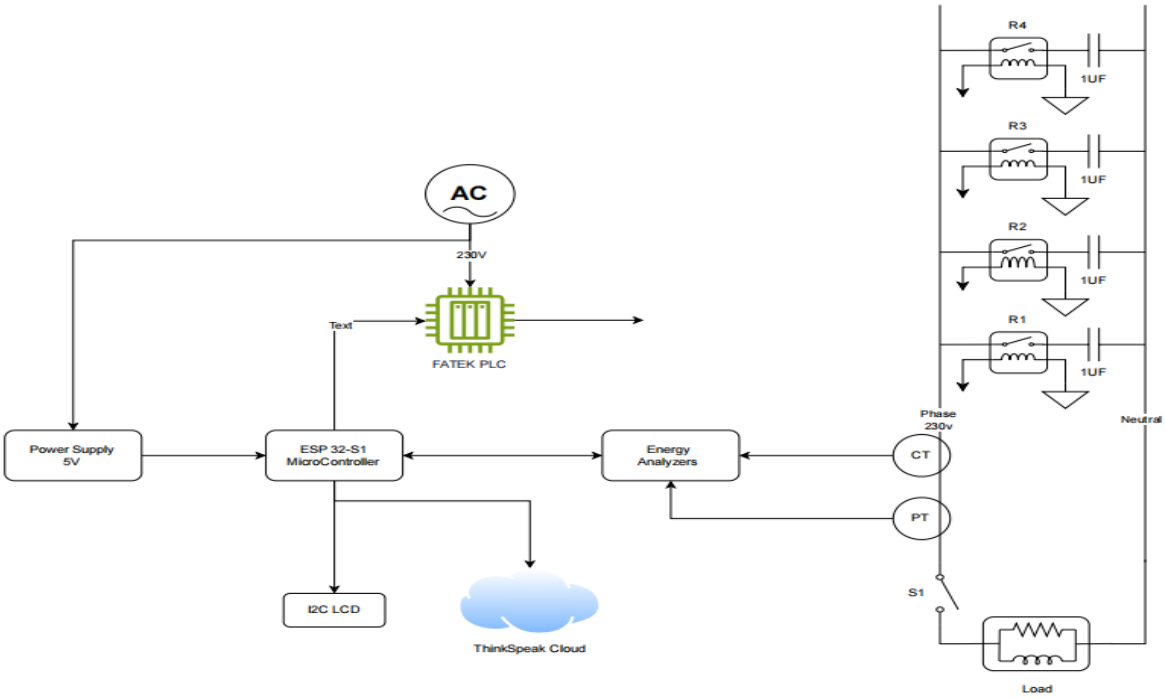

Figure 1. Circuit diagram of PLC-based automatic power factor correction system.

2.1 Flow Chart

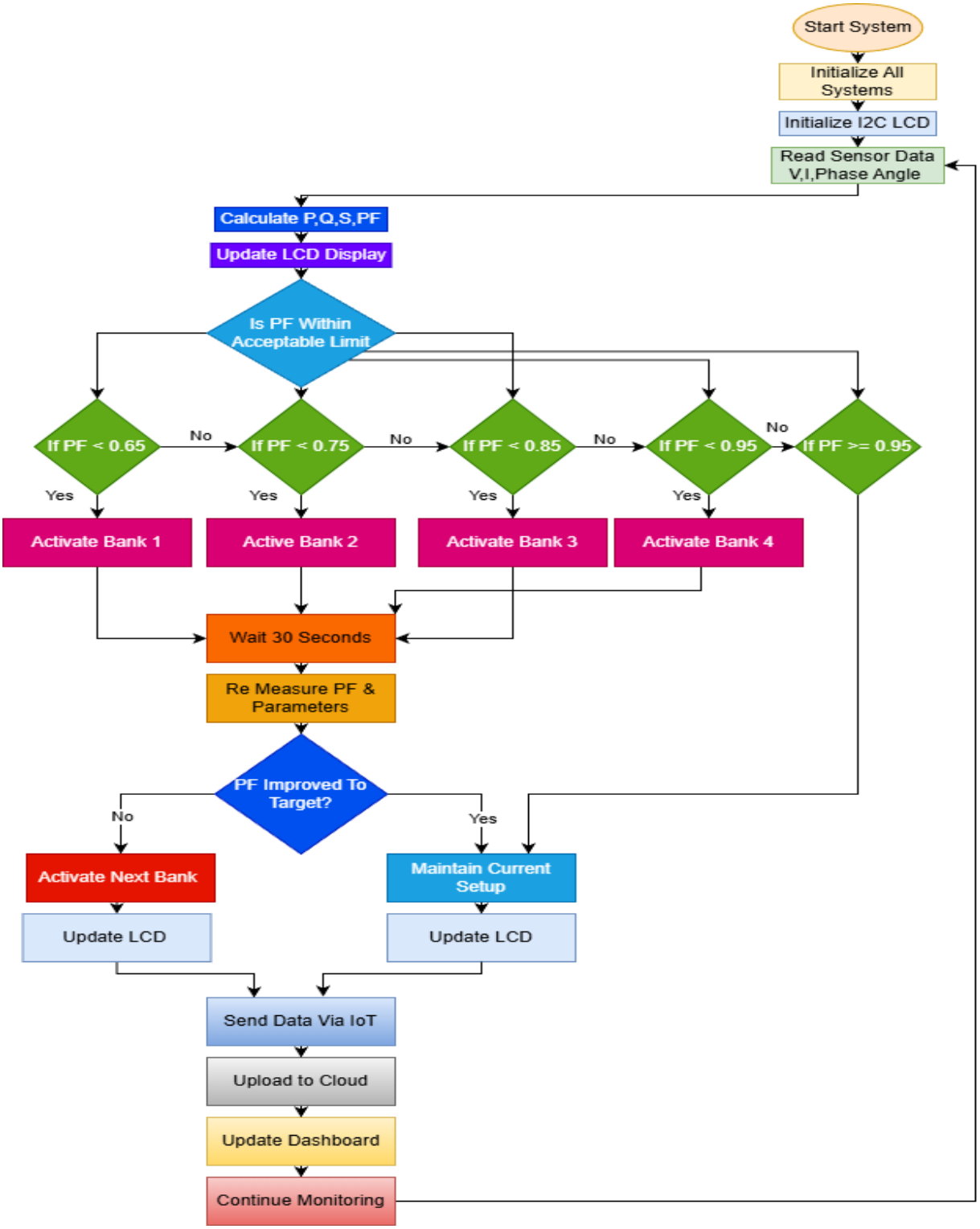

Figure 2. The system workflow and the data flow of the IoT system of the PLC power factor correction.

Table 1. Capacitor Switching Logic and Experimental Performance Analysis.

Operating Condition / Logic State	Supply Voltage (V)	Power Factor (cos ϕ)	Capacitor Bank Status	Total Capacitance (μF)	Reactive Power (Q) Impact
Initial Inductive Load (Baseline)	230	0.65	All OFF	0	High Reactive Demand
Correction Stage 1 (Logic Threshold)	230	< 0.65	Bank 1 ON	1	Initial Correction
Correction Stage 2 (Logic Threshold)	230	< 0.75	Banks 1 + 2 ON	2	Moderate Correction
Correction Stage 3 (Logic Threshold)	230	< 0.85	Banks 1 + 2 + 3 ON	3	High Correction
Correction Stage 4 (Logic Threshold)	230	< 0.95	Banks 1 + 2 + 3 + 4 ON	4	Maximum Correction
Final System State (After PFC)	230	0.95	Optimized	Variable	75% Reduction

2.2 Simulation

The simulation model uses MATLAB/Simulink to create an AC motor simulation which mimics the inductive characteristics of the experimental setup motor. The circuit consists of a series R-L branch which uses a 50 Ω resistor and a 0.15 H inductor to connect to a 230 V 50 Hz single-phase AC power source. The system uses measurement blocks to model current and potential transformers while the scope modules display their waveforms. The simulation results show the instantaneous voltage (top trace) and current (bottom trace) waveforms. The current lags behind the voltage by a phase shift of 49.5° according to our clear observation. The power factor equals 0.65 which matches the experimental baseline and provides justification for using the automatic capacitor-based correction system.

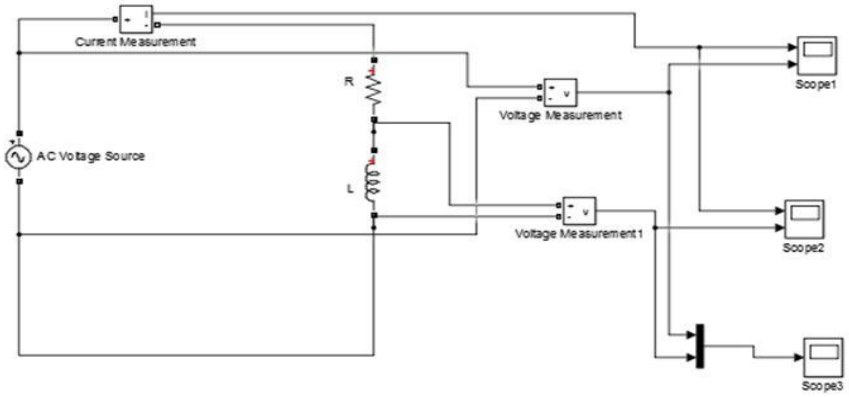

Figure 3. Simulation model of the R-L load.

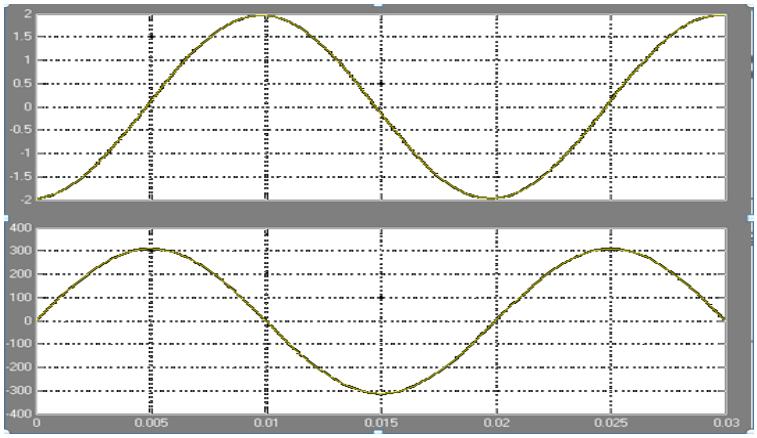

Figure 4. Simulated voltage and current waveforms of the R-L load.

3. Novelty and Uniqueness

The power factor (PF) shows the relationship between active power and apparent power according to its formula:

$$\text{PF} = \frac{P}{S} = \cos\ \phi$$

The phase angle ϕ describes the time difference between supply voltage and load current. Inductive loads create electrical currents that flow behind voltage signals which increases their reactive power consumption and decreases their power factor. The mathematical relationship between active power and reactive power shows that their combination creates apparent power:

$$S = \sqrt{P^2 + Q^2}$$

$$P = VI\cos\ \phi$$

$$Q = VI\sin\ \phi$$

where V represents the RMS voltage and I represents the RMS current. Power factor correction through reactive power compensation requires the installation of capacitors that operate in parallel with inductive loads. The required capacitive reactive power for power factor correction is calculated as:

$$Q_c = P(\tan\ \phi_1 - \tan\ \phi_2)$$

The initial phase angle before compensation ϕ_1and the desired phase angle after compensation ϕ_2. For a single-phase 230 V, 50 Hz system, the required capacitance is calculated using:

$$C = \frac{Q_c}{2\pi f V^2}$$

The system uses Programmable Logic Controller (PLC) to control automatic switching of four capacitor banks which each have a capacitance of 1 μF (230 V AC rated). Through its step-wise capacitor switching the system achieves power factor improvement from 0.65 to 0.94 which results in reactive power and apparent power reduction while active power stays the same. Fig. 5. The power triangle shows how active power (P) relates to reactive power (Q) and apparent power (S) while the power factor angle (ϕ) shows the energy distribution.

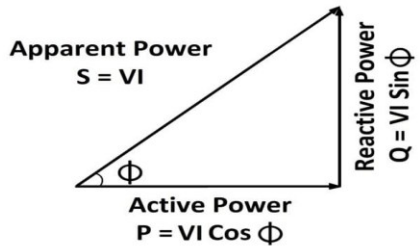

Figure 5. Power triangle illustrating active power (P), reactive power (Q), apparent power (S), and power factor angle (ϕ).

The novelty of the proposed system lies in the integration of an industrial-grade PLC with an IoT-enabled monitoring platform. A modular five-stage architecture is implemented to enable independent operation of power supply, sensing, control, switching, and load management modules. A hybrid switching strategy is adopted in which low-cost electromagnetic relays are combined with PLC-based zero-crossing logic to reduce capacitor inrush current. The PLC executes all time-critical switching locally, while an ESP32 microcontroller transmits real-time electrical parameters to the cloud for monitoring, analytics, and predictive maintenance. This cost-effective and scalable solution enables small and medium enterprises to adopt Industry 4.0-based energy management systems.

4. Benefit to mankind

The system provides important advantages to society through its ability to create energy-efficient solutions which generate economic resources and promote environmental protection. The system enables industries and businesses to achieve cost reductions because it removes utility power factor penalty charges which helps small and medium-sized enterprises to improve their

financial stability and market position. The system reduces electrical grid pressure through its power factor optimization and reactive power demand reduction which results in decreased transmission and distribution losses for the community. The improved grid efficiency results in stable voltage levels for all consumers while reducing the need for new infrastructure expenditures. The system decreases apparent power demand which leads to reduced electricity generation at power plants thus decreasing greenhouse gas emissions and fossil fuel use. The system provides electrical safety improvements through its continuous monitoring system which detects abnormal conditions that lead to equipment failure or fire hazards. The technology enables more people to access advanced energy management solutions which leads to increased participation in sustainable practices that support global climate action goals and foster responsible energy consumption.

5. Innovation and Entrepreneurial Impact

The project creates translational innovation through its combination of fundamental electrical engineering knowledge with Industry 4.0 technologies which enables the development of market-ready solutions from academic research. The institution establishes an innovation culture through its demonstration of interdisciplinary research through the development of a product that combines power systems with control theory and embedded programming and IoT data science. The project offers Johor manufacturing small and medium-sized enterprises (SMEs) an affordable way to enter smart energy management through its demonstration of how businesses can achieve digital transformation by using inexpensive local technology. The project creates a basic prototype that will develop into a startup business which will deliver economical single-phase automatic power factor correction (APFC) units to the Malaysian market. The organization promotes entrepreneurial development through its support of product development activities which include hardware design as well as firmware development and cloud integration and economic analysis. The student-built system solves an industrial problem which motivates students to conduct applied research while establishing their own businesses which supports Malaysia's national strategy to foster technology entrepreneurs and strengthen the engineering innovation ecosystem.

6. Potential commercialization

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strategy to foster technology entrepreneurs and strengthen the engineering innovation ecosystem.

7. Acknowledgment

The project supervisor from The Islamia University of Bahawalpur Department of Electrical Power Engineering received the authors' heartfelt appreciation for his essential support throughout their research work. The Department of Electrical Power Engineering allowed us to conduct our research work because they granted us access to their laboratories and their testing equipment and their research facilities. The technical support staff received special thanks for their help with the procurement of components and the implementation of safety measures during our system building and testing activities. The Islamia University of Bahawalpur provided funding for this project through its Final Year Project grant scheme. The authors recognized the main research work on power factor correction methods which they used to build their design according to the references they provided.

8. Researchers' Biography

Muhammad Saim Yaseen studies Electrical Engineering at The Islamia University of Bahawalpur in Pakistan because he wants to complete his final year of studies. His academic research interests include industrial automation systems and control systems and smart grid technology. For this project he developed the entire system design which included programming the PLC with ladder logic and creating the automatic power factor correction control algorithm which determines the best time to switch capacitor banks through actual power quality data.

Muhammad Faiq studies Electrical Engineering at The Islamia University of Bahawalpur in Pakistan because he wants to complete his final year of studies while specializing in embedded systems and power electronics. His work focused on designing and calibrating sensing circuitry that combined ZMPT101B voltage transformer and ACS712 current sensor components with the energy analyzer module. He developed firmware for the ESP32-S1 microcontroller system and implemented it so that the device could transmit data through Wi-Fi to ThingSpeak cloud services.

Dr. Zeeshan Ahmad Arfeen works as an Assistant Professor in The Islamia University of Bahawalpur Pakistan Department of Electrical Engineering. He obtained his Ph.D. degree from Universiti Teknologi Malaysia (UTM). He operates as a Senior Member of IEEE because his expertise covers power systems and smart grids and renewable energy fields. His research work has resulted in more than 50 publications which have received accolades including the UTM Young Scholarship Grant while his papers achieved top-cited and most-downloaded status in international journals.

Fatimah Khairiah Abd Hamid received the B.Eng. Degree in Electrical-Electronic from Universiti Teknologi Malaysia, in 2011. Meanwhile, she pursued her Master and PhD in Electrical Engineering in the same university in 2013 and 2016, respectively. She is currently a senior lecturer with the Faculty of Engineering, Universiti Teknologi Mara. Her research interests include modelling and simulation nanoscale transistor, radar and satellite system, sensor and IOT application.

KV Attendance Helper : Automated Attendance Management Tool for Vocational College Teachers

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ABSTRACT

KV Attendance Helper is a Chrome-based productivity extension designed to assist teachers at Kolej Vokasional in managing student attendance through the Integrated Digital Management System (iDME) efficiently. The innovation addresses the challenges of repetitive and time-consuming manual attendance marking, particularly during mass absence scenarios such as semester breaks, examination rotations, industrial training, and authorized school activities. KV Attendance Helper enables teachers to untick attendance in bulk and automatically assign predefined attendance categories and reasons with a single action, significantly reducing data entry time and minimizing human error. The extension features a user-friendly floating interface, customizable attendance options, and seamless integration with the existing iDME platform without altering its backend system. This innovation enhances administrative workflow efficiency, improves data consistency, and reduces teachers' workload, allowing educators to focus more on instructional responsibilities. KV Attendance Helper demonstrates strong potential for institutional adoption and commercialization as an educational productivity tool that can be expanded to vocational colleges and other educational institutions nationwide.

Keywords: Attendance automation, Chrome extension, iDME, vocational education, educational technology

1. Product Description

KV Attendance Helper is a Chrome Extension designed to assist vocational college teachers in managing student attendance efficiently within the iDME system. The tool enables bulk attendance actions by allowing users to untick all students and automatically assign predefined attendance categories and reasons such as semester breaks, examination rotations, and authorized activities with a single click. The extension integrates seamlessly with the existing iDME platform without modifying backend systems. It features a lightweight floating interface, customizable attendance options, and stable automation handling for large student lists. KV Attendance Helper significantly reduces repetitive administrative tasks, minimizes human error, and improves consistency in attendance records, making it a practical productivity tool for educators.

2. Project design and functionality

The process begins with the Start stage, where the user initiates the attendance recording procedure. The user first opens the iDME System, which serves as the main platform for managing student attendance. After accessing the system, a decision point is reached where the user determines whether attendance recording is required. If the answer is Yes, the user proceeds to

activate the KV Attendance Helper Chrome Extension. The extension assists in automating and simplifying the attendance recording process within the system. If the answer is No, the user continues by selecting the appropriate Reason and Category for the attendance status. After that, the user unticks all students in the attendance list to reset the selection. The selected Reason and Category are then applied to all students simultaneously using the extension's functionality. Once the necessary selections and adjustments have been made, the user submits the attendance through the system. Finally, the process concludes at the End stage, indicating that the attendance management procedure has been completed successfully.

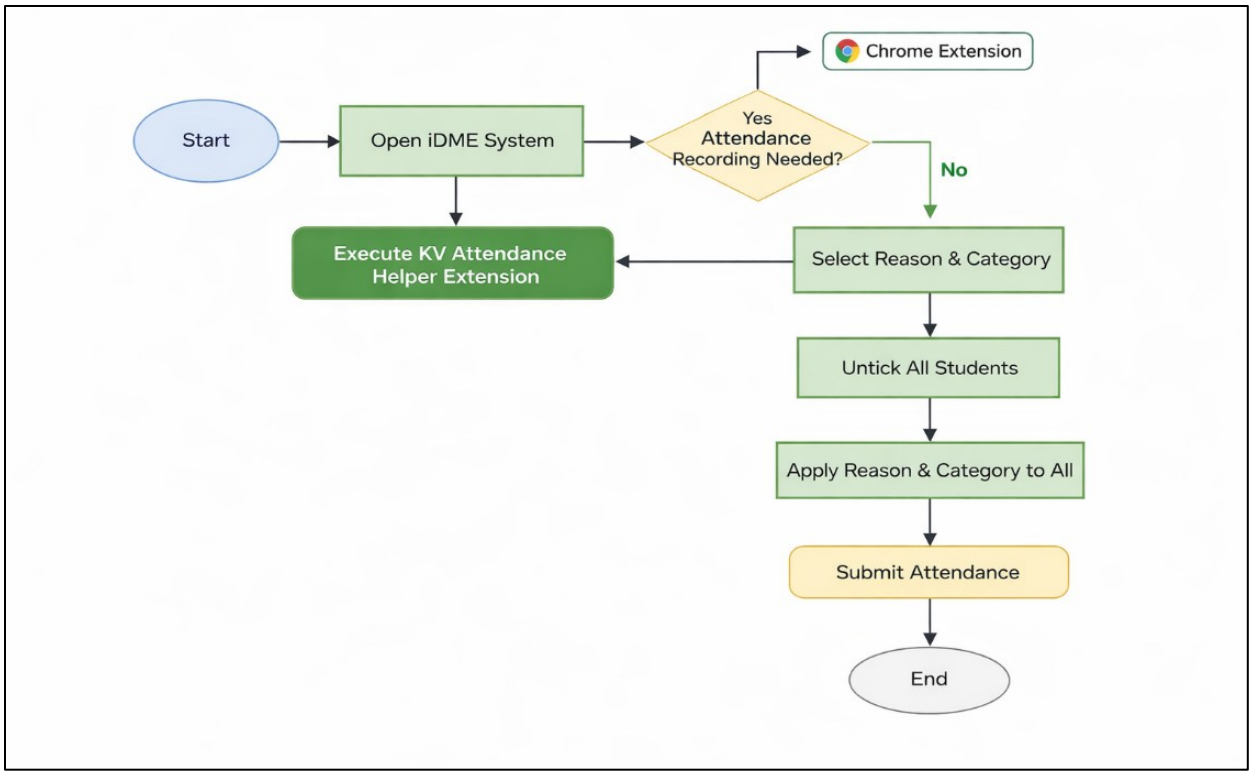

Figure 1. KV Attendance Helper flow chart.

3. Novelty and uniqueness

The novelty of KV Attendance Helper lies in its non-intrusive automation approach that enhances an existing institutional system without requiring backend modification or system redevelopment. Unlike conventional attendance solutions that depend on new platforms or database integration, this innovation operates as a browser-based Chrome Extension that interacts directly with the iDME interface to automate repetitive attendance tasks. The tool introduces bulk attendance marking functionality through a single-action workflow, allowing teachers to untick multiple students and assign predefined attendance categories and reasons simultaneously. Its lightweight floating interface, customizable options, and adaptive retry mechanism ensure stable and consistent operation even in dynamic web environments. This approach preserves data integrity while significantly improving administrative efficiency, making KV Attendance Helper a unique and practical innovation in educational technology.

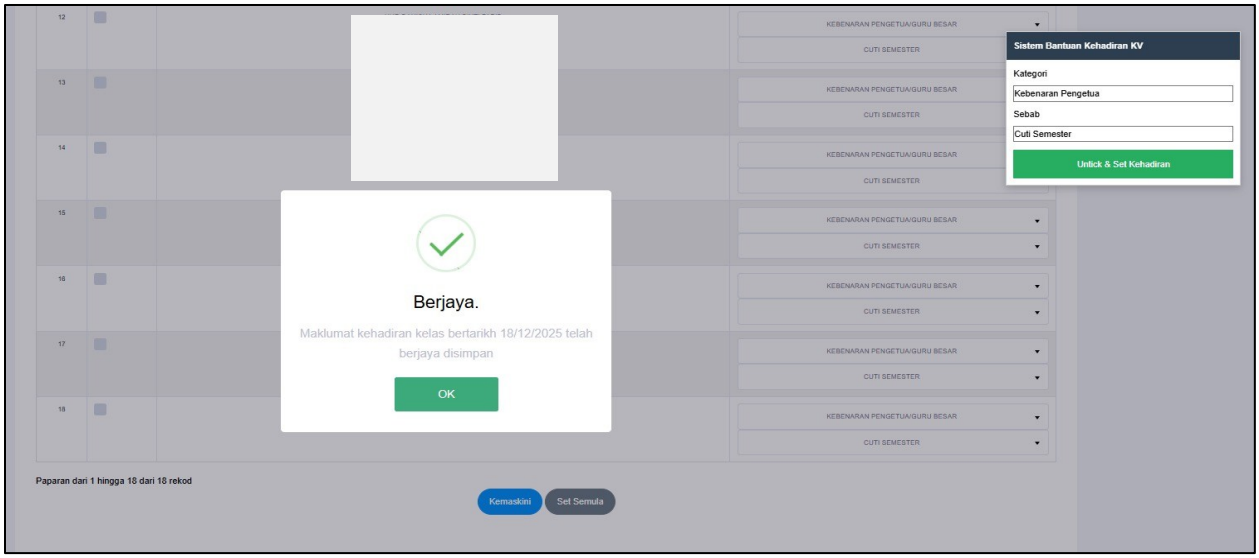

Figure 2. KV Attendance Helper interface.

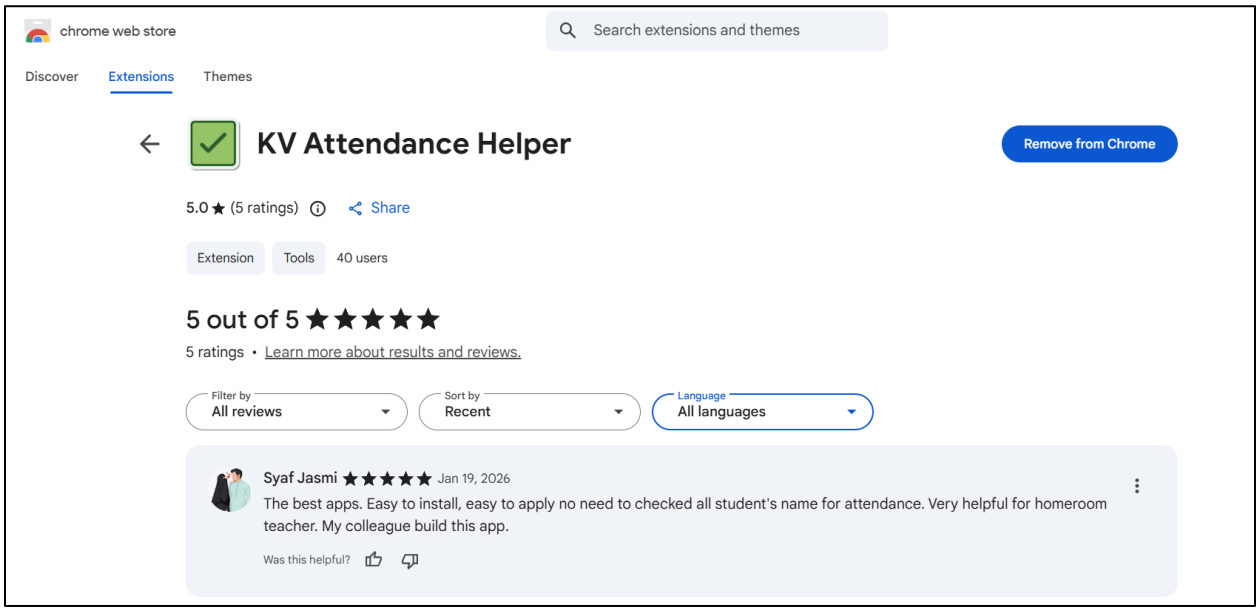

Figure 3. KV Attendance Helper in Chrome Web Store.

4. Benefit to mankind

KV Attendance Helper provides significant benefits to the education community by reducing the administrative workload of teachers and improving the efficiency of attendance management in vocational colleges. By automating repetitive attendance marking tasks, the innovation saves valuable time that educators can redirect towards teaching, student mentoring, and academic planning. The tool minimizes human error and enhances data consistency, ensuring more reliable attendance records that support accurate reporting and decision-making. From a societal perspective, improved administrative efficiency contributes to better-managed educational institutions, leading to higher teaching quality and improved student outcomes. Additionally, the innovation promotes digital productivity and smart automation within the public education sector, supporting the broader goal of technology-driven education management.

5. Innovation and Entrepreneurial Impact

KV Attendance Helper promotes innovation by introducing a practical, low-cost automation solution that enhances an existing educational system without requiring backend modification or infrastructure changes. The project demonstrates how browser-based technologies can be leveraged creatively to solve real administrative challenges faced by educators, encouraging a culture of problem-solving and digital innovation within educational institutions. From an entrepreneurial perspective, the project has strong potential for commercialization as an institutional productivity tool. It can be scaled and customized for deployment across vocational colleges and other educational institutions, with opportunities for licensing, feature expansion, and technical support services. The development of KV Attendance Helper also inspires educators and students to explore technology-driven solutions, fostering an entrepreneurial mindset that emphasizes efficiency, scalability, and value creation in the education sector.

6. Potential commercialization

KV Attendance Helper has strong potential for commercialization as a productivity and automation tool for educational institutions. The extension can be offered through institutional licensing to vocational colleges, secondary schools, and training centers that utilize digital attendance systems. A freemium model may be adopted, where basic bulk attendance features are provided free of charge, while advanced customization, reporting features, and technical support are offered as premium services. The solution can also be expanded through collaboration with educational authorities or private vendors for large-scale deployment. Additional revenue opportunities include system customization, maintenance services, and feature enhancements tailored to institutional needs. With minimal infrastructure requirements and easy scalability, KV Attendance Helper presents a cost-effective and sustainable commercialization opportunity in the education technology market.

7. Acknowledgment

The authors would like to express their sincere appreciation to the management and colleagues of Kolej Vokasional Datuk Seri Abu Zahar Isnin for their continuous support, encouragement, and valuable feedback throughout the development of this innovation. Special thanks are also extended to the teachers who provided practical insights and participated in the testing process, contributing to the improvement and validation of the KV Attendance Helper. Their cooperation and support were instrumental in the successful completion of this project.

8. Researchers' Biography

Nurul Syamimi binti Azali is a lecturer in Computer Systems and Networking programme and the MOEIS coordinator at Kolej Vokasional Datuk Seri Abu Zahar Isnin. She holds a Bachelor's Degree in Vocational Education (Creative Multimedia) from Universiti Tun Hussein Onn Malaysia (UTHM). She is responsible for managing institutional digital systems and educational data operations. She is the main developer of the KV Attendance Helper, an innovation focused on automating attendance management for vocational college teachers. Her professional interests

include educational technology, system automation, and digital solutions that enhance administrative efficiency within educational institutions.

Luqman Nurhakim bin Ahamad is a lecturer in Physical Education at Kolej Vokasional Datuk Seri Abu Zahar Isnin. He has been actively involved in student affairs since 2021, serving as the Head of the Student Management Unit. His professional interests include student development, educational administration, and school-based innovation. He has participated in innovation initiatives, including the 3rd Professional Teaching Innovation and Creativity Carnival (KIKPK) in 2025, contributing to the development of practical solutions that enhance educational management and institutional efficiency.

MyHydrology

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ABSTRACT

The development of MyHydrology represents a structured digital innovation designed to enhance conceptual understanding and problem-solving competencies in the DCC50212 Hydrology course. The platform integrates tutorial questions, comprehensive answers, and systematic step-by-step solutions within a centralized Google Site environment, emphasizing accessibility, logical content sequencing, and user-centered design. It supports self-directed learning, reinforces quantitative analysis skills, and strengthens student preparedness for Continuous Assessment and Final Examinations. System validation was conducted to ensure functional reliability, device compatibility, content accuracy, and overall usability. Post-implementation analysis indicates measurable improvement in Course Learning Outcome (CLO) 1 achievement, increasing from 69.8% and 63.7% to 73.7%. In terms of socio-economic impact, MyHydrology reduces dependence on printed materials and external academic support, lowering learning costs while ensuring equitable access to high-quality resources. Environmentally, its fully digital, paperless design promotes sustainable and eco-friendly instructional practices. The innovation also demonstrates strong commercial potential due to its scalable design and cost-effective development. The platform can be adapted for other courses or training programs, highlighting MyHydrology as a versatile and sustainable educational solution with both academic and commercial value.

Keywords: MyHydrology, digital learning innovation, hydrology, Course Learning Outcome (CLO), self-directed learning

1. Product Description

The development of MyHydrology reflects the digital transformation in education during the Fourth Industrial Revolution (IR 4.0), emphasizing technology integration in teaching and learning. The platform enhances students' understanding and confidence in solving calculation-based questions for the DCC50212 Hydrology course by providing structured practice questions with step-by-step solutions. Content is organized across five main topics, allowing students to follow logical procedures and build a strong foundation before tackling complex problems. Developed using Google Sites in Session 2: 2024/2025, MyHydrology is user-friendly, cost-effective, and easily updated without technical expertise. It centralizes materials, integrates supportive documents, and allows open access without login, ensuring consistent use. Before official implementation in Session 1: 2025/2026, the platform underwent testing for link functionality, content clarity, device compatibility, accuracy, and user experience. Feedback from 56 students evaluated design and usability. Analysis of Course Learning Outcome (CLO) 1 achievement showed improvement from 69.8% and 63.7% in previous sessions to 73.7% post-implementation, confirming that systematic practice with MyHydrology significantly enhances students' mastery of core concepts.

2. Innovation Implementation Method

Figure 1 illustrates the development process of the MyHydrology innovation, highlighting the key stages from initial design to implementation and evaluation. **Figure 2** displays the main website icons, while Figures 3 to 5 present the interface and QR code for student access. **Figure 6** presents a bar chart comparing CLO 1 achievement before and after the website's implementation, and Figures 7 to 9 show CLO 1 results in the Course Outcome Review Report (CORR) for the DCC50212 Hydrology course across three semesters.

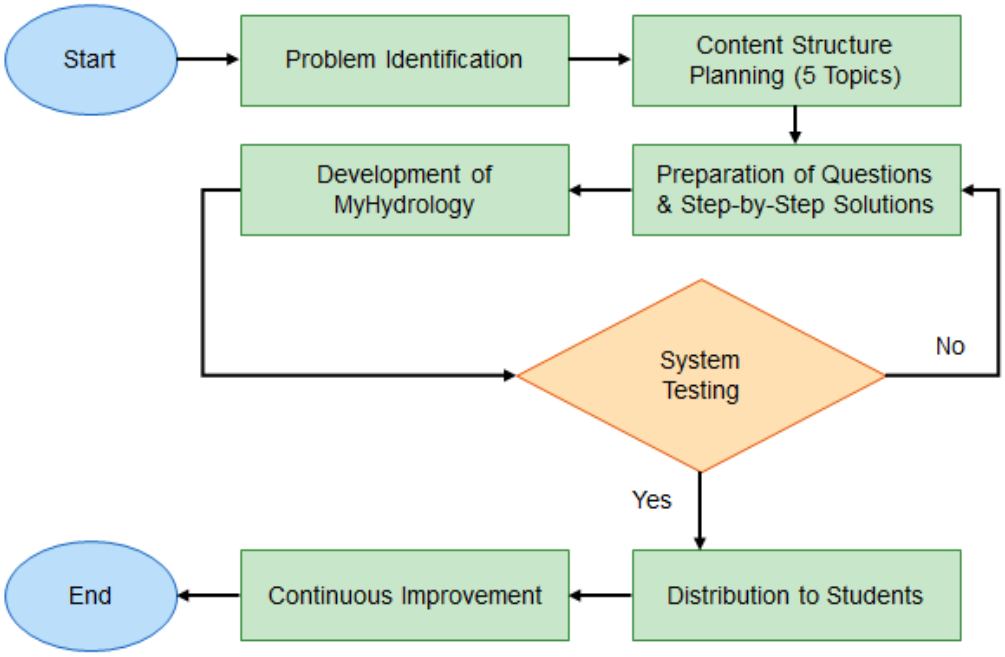

Figure 1. Flowchart of the MyHydrology innovation development.

Figure 2. Main Icons of the MyHydrology Website.

Figure 3. Main Interface Display of the MyHydrology Website.

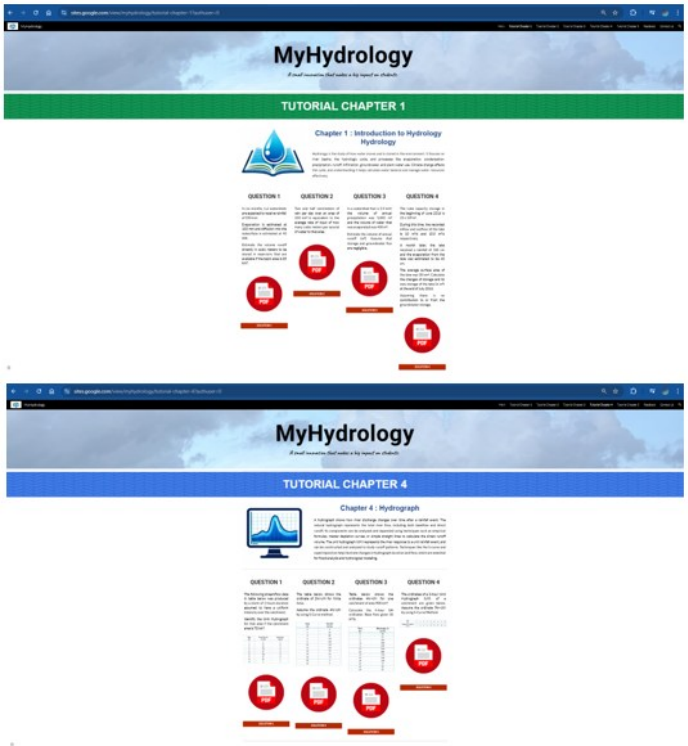

Figure 4. MyHydrology Content for Topic 1 and Topic 4.

Figure 5. QR Code for Direct Access to the MyHydrology Platform.

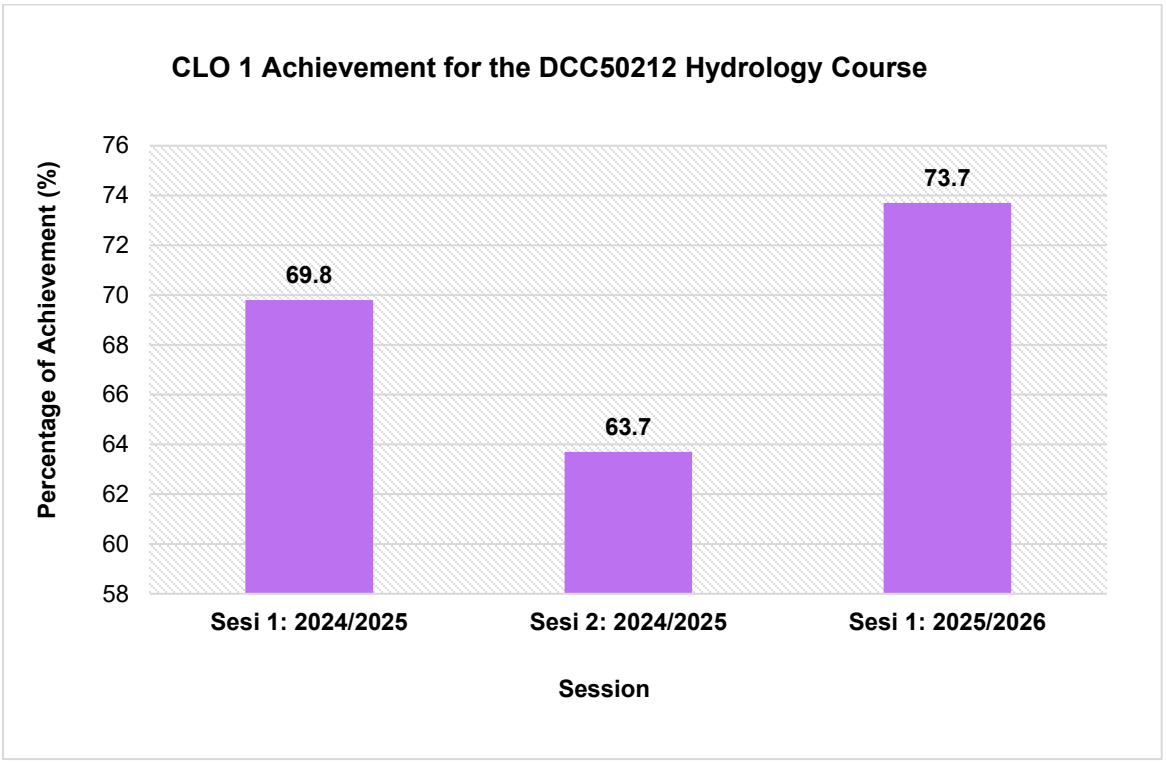

Figure 6. CLO 1 Achievement for the DCC50212 Hydrology Course.

POLITEKNIK SULTAN MIZAN ZAINAL ABIDIN
COURSE OUTCOME REVIEW REPORT (CORR)
SESSION : I : 2024/2025

1. COURSE INFORMATION

Programme	: DIPLOMA KEJURUTERAAN AWAM [DKA]
Class	: DKA4A, DKA5A, DKA5B, DKA5C, DKA5D, DKA6B,
Course Name	: DCC50212 - HYDROLOGY
Lecturer	*1. WAN SRIHATI AZURAHAYU BINTI WAN AHMAD @ WAN ADNAN* *2. NORMAWATI BINTI ABDUL RAHMAN* *3. RAHAYU BINTI MHD ADNAN* *4. NOR AFZAN BINTI ARIFFIN*
Number Of Student	: 77
Date	: 13/01/2025

2. PERFORMANCE INDICATOR

		TARGET (%)	ACHIEVEMENT
1.	Student Performance : % achieving grade C and above.	80	96.1
2.	CLO achievement: >50% attainment for CLO's.	80	100.0
3.	PLO achievement: >50% attainment for PLO's.	80	100.0
4.	Student achieve > 80% - attendance	100	100
5.	< 30% difference between continuos assessment (CA) and final exam (FE).	NA	57.1

3. STUDENT PERFORMANCE

Grade(% of student)

A+	A	A-	B+	B	B-	C+	C	C-	D+	D	E	E-	F
6.5	18.2	18.2	18.2	7.8	13.0	7.8	6.5	1.3	2.6	0.0	0.0	0.0	0.0

4. COURSE LEARNING OUTCOME

		Group Attainment (%)	Student Achieve >= 50%
CLO1C	apply basic concept of applied hydrology in civil engineering	69.8	89.6
CLO2C	solve problem in applied hydrology for civil engineering	74.0	94.8
CLO3P	construct hydrological analysis using available software	89.9	100.0

5. PROGRAMME LEARNING OUTCOME

		Group Attainment (%)	Student Achieve >= 50%
PLO001	Apply knowledge of applied mathematics, applied science, engineeringfundamentals and an engineering specialisation as specified in DK1 to DK4 respectively to wide practical procedures and practices	69.8	89.6
PLO002	Identify and analyse well-defined engineering problems reaching substantiated conclusions using codified methods of analysis specific to their field of activity (DK1 to DK4)	74.0	94.8
PLO007	Understand and evaluate the sustainability and impact of engineering technician work in the solution of well-defined engineering problems in societal and environmental contexts (DK7)	89.9	100.0

Figure 7. CLO 1 Achievement for the DCC50212 Hydrology Course, Session 1: 2024/2025.

POLITEKNIK SULTAN MIZAN ZAINAL ABIDIN
COURSE OUTCOME REVIEW REPORT (CORR)
SESSION : II : 2024/2025

1. COURSE INFORMATION

Programme	: DIPLOMA KEJURUTERAAN AWAM [DKA]
Class	: DKA5A, DKA6A, DKA6B, DKA6C, DKA6D,
Course Name	: DCC50212 - HYDROLOGY
Lecturer	*1. WAN SRIHATI AZURAHAYU BINTI WAN AHMAD @ WAN ADNAN*
Number Of Student	: 12
Date	: 29/06/2025

2. PERFORMANCE INDICATOR

		TARGET (%)	ACHIEVEMENT
1.	Student Performance : % achieving grade C and above.	80	91.7
2.	CLO achievement: >50% attainment for CLO's.	80	100.0
3.	PLO achievement: >50% attainment for PLO's.	80	100.0
4.	Student achieve > 80% - attendance	100	100
5.	< 30% difference between continuos assessment (CA) and final exam (FE).	NA	0.0

3. STUDENT PERFORMANCE

Grade(% of student)

A+	A	A-	B+	B	B-	C+	C	C-	D+	D	E	E-	F
0.0	0.0	33.3	16.7	16.7	0.0	8.3	16.7	0.0	0.0	0.0	8.3	0.0	0.0

4. COURSE LEARNING OUTCOME

		Group Attainment (%)	Student Achieve >= 50%
CLO1C	apply basic concept of applied hydrology in civil engineering	63.7	100.0
CLO2C	solve problem in applied hydrology for civil engineering	76.2	91.7
CLO3P	construct hydrological analysis using available software	88.3	100.0

5. PROGRAMME LEARNING OUTCOME

		Group Attainment (%)	Student Achieve >= 50%
PLO001	Apply knowledge of applied mathematics, applied science, engineeringfundamentals and an engineering specialisation as specified in DK1 to DK4 respectively to wide practical procedures and practices	63.7	100.0
PLO002	Identify and analyse well-defined engineering problems reaching substantiated conclusions using codified methods of analysis specific to their field of activity (DK1 to DK4)	76.2	91.7
PLO007	Understand and evaluate the sustainability and impact of engineering technician work in the solution of well-defined engineering problems in societal and environmental contexts (DK7)	88.3	100.0

Figure 8. CLO 1 Achievement for the DCC50212 Hydrology Course, Session 2: 2024/2025.

POLITEKNIK SULTAN MIZAN ZAINAL ABIDIN
COURSE OUTCOME REVIEW REPORT (CORR)
SESSION : I : 2025/2026

1. COURSE INFORMATION

Programme : DIPLOMA KEJURUTERAAN AWAM [DKA]
Class : DKA5A, DKA5B, DKA5C, DKA6A, DKA6C,
Course Name : DCC50212 - HYDROLOGY
Lecturer : *1. WAN SRIHATI AZURAHAYU BINTI WAN AHMAD @ WAN ADNAN*
2. NORMAWATI BINTI ABDUL RAHMAN
3. NOR AFZAN BINTI ARIFFIN
Number Of Student : 64
Date : 07/01/2026

2. PERFORMANCE INDICATOR

		TARGET (%)	ACHIEVEMENT
1.	Student Performance : % achieving grade C and above.	80	93.8
2.	CLO achievement: >50% attainment for CLO's.	80	100.0
3.	PLO achievement: >50% attainment for PLO's.	80	100.0
4.	Student achieve > 80% - attendance	100	100
5.	< 30% difference between continuos assessment (CA) and final exam (FE).	NA	64.1

3. STUDENT PERFORMANCE

Grade(% of student)

A+	A	A-	B+	B	B-	C+	C	C-	D+	D	E	E-	F
9.4	29.7	7.8	14.1	14.1	12.5	3.1	3.1	1.6	3.1	1.6	0.0	0.0	0.0

4. COURSE LEARNING OUTCOME

		Group Attainment (%)	Student Achieve >= 50%
CLO1C	apply basic concept of applied hydrology in civil engineering	73.7	93.8
CLO2C	solve problem in applied hydrology for civil engineering	73.3	90.6
CLO3P	construct hydrological analysis using available software	92.6	100.0

5. PROGRAMME LEARNING OUTCOME

		Group Attainment (%)	Student Achieve >= 50%
PLO001	Apply knowledge of applied mathematics, applied science, engineeringfundamentals and an engineering specialisation as specified in DK1 to DK4 respectively to wide practical procedures and practices	73.7	93.8
PLO002	Identify and analyse well-defined engineering problems reaching substantiated conclusions using codified methods of analysis specific to their field of activity (DK1 to DK4)	73.3	90.6
PLO007	Understand and evaluate the sustainability and impact of engineering technician work in the solution of well-defined engineering problems in societal and environmental contexts (DK7)	92.6	100.0

Figure 9. CLO 1 Achievement for the DCC50212 Hydrology Course, Session 1: 2025/2026.

3. Novelty and uniqueness

Before MyHydrology, learning materials for the DCC50212 Hydrology course were scattered across printed notes and WhatsApp, with no centralized platform for example questions and solutions. Students had to navigate multiple sources or request questions from lecturers, making revision unstructured and heavily dependent on individual initiative, limiting consistent understanding. MyHydrology transforms this process into a centralized, structured, and accessible digital platform. All questions and solutions are organized by topic, enabling logical, step-by-step learning. Accessible anytime without login, it removes technical barriers and promotes consistent engagement. Its clear layout guides problem-solving and reinforces calculation skills, supporting self-directed learning. By consolidating resources and emphasizing systematic practice, MyHydrology provides a unique, innovative approach that enhances learning efficiency, understanding, and academic performance compared to conventional methods.

4. Benefit to mankind

The impact of MyHydrology is clearly reflected in the improvement of CLO achievement to 73.7% and the positive trend observed in CLO1 performance, showing that the platform goes beyond being a mere supporting resource and directly enhances students' learning mastery. Academically, students demonstrate stronger conceptual understanding and greater confidence in solving calculation-based questions through consistent use of the platform. This innovation contributes to multiple areas of excellence: it enhances academic performance by improving understanding and calculation skills; it transforms teaching by shifting from conventional methods to a systematic digital approach and provides a question bank for formative assessment; it centralizes learning materials for easier management and access; it is scalable to other courses with structured calculations; and it is sustainable, being cost-effective and continuously updatable without additional funding. Overall, MyHydrology represents a small innovation that generates a significant and lasting impact on student learning, teaching practices, and resource management.

5. Innovation and Entrepreneurial Impact

MyHydrology demonstrates innovation by transforming conventional Hydrology teaching into a structured, digital, and accessible learning platform. It centralizes practice questions, step-by-step solutions, and supporting resources, allowing students to learn independently and systematically. The project fosters a culture of innovation within the academic community by encouraging lecturers and students to adopt digital solutions, explore self-directed learning, and improve problem-solving skills. It also inspires entrepreneurial thinking by showcasing how simple, low-cost digital platforms can create high-impact educational solutions. By emphasizing systematic content design, user accessibility, and practical application, MyHydrology serves as a model for developing similar innovations in other courses or educational contexts, promoting a mindset of creativity, efficiency, and scalability among students, faculty, and the wider educational community.

6. Potential commercialization

MyHydrology has strong commercialization potential due to its scalable, cost-effective, and user-friendly design. The platform can be adapted and customized for other STEM courses or professional training programs requiring structured problem-solving exercises. Institutions or private training providers could license the platform, offering subscription-based access to curated learning materials and interactive practice modules. The integration of analytics to track student progress could enhance its value, enabling institutions to monitor learning outcomes and

provide targeted interventions. Additionally, the platform's digital format allows integration with mobile applications, online workshops, or blended learning services, expanding market reach. By combining low development cost, ease of use, and demonstrable improvements in academic performance, MyHydrology presents a viable product for educational institutions and training providers, bridging the gap between innovative teaching practices and commercial educational solutions.

7. Acknowledgment

The development and implementation of MyHydrology would not have been possible without the support of the Head of the Department of Civil Engineering and the lecturers who applied the innovation in their teaching. Their guidance, encouragement, and active use of the platform in the teaching and learning process were invaluable. Special thanks are also extended to the students for providing feedback during the effectiveness study, which helped refine and improve the platform, ensuring it meets learning needs and enhances student understanding and engagement with the course material.

8. Researchers' Biography

Nor Afzan binti Ariffin is a Lecturer and Assistant Head of Program at the Department of Civil Engineering, Politeknik Sultan Mizan Zainal Abidin, with 22 years of professional experience. Her expertise lies in Hydrology, Water Supply, and Water & Sewerage Systems. She has been actively involved in applied research, practical training, and projects related to water resource management and sustainable infrastructure. Her work focuses on bridging theoretical knowledge with real-world applications, supporting student learning, and enhancing the capacity of the institution and community in hydrology and water systems engineering.

Bet-1 (Basic Electronic Trainer): An Innovative Hands-on Learning Platform for Basic Electrical Circuits

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ABSTRACT

BET-1 (Basic Electronic Trainer) is an educational innovation designed to enhance hands-on learning in DET10103 Electrical Circuit 1 at Politeknik Port Dickson. It was developed to overcome common problems found in traditional breadboards, such as frequent wiring mistakes, loose and unstable connections, long setup time, and low student confidence during practical activities. BET-1 uses clearly labelled 4 mm banana socket terminals arranged according to the actual electrical circuit diagrams. This design allows students to build circuits more quickly, safely, and accurately, while helping them better understand circuit concepts and improve practical skills.BET-1 is supported by QR code-based digital learning materials, including step-by-step experiment guides, demonstration videos, and self-assessment activities. These features encourage independent learning and support blended and Industry 4.0-ready education. From a socio-economic and environmental perspective, BET-1 offers strong benefits through its very low production cost of RM51.70 per unit, reduced laboratory maintenance, efficient use of teaching time, and durable, reusable modular design. By improving access to affordable, high-quality technical training, BET-1 contributes to workforce readiness, supports inclusive TVET education, and strengthens national human capital development, ultimately benefiting society and sustainable economic growth. By improving access to affordable and effective technical training, BET-1 enhances students' practical competencies, supports inclusive TVET education, and contributes to the development of a skilled workforce that benefits society and sustainable economic growth.

Keywords: *Basic Electronic Trainer, Practical Skills Training, Electrical Circuits, TVET Education, Teaching Innovation.*

Product Description

BET-1 (Basic Electronic Trainer) is a compact and high-performance electronic training system designed to provide structured, reliable, and repeatable hands-on learning for fundamental electrical circuit education. The system is enclosed in a durable thermoplastic casing and features a schematic-based front-panel layout that directly maps theoretical circuit diagrams to physical circuit configurations. This design simplifies laboratory activities, accelerates student understanding, and reduces cognitive load during practical sessions.

BET-1 integrates fixed-value resistors, variable resistors, and permanently mounted analogue voltmeters and ammeters to ensure stable connections and consistent measurement results. Circuit connections are made using clearly labelled 4 mm banana socket terminals to minimize wiring errors, loose contacts, and component wear commonly encountered when using

conventional breadboards. This configuration enables fast circuit assembly, significantly reduces setup time, and improves experimental accuracy and repeatability. To further support effective and independent learning, BET-1 is enhanced with QR code-based digital resources, including guided experiments, demonstration videos, and self-assessment modules accessible via smart devices. Designed for repeated and intensive laboratory use, BET-1 offers high durability, cost efficiency, and scalability, making it a practical training solution for TVET institutions and technical training centers.

2. Operational Workflow

Figure 1 illustrates the operational workflow of the BET-1 training process, beginning with lecturer guidance, followed by student circuit construction, measurement activities, result analysis, and self-assessment. Students then review and understand the practical tasks outlined in the laboratory worksheet. Once the procedures are clearly understood, circuit connections are constructed using the labelled 4 mm banana socket terminals in accordance with the schematic diagrams provided in the worksheet. Each connection is carefully checked against the schematic to ensure accuracy before proceeding. After the circuit is completed, electrical measurements are taken using the built-in meters, and relevant observations are recorded. Students subsequently analyze the experimental results and compare them with the corresponding theoretical values. Finally, students complete the self- assessment activities and submit their findings for evaluation.

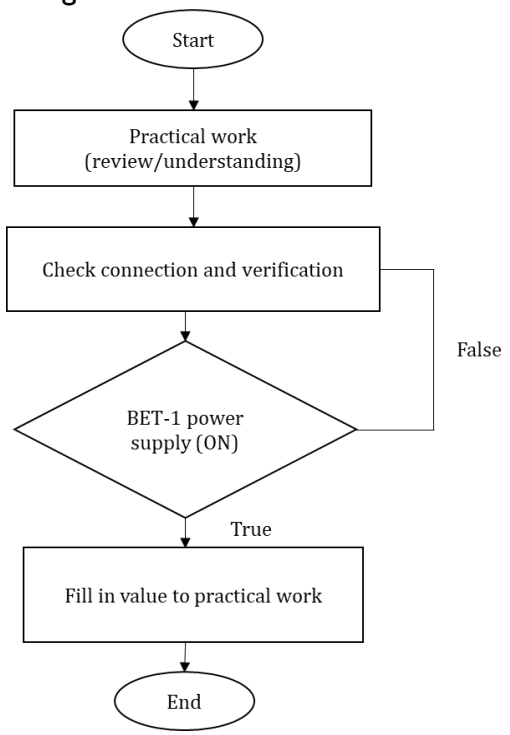

Figure 1. Flow chart BET-1 Process.

Figure 2 shows the physical design and components of the BET-1 (Basic Electronic Trainer). The trainer features a structured front panel with clearly labelled 4 mm banana socket terminals arranged according to electrical schematic diagrams. Built-in analogue voltmeters and ammeters are integrated to allow accurate measurement of voltage and current during experiments. The internal layout, as shown in the middle image, demonstrates the organized wiring system and

permanently mounted components, including fixed resistors and variable resistors. This design ensures mechanical stability, durability, and consistent experimental performance compared to conventional breadboards. The image on the right illustrates the practical application of BET-1 during a laboratory session, where students use the trainer to construct circuits and perform measurements. The compact and portable casing makes it easy to store and suitable for repeated classroom and laboratory use. Overall, the BET-1 Trainer reflects a structured, user-friendly, and durable training solution for effective hands- on learning in basic electrical circuit education.

Figure 2. BET-1 Trainer.

Table 1. Mini Comparison: BET-1 vs Conventional Breadboard.

Aspect	**Conventional Breadboard**	**BET-1 (Proposed Innovation)**
Connection Stability	Loose, wear-prone	Rigid, mechanically stable
Wiring Accuracy	High error probability	Clearly labelled, error- minimized
Setup Time	Time-consuming	Faster (clear display)
Pedagogical Design	Abstract, non-schematic	Schematic-aligned layout
Digital Integration	None	QR-based guided learning
Durability	Low	High, reusable, modular

Table 1 presents a comparison between the conventional breadboard and the proposed BET-1 trainer, highlighting improvements in stability, wiring accuracy, setup efficiency, and pedagogical design. It is designed to enhance the learning experience, reduce errors, and integrate modern educational tools, whereas the conventional breadboard is more prone to errors, slower, and less durable.

3. Novelty and uniqueness

The key novelty of BET-1 lies in its reengineering of basic electronic training architecture. It replaces standard breadboard wiring with a structured 4 mm banana-socket interconnection system. Breadboards are widely used in entry-level electronics education for their low cost and familiarity. However, they are mechanically unstable, prone to frequent connection failures, and limit consistent learning outcomes. These shortcomings are often accepted as unavoidable. BET-1 challenges this assumption with a purpose-built training platform designed for durability, accuracy, and repeatable hands-on learning. Unlike existing commercial electronic trainers, BET-1 features a schematic-oriented terminal layout.

Physical connection points are directly aligned with standard electrical circuit diagrams. This approach removes the need for abstract interpretation between theory and practice. It reduces cognitive load and enables learners to understand concepts more quickly. Such pedagogical alignment is rarely implemented in low-cost training systems. BET-1 also integrates QR code-enabled digital learning support. This creates a hybrid physical–digital learning environment. The combination of robust hardware design, instructional intelligence, and digital accessibility distinguishes BET-1 as a learner-centric, next- generation training solution. It goes beyond conventional incremental improvements.

4. Benefit to mankind

BET-1 enhances engineering education by improving students' confidence, reducing wiring errors, and strengthening conceptual understanding through structured hands-on experimentation. The integration of QR-code–based learning materials enables self-paced learning beyond laboratory hours, supporting independent and flexible education. For lecturers, the trainer reduces time spent troubleshooting circuit errors and allows greater focus on concept explanation and higher-order problem solving. Its durable design and low maintenance requirements also improve laboratory management efficiency. Overall, BET-1 contributes to more inclusive, effective, and sustainable technical education.

5. Innovation and Entrepreneurial Impact

The BET-1 project actively cultivates a culture of innovation. It demonstrates how educator- led, in-house development can generate high-impact, market-ready educational solutions. BET-1 transforms instructional challenges into engineering opportunities. It promotes design thinking, applied research, and problem-solving within academic institutions. This bottom-up innovation model reduces reliance on imported training equipment and strengthens local innovation capacity. From an entrepreneurial perspective, BET-1 is a commercially viable education technology product with a clear value proposition and low production cost. It has scalable manufacturing potential. Its business model adopts a B2B institutional approach. BET-1 targets TVET institutions, technical colleges, and training centers through direct sales, bulk institutional procurement, and licensing for local fabrication. Additional value comes from modular expansion kits and optional digital learning content packages. Beyond generating revenue, BET-1 acts as a real-world innovation case study that bridges academia and industry. It embeds entrepreneurial thinking into technical education and contributes to sustainable, innovative-driven TVET ecosystems.

6. Potential commercialization

BET-1 has a strong commercial appeal with its ultra-low production cost of RM51.70, robust construction, and versatile use in basic electrical and electronics training. Compared to commercial trainers priced above RM150, it offers high affordability and potential for attractive margins. Target markets include polytechnics, vocational colleges, secondary schools, skills training centres, and industrial training providers. Commercialization can be achieved through direct sales, bulk procurement, and local manufacturing licenses. Additional revenue streams include modular expansion kits and optional digital content packages. Designed for durability, mass deployment, and easy replication, BET-1 is ready for national rollout and regional TVET adoption. Its cost-effectiveness, scalability, and alignment with industry-relevant skills make it a competitive, export-ready educational technology solution.

7. Acknowledgment

The authors sincerely acknowledge the support and contributions of Politeknik Port Dickson and the Department of Electrical Engineering in the development of the BET-1 (Basic Electronic Trainer). Special thanks are extended to the lecturers, technical staff, and students who participated in the design, testing, and implementation phases. Their expertise, dedication, and collaborative efforts were instrumental in ensuring the success of this project and in realizing a practical, effective, and innovative training solution.

8. Researchers' Biography

Azrinawati Samaon is a Lecturer in Electrical Engineering at Port Dickson Polytechnic, Malaysia, with extensive experience in teaching and learning in electrical engineering. Her professional and research interests focus on practice-oriented engineering education, instructional and pedagogical innovation, and the development of effective hands-on training methodologies aligned with industry needs. She is actively involved in teaching, supervising, and evaluating student projects and contributes to advancing quality electrical engineering education through applied educational innovation, scholarly writing, and knowledge sharing.

Zulkurnain bin Hassan is an Electrical Engineering lecturer at Port Dickson Polytechnic, Malaysia, specializing in TVET-aligned academic writing and educational innovation. He actively supervises student projects and develops technical research focused on smart systems and sustainability. Committed to advancing technical education, he emphasizes impactful documentation and knowledge sharing to drive quality innovation in the industry.

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Cement Brick Innovation with Silica Sand

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Fouziah binti Ahmad, fouziah@psmza.edu.my

ABSTRACT
Silica sand has strong potential as an alternative material in the construction industry due to its ability to enhance the strength and durability of cement-based products. This study investigates the water absorption and compressive strength performance of cement bricks incorporating silica sand as a partial replacement for natural sand at replacement levels of 0%, 7%, and 10%, using a 1:6 mix ratio. Brick specimens measuring 215 mm × 103 mm × 65 mm were manufactured using wooden moulds and tested at curing ages of 7 and 14 days. The findings indicate that bricks containing 7% silica sand exhibited the highest water absorption, followed by bricks with 10% silica sand and the control samples. Although the inclusion of silica sand at 7% and 10% showed a reduction in water absorption over the curing period, the recorded values did not comply with the maximum limit of 7% specified in MS 7.6:1972. Compressive strength results showed an improvement in strength for the modified bricks; however, the values remained below the minimum standard requirement. Despite these limitations, the study demonstrates the potential of silica sand as a sustainable alternative material for cement brick production. With further optimization of mix design and manufacturing processes, this innovation has the potential to support sustainable construction practices and reduce dependence on natural sand resources.

Keywords: Silica sand, cement brick, sustainable construction, alternative aggregate, material innovation

1. Product Description
The silica sand cement brick is an innovative construction material developed to promote sustainable resource utilization in the building industry. By partially replacing sand with silica sand, this product addresses growing concerns over material depletion while enhancing the durability potential of conventional cement bricks. The bricks are produced using a 1:6 mix ratio and conventional moulding techniques, ensuring compatibility with existing manufacturing practices. Performance evaluation demonstrates that the incorporation of silica sand reduces water absorption due to time to time, providing valuable data to guide further product optimization. Although current results do not yet meet established standards, the observed improvements in material behavior confirm the feasibility of silica sand as a viable alternative aggregate. This research-driven approach positions the product as a platform for continuous improvement for cement brick production. Designed with scalability and practicality, the silica sand cement brick offers strong potential for future commercialization and sustainable construction initiatives. With further refinement of mix design and curing processes, this innovation can contribute to greener construction practices, reduced reliance on sand resources and the development of environmentally responsible building materials.

2. Implementation Process and Innovation Development

Figure 1 shows the implementation process of the silica sand cement brick production. The process begins with data collection and mix design, followed by material preparation and sample production (0%, 7%, and 10% silica sand). The samples are then dried and tested for water absorption and compressive strength. Finally, the results are compiled for data analysis and reporting.

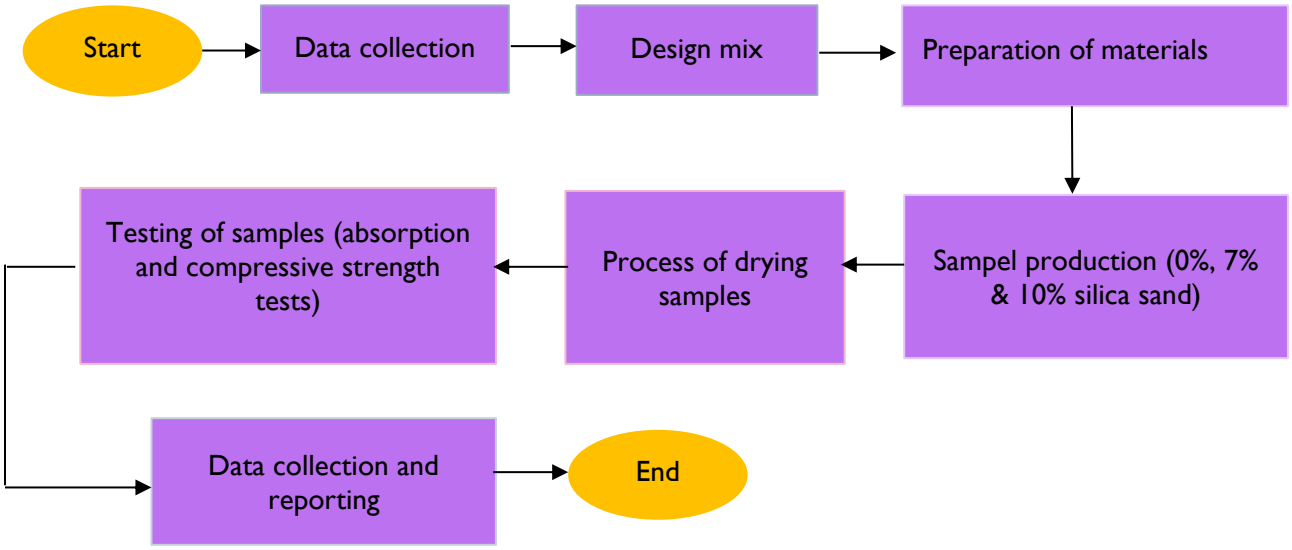

Figure 1. Flow chart for cement brick innovation with silica sand.

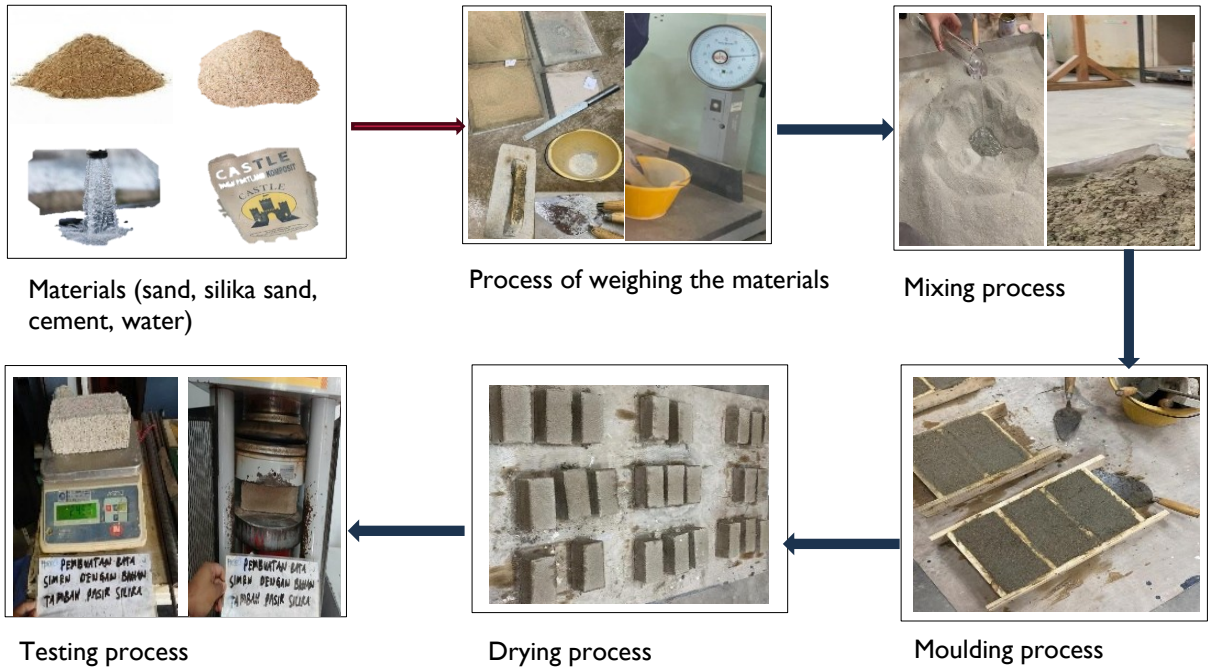

Figure 2. Process for producing cement brick innovation with silica sand.

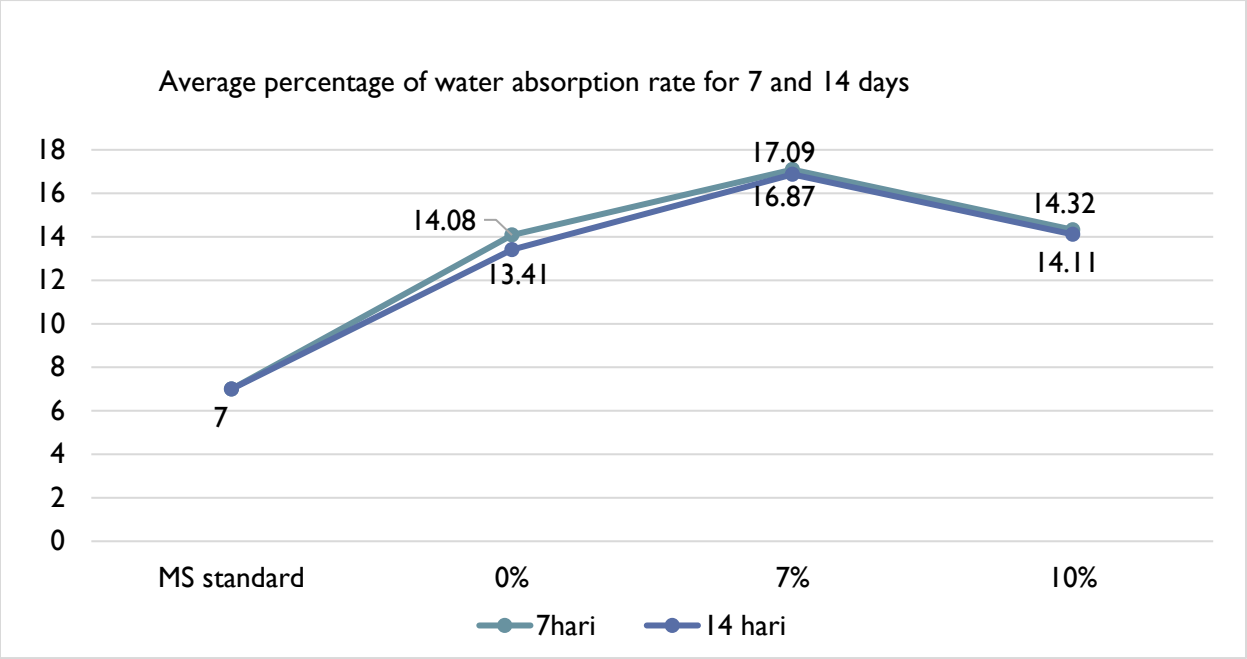

Figure 3. Average percentage of water absorption rate for 7 and 14 days.

Table 1. Average percentage of water absorption rate.

Percentage of silica sand	Average percentage of water absorption rate, 7 days	Average percentage of water absorption rate, 14 days
0%	14.08	13.41
7%	17.09	16.87
10%	14.32	14.11
MS Standard (max)	**7.0**	**7.0**

The results of the water absorption test for all samples are recorded as shown in **Table 1**. On day 7, the control brick sample recorded the lowest water absorption rate at 14.08%, followed by the modified brick containing 10% silica sand at 14.32%, while the modified brick with 7% silica sand recorded the highest value at 17.09%. For the test conducted on day 14, the modified brick with 7% silica sand continued to exhibit the highest water absorption rate at 16.87%, followed by the modified brick with 10% silica sand at 14.11%, whereas the control sample recorded the lowest value at 13.41%. **Table 2** presents the results of the compressive strength test for all samples at curing ages of 7 and 14 days. On day 7, the modified brick containing 10% silica sand recorded the highest average compressive strength of 3.22 N/mm², followed by the control sample (0%) at 2.20 N/mm², while the modified brick with 7% silica sand exhibited the lowest value at 1.93 N/mm². At 14 days, the control sample demonstrated the highest average compressive strength of 3.88 N/mm², followed by the 10% silica sand brick at 2.65 N/mm² and the 7% silica sand brick at 2.05 N/mm².

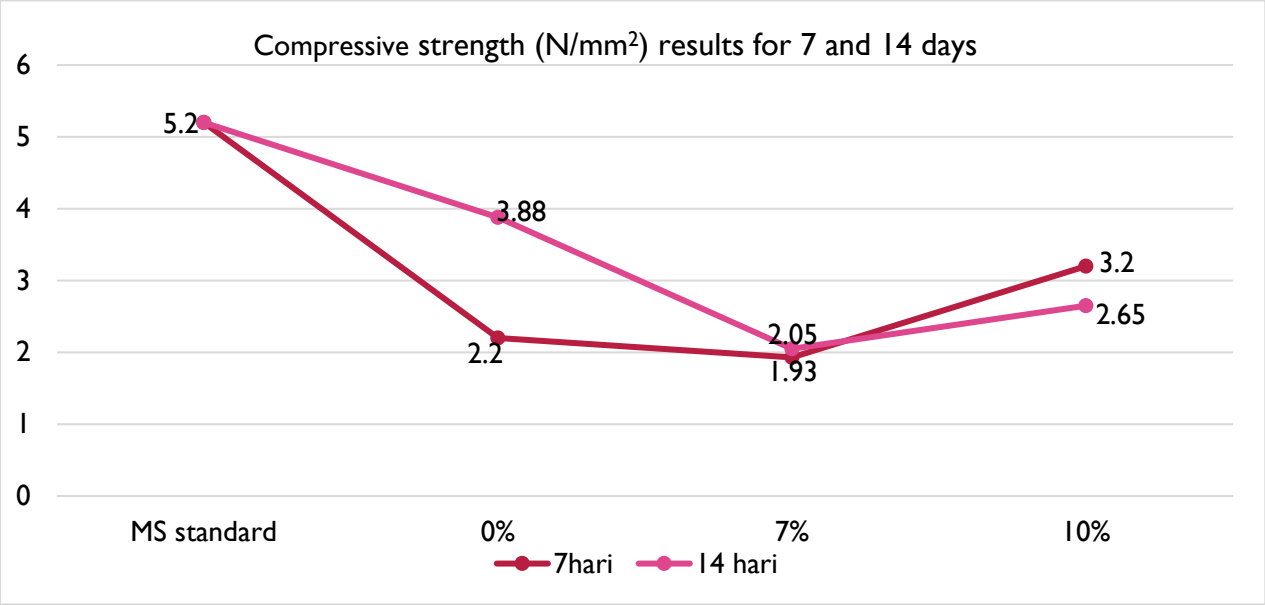

Figure 4. Compressive strength (N/mm^2) results for 7 and 14 days.

Table 2. Compression strength test results.

Percentage of silica sand	Average compressive strength (N/mm^2) 7 days	Average compressive strength (N/mm^2)14 days
0%	2.20	3.88
7%	1.93	2.05
10%	3.20	2.65
MS standard	**5.2**	**5.2**

2. Novelty and uniqueness

The silica sand cement brick lies in its research-driven use of silica sand as a partial replacement for sand in conventional cement brick production, supported by practical testing evaluation. This innovation improves existing construction material through material optimization making it practical and industry relevant. Its uniqueness is strengthened by its strong alignment with the TVET approach, as the product is manufactured using standard mix ratios, conventional moulding techniques, and readily available materials. This allows easy integration into theoretical teaching for construction materials, applied research, and skills training without the need for expensive equipment. By combining material innovation, sustainability, and practical skill development, the silica sand cement brick serves both as a viable construction material innovation and an effective learning platform, distinguishing it from conventional cement bricks in both educational and industry contexts.

3. Benefit to mankind

The silica sand cement brick benefits mankind by supporting sustainable construction through reduced reliance on sand resources. By incorporating silica sand as a partial replacement material, the innovation promotes responsible material usage and environmental conservation. It also provides educational and practical products that can be produced using simple methods, making

it accessible to TVET institutions, small manufacturers, and community based initiatives. Additionally, the product enhances skills development, applied learning, and innovation awareness, contributing to a more sustainable and industry sector.

4. Innovation and Entrepreneurial Impact

The silica sand cement brick promotes innovation by introducing a research-driven improvement to conventional cement brick production using silica sand as a partial replacement material. Rather than relying on complex technologies, the project shows the effective use of alternative materials, supported by practical testing evaluation, can create sustainable solutions within existing construction practices. This approach encourages innovation through continuous testing, refinement, and practical problem-solving. In terms of entrepreneurial impact, the product supports a culture of entrepreneurship by scalable solutions that can be produced using standard equipment and readily available materials. TVET institutions and community-based enterprises can engage in sustainable construction material production. The project also nurtures entrepreneurial thinking by linking research outcomes with product development, commercialization potential, and market-driven sustainability needs within the construction industry.

5. Potential commercialization

The silica sand cement brick shows strong commercialization potential due to its simple production process, use of readily available materials, and compatibility with conventional brick manufacturing methods. The product can be produced using standard mixing, moulding, and curing techniques without specialized equipment, enabling adoption by small- to medium-scale manufacturers, training institutions, and community entrepreneurs with minimal investment. Targeting non-structural masonry applications, the product offers a sustainable alternative to conventional cement bricks. The partial replacement of natural sand with silica sand adds market value by addressing resource depletion and material cost concerns. With further optimization to meet industry standards, the product can be scaled through pilot production, institutional adoption, and collaboration with industry stakeholders, providing a clear pathway from research to market.

6. Acknowledgment

Sincere appreciation to the Civil Engineering Department and the Polytechnic for their continuous support and provision of facilities throughout this study. This project contributes directly to the achievement of departmental and institutional Key Performance Indicators (KPIs), particularly in the areas of applied research, innovation output, and industry-relevant teaching and learning. Appreciation is also extended to academic staff, technical personnel, and students for their assistance in sample preparation, laboratory testing, and data collection. Their commitment and collaboration were essential to the successful completion of this innovation project.

7. Researchers' Biography

Rosmida Ab Ghani is a Senior Lecturer in the Department of Civil Engineering at Politeknik Sultan Mizan Zainal Abidin, with over 24 years of teaching experience in structural mechanics, reinforced concrete design, and concrete technology. She is actively engaged in applied research and innovation and has published extensively in her areas of expertise. Her outstanding contributions to research and innovation have earned her several accolades, including a Gold Medal for Product Innovation and First Runner-up in the Green Technology Category at the e-Festival Agro Makanan dan Bioteknologi (2020), as well as a Silver Medal for Product Innovation at the International Innovation Festival (Innofest 2024).

Fouziah Ahmad is a Senior Lecturer in Department of Civil Engineering at Politeknik Sultan Mizan Zainal Abidin with over 22 years of teaching experience in Construction Materials, Soil Mechanics, Building Services, Water Supply and Wastewater Engineering, and Environmental Pollution & Control. She is actively involved in applied research and innovation, with several publications in her areas of expertise. Her work focuses on sustainable construction and engineering education, and she was awarded a Gold Medal for Product Innovation at the International Research & Innovation Conference (iRIC) 2024 for her outstanding contribution to research-driven innovation.

CQI Civil Smartboard

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ABSTRACT

CQI Civil Smartboard is an innovative application specifically developed to support the teaching and learning process in Civil Engineering Program, Polytechnics Sultan Mizan Zainal Abidin. This application functions as a smart platform that displays Continuous Quality Improvement (CQI), Course Learning Outcome (CLO) and Course Outcome Review Report (CORR) for each Civil Engineering Diploma course offered in each semester. The Continuous Quality Improvement (CQI) and Course Learning Outcomes (CLO) monitoring process in most educational institutions is still carried out manually using printed reports which makes it difficult for lecturers and course coordinators to access data and makes it difficult to provide audit evidence for CQI and CORR reports. The objective of developing this application is to improve the efficiency of CLO monitoring by lecturers and course coordinators and minimize the time to access CLO, CQI and CORR reports each semester for each course. This application is developed by integrating CQI, CLO and CORR data from google sheets into a smart application that is easily accessible by lecturers and course coordinators. This system provides interactive visual displays in the form of tables and charts that allow lecturers and course coordinators to identify the strengths and weaknesses of the course CLO more quickly. With automated data processing and a user-friendly interface, the CQI Civil Smartboard reduces the burden of managing physical documents, speeds up CQI information searches and assists in information retrieval in the audit process, as well as supporting continuous improvement in teaching and learning.

Keywords: CQI Civil Smartboard, Continuous Quality Improvement (CQI), Course Learning Outcome (CLO), Program Learning Outcome (PLO), Course Outcome Review Report (CORR)

1. Product Description

The CQI Civil Smartboard innovation was developed as a digital interactive application that supports the Continuous Quality Improvement (CQI) process in the department's to improved academic management. This application was developed specifically to help lecturers and course coordinators obtain information related to Course Learning Outcome (CLO) Course Outcome Review Report (CORR) and Continuous Quality Improvement (CQI) achievements more quickly, accurately and systematically. This application was developed by integrating CQI, CLO and CORR data from google sheets into a smart application that is easily accessible by lecturers and course coordinators without having to do time-consuming manual analysis. The interactive dashboard displays graphical visualization in tables and pie charts which make data easier to understand and helps in making decisions related to course improvements. In addition, this application helps course coordinators prepare CQI and CORR reports more efficiently for audit and quality monitoring purposes. With CQI Civil Smartboard, the process of accessing course information

and assessing student achievement and course effectiveness can be done transparently, systematically and effectively, thus supporting continuous improvement efforts in ensuring that the quality of teaching and learning is always at an optimal level.

2. Innovation Implementation Method

Figure 1 illustrates the flowchart of the CQI Civil Smartboard application development process, starting from initial stage, development process, testing and deployment. **Figure 2** shows the CQI Civil Smartboard application interface. **Figure 3** also shows the menu available on CQI Civil Smartboard.

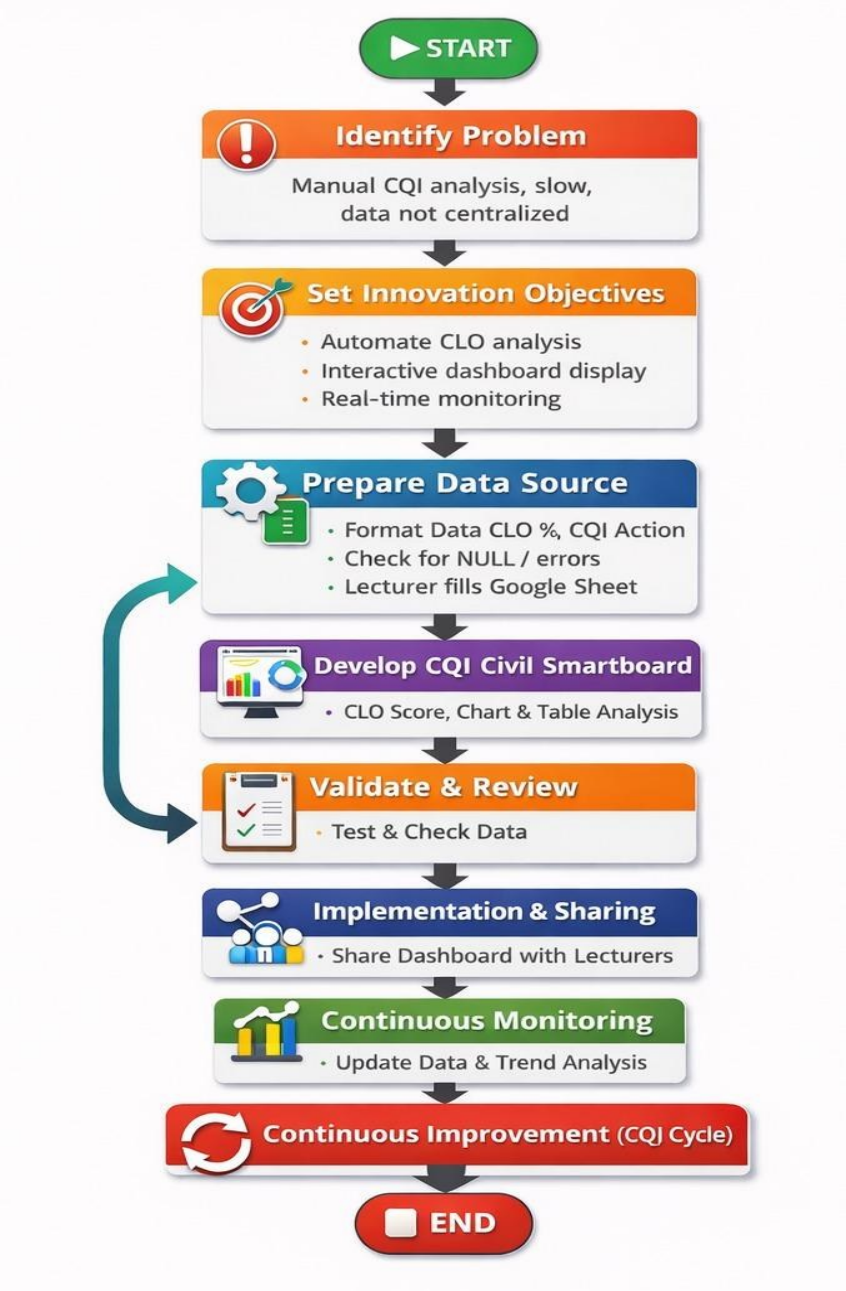

Figure 1. Flowchart of CQI Civil Smartboard Innovation development .

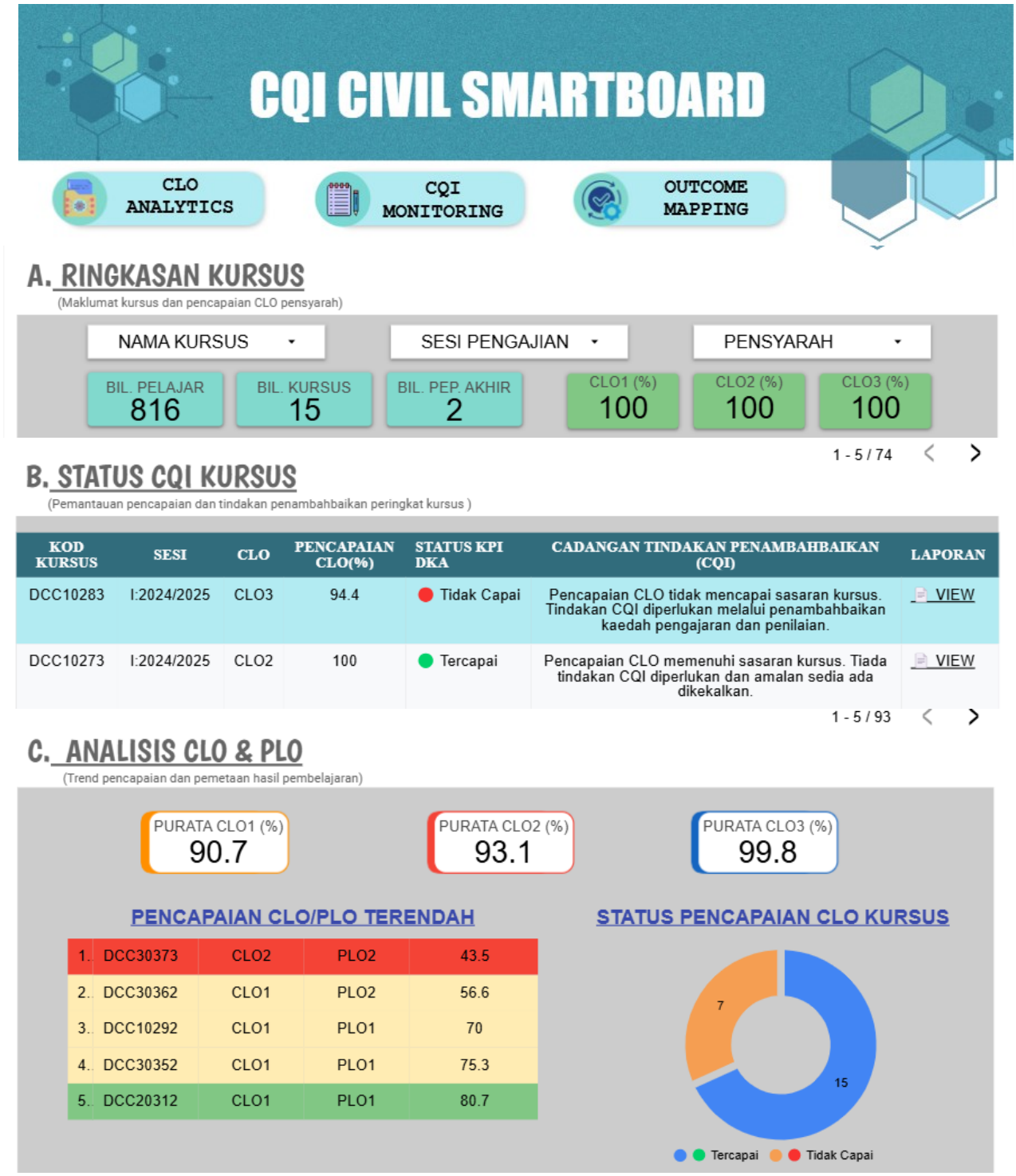

Figure 2. CQI Civil Smartboard Interface.

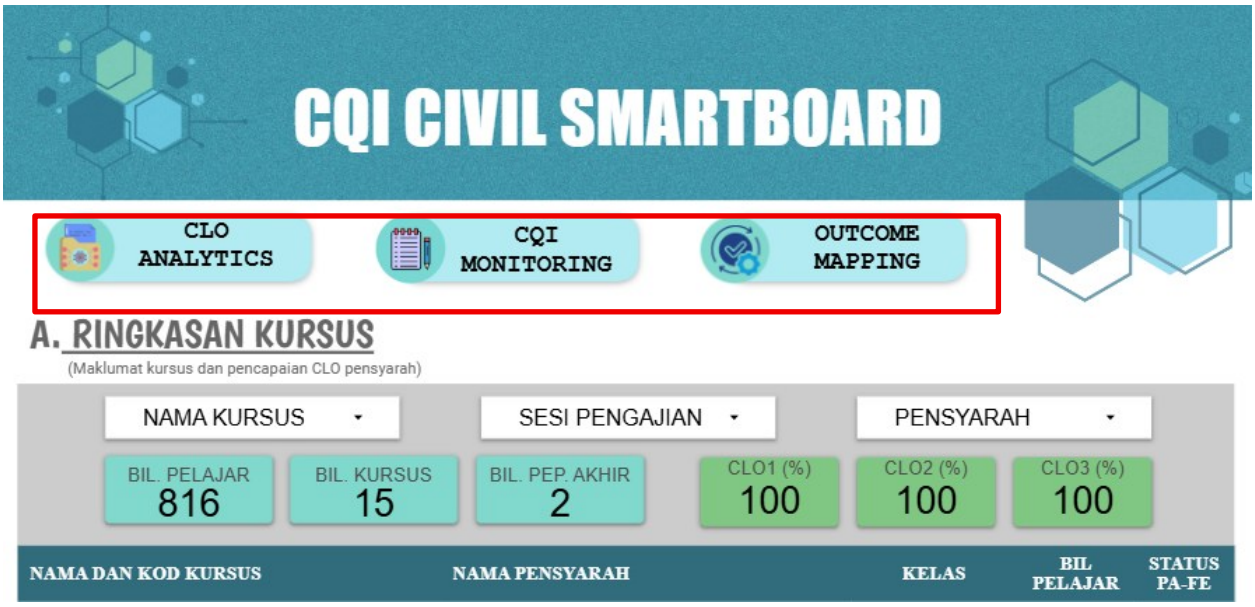

Figure 3. CQI Civil Smartboard Menu.

3. Novelty and uniqueness

The CQI Civil Smartboard innovation is unique because it provides an integrated platform that integrates CQI and CLO data from Google Sheets into a smart application that is easy to access and user-friendly. Usually, the process of accessing Course Report (CORR) information and Course Learning Outcomes (CLO) achievement analysis is manual and time-consuming. However, with this Smartboard, data can be generated automatically and displayed in the form of an easy-to-understand interactive dashboard. The specialty of this product lies in its ability to provide fast analysis, clear data visualization, and direct integration with existing academic management systems. In addition, it offers a real-time update feature that allows lecturers and course coordinators to assess the effectiveness of teaching and student achievement immediately. From a novelty point of view, CQI Civil Smartboard is not just a reporting tool, but also functions as a decision support mechanism that accelerates the continuous improvement process. This uniqueness makes the product more relevant, practical, and has a high impact in improving the quality of teaching and learning in educational institutions. CQI and CLO information is presented through a smart, user-friendly interface with graphs and tables, making data interpretation more engaging and accessible. Both lecturers and course coordinator can instantly access CQI and CLO information, enhancing efficiency in teaching and learning evaluation. The application is designed to be intuitive, requiring minimal technical training, making it practical for lecturers and course coordinators.

4. Benefit to mankind

The CQI Civil Smartboard innovation provides great benefits to humanity because it speeds up and simplifies the process of assessing teaching quality and student achievement. With the automation system and interactive displays, lecturers and course coordinators can assess the effectiveness of teaching more quickly, thus allowing for continuous improvement actions. For lecturers, this application Efficient Monitoring: Enables real-time tracking of CQI and CLO

without relying on manual reports. Data Accuracy: Automatic integration with Google Sheets reduces human error in data entry. Timesaving: Reduce the time lecturers and course coordinators to obtain information regarding CQI, CLO and CORR for the required courses. For institutions, this innovation can ensure CQI and CLO monitoring is implemented consistently across all courses. In addition, it also supports the move towards a paperless, sustainable and smart education system. This smartboard can improve the efficiency of academic management as CQI and CORR reports can be prepared more systematically, transparently and consistently. It also helps institutions meet quality audit requirements and strengthen their academic reputation through continuous monitoring of student achievement. Overall, the benefits to lecturers and institution make the CQI Civil Smartboard a high impact innovation in improving the quality of teaching, learning and academic management.

5. Innovation and Entrepreneurial Impact

The CQI Civil Smart Board introduces an innovative approach to academic data management by seamlessly integrating Continuous Quality Improvement (CQI), Course Learning Outcome (CLO) and Course Outcome Review Report (CORR) into a single, accessible platform. This innovation enhances efficiency for lecturers and course coordinators, enabling faster analysis and continuous quality improvement while reducing reliance on time-consuming manual processes. From an entrepreneurial perspective, the system holds strong commercialization potential as a digital solution for higher education institutions. Its scalability allows it to be adapted across faculties and universities, positioning it as a competitive edutech product that supports digital transformation in academia and contributes to the broader digital transformation agenda in higher education.

6. Potential commercialization

The CQI Civil Smartboard demonstrates strong commercialization potential as a scalable edutech solution for higher education institutions. By automating CQI, CLO, and CORR reporting, it directly addresses critical needs in academic quality assurance, making it highly attractive for adoption across universities and faculties. One of its key strengths is its cross-platform accessibility where users can easily access the system via mobile phones, laptops, tablets, and desktops. This flexibility not only increases usability and adoption rates but also ensures that academic staff can engage with the system anytime, anywhere, supporting a culture of continuous improvement. By combining efficiency, accessibility, and scalability, the CQI Civil Smartboard positions itself as a competitive product in global education technology market, capable of generating sustainable revenue streams while driving digital transformation in academia.

7. Acknowledgment

The success of developing CQI Civil Smartboard innovation would not have been possible without the support of the Head of Civil Engineering Department. Their leadership and dedication have played a critical role in driving this project forward and ensuring its relevance to academic excellence. Special thanks are also extended to the lecturers and course coordinators who provided valuable feedback during the testing and implementation phases. Their contributions were instrumental in refining the innovation and ensuring its relevance to academic needs.

8. Researchers' Biography

Siti Satilawati Binti Mohamed is a Senior Lecturer in Department of Civil Engineering at Politeknik Sultan Mizan Zainal Abidin with more than 17 years of teaching experience. She teaches core courses such as Structural Mechanics, Technician and Sustainable Development, Entrepreneurship, Engineering in Society and Structural Laboratory. In addition, she is actively engaged in research writing and conference presentations in the areas of engineering education and teaching innovation.

Mazlina binti Harun is a Senior Lecturer in Department of Civil Engineering at Politeknik Sultan Mizan Zainal Abidin with 23 years of teaching in Project Management and Practices, Contract and Estimating, Building Services, Occupational Safety & Health for Engineering and Construction Material. She is actively engaged in research writing and conference presentation in areas of engineering education and teaching innovation, and she was awarded a Bronze Medal for Product Innovation at the Borneo Innovation Festival 2019 (bif19) for her outstanding contribution to research-driven innovation.

Muhamad Waridi Bin Hadzali is a Head of Program of Diploma in Civil Engineering at Politeknik Sultan Mizan Zainal Abidin with 23 years of teaching in Highway and Traffic Engineering, Reinforced Concrete Design, Steel Structure Design, Computer Aided Design Drafting (CADD) and Building Information modelling (BIM). He is actively engaged in research writing and conference presentations in engineering and innovation areas.

LabTech GeoCalc

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ABSTRACT
The LabTech GeoCalc project introduces a computer-based automation system designed to revolutionize the processing of laboratory data within the field of geotechnical engineering. Traditionally, geotechnical tests like Grain Size Sieve Analysis and Standard Proctor Compaction Tests rely on manual calculations that are time-consuming and highly susceptible to human error. The primary objective of this system is to minimize these errors, save significant time, and enhance the overall accuracy and efficiency of laboratory data processing. Through its automated functions, LabTech GeoCalc performs complex calculations and generates visual data representations much faster than traditional manual methods. The system is built with a user-friendly interface that accommodates users of all skill levels, from students to professional engineers, without requiring advanced programming knowledge. Research findings demonstrate that the system can reduce calculation time from 25 minutes to under 5 minutes while maintaining a 100% accuracy rate. Ultimately, LabTech GeoCalc supports a modern, interactive digital learning experience and proves to be a vital innovation for the geotechnical field.

Keywords: LabTech GeoCalc, geotechnical engineering, digital learning innovation, self-directed learning

1. Product Description
LabTech GeoCalc is an advanced, computer-based automation system specifically tailored for the geotechnical engineering sector, serving as a digital bridge between theoretical classroom concepts and practical laboratory applications. Developed with Python as its core back-end logic, the system leverages the NumPy and Pandas libraries to handle complex mathematical operations and systematic data analysis. For visualization, the integration of Matplotlib and Plotly enables the generation of interactive technical graphs, while the use of SQLite ensures efficient local database management without the need for an external server connection. Furthermore, application stability is continuously maintained through Firebase for real-time error detection, all within a professional and intuitive user interface (UI) meticulously crafted using Figma and Adobe XD. By utilizing this system, users can input raw data from sieve and compaction tests to immediately receive systematically organized results, including precise, automatically plotted digital graphs that replace the need for manual sketching.

2. Innovation Implementation Method
The development of LabTech GeoCalc followed a systematic and iterative process, commencing with a comprehensive information gathering and requirements analysis phase that utilized interviews with students and lecturers to identify critical needs such as automated calculations. This was followed by the UI/UX design and prototyping stage, where Figma and Adobe XD were

used to create an organized, step-by-step interface. During the module development and coding phase, the core logic was built using Python, integrating NumPy and Pandas for high-speed mathematical and statistical analysis. To ensure reliability, the application underwent rigorous functional testing and debugging cycles to refine performance based on user feedback. Finally, the process culminated in deployment and distribution, making the system accessible via web and mobile platforms to ensure students and professionals could utilize the tool in the lab, at home, or directly in the field.

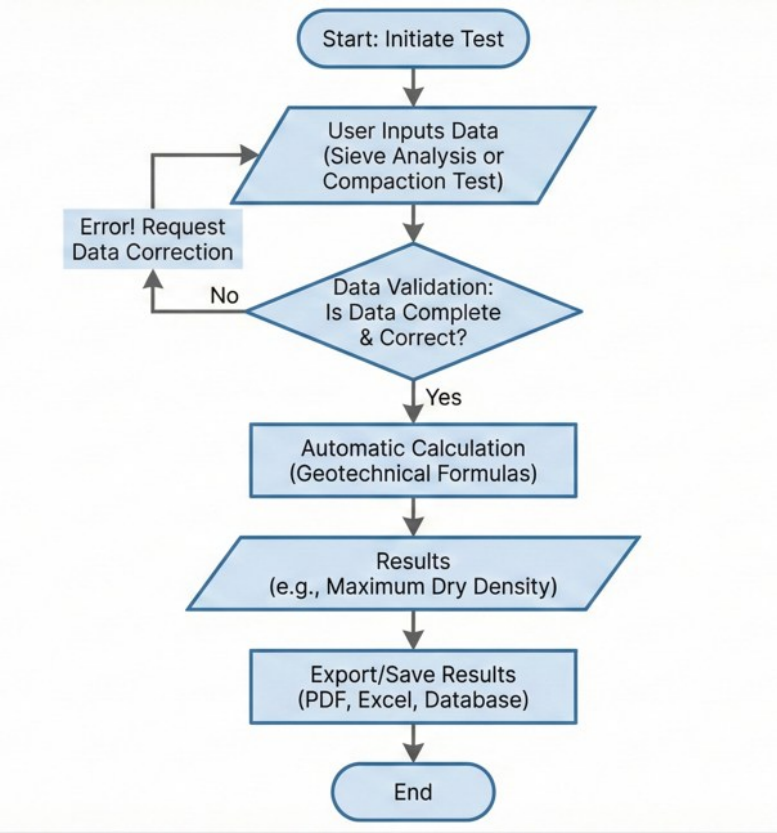

Figure 1. Flowchart of the LabTech GeoCalc innovation development .

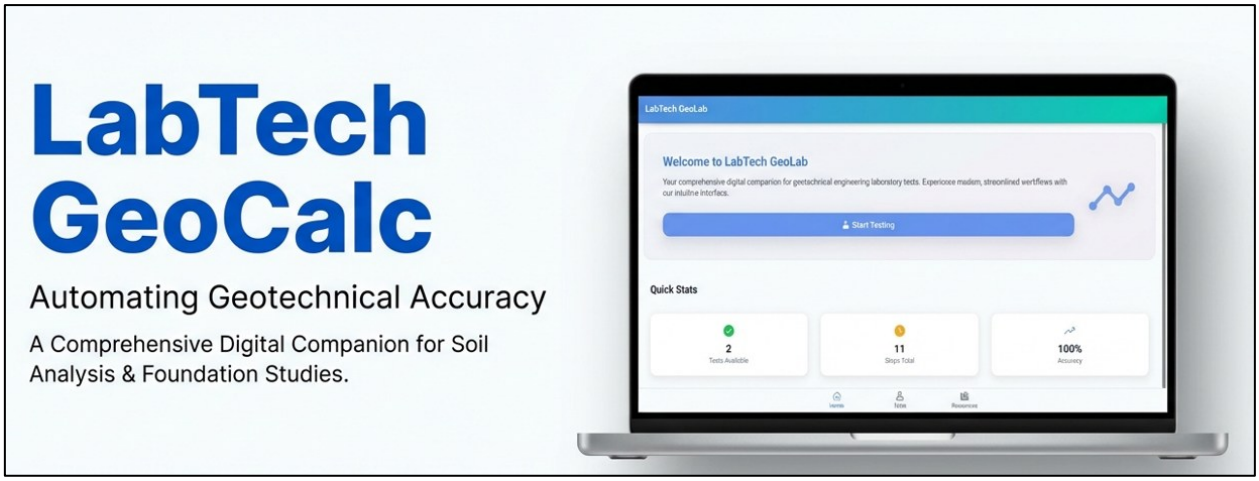

Figure 2. Main Interface Display of the LabTech GeoCalc .

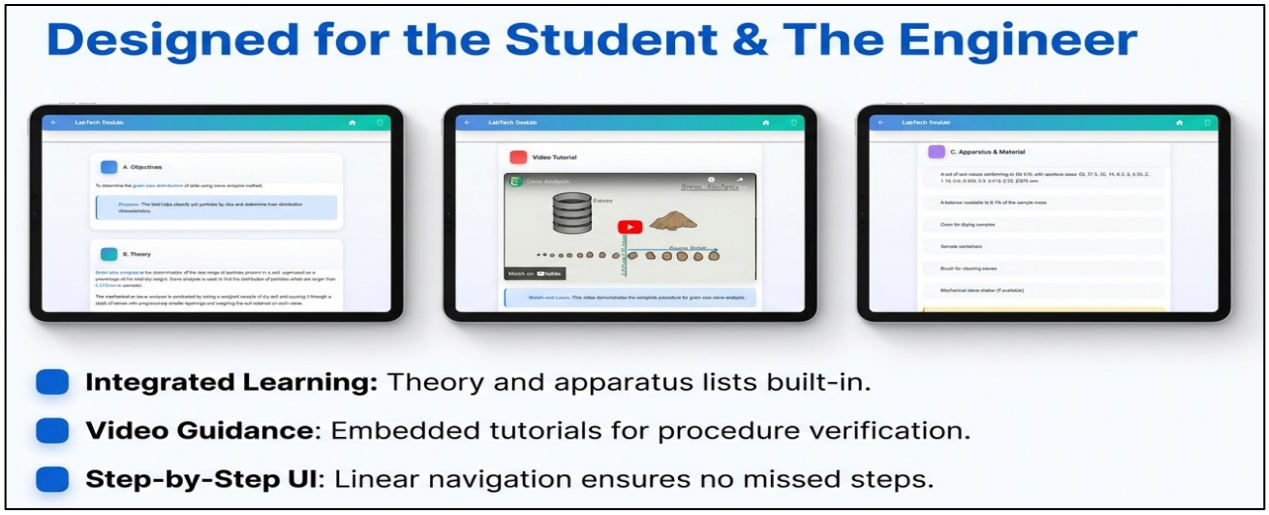

Figure 3. Display Icon of the LabTech GeoCalc .

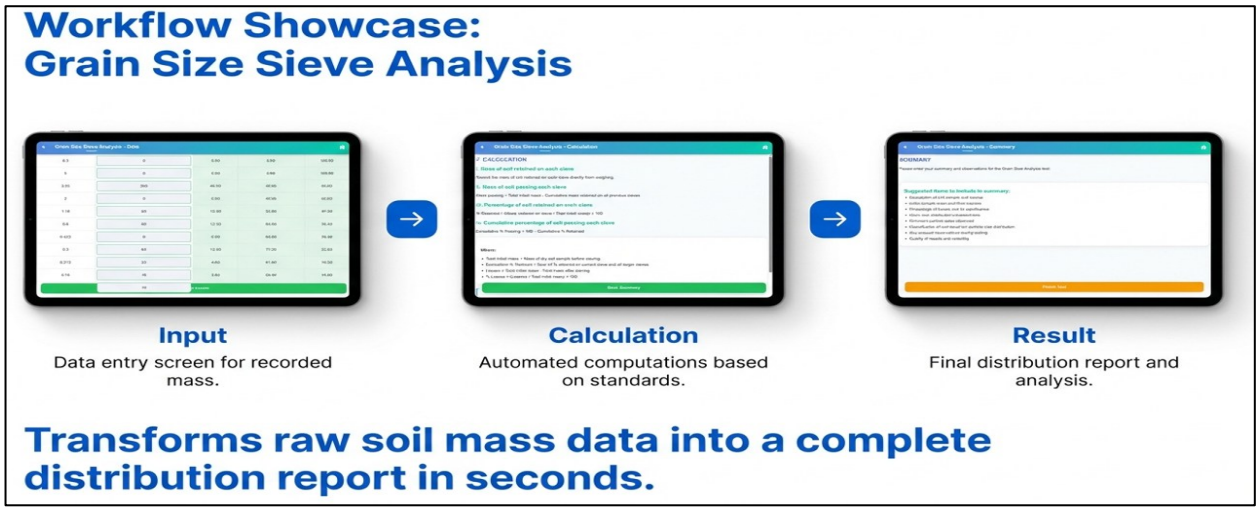

Figure 4. LabTech GeoCalc workflow.

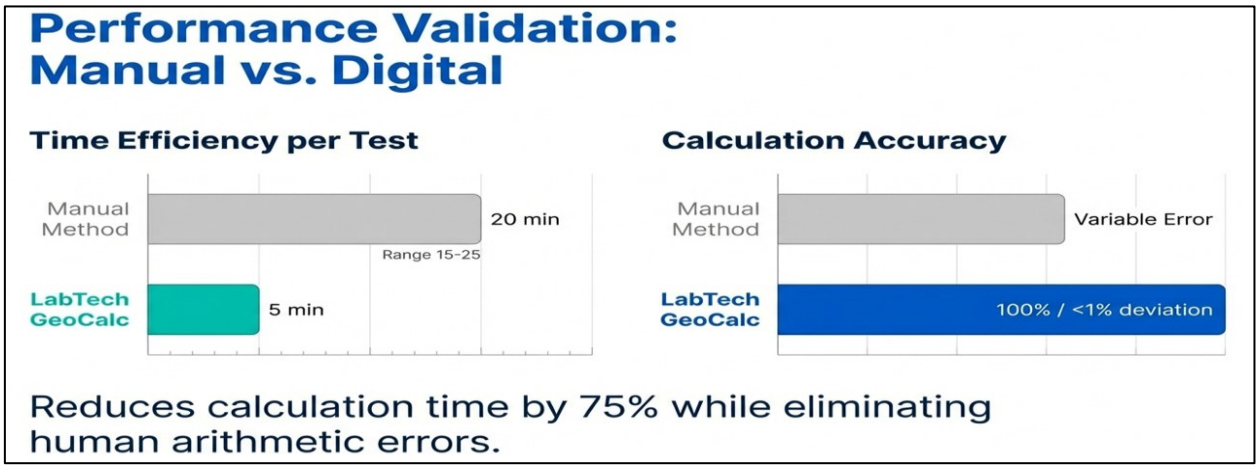

Figure 5. Comparison by using LabTech GeoCalc Innovation.

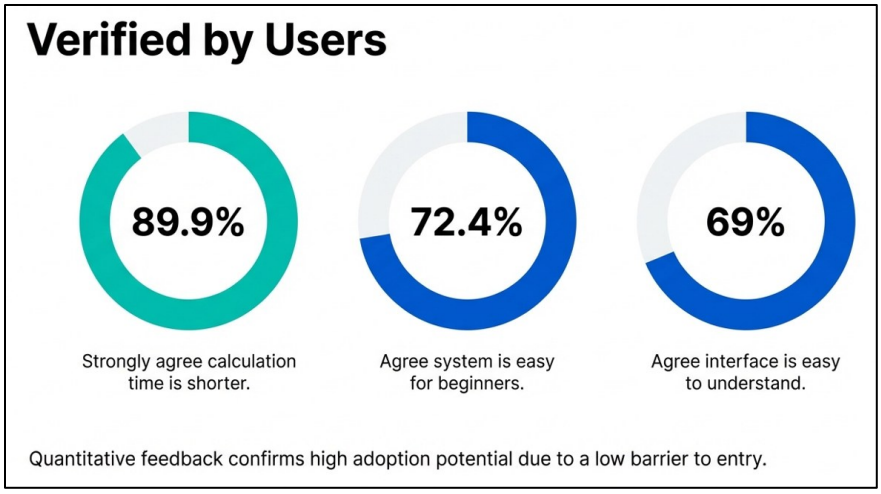

Figure 6. Achievement for the LabTech GeoCalc.

3. Novelty and uniqueness

LabTech GeoCalc distinguishes itself from traditional methods and existing digital tools through its automated visual interpretation, providing instant graphical results that eliminate the need for manual plotting on semi-logarithmic paper. Unlike complex alternatives such as MATLAB or Excel VBA, it is built on a "no-tutorial-required" philosophy, significantly lowering the technical barrier for beginners. Furthermore, the system offers comprehensive test integration by providing a unified platform for multiple geotechnical procedures, rather than focusing on a single test type. This efficiency is bolstered by a real-time feedback loop powered by Firebase, which ensures immediate error detection and allows users to correct data entries instantly before finalizing their analysis.

4. Benefit to mankind

The implementation of LabTech GeoCalc offers widespread benefits to the engineering community and society by significantly enhancing structural safety through the elimination of manual calculation errors, ensuring that soil data for infrastructure design is both accurate and reliable. Furthermore, the system delivers drastic time efficiency, reducing processing time by up to 80% which allows engineers to prioritize critical decision-making over repetitive arithmetic. It also elevates the quality of education by providing students with an interactive, visual learning experience that simplifies complex geotechnical concepts, moving away from tedious manual work. Finally, the system promotes the standardization of data by generating professional, organized reports that are ready for technical documentation and high-level presentations.

5. Innovation and Entrepreneurial Impact

The project has demonstrated a significant impact within the academic and technical communities,highlighting its high level of innovation. Furthermore, it spearheads digital transformation by introducing modern technology into a traditional manual field, setting a vital precedent for future digital advancements in civil engineering education. This success is reinforced by proven effectiveness, where survey results from 29 respondents indicated high levels of satisfaction, with the majority confirming that the system is intuitive, significantly shortens calculation time, and effectively minimizes human error.

6. Potential commercialization

The current version of LabTech GeoCalc serves as robust foundation for a commercial product, offering significant potential for the expansion of test capabilities to include advanced modules such as Permeability, Triaxial, and California Bearing Ratio (CBR) tests, which would increase its market value for large-scale engineering firms. Moving forward, the system is positioned for IoT and hardware integration, allowing for automatic data import from smart lab sensors to eliminate manual entry altogether. Furthermore, it can be commercialized through a SaaS model for education, providing subscription-based access integrated with Learning Management Systems (LMS) for global academic institutions. These commercial prospects are strongly validated by industry support, including positive endorsements from experts such as JKR Terengganu, who recognize the project as a viable, forward-looking, and industry-ready solution.

7. Acknowledgment

The development and implementation of LabTech GeoCalc would not have been possible without the support of the Head of the Department of Civil Engineering and the lecturers who applied the innovation in their teaching. Recognition is given to the administration and lecturers of Politeknik Sultan Mizan Zainal Abidin (PSMZA) for providing the necessary facilities and technical feedback. Their guidance, encouragement, and active use of the platform in the teaching and learning process were invaluable. Special thanks are also extended to the students for providing feedback during the effectiveness study, which helped refine and improve the platform, ensuring it meets learning needs and enhances student understanding and engagement with the course material.

8. Researchers' Biography

Mohd Firdaus Bin Che Soh is a Senior Lecturer in Department of Civil Engineering at Politeknik Sultan Mizan Zainal Abidin with 22 years of teaching in Geotechnical Engineering, Soil Mechanic, and Pavement Engineering Laboratory. He has been actively involved in applied research, practical training, and projects related to geotechnical engineering and teaching innovation areas. His work focuses on bridging theoretical knowledge with real-world applications, supporting student learning, and enhancing the capacity of the institution and community in geotechnical engineering.

Mazlina binti Harun is a Senior Lecturer in Department of Civil Engineering at Politeknik Sultan Mizan Zainal Abidin with 23 years of teaching in Project Management and Practices, Contract and Estimating, Building Services, Occupational Safety & Health for Engineering and Construction Material. She is actively engaged in research writing and conference presentation in areas of engineering education and teaching innovation, and she was awarded a Bronze Medal for Product Innovation at the Borneo Innovation Festival 2019 (bif19) for her outstanding contribution to research-driven innovation.

Slay the Lab: Evaluating User Acceptance of a Centralised Platform for Gross Anatomy and Histology Practical Guides

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ABSTRACT

Medical students at UiTM have already transitioned to *Ufuture*, a digital learning environment. However, *Ufuture* itself presents significant limitations, including navigational clutter, overlapping interdisciplinary materials, and the persistence of outdated files. To address this, we utilized Google Sites as a centralised, easy-to-navigate platform where Anatomy Practical Guides can be easily accessed and downloaded. To evaluate user acceptance, we surveyed 168 students using the Technology Acceptance Model (TAM). The results were highly positive, multiple linear regression analysis demonstrated that Perceived Ease of Use significantly influenced Perceived Usefulness ($R^2 = 0.562$). Both factors strongly predicted the students' Attitude Toward Using the platform ($R^2 = 0.799$). Ultimately, Attitude proved to be the strongest predictor of Behavioral Intention to continue using the platform ($\beta = 0.820$). The uniqueness of this project lies in utilizing a universally accessible tool to centralise anatomy practical guides through an open-access platform, ensuring effortless navigation and on-demand access without the need to log in. This benefits undergraduate medical students by reducing academic burden and enhancing study preparation, fostering more adept future medical professionals. Additionally, it has the potential to expand beyond these practical guides to include resources like case studies, digital histology slides, 3D specimens and quizzes.

Keywords: Medical Education, Anatomy Practical, Technology Acceptance Model (TAM), E-learning, Google Sites

1. Product Description

"Slay the Lab" is an open-access Google Site that centralises practical guides for Gross Anatomy and Histology for Year 1 and Year 2 medical students. The homepage features a dynamic live schedule tracker providing countdowns to upcoming practical sessions (updating to "Complete" once finished), alongside clear navigation buttons for all 11 system-based modules. These cover Year 1 (General Module 1, General Module 2, Musculoskeletal System, Cardiovascular System, Respiratory System, Urinary System) and Year 2 (Haemopoietic and Lymphatic System, Central Nervous System, Gastrointestinal System, Endocrine System, Reproductive System). Clicking any module buttons directs students to a dedicated page structured for seamless learning. The top "Practical Guides Download" section offers instant, one-click access to view and download the practical guide specific to that practical session. The lower "Videos" section features embedded YouTube videos and video links demonstrating anatomical specimens and histology slides, supporting students before, during, and after their anatomy laboratory sessions relating to that module. Additionally, Year 2 students can effortlessly access Year 1 materials without logging into

Ufuture. This seamless access aids comprehensive revision, helping them prepare for their upcoming preclinical professional exam where tested topics include content from Year 1, not just Year 2.

2. Platform Design Overview and Statistical Evaluation of User Acceptance Using Technology Acceptance Model (TAM).

The "Slay the Lab" Google Site was created to centralise Gross Anatomy and Histology practical guides into an easily accessible digital platform. An overview of the homepage is shown in **Figure 1**. The platform provides intuitive, centralised information featuring a dynamic live schedule tracker and module-specific navigation, as detailed in **Figure 2**. Furthermore, clicking any module directs students to a dedicated learning page offering one-click downloadable guides and embedded demonstration videos, an example of which is illustrated in **Figure 3**. To evaluate user acceptance, multiple linear regression was used to test predictive associations between TAM constructs among 168 medical students **Figure 4**. First, a significant regression equation was found between Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) ($R^2 = 0.562$, $\beta = 0.749$, $p < 0.001$). This indicates that 56.2% of the variance in the platform's perceived usefulness is directly explained by how easy it is to navigate. Second, the students' highly positive Attitude Toward Using (ATU) the platform ($R^2 = 0.799$) is collectively explained by both PEOU and PU. Third, the Behavioral Intention (BI) to continue using the platform yielded an R^2 of 0.781, driven primarily by user attitude. This indicates that when a student develops a positive attitude toward the site, they are highly predisposed to continue using it for their ongoing studies and exam revision. Furthermore, the participants' demographic profile, alongside the reliability statistics (Cronbach's Alpha > 0.9) for all measured constructs, are summarized in **Table 2.**

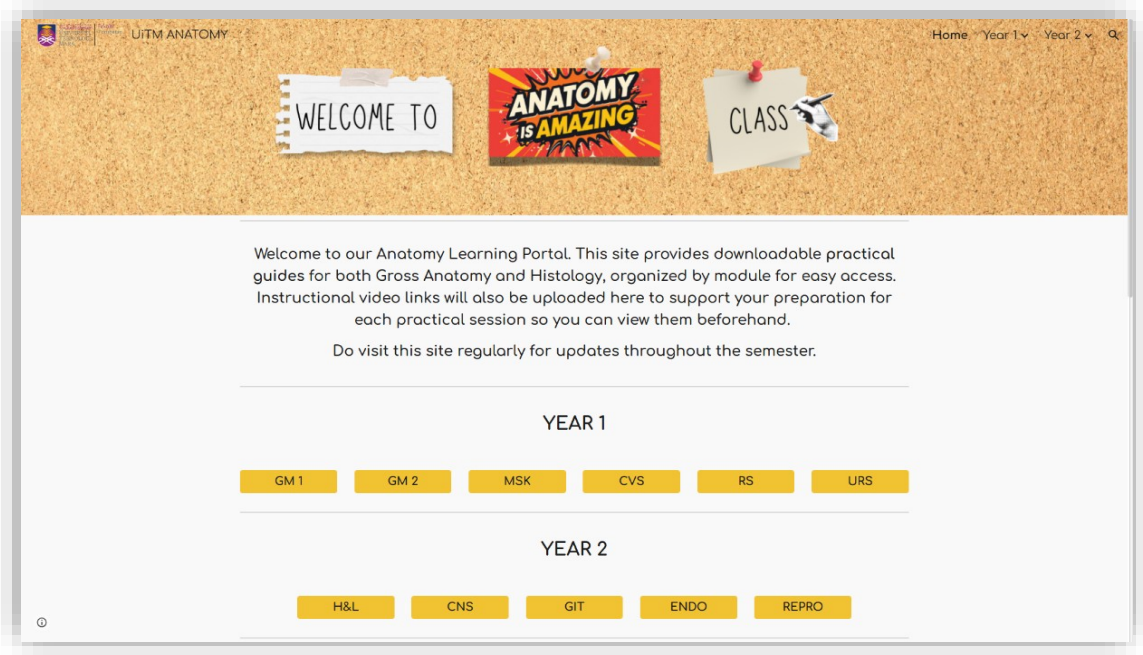

Figure 1. Overview of the platform homepage with cross-year, module-specific navigation buttons.

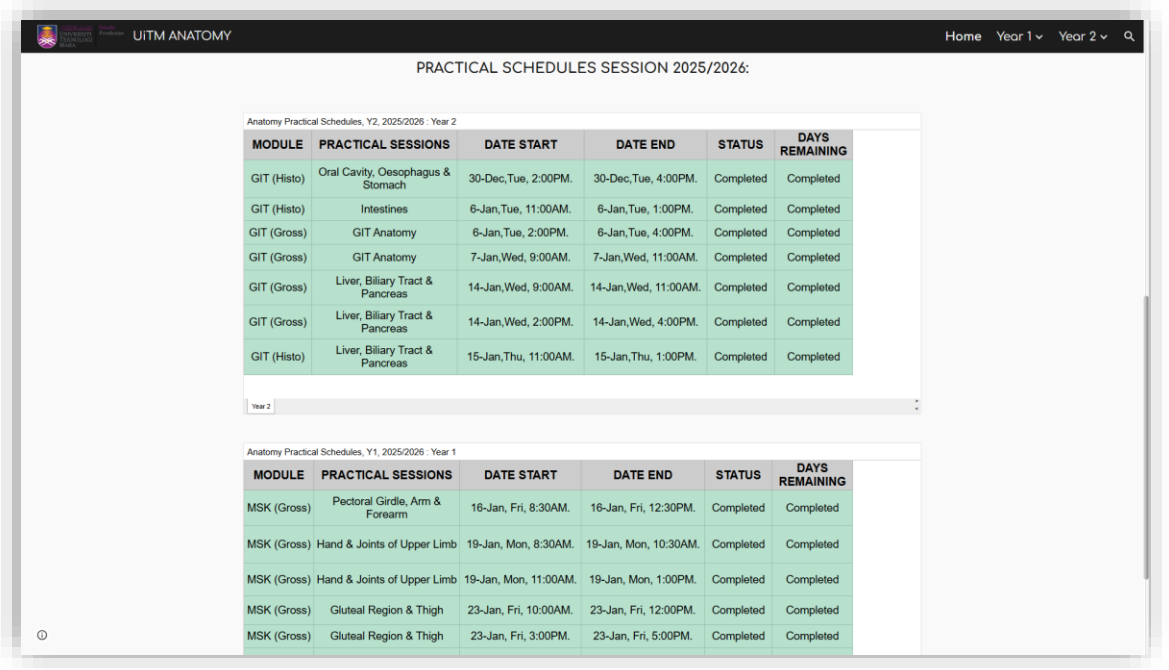

Figure 2. View of the homepage featuring the dynamic live schedule tracker of the anatomy practical sessions.

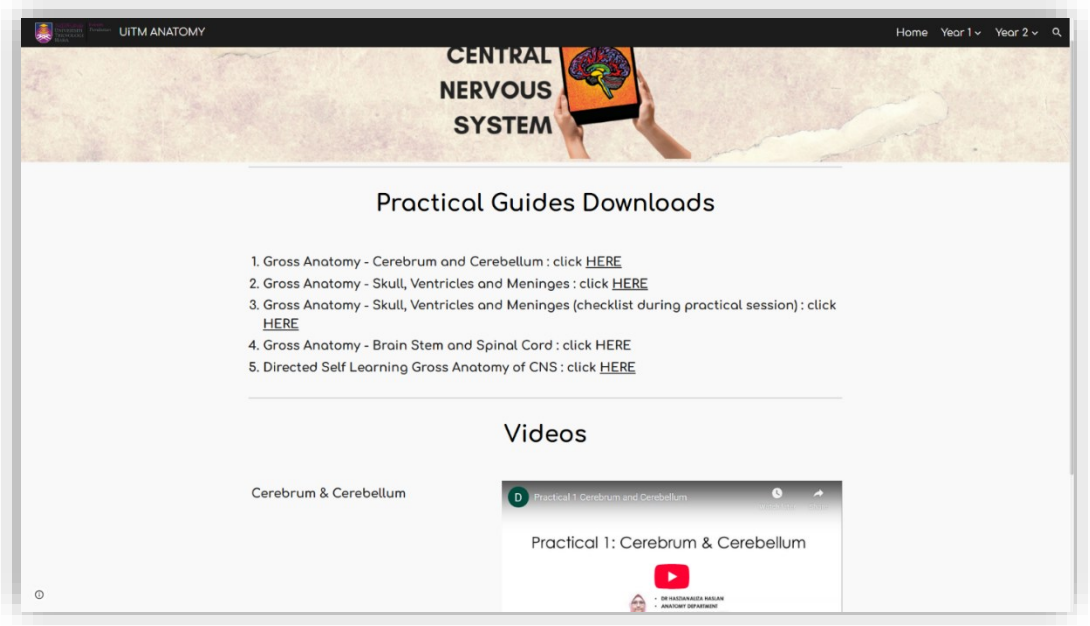

Figure 3. A module-specific learning page layout, showcasing instant download links for practical guides alongside embedded supplementary YouTube videos.

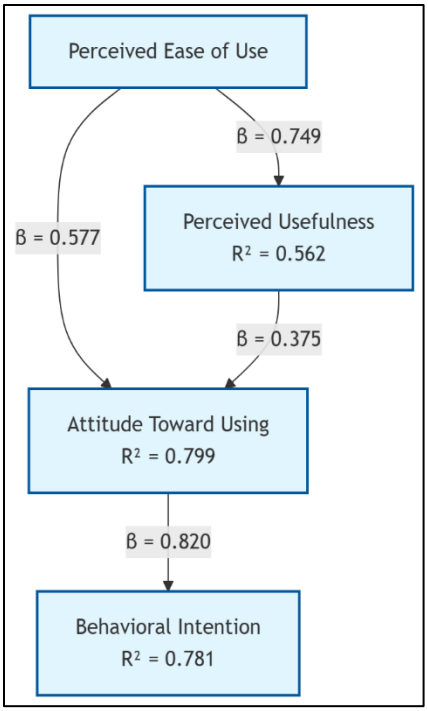

Figure 4. Relationships between TAM constructs, displaying standardized regression coefficients (β) and R-squared (R^2) values based on multiple linear regression analyses.

Table 2. Participants demographic profile and reliability statistics for the TAM constructs.

Demographic / Construct	Category	Frequency (N)	Percentage (%)	Cronbach's Alpha
Gender	Male	47	28.0%	
	Female	121	72.0%	
Prior Online Learning Experience	Yes	159	94.6%	
	No	9	5.4%	
Perceived Usefulness (PU)	4 items	168	-	0.925
Perceived Ease of Use (PEOU)	4 items	168	-	0.934
Attitude Toward Using (ATU)	4 items	168	-	0.942
Behavioral Intention (BI)	4 items	168	-	0.938

3. Novelty and uniqueness

The "Slay the Lab" Google Site provides an alternative to standard institution systems like Ufuture. While institutional platforms often involve tedious login processes and navigation through multiple layers of scattered or outdated files, this site offers instant, one-click access to essential Gross Anatomy and Histology practical resources. Additionally, this site also integrated live schedule tracker, which provides real-time countdowns to laboratory sessions, enabling students to plan their study schedules with precision and arrive better prepared. Furthermore, the platform facilitates vertical integration by allowing Year 2 students to effortlessly access Year 1 materials, a feature vital for revision during preclinical professional exams. By centralising gross

anatomy and histology practical guides, and embedded practical demonstration videos, in a single location, the platform effectively eliminates information retrieval friction. Our TAM research supports that this alternative site's ease of use is the primary driver of the positive student attitudes that sustain long-term academic engagement in anatomical subjects.

4. Benefit to mankind

This platform provides significant advantages to medical students, particularly those in the high-pressure preclinical phase. As students in their early years of medical school must digest a vast volume of complex information, centralising all practical session materials, including guides and videos, into a single accessible hub greatly eases their academic burden. Additionally, the integrated live tracker enhances study preparation, contributing to the development of more confident and skilled future medical professionals.

5. Innovation and Entrepreneurial Impact

This platform is a scalable and cost-effective innovation that can be easily replicated. Because it is built on an open-access Google Site, it is free for all students to use and does not require expensive software or subscriptions. While this version currently focuses on Anatomy practicals, the model serves as a universal blueprint that can expand to include case studies, digital histology slides, 3D specimens, and self-assessment quizzes. This project offers a way to generate income by offering these resources to medical students outside of UiTM. Since students globally often have to pay for expensive study aids, this platform can provide a more affordable, high-quality alternative.

6. Potential commercialization

The content materials of this platform have significant potential to be commercialized through a subscription strategy in the future, moving beyond just practical guides. By combining the current materials on the Google Site with advanced features such as case studies, digital 3D specimens, and self-assessment quizzes, it can generate a sustainable income stream from medical students outside of UiTM.

7. Acknowledgment

We sincerely thank the UiTM Anatomy lecturers for their invaluable guidance and support in helping to create the centralised Google Site, "Slay the Lab." We also deeply appreciate the preclinical medical students who participated in the TAM survey, whose honest feedback and enthusiastic participation were vital in validating this project's effectiveness.

8. Researchers' Biography

Dr. Nur Zuliani Ramli is an anatomist at the Faculty of Medicine, Universiti Teknologi MARA (UiTM), with research experience in basic medical sciences, particularly neuroscience and experimental models. She is currently expanding her scholarly focus into medical education, with a specific interest in e-learning and digital innovations in teaching and learning.

Dr. Nurul Hannim is a medical doctor and Lecturer in Anatomy since 2015, holding an MBBS and MSc in Medicine. Formerly a Medical Officer in the Ministry of Health, she worked across multiple departments before transitioning to academia. She publishes in anatomy education and is currently pursuing a PhD.

Dr. Nurul Sazmi Rosani is an anatomy lecturer and dedicated innovator at the Faculty of Medicine, Universiti Teknologi MARA (UiTM). She has spearheaded numerous digital innovations in medical education, successfully copyrighting a wide array of products ranging from digital apps to student-centric learning tools.

Dr. Muhammad Fairuz Azmi is the Head of the Department of Anatomy at the Faculty of Medicine, Universiti Teknologi MARA (UiTM). He is a highly accomplished medical lecturer who has received multiple prestigious awards for his continuous innovations in teaching and learning.

Grip-O-Matic
Home-Based, DIY Hand Strengthening Exercise

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ABSTRACT
This project introduces a home-based DIY hand-strengthening solution—a "frugal innovation" designed to democratize orthopedic rehabilitation. Invented to bypass the high costs of clinical hardware, the Grip-O-Matic uses a simple, anchor-based design to facilitate both hand-opening and hand-closing motions. Patients weave their fingers through rubber bands to engage in resistance-based expansion, a unique feature that isolates intrinsic muscles without the need for specialized sensors. Its primary advantage is its user-driven adaptability: patients can modify tension levels to match their specific progress, ensuring a personalized recovery regardless of economic status. By lowering financial barriers, the device helps reduce the global burden of post-surgical disability. The project holds significant commercialization potential, offering a scalable Direct-to-Consumer (DTC) kit model that aligns perfectly with modern telehealth and remote patient monitoring trends.

Keywords: hand grip, strength, muscle weakness, hand injury, rehabilitation equipment

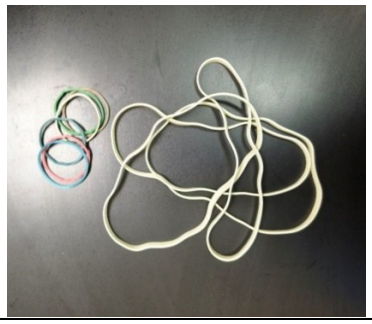
1. Product Description
Grip-O-Matic is a simple, effective tool designed for patients regaining hand function after orthopedic surgery or have hand weakness. While most rehabilitation focuses on squeezing, this tool targets the "opening" motion of the hand—the movement essential for releasing objects and stretching the palm. The device consists of two to ten sturdy anchor points fixed six inches apart. Users weave their fingers through rubber bands stretched between these points. By pushing outward against the bands, the patient builds strength in the small muscles on the back of the hand and fingers. The difficulty is fully adjustable; simply add more bands to increase the effort required to pull the band out, for single-finger or full-grip.

2. Material and item for Grip-O-Matic
Grip-O-Matic is constructed from common hardware store materials, allowing for easy adjustments based on patient preference. Its resistance can be graded to match the patient's current hand strength and functional ability. Items needed are a board frame, a hook, and 2 different types of rubber for different grades of resistance. In **Table 1**, is the material and the budget required are listed, and in **Table 2**, the material with the end product for Grip-O-Matic.

Table 1. List of materials and budget.

Material	Unit	Price (RM)
Board frame (10" x 10")	1	4.00
Hook	10	2.60
Rubber band (wide, white)	10	2.60
Rubber band	1	2.60
TOTAL (RM)		**11.80**

Table 2. Image Of Material and End Product of Grip-O-Matic.

	BOARD FRAME
	HOOK
	**RUBBER**
	GRIP-O-MATIC

3. Novelty and uniqueness

Grip-O-Matic disrupts the traditional focus of orthopedic rehabilitation, which disproportionately emphasizes grip strength (flexion). Its novelty lies in its "Reverse-Load" mechanical design, specifically engineered to isolate and train the extensor tendons and intrinsic hand muscles—the primary components responsible for hand opening and object release. Unlike handheld squeeze balls or spring-loaded grips that move freely in space, the Grip-O-Matic uses a fixed-plane anchor system. By securing the resistance to a static board, it eliminates "compensatory movement," preventing the patient from using their wrist or forearm to "cheat" the exercise. This ensures 100% of the effort is concentrated on finger dexterity and expansion. Furthermore, it introduces a Modular Tension Scale. By using standard household elastics of varying thicknesses, patients can achieve granular, incremental resistance levels that usually require expensive clinical hardware. This "analog-programmable" approach allows for a customized recovery curve that can be adjusted daily based on the patient's pain threshold and surgical progress.

4. Benefit to mankind

The Grip-O-Matic democratizes high-quality orthopedic recovery by removing the financial and geographical barriers to rehabilitation. For patients in low-resource settings or those with limited mobility, this tool provides a zero-cost pathway to independence.

By mastering the "controlled release" and "palm expansion" movements, patients regain the ability to dress themselves, handle hygiene tools, and eat independently—tasks that are often lost when rehab only focuses on grip. By reducing the need for expensive clinical visits and specialized equipment, it lowers the global economic burden of post-surgical care. It empowers the patient to transition from a passive recipient of therapy to an active participant in their own healing, using nothing more than common household items to rebuild a functional life.

5. Innovation and Entrepreneurial Impact

The Grip-O-Matic fosters a culture of "frugal innovation" by proving that high-tier medical outcomes do not require high-cost infrastructure. It promotes entrepreneurship within the healthcare community by providing a scalable, "Open-Source" blueprint that occupational therapists and local clinics can adapt and personalize without proprietary hardware constraints.

In a clinical setting, this project encourages a shift from passive equipment purchasing to active problem-solving, empowering practitioners to become "micro-entrepreneurs" who design custom rehab solutions for their specific patient demographics. For the industry, it challenges the monopoly of expensive, motorized rehab devices by introducing a mechanical, zero-energy alternative. This democratizes medical technology, allowing startups in emerging markets to enter the medical device space with low capital requirements. By prioritizing accessibility and modularity, the project serves as a catalyst for community-led healthcare solutions that are sustainable, affordable, and locally manufactured.

6. Potential commercialization

The commercial potential of the Grip-O-Matic lies in its transition from a DIY concept and low cost to a Professional Rehab Kit (PRK). A commercial version would include a high-durability, medical-grade polymer board with calibrated "Tension-Tested" bands, packaged as an affordable, prescription-ready home therapy kit. Direct-to-Consumer (DTC) model through telehealth platforms offers a significant revenue stream, targeting the growing "home-rehab" market. With global healthcare trends shifting toward remote patient monitoring and early hospital discharge,

a low-cost, certified mechanical trainer represents a scalable, high-margin opportunity for healthcare distributors and medical equipment startups.

7. Acknowledgment

Heartfelt thanks go to my peers for their insightful critiques, which helped shape this DIY idea into a professional rehabilitation tool dedicated to helping patients regain their independence safely. We are also incredibly grateful to Universiti Teknologi MARA, Pulau Pinang Branch, Bertam Campus for their support and for providing the perfect environment to bring this research to life.

8. Researchers' Biography

Nurul'ain Shuhaimi is a dedicated Lecturer in the Occupational Therapy Department at Universiti Teknologi MARA (UiTM) Cawangan Pulau Pinang, Kampus Bertam. She has experience both in clinical and teaching for 9 years as an Occupational Therapist. With an extensive background in clinical rehabilitation and health sciences, her work focuses on enhancing functional independence and quality of life for diverse patient populations. She also specialized in medical neuro-rehabilitation and orthopedic interventions.

Nurshazana Akmal Jamaludin is a Physiotherapy Lecturer at UiTM Cawangan Pulau Pinang, Kampus Bertam, with an academic career spanning over 15 years. Her expertise encompasses physiotherapy rehabilitation, musculoskeletal health, neurology, and women's health conditions. Throughout her career, she has published various research papers and secured multiple innovation awards for her contributions to the field. Her extensive experience makes her a key figure in developing healthcare solutions that address diverse and complex patient needs.

Sakinah Rasli has been involved with studies related to Mental Health and Well-being, Rehabilitation and Therapy, Occupational Therapy in neurorehabilitation, stroke rehabilitation, and community centers. Sakinah Rasli worked at the School of Integrative Medicine and Life Sciences, KPJ Healthcare University as a lecturer and has been actively in private practice as an occupational therapist.

Nurul Izzah binti Abdul Razak is a dedicated Occupational Therapist currently serving at Universiti Teknologi MARA (UiTM) Kampus Bertam. In addition to her clinical roles, she has extensive experience teaching and supervising students during clinical attachments, guiding them in clinical reasoning and hands-on skills development. Passionate about innovation in rehabilitation, she actively develops practical, low-cost therapeutic products and has received several awards, including gold medals, for her contributions. Her professional interests focus on integrating clinical excellence, education, and innovation to enhance patient care and learning.

Shoe Seguro: Choosing the Best Sports Shoes for You!

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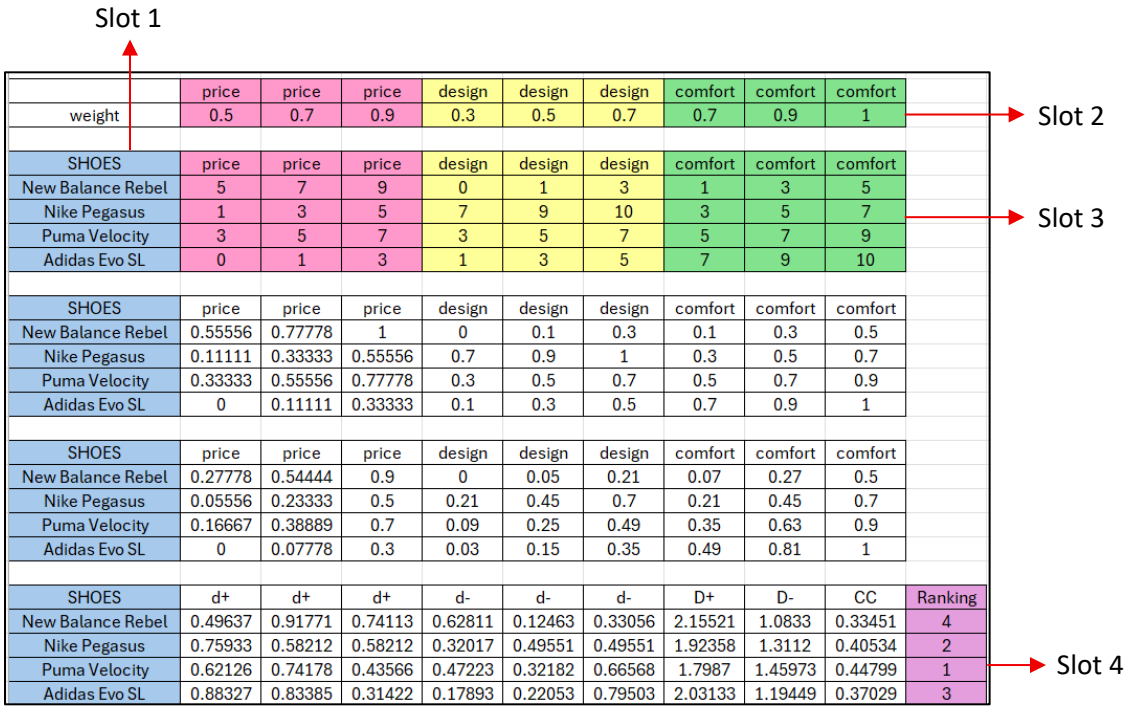
ABSTRACT
Choosing a pair of sports shoes to buy is not easy. There are many options available and many criteria to be considered. Shoe Seguro is a tool that uses fuzzy Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) to help people choose the best sports shoes for them to buy. It is created in Microsoft Excel and easy to use. The target users are people, particularly consumers, who want to buy sports shoes and sports store promoters who are responsible to assist people to buy sports shoes. The tool offers a systematic and an efficient decision-making process by reducing time, level of stress, and the ambiguity in people's thoughts which allows for a better buying or shopping experience. To expand its commercialization potential, the tool can be further developed into mobile apps and sold to sports stores worldwide.

Keywords: Sport shoes, choose, ranking, fuzzy TOPSIS

1. Introduction
Oftentimes when we walk into a sports store with an intention to buy a pair of sports shoes, we will feel overwhelmed with choices. There are many types and brands of sports shoes available with various designs and ranges of prices. We pick one shoe admiring its design but gasp at its price. We then pick another shoe with lesser price but turns out, the shoe is too stiff or ill-fitting at the toes. Sometimes, we ask for assistance from store promoter. However, the advice and suggestion given by the store promoter are typically biased and neither fully helpful nor reliable. At the end of the day, we become frustrated and indecisive.

Clearly, deciding on which sports shoes to buy is a tough thing to do. Apart from having many options, people also need to consider many criteria. Furthermore, people's perceptions are subjective. Every person has different preference, interest, as well as financial condition. Therefore, Shoe Seguro is created to help people choose the best sports shoes for them to buy.

1. Product Description
Shoe Seguro is a tool built in Microsoft Excel using fuzzy Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method. The formulas have been embedded in the Microsoft Excel, hence, all calculations will be done automatically. All users need to do is insert the information in the required slots, and the result in the form of ranking will be displayed right away. The snapshot of Shoe Seguro is shown in **Figure 1**.



	price	price	price	design	design	design	comfort	comfort	comfort
weight	0.5	0.7	0.9	0.3	0.5	0.7	0.7	0.9	1

SHOES	price	price	price	design	design	design	comfort	comfort	comfort
New Balance Rebel	5	7	9	0	1	3	1	3	5
Nike Pegasus	1	3	5	7	9	10	3	5	7
Puma Velocity	3	5	7	3	5	7	5	7	9
Adidas Evo SL	0	1	3	1	3	5	7	9	10

SHOES	price	price	price	design	design	design	comfort	comfort	comfort
New Balance Rebel	0.55556	0.77778	1	0	0.1	0.3	0.1	0.3	0.5
Nike Pegasus	0.11111	0.33333	0.55556	0.7	0.9	1	0.3	0.5	0.7
Puma Velocity	0.33333	0.55556	0.77778	0.3	0.5	0.7	0.5	0.7	0.9
Adidas Evo SL	0	0.11111	0.33333	0.1	0.3	0.5	0.7	0.9	1

SHOES	price	price	price	design	design	design	comfort	comfort	comfort
New Balance Rebel	0.27778	0.54444	0.9	0	0.05	0.21	0.07	0.27	0.5
Nike Pegasus	0.05556	0.23333	0.5	0.21	0.45	0.7	0.21	0.45	0.7
Puma Velocity	0.16667	0.38889	0.7	0.09	0.25	0.49	0.35	0.63	0.9
Adidas Evo SL	0	0.07778	0.3	0.03	0.15	0.35	0.49	0.81	1

SHOES	d+	d+	d+	d-	d-	d-	D+	D-	CC	Ranking
New Balance Rebel	0.49637	0.91771	0.74113	0.62811	0.12463	0.33056	2.15521	1.0833	0.33451	4
Nike Pegasus	0.75933	0.58212	0.58212	0.32017	0.49551	0.49551	1.92358	1.3112	0.40534	2
Puma Velocity	0.62126	0.74178	0.43566	0.47223	0.32182	0.66568	1.7987	1.45973	0.44799	1
Adidas Evo SL	0.88327	0.83385	0.31422	0.17893	0.22053	0.79503	2.03133	1.19449	0.37029	3

Figure 1. Shoe Seguro snapshot.

To use the tool, the following steps must be followed:

Step 1: List out the sports shoe models that user has in mind. Insert the sports shoe models in slot 1.

Step 2: Determine the order of criteria (price, design, comfort) that user considers when buying sports shoes using the information given in **Table 1**. Key in the corresponding fuzzy number of order of each criterion in slot 2.

Step 3: Rate sports shoe models based on each criterion using the information given in **Table 2**. Key in the corresponding fuzzy number of rating of each sports shoe model in slot 3.

Step 4: Look at the ranking of sports shoe models in slot 4. Sports shoe model with ranking number 1 is the best sports shoe model for the user.

Table 1. Fuzzy number for order of considered criteria when buying sport shoes.

Order of criteria	Fuzzy number
First criterion I consider	(0.7, 0.9, 1.0)
Second criterion I consider	(0.5, 0.7, 0.9)
Third criterion I consider	(0.3, 0.5, 0.7)
Fourth criterion I consider	(0.1, 0.3, 0.5)
Last criterion I consider	(0, 0.1, 0.3)

Table 2. Fuzzy number for rating of sports shoes based on criteria.

Price	Design	Comfort	Fuzzy number
That's a great deal!	Stunning	I could wear this all day	(7, 9, 10)
I can afford that	Stylish enough	Comfortable enough	(5, 7, 9)
I'll be broke	Not bad	Quite bearable	(3, 5, 7)
Pretty overpriced	Not my style	Slightly uncomfortable	(1, 3, 5)
Out of my budget	Horrible	Not comfortable at all	(0, 1, 3)

2. Novelty and uniqueness

Shoe Seguro is a tool that uses fuzzy TOPSIS method which takes into account human's subjective and ambiguous judgement. Fuzzy TOPSIS supports decision-making process that involves multiple criteria. Using fuzzy TOPSIS, decision can be made in a more scientific and systematic manner. Thus, people can stop relying on other people's opinion and avoid making hasty and impulsive decision in buying sports shoes when using Shoe Seguro. Fuzzy TOPSIS method involves a number of procedures and calculations using mathematical formulas. The formulas have been set in a Microsoft Excel, hence, the calculations do not need to be done manually, making Shoe Seguro easy to use. It gives immediate result which is the ranking of sports shoes.

3. Benefit to mankind

Shoe Seguro can help people make better judgement and decision in buying sports shoes. With Shoe Seguro, decision on which sports shoes to buy can be made more systematically and efficiently. People, specifically consumers can have better experience when buying sports shoes if they use Shoe Seguro because it can reduce not only time, but also the stress level. In addition, Shoe Seguro can be used by sports store promoters to provide valuable guidance and assistance to customers who want to buy sports shoes at the store. They can practically suggest the sports shoes that match with customers' preference and interest without bias. This could result in extremely satisfied customers which consequently lead to high profit returns.

4. Innovation and Entrepreneurial Impact

Shoe Seguro is an innovation that supports digital transformation recommendations. It shifts practice from traditional to intelligent and technology-driven system. It also encourages the collaboration between information technology and sports industry. It is evident that Shoe Seguro can significantly impact entrepreneurship. This is due to the fact that Shoe Seguro is basically a system, thus, it is highly scalable. It does not require a huge amount of cost to be implemented. Apart from that, it can also improve operational efficiency by minimizing manual work and human error.

5. Potential commercialization

Shoe Seguro can be patented and sold to sports stores such as Al-Ikhsan Sports, Decathlon, and Sports Direct. Since it is built in Microsoft Excel, Shoe Seguro can be further developed into mobile apps to make it more practical, and the sports stores can either integrate Shoe Seguro with their already-existing store apps or use the tool on its own.

6. Acknowledgment

Special thanks to my nerdy student and an avid runner, Muhammad Aiman Hakim bin Mohd Basri for his willingness to participate in my study.

7. Researchers' Biography

Raihana Zainordin is a senior lecturer in UiTM Perlis with over 15 years of experience in teaching. She obtained her Bachelor and Master's degree in Mathematics from Universiti Teknologi Malaysia (UTM). Her research area of interest is fuzzy multi-criteria decision making, mainly fuzzy TOPSIS, fuzzy PROMETHEE, and fuzzy ELECTRE. She loves reading fiction books and enjoys playing volleyball. She also owns a YouTube channel with almost 5000 subscribers, where she posts videos on Statistics, Probability, Operations Research, and occasionally Calculus.

NestLab Compost: An Inclusive, User-Friendly Rotating Compost System for Community-Based Nursery at PPDK Teluk Bahang

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ABSTRACT
NestLab Compost is a community-based composting prototype designed to support sustainable nursery operations and inclusive skill development at the Nursery of Teluk Bahang Community Rehabilitation Centre or Pusat Pemulihan Dalam Komuniti (PPDK) Teluk Bahang. The system converts organic waste into usable compost to improve soil quality and reduce operational costs. The prototype is innovated with a manual handle to rotate the compost bin and an overflow pipe at the bottom to ease the user to drain out excessive moisture, ensuring better aeration, leachate control and user safety. The system is intentionally designed for low-cost fabrication, ease of operation and minimal physical strain. Beyond waste management, this innovation targets the enhancement of motor skills of people with disabilities (OKU) at PPDK through the practise of rotating the handle and opening and closing the overflow pipe at the bottom of the bin. The simple rotation mechanism allows repetitive, guided movement suitable for therapeutic and vocational training. NestLab Compost contributes to socio-environmental impact by reducing organic waste, producing local organic compost and empowering OKU trainees with practical green skills. The prototype has strong potential for replication in community nurseries, schools and small-scale urban farming initiatives, providing a scalable and socially inclusive composting solution.

Keywords: compost system, inclusive innovation, community nursery, organic waste, OKU training

1. Product Description
NestLab Compost is a vertical drum-based composting system developed for small community nurseries with limited space and manpower. The system consists of a closed plastic drum mounted on a steel frame and equipped with a front access panel, a manual rotating handle and a bottom overflow pipe. Organic waste such as vegetable residues, fruit peels and nursery trimmings are inserted from the top opening. The composting process is accelerated through regular manual rotation to improve aeration and mixing. The key innovation lies in the handle mechanism that allows users to rotate the compost drum safely with minimal force, and the overflow pipe at the bottom that enables easy drainage of excessive moisture. These features improve compost quality by preventing waterlogging and odour formation, while also simplifying routine maintenance. The prototype is designed to be operated by OKU trainees under supervision as part of agriculture and nursery activities at PPDK Teluk Bahang. The repetitive

rotation task is integrated into training modules to support basic motor coordination and vocational exposure, while simultaneously producing compost for on-site planting activities.

2. Pictures of the NestLab Compost

System configuration and operational features of NestLab Compost. **Figure 1a-d** shows the NestLab compost prototype, consisting of three vertical compost drums mounted on steel frames with individual rotating handles and top feeding inlets. The bottom section of each drum is equipped with an overflow pipe to discharge excess leachate and prevent excessive moisture accumulation.

Figure 1a. The NestLab compost prototype with rotating handle.

b. Close up of the rotating handle on top of the bin for motor skills practise

c. Front access door panel and the black steel stand, framing the bin as an added safety measure

d.The overflow pipe at the bottom of the bin

3. Novelty and uniqueness

The novelty of NestLab Compost lies in its inclusive and user-centred mechanical design for community rehabilitation environments. Unlike conventional static compost bins, the system integrates a simple manual handle that enables controlled drum rotation without lifting, bending or heavy manual turning. This significantly reduces physical barriers for users with limited strength

or coordination. In addition, the integration of a bottom overflow pipe for moisture discharge is a practical improvement that directly addresses common operational issues in small-scale composting, such as leachate accumulation, anaerobic conditions and odour. The drainage feature simplifies daily management and improves compost stability and quality. The system is uniquely positioned as a dual-function innovation: a waste-to-resource technology and a motor-skill enhancement tool for people with disabilities. Its design allows repetitive, low-risk movement activities to be embedded into daily nursery routines. The low-cost fabrication, modular frame structure and simple components make the system suitable for replication in community rehabilitation centres and small institutions.

4. Benefit to mankind

NestLab Compost benefits society by reducing organic waste disposal and supporting local production of organic compost for community nurseries. The system promotes sustainable agriculture practices and improves soil health without reliance on chemical fertilisers. More importantly, it provides an inclusive learning environment for people with disabilities by embedding simple mechanical tasks into real agricultural activities. This approach strengthens practical skills, self-confidence and participation in green livelihood pathways. The model supports community resilience through environmental stewardship while enhancing the well-being and employability of vulnerable groups.

5. Innovation and Entrepreneurial Impact

NestLab Compost promotes innovation through the integration of inclusive design principles into environmental technology. The prototype encourages a culture of social entrepreneurship by transforming waste management challenges into value-generating products such as compost for nursery operations and local sales. The system enables PPDK to explore small-scale green enterprise opportunities, including compost selling to the local communities in the area and selling vegetables to the nearby tomyam shops, flats and SME enterprise. By involving OKU trainees in daily operations, the project nurtures an inclusive innovation ecosystem that combines environmental solutions with social empowerment and skills development.

6. Potential commercialization

NestLab Compost has strong commercialization potential as a low-cost, modular composting unit for community nurseries, schools, urban farms and rehabilitation centres. The system can be produced through local fabrication workshops and offered as a complete kit or customised installation package. Its inclusive design and training-oriented features differentiate it from conventional compost bins in the market. Potential business models include direct sales, institutional procurement, social enterprise partnerships and training-plus-equipment bundles for community-based organisations.

7. Acknowledgment

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8. Researchers' Biography

Dr. Widad Fadhullah is a Senior Lecturer under Environmental Technology, School of Industrial Technology, Universiti Sains Malaysia with expertise in community-based sustainability projects, community-focused waste-to-resource systems and inclusive environmental innovation. Her work focuses on integrating green technologies, practical ecological solutions into community empowerment. With over 14 years of experience, her work bridges academia and community, championing sustainability led projects.

Dr. Harlina binti Ahmad is a senior lecturer under Environmental Technology, School of Industrial Technology, Universiti Sains Malaysia specialising in sustainable agriculture through her work in environmental monitoring, assessment, and agricultural environmental science. Her background also aligns with wetland-related agricultural concerns and eco-engineering solutions that enhance innovative problem-solving in land and water resource management within agriculture-linked systems.

Dr. Mohd Asyraf Kassim is a senior lecturer under Bioprocess Engineering Technology, School of Industrial Technology, Universiti Sains Malaysia with specialty in integrating green technology through renewable biomass processing and bioprocess innovation while contributing to sustainable agricultural systems. His research focused upon microalgal applications in bioremediation, CO_2 biofixation, and biomass optimization, reflecting his broader commitment to scientific innovation and excellence demonstrated across research projects, academic leadership, and participation in technology-driven innovation platforms.

Prof. Dr. Norli binti Ismail is a professor in Environmental Technology, School of Industrial Technology, Universiti Sains Malaysia and leading environmental technologist whose expertise spans sustainable agriculture and green technology. This is demonstrated through her extensive work on biogas production and purification from municipal solid waste via anaerobic digestion, as the development of green and bioactive materials for wastewater treatment and biogas purification, alongside broader contributions to bioenergy, bioremediation, and sustainable environmental solutions that support circular resource use and low-carbon development in both industrial and agricultural sectors.

GenusGenius: Machine Learning–Based Web Application for Bacterial Genus Identification Using Microscopy, Colony Morphology, and Biochemical Test Profiles

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ABSTRACT

In microbiology education, the transition from laboratory data acquisition to taxonomic inference often suffers from manual interpretative bottlenecks. This project introduces a web-based bacterial identification platform that leverages supervised machine learning to analyse structured phenotypic and biochemical data. By integrating a computational layer into the traditional workflow, the system performs rapid pattern recognition using colony morphology and biochemical profiles to provide real-time probabilistic identification without replacing essential wet-lab practices. The classification models were developed using a synthetic dataset to ensure robust feature encoding and cross-validation while bypassing biosafety constraints. This dataset includes standardized descriptors such as pigmentation, hemolysis, and enzymatic activities (e.g., catalase, oxidase). Beyond its technical utility, the platform holds significant entrepreneurial value as a scalable SaaS (Software as a Service) product. Its low maintenance costs and high scalability make it ideal for subscription-based deployment in educational institutions and preliminary diagnostic support in resource-limited research centers. By merging digital learning with healthcare technology, the platform offers a sustainable, market-ready solution for enhancing microbiological training and diagnostic efficiency.

Keywords: Bacteria Identification, Microbiology Learning, Web based System, Bacterial Morphology, Machine Learning

1. Product Description

This project describes a web-based bacterial identification platform integrating supervised machine learning to analyze structured phenotypic data, including colony morphology and biochemical test profiles. The system is designed as a decision-support tool for preliminary taxonomic inference in microbiology education and training settings. In conventional laboratory practice, bacterial identification relies on sequential biochemical assays and manual interpretation of phenotypic characteristics. Although these procedures are essential for developing technical competency, integrating multiple morphological and biochemical variables into a coherent taxonomic conclusion can be cognitively demanding and time-consuming. The proposed platform introduces a computational framework that processes multiple structured phenotypic variables simultaneously and generates probabilistic classification outputs. The system operates exclusively on non-image laboratory data entered after experimental procedures, ensuring that hands-on culture and biochemical testing remain central to the learning process. Machine learning models are trained on curated phenotypic datasets to recognize taxonomic patterns and support rapid interpretative synthesis. The web-based architecture provides real-time feedback, enables iterative hypothesis testing, and supports scalable deployment across educational institutions. Rather than replacing laboratory methodology, the platform enhances interpretative consistency and accelerates preliminary identification, addressing the limited availability of accessible digital tools for structured bacterial identification in microbiology education.

2. Methods and Discussion

This schematic diagram presents the workflow of the proposed machine learning system, beginning with Data Collection and ending with Knowledge generation (**Figure 1**). The collected data are first processed in the Data Preprocessing stage, which includes Missing Data Handling, Tokenization, and Data Normalization to improve data quality. The preprocessed data are then transformed into numerical features using Bag of Words (BoW) and TF-IDF techniques during the Data Transformation phase. These features are used in the Model Development stage, where a Logistic Regression algorithm is applied to build the classification model. Subsequently, the model is evaluated using Accuracy, Precision, Recall, and F-measure during the Model Evaluation stage to assess its effectiveness. Finally, the evaluated model forms the Proposed Machine Learning System, which produces meaningful knowledge from the analyzed data.

Data collection: consists of 24 attributes, the target class, and 360 simulated data points. Data preprocessing: Handle missing values, standardize labels, and normalize the dataset (e.g., convert symbols such as "+" and "–" into textual categories "Positive" and "Negative"), Tokenize free-text fields (e.g., colony morphology descriptions/image cues) and perform basic cleaning (lowercasing, symbols removal if needed. Data transformation: Convert text features using Bag-of-Words (BoW) and TF–IDF representations. Model development: Train a Logistic Regression classifier using an 80:20 train–test split (80% training, 20% testing). Model evaluation: Evaluate performance using accuracy, precision, recall, and F1-score, derived from the confusion matrix (**Figure 2**)

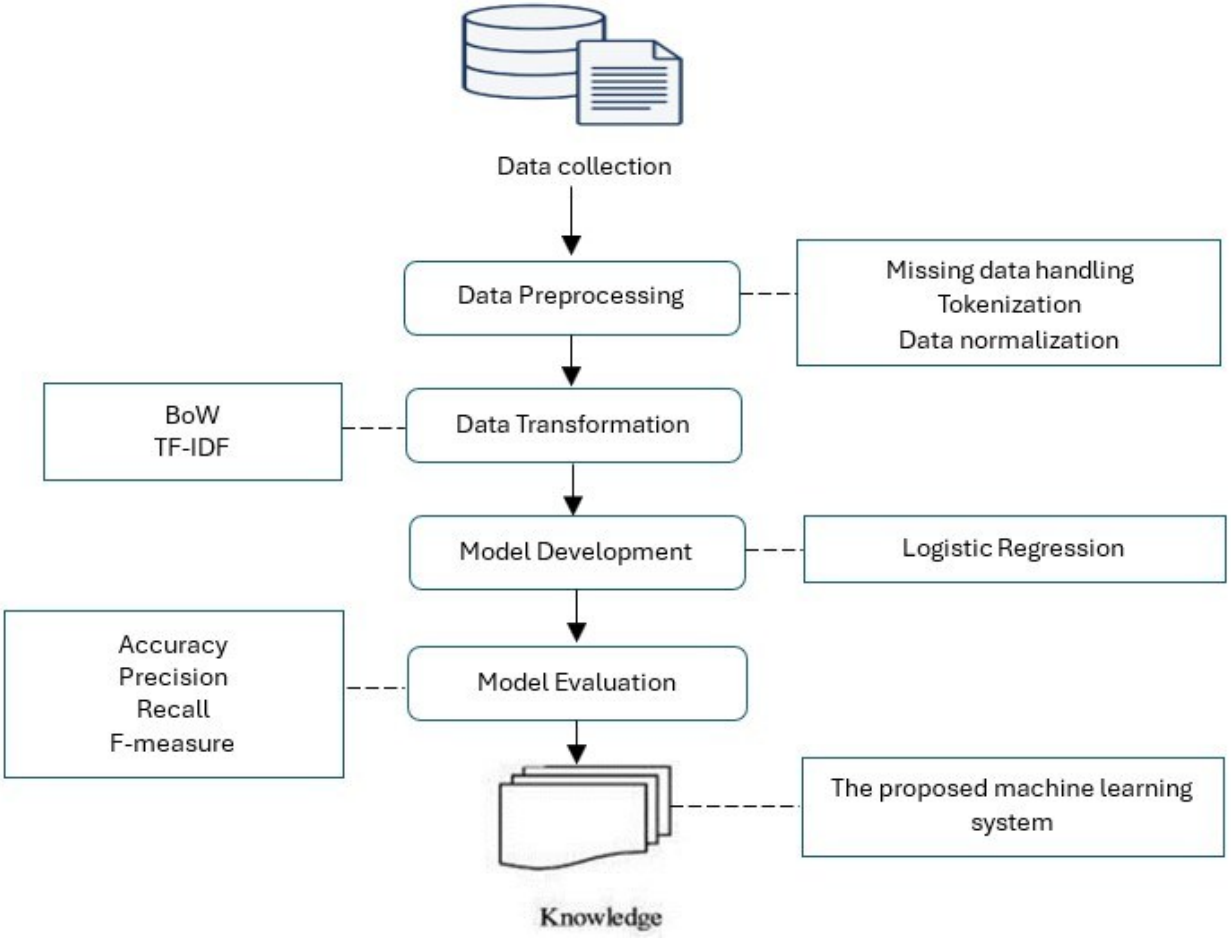

Figure 1. GenusGenius Machine learning Based Web Application Schematic Diagram.

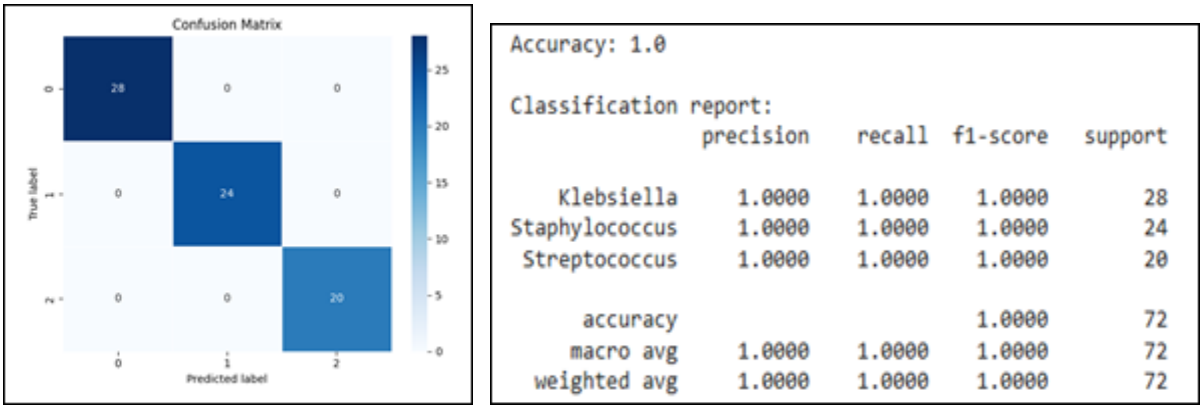

Figure 2. Performance metrics of the Logistic Regression classifier.

Knowledge: Development of GenusGenius, a machine learning–based web application that predicts bacterial genus from microscopy, colony morphology, and biochemical test profiles (**Figure 3 and Figure 4**).

3. Result

Figure 3 shows the main interface of the proposed web-based system. The interface is organized into three sections: (i) input panel, (ii) input completeness indicator, and (iii) the output panel. **Figure 4** presents the system interface, including the input panel, real-time input completeness indicator, and output panel. Users enter microscopy and phenotypic characteristics, and the progress bar dynamically reflects data sufficiency for stable genus-level prediction. The output panel displays the predicted bacterial genus along with a ranked class-probability distribution, allowing users to assess predictive confidence and alternative candidate genera.

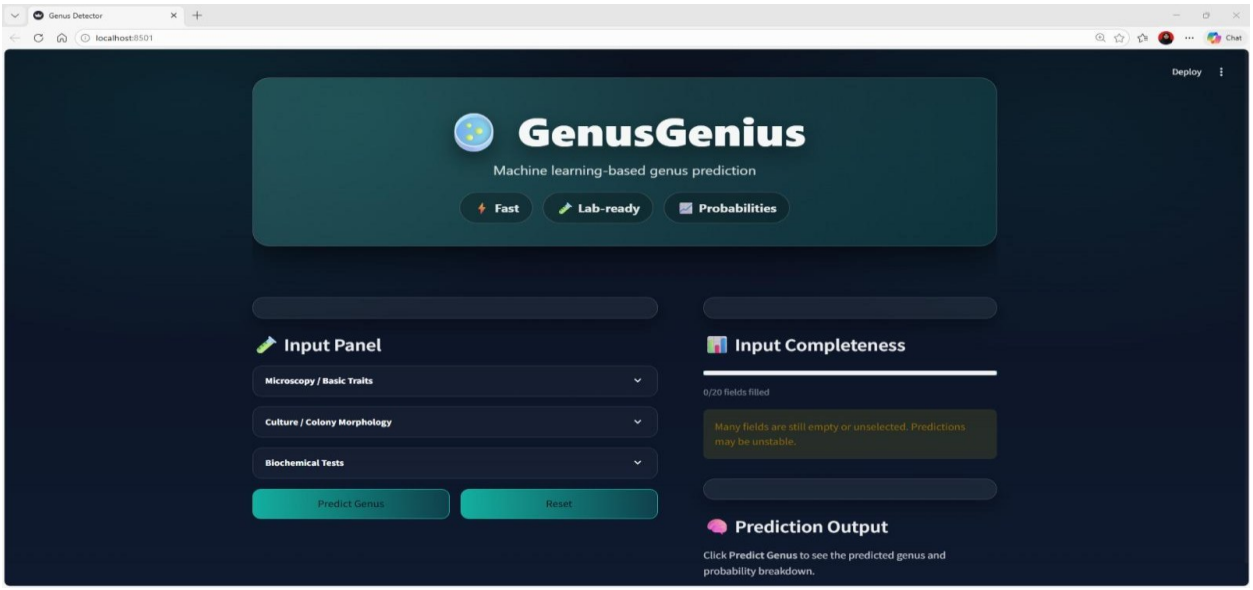

Figure 3. Main Interface.

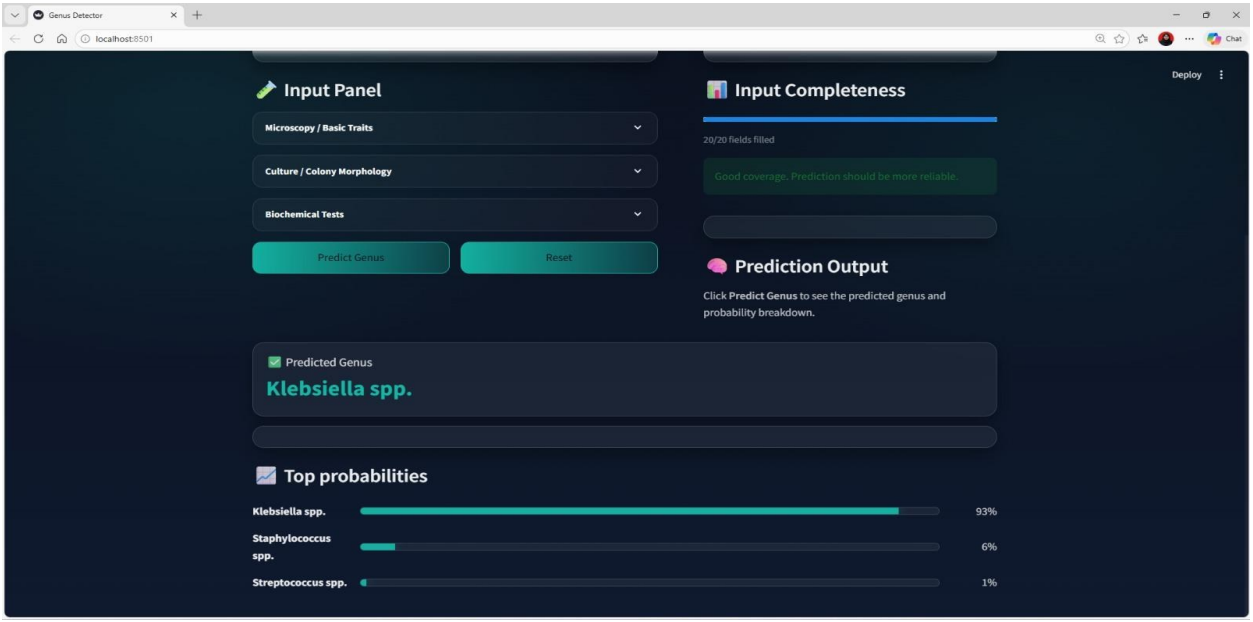

Figure 4. The input panel, input completeness indicator and output panel.

4. Novelty and uniqueness

This project introduces a web-based bacterial identification platform that applies supervised machine learning to structured phenotypic data derived from standard microbiological testing. Its novelty lies in formalizing phenotypic interpretation as a computational classification problem within an educational decision-support system. Conventional bacterial identification in teaching laboratories relies on sequential reasoning, where morphological observations and biochemical reactions are manually synthesized to reach taxonomic conclusions. Although essential for training, this interpretative process is often heuristic, instructor-dependent, and variable among learners. The proposed system reconceptualizes phenotypic identification as a multivariate pattern recognition task. Morphological descriptors (e.g., Gram reaction, colony form, elevation, hemolysis, and motility) and biochemical outcomes are encoded as structured features and analyzed simultaneously using supervised classification algorithms to generate probabilistic taxonomic predictions. Unlike image-based diagnostic tools that depend on microscopy or colony imaging, this platform operates exclusively on structured, non-image phenotypic inputs. This preserves alignment with traditional microbiology curricula while introducing algorithmic consistency into interpretative synthesis. Web-based architecture enables real-time inference and scalable deployment without specialized software, supporting iterative hypothesis testing. By transforming manual phenotypic reasoning into a reproducible computational workflow, the platform enhances interpretative efficiency in microbiology education.

5. Benefit to mankind

This web-based machine learning bacterial identification system enhances microbiology education and research by accelerating the interpretation of complex phenotypic data while preserving essential laboratory skills. It provides immediate, data driven feedback, improving learners' understanding of microbial taxonomy and standardizing interpretative training, thereby producing a more competent scientific workforce. By reducing the time and consumables required for preliminary bacterial identification, the system increases efficiency and lowers educational costs, enabling broader access to high quality microbiology training. Beyond education, the platform supports public health preparedness by facilitating rapid, consistent phenotypic data collection for research, epidemiological monitoring, and antimicrobial resistance studies. Its web-based architecture ensures scalable, global accessibility, promoting self-directed learning and bridging the gap between traditional laboratory practice and computational microbiology. Overall, the system contributes to scientific literacy, equitable access to microbiology education, and the development of reproducible, technology-enhanced workflows that advance both training and research in microbial sciences.

6. Innovation and Entrepreneurial Impact

This project promotes innovation by introducing a web-based bacterial identification system that applies machine learning to analyse morphological characteristics and biochemical test results. By integrating machine learning into microbiology education, the system demonstrates how traditional laboratory practices can be enhanced through digital and data-driven approaches. From an entrepreneurial perspective, the platform has strong potential to be developed into a scalable digital product. It can be implemented as an educational platform for academic institutions, a training tool for laboratory personnel, or a preliminary decision-support system for small diagnostic laboratories. The software-based approach reduces development and operational costs, supporting commercialisation and wider adoption. Additionally, the project encourages an

entrepreneurial mindset by exposing students to real-world problem solving and innovation-driven development. Overall, this innovation contributes to transforming academic research into a practical, market-ready solution with educational and societal value.

7. Potential commercialization

This project has strong potential for commercialization as a software-based bacterial identification platform powered by machine learning. The web-based system can be developed into a subscription-based service for educational institutions, providing an interactive tool for teaching microbiology and laboratory techniques. It may also be commercialised as a training and decision-support platform for laboratories, research centres, and small diagnostic facilities that require rapid preliminary bacterial identification. The system's low development and maintenance costs, combined with its scalability, support widespread adoption. Additional features such as expanded bacterial databases, advanced analytics, user management, and certification modules could further increase its market value. With the growing demand for digital learning platforms and machine learning-driven healthcare technologies, the system has strong commercial potential. Overall, the project demonstrates viability as a market-ready digital product with opportunities for continuous development, licensing, and long-term sustainability in both the education and healthcare technology sectors.

8. Acknowledgment

The research team would like to express our sincere appreciation to Universiti Teknologi MARA (UiTM) Cawangan Negeri Sembilan for providing the facilities, resources, and institutional support that made this work possible. Our deepest gratitude also goes to the dedicated laboratory staff and technical personnel, whose invaluable assistance in sample preparation, culture handling, and experimental coordination greatly contributed to the successful completion of this study.

9. Researchers' Biography

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Autonomous AI-Powered Wall-Climbing Robot for Real-Time Structural Crack Inspection

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ABSTRACT
Concrete structures are susceptible to cracks due to environmental exposure, material fatigue, and structural loading. Conventional inspection methods rely heavily on manual visual inspection, which is time-consuming, labor-intensive, and potentially unsafe when inspecting high or inaccessible structures. This project presents an autonomous AI-powered wall-climbing robotic system designed for real-time concrete crack inspection and classification. The system integrates a wall-climbing robot equipped with a camera module and a Deep Convolutional Neural Network (DCNN)-based crack detection model to enable automated structural health monitoring. The robotic platform employs a hybrid adhesion mechanism combining an Electric Ducted Fan (EDF) and polyurethane rubber wheels to ensure stable movement on inclined and vertical surfaces. Image data captured by the onboard camera are processed using DCNN models to classify crack patterns. The proposed framework utilizes ResNet50 enhanced with Squeeze-and-Excitation (SE) blocks for feature extraction and classification, while MobileNetV2 transfer learning is incorporated to optimize computational efficiency. Experimental results demonstrate reliable classification performance and effective real-time crack detection. The proposed system improves inspection safety, reduces maintenance costs, and supports sustainable infrastructure monitoring. Furthermore, the technology offers strong commercialization potential for infrastructure inspection services, smart city monitoring systems, and automated structural maintenance platforms.

Keywords: Wall-climbing Robot, Crack Detection, Deep Convolutional Neural Network (DCNN), Structural Health Monitoring, Autonomous Inspection

1. Product Description
The proposed system is an autonomous wall-climbing robotic platform designed for automated inspection of concrete structures. The robot is equipped with a camera module and wireless communication system to capture structural surface images and transmit the data for real-time analysis. The wall-climbing robot utilizes a hybrid adhesion mechanism consisting of an Electric Ducted Fan (EDF) and polyurethane rubber wheels. This configuration generates negative pressure that allows the robot to maintain adhesion while moving across inclined and vertical surfaces. The robotic system is controlled using a Raspberry Pi microcontroller which manages locomotion, image acquisition, and wireless communication. Captured images are analyzed using a Deep Convolutional Neural Network (DCNN) for crack detection and classification. The DCNN architecture is based on ResNet50 enhanced with Squeeze-and-Excitation blocks to improve feature extraction capability. In addition, MobileNetV2 transfer learning is incorporated

to improve computational efficiency for real-time inference. By integrating robotics and DCNN-based crack classification, the proposed system enables automated inspection of structural surfaces and provides accurate crack detection without requiring manual monitoring.

2. Methods and Results

The prototype of the developed wall-climbing robot is illustrated in **Figure 1**. The robotic platform is designed with several key components that enable stable adhesion, mobility, and image acquisition for structural inspection. The Electric Ducted Fan (EDF) or motorized propeller is installed at the center of the robot to generate suction force within the chamber, producing negative pressure that allows the robot to adhere securely to vertical concrete surfaces. The chamber acts as a confined space that enhances the suction effect produced by the EDF, ensuring sufficient adhesion during climbing operations. For locomotion, the robot is equipped with polyurethane rubber wheels, which provide adequate traction and allow the robot to move smoothly along vertical surfaces while maintaining stability. A camera module is mounted at the front of the robot to capture images of the concrete surface during inspection. The captured images are subsequently used for crack detection and classification using a Deep Convolutional Neural Network (DCNN). The integration of these components enables the robot to perform automated structural inspection while maintaining stable movement and reliable image acquisition.

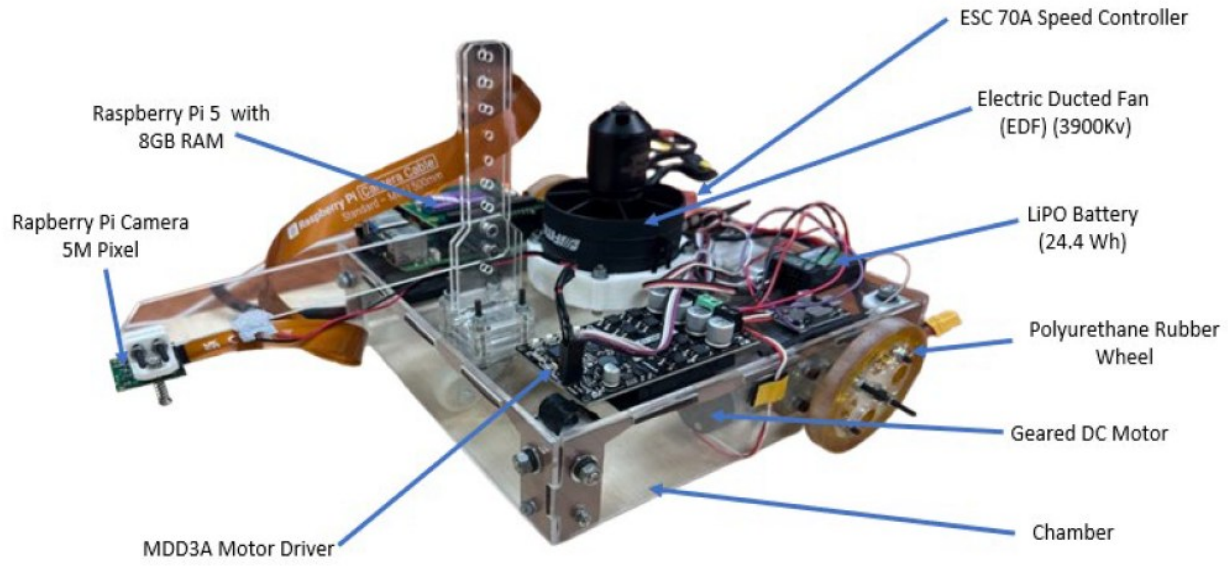

Figure 1. Prototype of the developed wall-climbing robot.

The laboratory testing phase is essential to ensure that the wall-climbing robot (WCR) operates reliably before deployment in real structural environments. As shown in **Figure 2**, the testing setup includes a cement board platform that simulates a vertical concrete surface, a ground monitoring station for real-time data observation, and a safety net installed beneath the testing area to prevent damage to the robot during operation. During the experiment, the WCR is controlled remotely using a robot controller while transmitting visual data to the monitoring station. In the second stage of testing, the robot is deployed on the vertical cement board to

evaluate its climbing capability and crack detection performance. These controlled experiments allow the researchers to analyze the robot's adhesion performance, mobility stability, and real-time data transmission. The results confirm that the system is capable of performing structural inspections and is suitable for practical deployment in building crack monitoring applications.

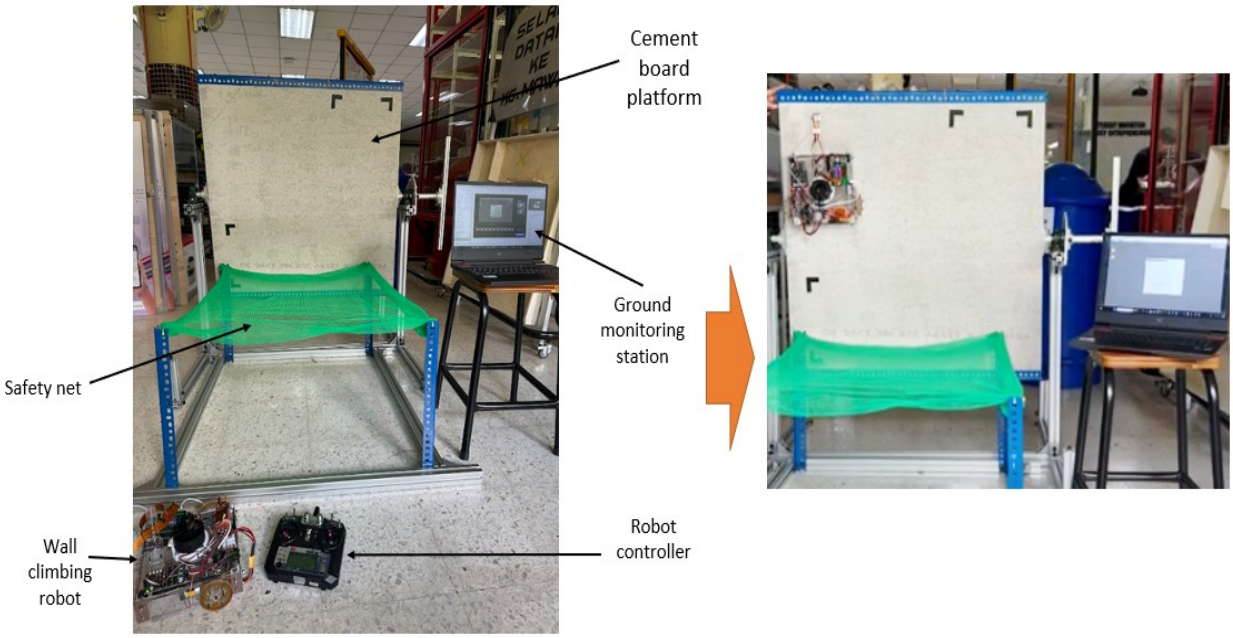

Figure 2. Laboratory testing setup for evaluating the wall-climbing robot during crack inspection experiments.

Figure 3 illustrates the overall framework of the proposed inspection system. The wall-climbing robot captures images of concrete surfaces using an onboard camera while adhering to vertical structures. The captured images are transmitted to the processing unit where crack features are analyzed using a Deep Convolutional Neural Network (DCNN). The proposed DCNN architecture incorporates a ResNet50 backbone enhanced with Squeeze-and-Excitation blocks to improve feature recalibration and classification performance. The system then classifies the structural condition into crack or non-crack categories for automated structural health monitoring. A comparison between the ResNet50 model and the proposed ResNet50-SE model is presented in **Figure 4**. The baseline model occasionally produces misclassifications when dealing with complex surface textures and background noise. By incorporating the Squeeze-and-Excitation (SE) block, the proposed model improves channel-wise feature recalibration, allowing the network to focus more effectively on crack-related features. As a result, the ResNet50-SE model achieves higher prediction confidence and improved classification reliability for both crack and non-crack images.

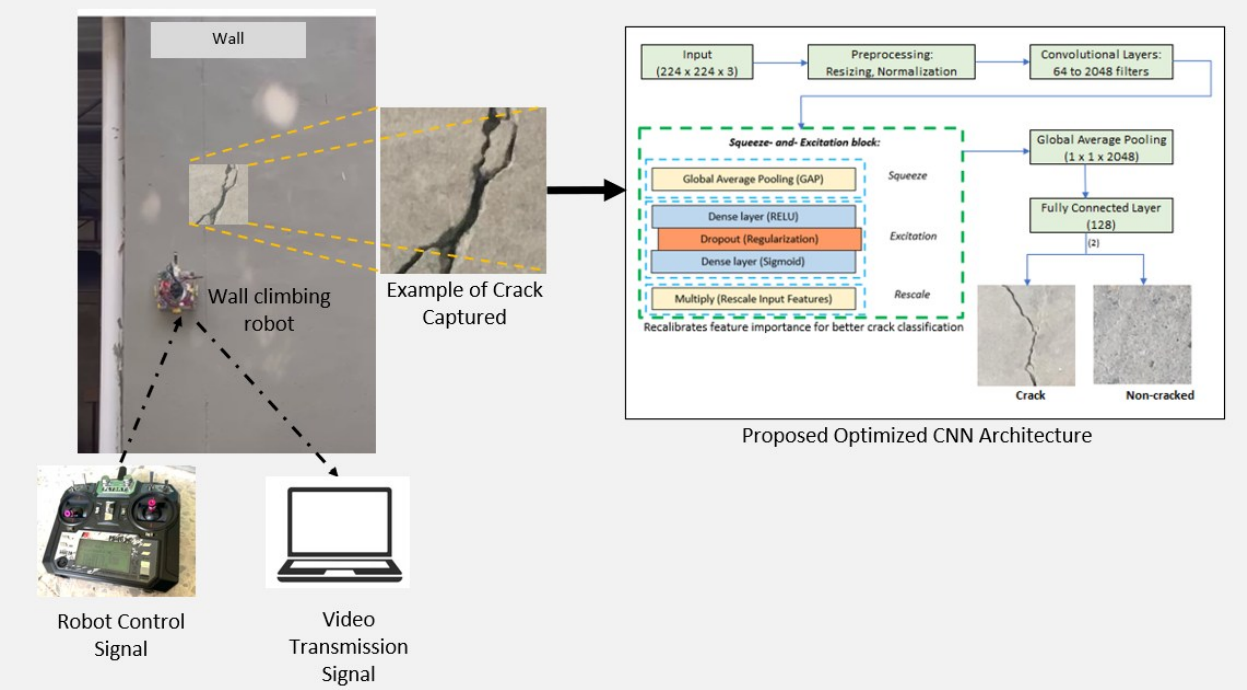

Figure 3. Autonomous Wall-Climbing Robotic System with SE-Enhanced DCNN for Real-Time Concrete Crack Inspection.

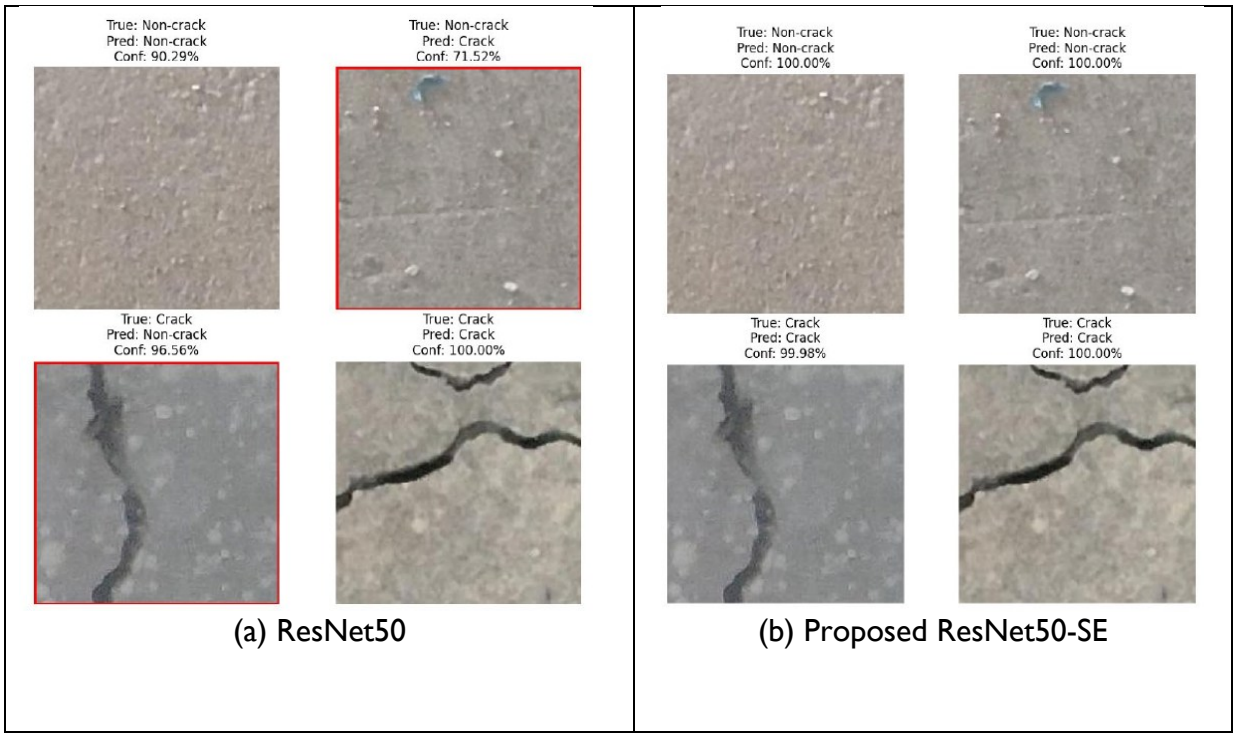

Figure 4. Performance comparison between the baseline ResNet50 (a) and ResNet50-SE (b) for crack/non-crack inspection images. The SE enhancement improves prediction reliability and reduces misclassification.

3. Novelty and uniqueness

The proposed Deep Convolutional Neural Network (DCNN) improves the accuracy of automated crack detection in concrete structures. By enhancing feature extraction through the integration of Squeeze-and-Excitation blocks, the model is able to distinguish crack patterns from complex surface textures more effectively. This allows structural defects to be identified at an early stage, supporting timely maintenance and improving infrastructure safety.

4. Benefit to mankind

The proposed Deep Convolutional Neural Network (DCNN) improves the accuracy of automated crack detection in concrete structures. By enhancing feature extraction through Squeeze-and-Excitation blocks, the model can distinguish crack patterns from complex surface textures more effectively. This supports early detection of structural defects and enables timely maintenance, contributing to safer infrastructure and improved structural reliability. The proposed approach also aligns with Sustainable Development Goal (SDG) 9: Industry, Innovation and Infrastructure and SDG 11: Sustainable Cities and Communities by supporting intelligent infrastructure monitoring and sustainable urban development.

5. Innovation and Entrepreneurial Impact

The innovation lies in the development of an optimized ResNet50 enhanced with Squeeze-and-Excitation blocks for crack classification. The improved model provides higher prediction confidence and more reliable crack detection compared to conventional approaches. This advancement creates opportunities for AI-driven structural monitoring solutions and encourages the development of intelligent inspection technologies for infrastructure management.

6. Potential commercialization

The proposed DCNN-based crack inspection approach has strong commercialization potential in infrastructure monitoring and building inspection services. The model can be integrated into automated inspection systems, mobile monitoring platforms, or digital infrastructure management tools to support efficient and accurate structural condition assessment. Such technology can assist government agencies and engineering industries in maintaining safer and more sustainable infrastructure systems.

7. Acknowledgment

The authors would like to express their sincere appreciation to Universiti Teknologi MARA (UiTM) for the support provided in conducting this research. The authors also gratefully acknowledge the financial support from the Ministry of Higher Education (Kementerian Pengajian Tinggi, KPT), Malaysia, through the UTM HIR research grant (Q.J13000.245108G87).

8. Researchers' Biography

Ts. Dr. Mazleenda Mazni completed her Ph.D. at Universiti Teknologi Malaysia (UTM), focusing on deep learning models for structural health monitoring, particularly in surface crack classification and measurement. Prior to joining academia, she gained industry experience as an engineer in manufacturing companies. She is currently a Senior Lecturer at Universiti Teknologi MARA (UiTM), Pasir Gudang Campus. Her research interests include control applications in dynamic systems, networked control systems, mechatronics, and artificial intelligence.

Assoc. Prof. Dr. Abdul Rashid Husain received the B.Sc. degree in Electrical and Computer Engineering from The Ohio State University, Columbus, Ohio, U.S.A, in 1997, M. Sc. degree in Mechatronics from University of Newcastle Upon Tyne, U.K., in 2003, and Ph.D. in Electrical Engineering (Control) from Universiti Teknologi Malaysia (UTM) in 2009. Prior joining UTM, he worked as an engineer in semiconductor industry specializing in precision molding and IC trimming process. He is a member of IEEE Malaysia Chapter, Malaysia Simulation Society and Institute of Engineer Malaysia. His research interests include application of control in dynamic systems, robot navigation, mechatronic system design and electrical drives and motion control.

Dr. Munirah Onn is a Senior Lecturer at Universiti Teknologi MARA (UiTM), Pasir Gudang Campus. She obtained her Bachelor's degree in Science from Universiti Teknologi MARA (UiTM) and a Master's degree in Science from Universiti Teknologi Malaysia (UTM). During her studies, she received several academic recognitions including the Best Degree Student, Best Thesis Writing Award, and Vice Chancellor Award from UiTM, as well as the Best Student Award for the Master's Programme from UTM. She also has industrial experience as a Production Engineer, Research Officer, and Executive Chemist for four years. Her current research interests focus on renewable and advanced materials.

Mr. Riyadh Zulkifli received the B.E. Degree in Mechatronic Engineering from Universiti Teknologi Malaysia (UTM), Johor Bahru, Malaysia in 2020. He is currently pursuing MPhil Degree in Electrical Engineering in the field of robotics in UTM. His research interest includes the development of optimal adhesion wall climbing robot. In recognition of his outstanding academic performance, he has been named to the Dean's List at UTM's 64th convocation.

Smouldering Risk Indicator for Peatland Fire Assessment

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ABSTRACT

This study presents an integrated approach for understanding and detecting smouldering behaviour in tropical peat by examining how key physical and chemical properties influence ignition resistance and combustion propagation. The work focuses on moisture content, pH, specific gravity, organic matter and fibre content as the primary factors governing subsurface heating patterns. A custom designed burn box equipped with multi-depth thermocouples was used to simulate controlled moisture content of 5%, 50%, 100%, 150% and 200% which allowing detailed observation of temperature evolution throughout the combustion cycle. A central contribution of this study is the development of a peat-specific combustion profile that characterises how tropical peat transitions from sustained smouldering to weakened combustion and finally suppression. This profile provides a new refence that bridges laboratory behaviour with filed relevant moisture conditions which addressing gaps in existing temperate based studies. Findings show that smouldering is maintained below 50% moisture content can declines at intermediate levels and becomes fully inhibited above 150%. The study offers socio environmental benefits by enabling earlier recognition of fire prone peat layers, supporting haze reduction and promoting sustainable peatland management. With growing demand for practical and cost-effective fire risk evaluation methods, this laboratory driven framework demonstrates strong potential for application by land owners, government agencies and environmental monitoring sectors across diverse landscapes.

Keywords: Peat soil, Peat smouldering, Smouldering behaviour, Combustion temperature, Moisture threshold

1. Product Description

This modelling threshold introduces a practical and reliable way to detect smouldering peat fires by integrating controlled laboratory findings with field based thermal observations. The threshold was developed to address the challenge of identifying fire risks early, particularly in tropical peatlands where smouldering can progress beneath the surface long before any visible signs appear. Through systematic laboratory experiments, moisture-temperature limits were established to determine when peat is likely to ignite, sustain smouldering or completely resist combustion. These threshold values serve as scientific reference for interpreting thermal patterns recorded during ground monitoring activities, allowing early detection of abnormal subsurface heating. A key contribution of this system is its integration of combustion specific temperature behaviour with practical guidelines for filed assessment which creating a more structured and quantifiable approach to peat-fire detection. Overall, this product supports quicker decision-making, helps prevent large-scale fire outbreaks and reduces environmental and health impacts associated with haze. It also offers strong potential for adoption by government agencies, plantation managers and environmental monitoring sectors.

2. Flowchart and Prototype of burn box

Figure 1 outlines the sequence beginning with peat sampling and followed by laboratory characterisation using Index Properties test. The process then advances to controlled burn box experiments where multi-depth thermocouples record temperature responses under five moisture conditions. The final stage involves analysing combustion patterns to establish the moisture-temperature thresholds for predicting smouldering behaviour. **Figure 2** and **Figure 3** presents the design of the custom peat control burn box where the box is equipped with insulated walls, ignitions points and thermocouples ports at multiple depths to accurately simulate the propagation of the smouldering peat. This prototype enables repeatable experiments and provides high-resolution in thermal data.

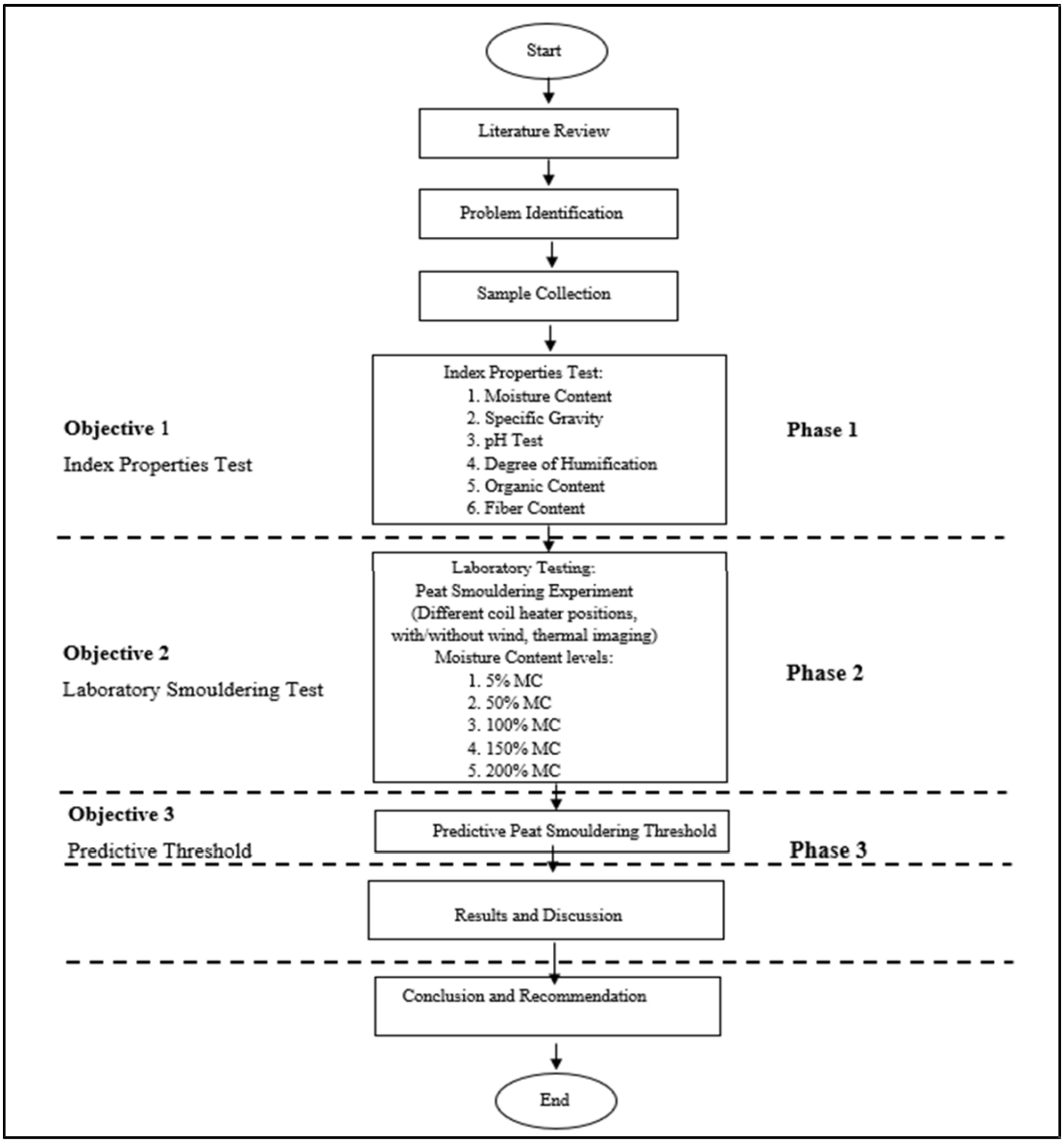

Figure 1. Flowchart of research activities.

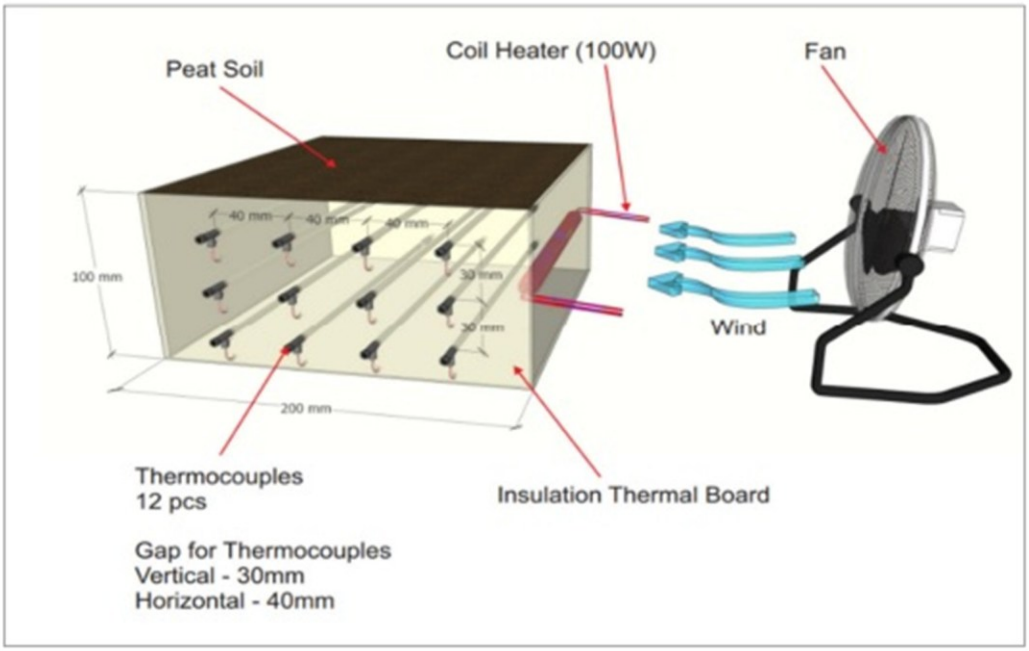

Figure 2. Diagram of peat control burn box.

Figure 3. Peat smouldering burn box experiments.

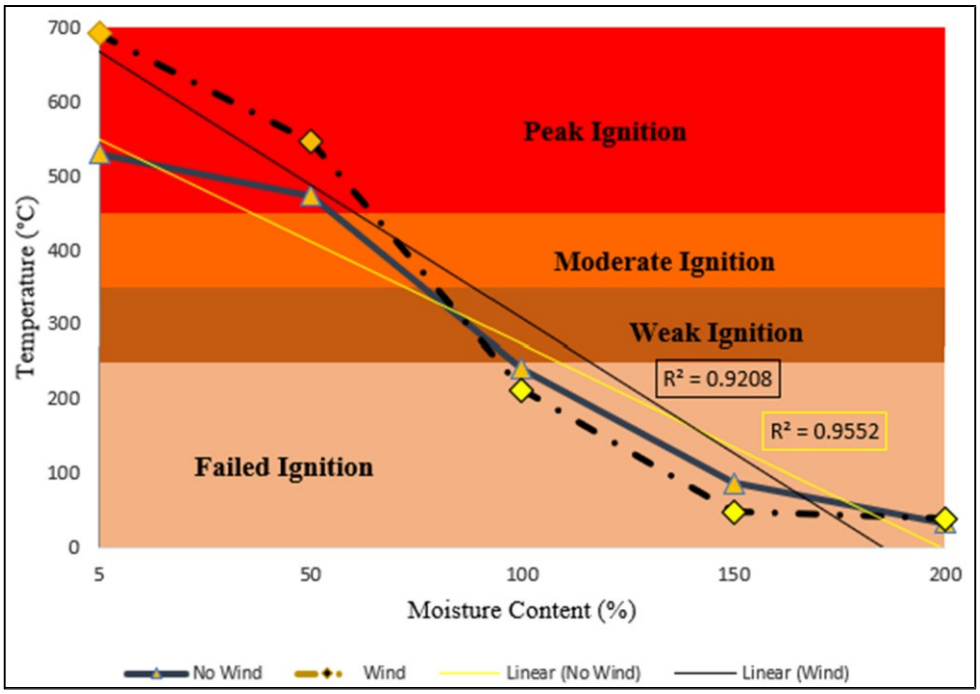

Figure 4. Predictive burning threshold indicators.

3. Novelty and uniqueness

This project introduces a threshold-based combustion model specifically for tropical peat which filling a major scientific gap where most existing references originate from temperate regions. Its novelty lies in the development of threshold response pattern that accurately characterises the smouldering behaviour. The burn box itself serves as an innovative experimental platform that allows consistent, repeatable and quantifiable simulation of peat fire conditions under varied moisture and temperature level. **Figure 4** illustrates the predictive burning threshold indicators that derived from laboratory data. These indicators visualise the transition between sustained smouldering, wakened combustion and suppression which serving as the foundation of the proposed prediction model. Additionally, the project transforms laboratory thermal behaviour into a structured field assessment guideline, bridging fundamental combustion with practical fire risk evaluation. The uniqueness of this project lies in its ability to establish a predictive tool capable of preventing smouldering from progressing into severe peat fire events, thus offering a new reference standard for tropical peatland fire studies.

4. Benefit to mankind

This project provides early identification of fire-prone peat conditions which allows preventive actions before smouldering grows into widespread peat fires. By reducing the possibility of haze formation, the system directly contributes to improved public health, particularly from air pollution that forms of life including humans, wildlife and surrounding ecosystems. Communities benefit from better air quality and reduced economic losses caused by fire related damages. The threshold model also supports sustainable peatland management including the Malaysian Fire and Rescue Department (Bomba), the Department of Environment (DOE) and other related authorities. Overall, the project enhances societal safety, environmental stability and community well-being.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by converting scientific combustion data into a practical assessment tool that can be applied directly in peatland management. It encourages the development of new service ecosystems such as peat-risk diagnostics, thermal mapping services and fore prevention consulting. The model supports entrepreneurship by creating opportunities for start-ups, researches and industry partners to commercialise related monitoring tools, analytical software or early warning systems. Apart from that, the framework introduces a more systematic and cost-effective approach to peat fire management by reinforcing demand for technology based environmental safety products. It is also a benchmark for integrating scientific research with real world applications and providing quantifiable metrics by reducing the risk and impact of peatland fires.

6. Potential commercialization

The threshold model offers strong commercial potential due to its simplicity, low operational cost and wide applicability across government, plantation and environmental sectors. It can develop into a field assessment kit or integrated thermal interpretation platform that uses the established threshold values to evaluate peat-fire risks. Agencies may adopt it as a standard decision support tools especially for peatland real time monitoring. The model can detect early signs of peatland fires by identifying areas that are potential at risk of burning thus preventing major losses and providing a financial reason to use it. Although this experiment is simple and inexpensive, the threshold model has the potential to support the development of a fire monitoring ecosystems by providing early warnings and enhancing peatland management and safety.

7. Acknowledgment

This project was made possible through the guidance and support of Prof. Ir. Ts. Dr. Ahmad Safuan A. Rashid, as well as dedication and contribution of our team members. The author also like to extend gratitude to Faculty of Civil Engineering, UiTM Pasir Gudang for providing facilities, resources and collaborative environment that enabled the successful completion of this work.

8. Researchers' Biography

Dr. Nor Azizah Che Azmi is a Senior Lecturer at the UiTM, specializing in soil and peat smouldering combustion. She obtained her PhD in Civil Engineering from Universiti Teknologi Malaysia (UTM) and has since been actively engaged in research and academic activities within her field. She received Merit Thesis Award for her doctoral research and has published high impact journal articles including papers in Q1 and Q2 journals, focusing on peat smouldering and related environmental management topics. In addition to her responsibilities in teaching and research, she actively supports student development and promotes an environment that encourages inquiry and critical thinking. Her ongoing efforts in advancing education and engineering practices have strengthened her impact within the field.

T s. Dr. Roslizayati Razali is currently a senior lecturer at the Universiti Teknologi Mara (UiTM). Her research interests including soil stabilization, saturated and unsaturated soil mechanics. She has been actively engaged in research projects that focus on sustainable geotechnical solutions, including the use of eco-friendly materials in soil stabilization. She has published research papers, attended international conferences, and collaborated with lecturer from others university to enhance geotechnical practices. Beyond her academic and research roles, she is also passionate about mentoring students and fostering a research-driven learning environment. Her commitment to education and engineering excellence continues to make a positive impact in the field

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Nurul Ain Umaiban Binti Yusof is a Senior Lecturer at the Faculty of Civil Engineering, Universiti Teknologi MARA (UiTM) Pasir Gudang. She holds a master's degree in civil engineering from UiTM and a bachelor's degree from Universiti Tun Hussein Onn Malaysia (UTHM). Before transitioning to academia, she gained 3.5 years of industry experience as a Civil Engineer at KT Ong Engineering Sdn Bhd. Currently, she teaches a range of subjects at both the Diploma and Degree levels, including Water and Wastewater Engineering, Basic Hydraulics, Fluid Mechanics, Highway Engineering, Geology, Surveying, Basic Structural Analysis, and Environmental Engineering. In addition to her teaching responsibilities, Nurul is pursuing a PhD at Universiti Teknologi Malaysia (UTM), with her research focused on microplastics. Her academic and professional experiences have shaped her dedication to teaching and research in the field of civil engineering and environmental sustainability.

Shaping Academic Innovation: A Framework Modelling the Drivers of Innovative Work Behavior in HEIs

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ABSTRACT

This innovation introduces a comprehensive conceptual framework designed to enhance innovative work behavior among academics in Malaysian higher education institutions by integrating psychological empowerment, flexible work arrangements, perceived organizational support, knowledge sharing, and transformational leadership, with individual innovation capability functioning as a mediating mechanism. The framework was developed to address persistent challenges in cultivating sustainable academic innovation amid growing demands for teaching excellence, research productivity, and societal engagement, and was innovated through the integration of Social Exchange Theory, Social Cognitive Theory, and Self-Determination Theory to explain how organizational, motivational, and cognitive factors interact to drive innovation. The main advantage of this framework lies in its tri-theoretical foundation and the novel positioning of individual innovation capability as a mediator, offering a holistic and systematic explanation of innovation processes within academic settings. Its implementation is expected to strengthen teaching quality, research innovation, and knowledge transfer, thereby contributing to human capital development and long-term socio-economic sustainability. With strong commercialization potential, the framework can be translated into academic development programs, innovation assessment tools, leadership training modules, consultancy services, and policy guidelines, supporting higher education institutions in building a sustainable and innovation-driven academic ecosystem.

Keywords: Innovative Work Behaviour, Individual Innovation Capability, Higher Education Institutions, Organizational Support and Academic Innovation.

1. Product Description

The product of this research is a conceptual innovation framework developed from a PhD thesis that systematically explains the drivers of innovative work behavior among academics. Unlike physical or digital products, this framework functions as a decision-support and strategic planning tool for higher education institutions. It identifies critical organizational and individual factors that influence innovation and clarifies the mediating role of individual innovation capability in translating supportive environments into innovative academic outcomes. The framework is designed to be adaptable for institutional policies, academic development programs, leadership training, and innovation assessment within higher education settings.

2. Conceptual Framework.

This section includes a schematic diagram of the proposed conceptual framework, illustrating the relationships between psychological empowerment, flexible work arrangements, perceived organizational support, knowledge sharing, transformational leadership, individual innovation capability, and innovative work behavior. The framework is innovatively designed through the integration of Social Exchange Theory, Social Cognitive Theory, and Self-Determination Theory, providing a holistic explanation of how organizational, motivational, and cognitive factors jointly drive academic innovation. **Figure 1** visually illustrates the mediating role of individual innovation capability and the interconnected theoretical foundations that support the framework.

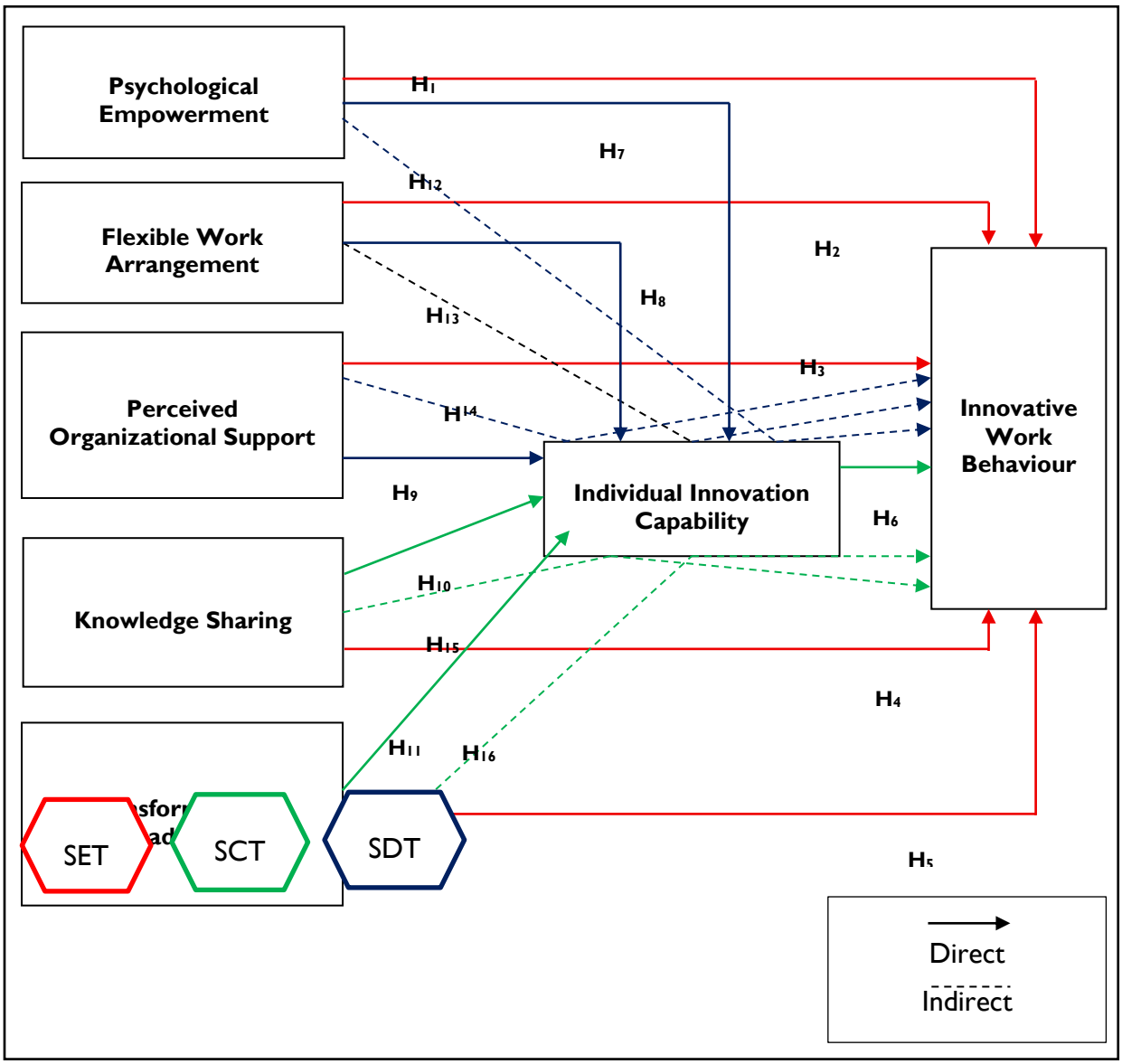

Figure 1. Conceptual Framework of Study.

3. Novelty and uniqueness

The primary novelty of this innovation lies in its integrated tri-theoretical foundation, combining Social Exchange Theory, Social Cognitive Theory, and Self-Determination Theory within a single explanatory framework. Previous studies on innovative work behavior in higher education typically rely on a single theoretical perspective and examine antecedents independently. This framework advances the literature by providing a comprehensive explanation of how motivational, cognitive, and relational factors collectively influence innovation. Additionally, the framework is among the first to position individual innovation capability as a mediating mechanism between organizational practices and innovative work behavior in the academic context. This mediating approach provides deeper insight into how and why institutional support and leadership practices translate into innovation. The framework's contextual focus on Malaysian higher education institutions further enhances its uniqueness by addressing cultural, organizational, and systemic characteristics often overlooked in global models.

4. Benefit to mankind

This framework benefits society by strengthening the innovation capacity of higher education institutions, which play a critical role in human capital development and knowledge creation. By promoting innovative work behavior among academics, the framework supports improved teaching quality, research productivity, and community engagement. Enhanced academic innovation contributes to the development of graduates who are more creative, adaptable, and industry-relevant. In the long term, the framework supports socio-economic advancement by enabling universities to generate impactful research, address societal challenges, and contribute to sustainable national development.

5. Innovation and Entrepreneurial Impact

The proposed framework promotes innovation by encouraging higher education institutions to systematically cultivate environments that support creativity, experimentation, and knowledge sharing. By translating abstract theoretical concepts into a practical innovation model, the framework fosters an entrepreneurial mindset among academic leaders and policymakers. It supports the development of innovation-driven academic cultures, where academics are empowered to generate new ideas, engage in interdisciplinary collaboration, and pursue impactful research initiatives. The framework also encourages institutional entrepreneurship by guiding universities in designing innovation-focused strategies, training programs, and performance systems aligned with long-term competitiveness.

6. Potential commercialization

The framework has strong commercialization potential through its transformation into academic consultancy services, institutional innovation assessment tools, leadership development modules, and professional training programs. It may be packaged as a structured innovation framework for universities, research centers, and higher education agencies. Additionally, the framework can support policy advisory services, academic capability diagnostics, and customized innovation workshops, making it suitable for collaboration with government agencies, private education providers, and consultancy firms.

7. Acknowledgment

The author would like to acknowledge the support of the university, supervisors, and participating academics from Malaysian higher education institutions who contributed to the development and validation of this framework. Sincere appreciation is also extended to the Ministry of Higher Education (MOHE), Malaysia, for sponsoring the author's doctoral studies. Gratitude is further conveyed to the relevant authorities and ethical committees for their guidance and approval.

8. Researchers' Biography

Zarina Begum Ebrahim is a Senior Lecturer at the Faculty of Business and Management, Universiti Teknologi MARA (UiTM) Melaka, Kampus Bandaraya Melaka, and a PhD candidate in Business and Management. Her research specialises in innovative work behaviour in higher education, integrating psychological empowerment, flexible work arrangements, organisational support, leadership, and individual innovation capability using Social Exchange, Social Cognitive, and Self-Determination theories. She has published in ERA-, MyCite-, and Scopus-indexed journals, presented at international conferences, and received multiple innovation accolades, including two gold medals and one bronze medal. Her work demonstrates strong potential for impactful academic innovation and institutional application.

Dr. Irzan Ismail (PhD), is a senior lecturer at the Faculty of Business & Management, UiTM Melaka. Irzan's background as a PhD in Management led him to share his expertise in research methods and managerial courses. He has been teaching for more than 25 years and actively engaged in seminars and workshops pertaining to management, risk management, crisis management, research methodology, data analysis, and business analytics. His engagement covers government agencies, training academies, public universities and private institutions or industry.

Erne Suzila Kassim is an Associate Professor at the Faculty of Business and Management, Universiti Teknologi MARA, Puncak Alam Campus, and currently serves as Head of Innovation Management. Her research focuses on the use of information technologies for sustainability across government, business, and society, supported by international and national bodies, including the United Nations University and Malaysian ministries. She is a co-author of two Springer books and has published extensively in journals and conferences. Appointed by the Ministry of Science, Technology and Innovation, she led the development of the Malaysia Social Innovation Roadmap.

RE:CITY - A Replicable, Community-Owned Water Security Framework for Orang Asli Communities

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ABSTRACT

RE:CITY addresses critical water insecurity in Malaysia's Orang Asli settlements, where reliance on contaminated tandak air (water catchment sites) poses severe health risks due to logging, erosion, and animal intrusion. Traditional approaches focus narrowly on infrastructure delivery, neglecting source protection and long-term community ownership. RE:CITY introduces a three-pillar framework which is Access, Education, Empowerment that integrates gravity-driven multi-stage filtration, upstream environmental protection through Pokok Gapis tree planting, structured WASH modules, menstrual hygiene education, and hands-on skill transfer training. Unlike competitors delivering hardware-only solutions, RE:CITY embeds environmental stewardship, health education, and community governance into a single replicable model requiring minimal maintenance. Water quality improved from DOE Class III-IV to Class II with 90% contaminant reduction, Soil erosion decreased 50-65%, reducing filtration maintenance frequency proportionally. Over 90% of participants adopted safe water practices, and 86% were trained in system maintenance. Commercialization potential exists through modular deployment packages, social enterprise models, licensing of guidebooks and training kits, and CSR partnerships. The validated Kampung Kajang pilot enables nationwide scaling by NGOs, universities, and government agencies, transforming short-term aid into sustainable community development aligned with SDGs 3, 6, 11, and 13.

Keywords: water insecurity, orang asli, tandak air, replicable model, three-pillar framework

1. Product Description

RE:CITY is a comprehensive water security framework designed to provide sustainable clean water access to Malaysia's Orang Asli communities who depend on contaminated tandak air (water catchment sites). The system comprises three interconnected pillars: Access, Education, and Empowerment. The Access component features a customized gravity-driven multi-stage filtration system consisting of three sand filtration units and one outdoor membrane filtration system, designed in partnership with Filken Sdn Bhd. This pressure-based system requires no electricity and uses simple weekly backwash maintenance. Environmental protection is integrated through Pokok Gapis tree planting at water sources to stabilize soil, reduce erosion, and filter

impurities upstream. The Education pillar delivers structured WASH modules, menstrual hygiene sessions, and water safety awareness aligned with Department of Environment (DOE) standards. The Empowerment component establishes community ownership through a Water Committee, provides a Water Security Guidebook for long-term reference, conducts health screenings, and delivers hands-on skill transfer training for system maintenance. Piloted successfully at Kampung Kajang, Sungai Siput, Perak, RE:CITY transforms water quality from DOE Class III-IV to Class II, achieving 90% contaminant reduction while building community capacity for independent system management.

2. Flow Charts & Picture

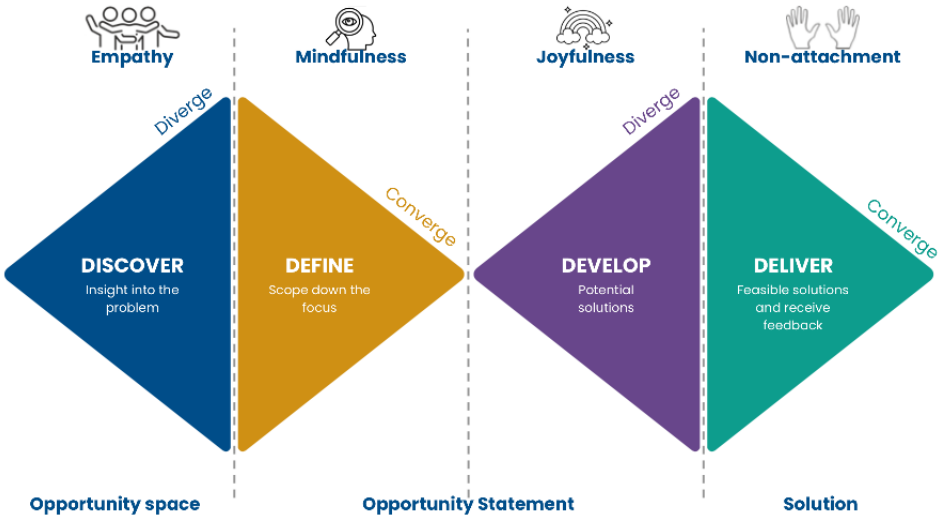

Figure 1. UTP Double Diamond Design Thinking Framework guiding RE:CITY implementation.

Figure 2: RE:CITY Implementation Flow Chart

Figure 3. Water Intake Source from Water Catchment Site (Tandak Air).

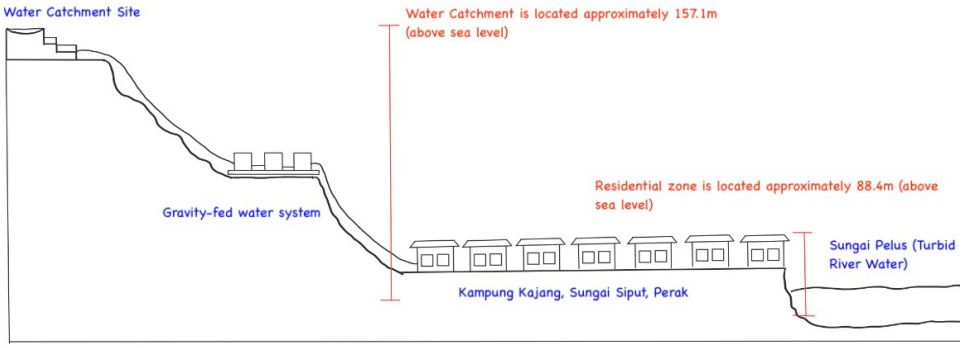

Figure 4. Elevation Difference from Water Catchment Site to Kampung Kajang.

Figure 5. Installation & Demonstration of Multi-Stage Filtration System .

Figure 6. Pokok Gapis Tree Planting at Water Catchment Site .

Figure 7. Medical Health Screening.

Table 1. Result Table.

LABORATORY PARAMETERS DATA SHEET							
Parameters	**Unit**	**DOE Baseline - Class I**	**DOE Baseline - Class II**	**Before Filtration System**	**After Filtration System**	**Reduction Percentage (%)**	**Equipment**
Total Suspended Solids (TSS)	mg/L	≤ 25	≤ 50	66.70	4.67	93.00	Complete set 6 place suspended solid test
Total Dissolved Solids (TDS)	mg/L	≤ 500	≤ 1,000	83.3	14	83.20	Drying oven MEMMERT
Iron (Fe)	mg/L	≤ 1.0	≤ 1.0	0.60	0.04	93.33	DR3900 Spectrophotometer
Turbidity	NTU	≤ 5	≤ 50	22.80	0.02	99.91	Dissolved Oxygen Meter
Chemical Oxygen Demand (COD)	mg/L	≤ 10	≤ 25	67	11	83.58	DRB200 COD Reactor
Hydrocarbons (TPH/PAHs)	ppm	≤ 0.1–1.0*	≤ 1.0–10*	1117	601	46.20	Total Oil & Grease Analyzer
Ammonium Nitrogen	mg/L	≤ 0.1	≤ 0.3	3.0	0.09	97.00	DR3900 Spectrophotometer

LABORATORY PARAMETERS DATA SHEET							
Parameters	**Unit**	**DOE Baseline - Class I**	**DOE Baseline - Class II**	**Before Filtration System**	**After Filtration System**	**Reduction Percentage (%)**	**Equipment**
Phosphate	mg/L	≤ 0.1	≤ 0.2	0.58	0.47	18.97	DR3900 Spectrophotometer
Nitrate	mg/L	≤ 7	≤ 10	1.0	0.7	30.00	DR3900 Spectrophotometer
E-coli	MPN	0	≤ 100	686.7	<1 (not detected)	>99.8	Bacteria test (Quantri-tray) with incubator
Total coliform	MPN	0	≤ 5,000	136.4	<1 (not detected)	>99.8	Bacteria test (Quantri-tray) with incubator
Water Classification based on DOE Standard		Class I (practically no treatment is needed)	Class IIA (good quality water supply)	Class III-IV (poor quality, extensive treatment required)	Class IIA (good quality water supply)		

3. Novelty and uniqueness

RE:CITY's novelty lies in its holistic, end-to-end implementation framework that addresses water security as a combined technical, environmental, social, and governance challenge rather than a standalone infrastructure problem. While competitors like Global Peace Foundation focus primarily on hardware installation (gravity-fed systems, solar pumps), Nestlé on large-scale dams, and Waterco Malaysia on filter distribution, RE:CITY uniquely integrates all components into a single replicable model. The innovation includes upstream source protection through nature-based solutions (Pokok Gapis planting), eliminating the root cause of contamination rather than only treating symptoms. Unlike projects where education is supplementary, RE:CITY structurally embeds WASH modules, menstrual hygiene education, and transparent water quality communication as core deliverables. The framework establishes genuine community ownership through a trained Water Committee and comprehensive guidebooks, ensuring sustainability beyond project completion. Most significantly, RE:CITY is designed as a modular, scalable implementation strategy that is adaptable across different village contexts with minimal modification. Each component of RE:CITY—filtration design, environmental protection, educational content, and empowerment tools—is documented and transferable, enabling replication by universities, NGOs, corporate CSR programs, and government agencies without reinventing the approach.

4. Benefit to mankind

RE:CITY directly improves public health by reducing waterborne disease risks through 90% contaminant reduction and upgrading water from unsafe Class III-IV to usable Class II standards. The project impacts entire communities, with over 90% of participants adopting safe water practices including proper boiling of untreated water and improved hygiene behaviors. Health screenings enable early detection of water-related diseases affecting 60-75% of households. Menstrual hygiene education enhances dignity and health outcomes, particularly for women and girls. Environmental benefits include 50-65% reduction in soil erosion, protecting ecosystems for future generations. The establishment of a Water Committee empowers indigenous communities with technical skills and decision-making autonomy, fostering self-reliance rather than dependency. By addressing fundamental needs such as clean water, health, education, and environmental stewardship, RE:CITY creates conditions for thriving communities aligned with SDGs 3, 6, 11, and 13, contributing to inclusive rural development and indigenous community empowerment across Malaysia.

5. Innovation and Entrepreneurial Impact

RE:CITY cultivates entrepreneurial mindset by demonstrating how student-led initiative can deliver scalable social impact through strategic partnership and resource optimization. The project mobilised diverse collaborators such as Filken Sdn Bhd, Persatuan Aktivis Sahabat Alam (KUASA), Malaysian Relief Agency (MRA) Perak and Da Yi Ma, showcasing entrepreneurial partnership-building skills. By developing modular, replicable solutions rather than one-off interventions, RE:CITY creates a blueprint for social entrepreneurship that balances impact with financial sustainability. The framework positions universities as innovation hubs capable of addressing real-world challenges, inspiring future cohorts to pursue impact-driven ventures. Within communities, the Water Committee model fosters local entrepreneurship by training

members in system management, creating potential micro-enterprise opportunities for maintenance services. The documented methodology enables knowledge transfer to other institutions and NGOs, multiplying entrepreneurial impact across sectors. RE:CITY proves that sustainable solutions emerge when technical innovation, community engagement, and strategic collaboration converge within an entrepreneurial framework.

6. Potential commercialization

RE:CITY holds strong commercialization potential through ethical, ESG-aligned pathways. The modular water solution deployment model offers customizable filtration systems tailored to rural conditions, deployable through corporate CSR programs, NGO partnerships, or government initiatives. A social enterprise model could establish a hybrid organization implementing, maintaining, and scaling RE:CITY solutions nationwide, generating revenue through service contracts, grants, and corporate sponsorships while maintaining social mission focus. Licensing and training packages present opportunities to commercialize the Water Security Guidebook, WASH modules, and maintenance training kits for adoption by universities, NGOs, and rural development agencies. Industry partnerships with water technology providers enable co-development of affordable rural filtration solutions, expanding market reach while maintaining accessibility. This positions RE:CITY as a scalable impact venture balancing financial sustainability with measurable social and environmental returns.

7. Acknowledgment

The RE:CITY team extends sincere gratitude to all collaborators, partners, and supporters who made this project possible. We acknowledge our collaborators: Persatuan Aktivis Sahabat Alam (KUASA), Malaysian Relief Agency (MRA) Perak, Da Yi Ma Project (Roots & Shoots Malaysia), and Laboratory Management UTP (LMG) for their invaluable support and expertise. Our deepest appreciation to our supporters: Student Affairs UTP (SA), Yayasan Universiti Teknologi PETRONAS (YUTP), Jabatan Kemajuan Orang Asli (JAKOA), Verdant Solar Sdn Bhd, GoodMorning Global Sdn Bhd, Heritage, GoBites, and Berjaya Time Square Theme Park for their generous contributions and resources. Special thanks to our technical partners: Filken Sdn Bhd (Malaysia) and ELM Lighting Sdn Bhd for their technical expertise and collaboration in developing the water filtration system. Most importantly, we extend our heartfelt gratitude to the Orang Asli community of Kampung Kajang, Sungai Siput, Perak, for their trust, active participation, and commitment to building a sustainable water future together. This project would not have been possible without the collective efforts and dedication of all involved.

8. Researchers' Biography

Ammar Dzulkarnain bin Muhammad Najib is a second-year student at Universiti Teknologi PETRONAS (UTP), Seri Iskandar, Perak, Malaysia, pursuing a Bachelor of Chemical Engineering with Honours and a Minor in Data Science. He has strong practical experience in water quality assessment, multi-stage filtration system design, sustainable & green energy applications, hydroponic food systems, and environmental protection. Ammar is also experienced in data-driven analysis, project leadership, community engagement, and human-centric solution design, particularly within rural and indigenous communities. He is passionate

about integrating engineering principles with sustainability to deliver scalable, inclusive solutions aligned with the United Nations Sustainable Development Goals (SDGs).

Ammar Syafiq bin Rosli is a second-year Chemical Engineering student with a Minor in Data Science at Universiti Teknologi PETRONAS (UTP), Seri Iskandar, Perak, Malaysia. As an active member of the IChemE–UTP Student Chapter, he has gained exposure to industrial operations, chemical process management, and safety practices. His interests include renewable energy, sustainable technologies, and applying chemical research to practical solutions. Through coursework and collaborative projects, he has developed skills in data analysis, engineering problem-solving, project planning, and user-focused solution design. He seeks hands-on and industry-relevant experience to further enhance his expertise.

Nurishsyafiah Ezany binti Zamzuri is a second-year Chemical Engineering student at Universiti Teknologi PETRONAS, with a minor in Data Science. Her research interests include renewable energy, biomass utilization, sustainable chemical processes, and data-driven engineering solutions. She has participated in multiple student-led projects and competitions focused on technological innovation, sustainability, and community impact. Through these experiences, she has applied chemical engineering principles and data analysis techniques, while developing strong skills in teamwork, problem-solving, and project management. She is motivated to apply engineering knowledge to address real-world challenges in an environmentally and socially responsible manner.

Radin Ainur Shafiqa Binti Radin Fathullah is an undergraduate student in her second year pursuing a Bachelor of Chemical Engineering with Honours at Universiti Teknologi PETRONAS (UTP), Seri Iskandar, Perak. She is actively involved in academic and community-based initiatives with extensive experience in event management including planning and executing student-led programmes which has strengthened her skills in project management and team coordination. Ainur also has hands-on experience in community service projects and sustainability-focused programmes where she applies engineering knowledge and organizational abilities to create meaningful impact. Driven, responsible, and adaptable, she possesses strong leadership and is passionate about contributing to initiatives that promote sustainability and social well-being.

Greenalyze: Greenwashing Detection Tool 2.0

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ABSTRACT

Environmental reporting has become increasingly prominent in Malaysia as companies respond to rising environmental, social and governance (ESG) expectations and climate-related commitments. However, this expansion has raised concerns about greenwashing, where environmental commitments may be overstated or selectively presented. In January 2025, RimbaWatch reported fourteen instances of potential greenwashing involving nine companies operating in Malaysia, signaling the need for a standardized and practical verification framework that aligns reported disclosures with actual performance. Greenalyze is a web-based greenwashing detection tool, designed to address this gap. It converts environmental disclosure into an Environmental Disclosure Index (EDI) aligned with Global Reporting Initiative (GRI) 301–308 and benchmarks it against Refinitiv Environmental Pillar scores. Greenalyze then automatically applies z-score standardization and compute the disclosure–performance gap to generate a comparable greenwashing risk signal, which is presented through an intuitive dashboard for rapid screening and benchmarking. A key enhancement of Greenalyze is the Supervisor Dashboard with read-only access, enabling authorized users to view three-year trends and self-download the reports while preventing any data alteration or deletion. Greenalyze improves reporting credibility, reduce information asymmetry, and supports stronger accountability in environmental reporting. Commercially, Greenalyze is feasible through subscription-based analytics service and institutional licensing tool for market-wide monitoring.

Keywords: Greenwashing, Environmental Reporting, Environmental Disclosure Index, Refinitiv, Disclosure-Performance Gap

1. Product Description

Greenalyze is a decision-support analytics product that detects potential environmental greenwashing by comparing "what a company discloses" with "how the company performs" on environmental outcomes. It operationalizes environmental disclosures in annual and/or sustainability reports using a GRI-based EDI aligned with GRI 301–308, and benchmarks this against Refinitiv Environmental Pillar scores for the same firm-year. Greenalyze automatically standardizes both measures using z-scores and computes the disclosure–performance gap to generate a comparable greenwashing risk signal. A larger positive gap indicates disclosure exceeds performance (higher risk), while smaller gap suggests stronger alignment. The prototype provides a guided workflow in which users enter company details, tick relevant disclosures, input the Refinitiv score and generate results with one click, with outputs saved instantly. Results are visualized in an interactive user-friendly dashboard displaying overall greenwashing risk signal and theme-level disclosure summaries. A key enhancement of Greenalyze is the read-only Supervisor

Dashboard, where authorized users log in using a given password to view results and three-year trends, and directly download reports in comma-separated values (CSV) or HyperText Markup Language (HTML) formats, without administrator requests. Importantly, read-only permissions prevent any alteration or deletion of data, strengthening governance and controlled access for multi-stakeholders use.

2. Workflow Diagram

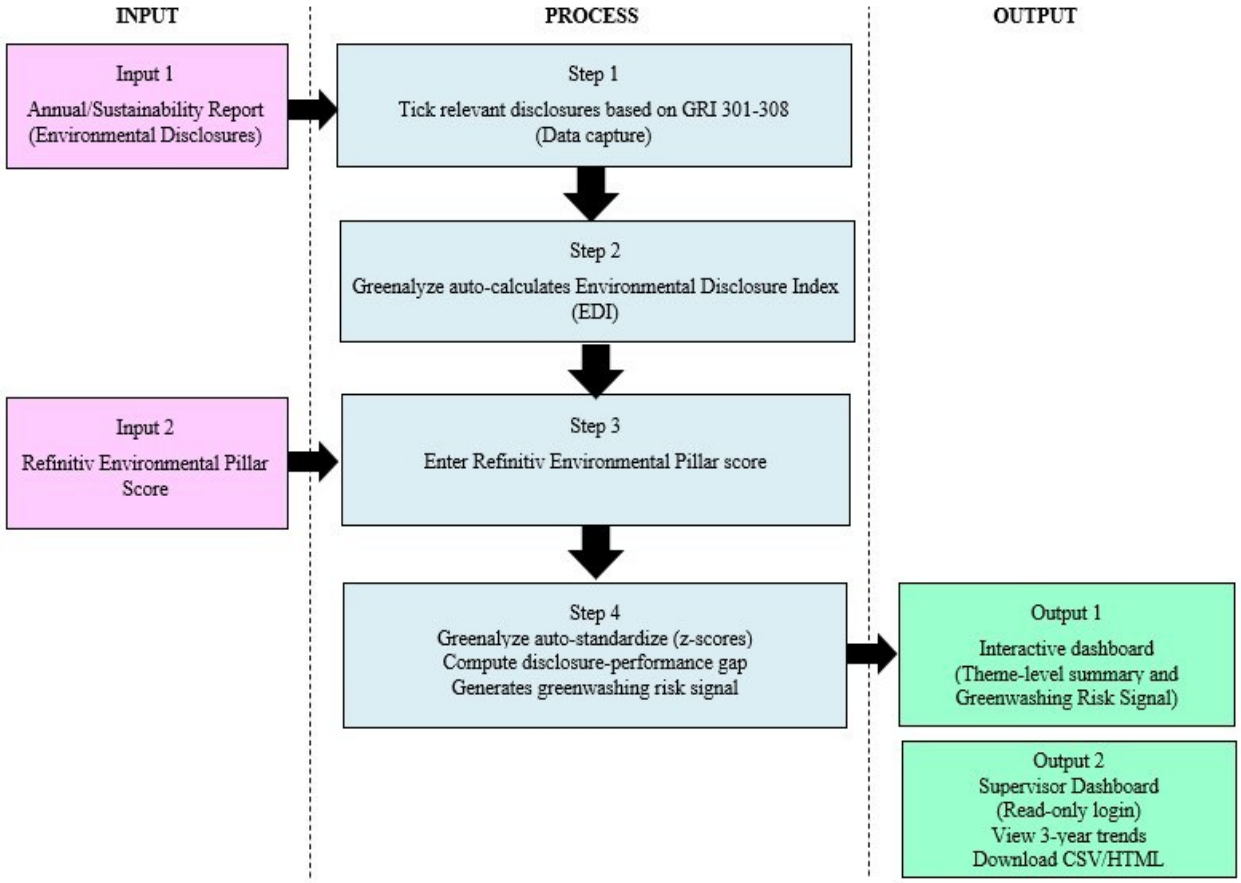

Figure 1. Greenalyze workflow.

Figure 1 illustrates the Greenalyze workflow using input, process, and output structure. Under input stage, Environmental disclosures are sourced from company's annual and/or sustainability reports, while the corresponding Refinitiv Environmental Pillar score is used as the external performance input for the same firm-year. In the process stage, **Step 1** User first tick relevant environmental disclosure according to GRI 301–308 indicators. **Step 2** Greenalyze automatically calculated the EDI**. Step 3** User then import/enter the corresponding Refinitiv Environmental Pillar score and **Step 4** Greenalyze automatically applies z-score standardization to both the EDI and Refinitiv scores and computes the disclosure–performance gap and converts this gap into greenwashing risk signal. Finally, the outputs are delivered through (i) an interactive dashboard showing the risk signal and theme-level summaries for screening and benchmarking, and (ii) a Supervisor Dashboard (read-only login) that enables authorized users to view three-year trends and download reports in CSV/HTML formats without editing or deleting any data.

3. Novelty and uniqueness

Greenalyze is novel in applying a disclosure–performance gap approach to operationalize greenwashing in a standardized and scalable manner. Many existing tools emphasize disclosure volume or narrative quality, which limits their ability to detect symbolic environmental disclosures and may unintentionally reward companies that communicate extensively regardless of actual outcomes. The uniqueness of Greenalyze lies in the three aspects. **First**, Greenalyze integrates two independent dimensions: (i) GRI-aligned EDI based on GRI 301-308, representing reported environmental commitments, and (ii) Refinitiv Environmental Pillar scores, representing externally assessed environmental performance. **Second**, it automates quantification by applying z-score standardization to both measures and computing disclosure-performance gap to generate a comparable risk signal across companies and reporting years, while reducing subjective judgment and enabling consistent screening. **Third**, Greenalyze is delivered as an end-to-end web platform that integrates data capture, computation, visualization and exportable outputs within one workflow, strengthened by a read-only Supervisor Dashboard that enables authorized users to view trends and download reports while preventing any alteration or deletion of data. Collectively, these features position Greenalyze as a practical innovation for greenwashing detection.

4. Benefit to mankind

Greenalyze strengthens transparency and accountability in environmental reporting by enabling evidence-based verification of corporate environmental claims against independent performance indicators. The tool aligns with the Twelfth Malaysia Plan sustainability agenda and supports SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action) by improving the credibility of information used in sustainability-related decision-making. For **investors**, it facilitates more credible sustainable investment decisions and reduce exposure to misleading sustainability claims. For **regulators**, Greenalyze provides standardized screening tool for monitoring and enforcing environmental disclosure requirements. For **communities**, it improves the ability to identify which companies are truly committed to environmental protection. For **companies**, diagnostic outputs highlight areas where disclosure outpaces performance, encouraging improved environmental management and improve reporting integrity. In addition, Greenalyze provides a standardized framework that supports replicable cross-country greenwashing **research** in emerging markets.

5. Innovation and Entrepreneurial Impact

Greenalyze promotes innovation by translating a research-based greenwashing measurement concept into a deployable digital tool that addresses a practical market problem: standardized verification of environmental claims. Within the institutional ecosystem, Greenalyze supports innovation culture by encouraging interdisciplinary collaboration between accounting, sustainability, and digital technology development, while providing students and staff with training in ESG data and analytics. For industry stakeholders, Greenalyze encourage entrepreneurial mindsets by demonstrating how environmental reporting challenges can be converted into value-creating services, such as ESG benchmarking, targeted advisory, and training programs on credible environmental reporting. The read-only Supervisor Dashboard further improves implementation readiness by enabling controlled, self-service access to results and downloads, reducing administrative burden while preserving data integrity. By lowering the cost and complexity of

detecting potential greenwashing, Greenalyze strengthens market confidence in environmental information and supports a culture of innovation and entrepreneurship in sustainability-related decision making.

6. Potential commercialization

Greenalyze has strong commercialization potential as a business-to-business (B2B) analytics solution. Target customers include investors, audit firms, ESG consultants, and listed companies through **subscription-based access**, as well as regulators, stock exchanges, and government agencies through **institutional licensing** for market-wide monitoring. **Commercial offerings** can be structured in tiers, ranging from single-firm screening to sector benchmarking, supported by customized dashboards, downloadable reports, and application programming interface (API) integration with existing ESG systems. **Market entry strategy** may begin with Malaysian listed companies and subsequently expand to broader Association of Southeast Asian Nations (ASEAN) markets where GRI-aligned reporting and verification needs are increasingly required. **Strategic partnerships** with professional bodies, ESG assurance providers, and universities can accelerate market penetration through training and adoption programs. In response to the increasing of ESG compliance expectations and heightened scrutiny of corporate environmental claims, Greenalyze addresses a growing global market demand for reliable greenwashing detection services.

7. Acknowledgment

The authors would like to express their sincere gratitude to MyBrain 2.0 for the financial support that enabled the development, refinement and dissemination of this innovation. Greenalyze is an original innovation developed by the authors and is protected under Malaysian copyright law (Copyright Registration No: LY2025P08321, Year: 2025).

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Kontrak+: A Digital Platform for Performance Monitoring in Construction Projects

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ABSTRACT
Kontrak+ is a digital construction management platform designed to improve contractors' financial visibility, productivity tracking, and integrated project performance monitoring. It addresses persistent reporting and monitoring gaps, especially among small to medium-sized firms, where practices rely on manual spreadsheets and segregated tools that are difficult to integrate, causing delays, limited transparency, and weak performance oversight. The innovation originated from a Construction Industry Development Board (CIDB) construction innovation competition and was strengthened through evidence gathering (literature and industry reports) and a preliminary industry survey for needs validation. Development follows a structured Technology Readiness Level pathway (TRL 1–TRL 4), applying an evidence-to-prototype approach with iterative expert-panel review cycles involving industry leaders, supporting requirement refinement and recognition as a top-ten innovation. Kontrak+'s advantages include low-cost, easy-to-use digital documentation and a modular architecture that consolidates work-progress reporting, cost monitoring, and performance indicators within one platform, enabling scalable adoption from pilots to wider deployment. Expected socio-economic impact includes improved cost control, reduced reporting delays, higher transparency, and better stakeholder decision-making. Commercialization prospects are supported by positive industry feedback, Malaysia's large contractor base (over 130,000 registered contractors), and potential expansion beyond Malaysia via subscription, training, and commission-based models.

Keywords: Construction digitalization, Contractor productivity, Progress monitoring, Project performance, Decision support

1. Product Description
Kontrak+ is a proposed platform for contractors (G1–G7) and project managers in small and medium-sized firms to record and monitor project finances, productivity, work progress, and overall performance through a structured digital workflow. It offers a low-cost, practical alternative where expensive project monitoring systems are not feasible. Kontrak+ replaces fragmented manual reporting, such as spreadsheet notes, with standardized inputs that enable faster reporting, clearer visibility, and more consistent performance tracking. Early validation includes a preliminary pilot survey with contractors and early-adopter project managers. The intended customer ecosystem includes contractor and project-management associations to

support dissemination and uptake. Development is strengthened through industry collaboration and mentoring to improve credibility, practicality, and adoption readiness. Innovation development follows an iterative workflow: issue gathering, survey justification, Technology Readiness Level (TRL) 1 to TRL 4, an expert panel review loop, and prototype development **(Figure 1)**. This sequence anchors each TRL stage to industry needs and refines outputs through expert feedback before prototyping. Early market and validation indicators are summarized in **Table 1**, including participation rates, target segments, and baseline industry practices.

2. Kontrak+ Innovation Development Workflow. .

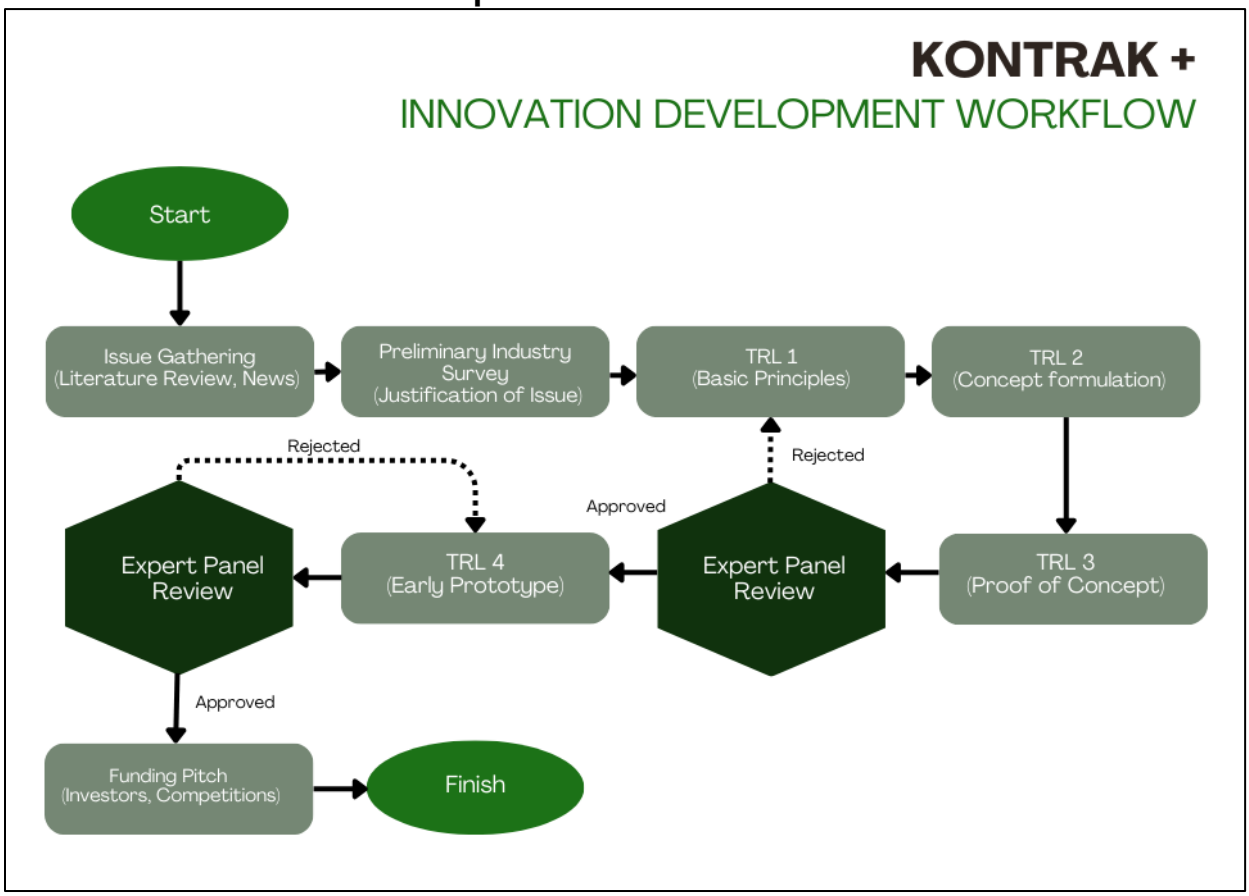

Figure 1. Kontrak+ Innovation Development Workflow.

Table 1. Early Market and Validation Metrics for Kontrak+.

Metric	Description
Pilot respondents	Number of respondents involved in preliminary validation
Primary contractor market	Estimated number of contractors targeted
Early adopter segment	Estimated early adopter project managers targeted
Baseline practice	Current practice is manual/conventional documentation
Operational focus	Finance, productivity, and work progress tracking

3. Novelty and uniqueness

Kontrak+ demonstrates novelty by combining a Technology Readiness Level (TRL) development pathway with an explicit expert-panel feedback loop, which reduces the common mismatch between what developers build and what contractors and project managers adopt. Its uniqueness goes beyond simple digitization. It structures reporting around four operational anchors, financial status, productivity, work progress, and project performance, areas that are often tracked in disconnected spreadsheets, site notes, and informal updates. By standardizing inputs across these anchors, Kontrak+ enables clearer performance visibility, more consistent tracking, and faster decision-making at project level. The platform also prioritizes affordability and ease of use as primary adoption drivers for small and medium-sized firms where enterprise monitoring systems are impractical. Its proof-of-concept approach embeds real contractor involvement through early surveys, iterative mock-ups, and staged validation, while expert review strengthens credibility and ensures each TRL stage addresses industry needs before advancing to a production-ready prototype.

4. Benefit to mankind

Kontrak+ improves project transparency by strengthening how contractors capture and communicate financial status, work progress, productivity, and overall project performance in a consistent digital workflow. This reduces delays caused by fragmented reporting, supports faster corrective actions when performance drops, and improves day-to-day decision-making for contractors and project managers. Standardized records also reduce disputes by providing clearer evidence on costs, progress claims, and productivity trends. Importantly, better visibility helps teams identify early warning signals, such as declining productivity, budget drift, or schedule slippage, which reduces operational risk and supports timely mitigation. At wider scale, adoption can strengthen governance and accountability in construction delivery, especially among small and medium-sized firms that still rely on manual documentation. By enabling reliable tracking and timely reporting, Kontrak+ supports better resource planning, fewer cost overruns, and reduced likelihood of project failure, benefiting clients, workers, and communities through more predictable outcomes.

5. Innovation and Entrepreneurial Impact

This project delivers innovation impact by converting a fragmented, manual reporting culture into a structured digital workflow that strengthens financial control, productivity tracking, work progress monitoring, and project performance visibility. Validation is embedded through industry surveys, staged Technology Readiness Level (TRL) progression, and an expert-panel feedback loop, which reduces solution–user mismatch and improves adoption readiness. It also creates entrepreneurial impact through a clear commercialization pathway, well-defined customer segments, and an affordability-first value proposition tailored to small and medium-sized firms. Revenue potential is diversified via subscriptions, implementation and training services, and commission-based partner channels, supported by contractor and project-management associations for scaling and credibility. Kontrak+ was selected as a Top 10 Best Innovation in the CIDB SFERA competition and showcased at Construction Industry Development Board (CIDB) International Construction Week (CIDB ICW), encouraging more industry players to compete on real problems and deploy practical, scalable solutions.

6. Potential commercialization

Commercialization is planned under a startup model that serves contractors and project managers with an affordability-first digital workflow for monitoring finance, productivity, work progress, and project performance. The total addressable market includes approximately 130,000 registered construction companies, providing strong scale potential. Revenue can be generated through tiered subscription access, implementation and training services, and commission-based partner channels (for example, referrals and association-linked offerings). The go-to-market strategy starts with proof-of-concept pilots and early-adopter onboarding through contractor and project-management associations. During the validation and pitching process with contractor associations, industry representatives indicated strong willingness to adopt the application, strengthening the market-fit signal and reducing early sales friction. Mentoring and strategic networks further support credibility, partnerships, and scaling. Budgeting can be structured across platform development, system integration and project-data capabilities, technical support and training, and continued research and validation activities, with early mock-up development positioned as a measurable initial milestone before full prototype deployment.

7. Acknowledgment

The authors acknowledge the support of industry stakeholders, associations, and institutional partners who contributed insights, validation inputs, and engagement opportunities that strengthened the development pathway of Kontrak+.

8. Researchers' Biography

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Smart Food Conveyor System: A Sustainable Automation Solution for Efficient Café Service Delivery

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ABSTRACT

A cafe in Dungun, Terengganu uses a QR-based ordering system in a semi automated kitchen environment. Despite technological integration, the establishment faces persistent operational challenges such as high staff turnover, long training periods, and frequent order delivery errors. These issues significantly impact service efficiency, particularly during peak hours from 6-8 PM. Based on interview sessions conducted with the cafe manager, key operational data was gathered, including recorded order error rates, staff training durations, and direct feedback from frontline employees regarding workflow pain points. This primary data further substantiates the identified challenges. To address these limitations, this study proposes the implementation of an innovative conveyor belt delivery system at the cafe which aims to streamline order distribution processes, minimize human error, reduce dependency on manual labor, and enhance overall customer experience.

Keywords: Food conveyor system, cafe automation, order accuracy, QR ordering, service efficiency

1. Product Description

The purpose of this innovation is to improve the efficiency of the operation of food and beverage companies particularly at a local cafe in Dungun, Terengganu. Although the cafe already utilises the usage of QR code ordering system, delays in manual food delivery and congested service staff movement continue to occur especially during peak hours (Kulkarni et al., 2024) . These delays create longer wait times, undercutting operational efficiencies due to the manual delivery method (Tasar et al., 2020). This primarily affects staff and customers alike. The semi-automated food delivery system that this innovation seeks to implement transports completed orders to customers' tables to minimize wasted movements, order errors, and wait time from the kitchen.

2. Diagrams

Conveyor belts, which are made to maximize efficiency and service speed, will be used to implement the Smart Food Conveyor System. The development process will concentrate on developing a food distribution prototype while minimizing employee workload and customer wait times.

Figure 1. The original layout of the café.

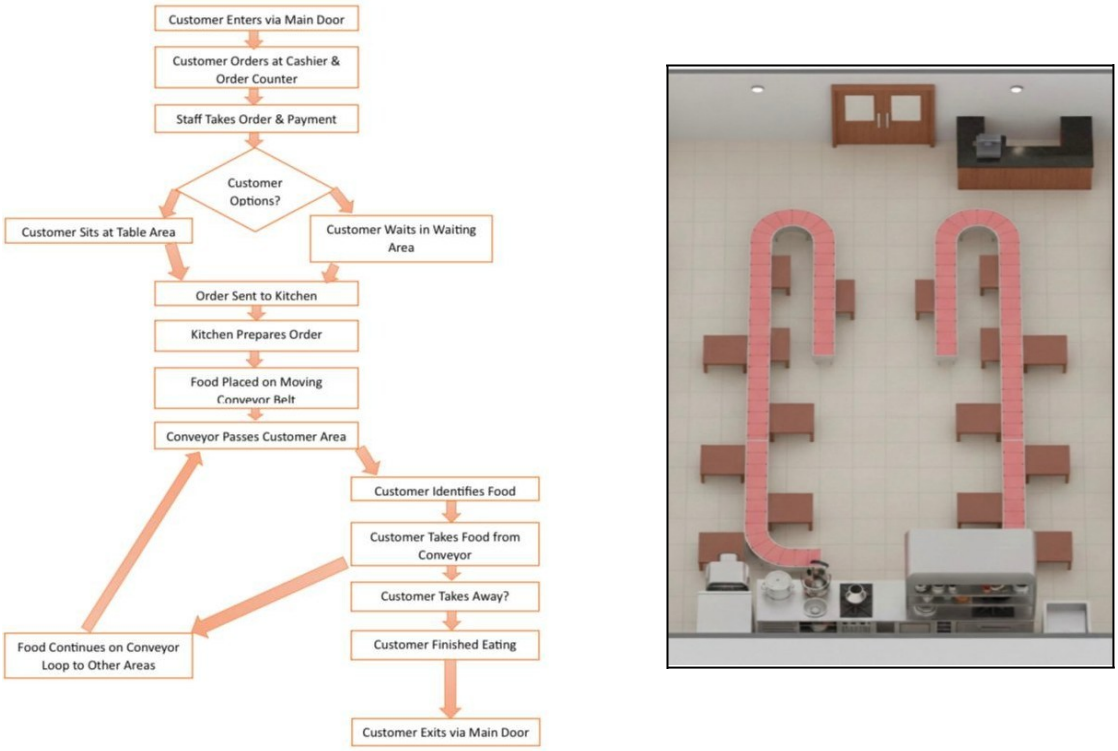

Figure 2. Flowchart and Innovation for the Cafe.

3. Results and findings

A survey conducted revealed that customers are concerned about long waiting times and heavy workload at the café. Based on feedback from 53 customers, during peak hours, 79.2% of respondents have to wait over 20 minutes for their order to arrive. Although 20.8% received their order within 20 minutes, over half (54.7%) experienced more than 20 minutes wait times. Customer perceptions support this finding, with 45.3% rating service speed as average and 35.8%

rating it as slow or very slow during busy hours. Only a small proportion perceived the service as fast. These show that during peak hours will result in bottleneck caused by dependence on the manual delivery.

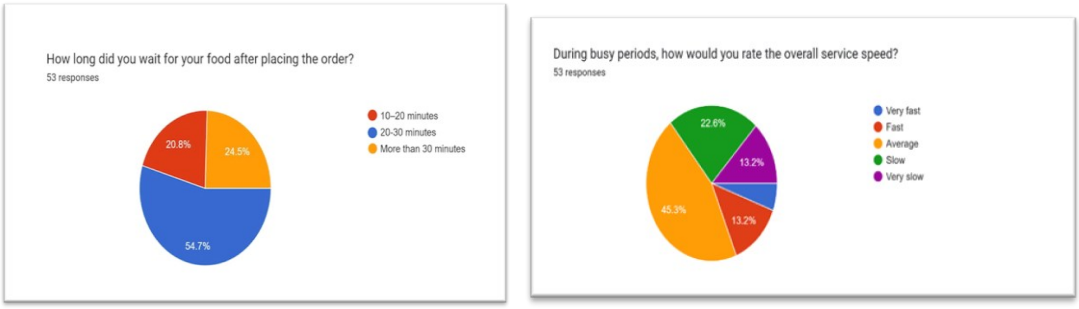

Figure 3. Analysis of the survey.

Based on feedback from 53 customers, during peak hours, 79.2% of respondents have to wait over 20 minutes for their order to arrive. Although 20.8% received their order within 20 minutes, over half (54.7%) experienced more than 20 minutes wait times. Customer perceptions support this finding, with 45.3% rating service speed as average and 35.8% rating it as slow or very slow during busy hours. Only a small proportion perceived the service as fast. These show that during peak hours will result in bottleneck caused by dependence on the manual delivery (see **Figure 4**)

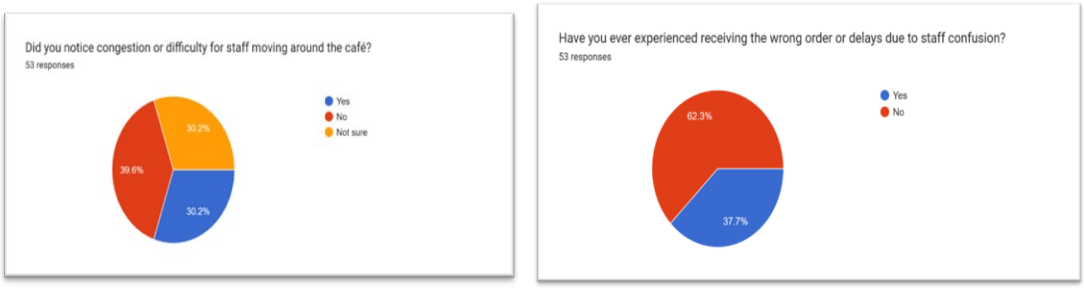

Figure 4. Analysis of the survey.

Based on the survey of 53 respondents, several operational issues at the cafe have been identified. About 36% of consumers reported experiencing staff movement and congestion, whilst almost 33% did not. This suggests that, even if they might not be constant, mobility problems nevertheless occur, especially during busy times. More than 62% of customers have gotten incorrect orders or had delays as a result of staff uncertainty, making the situation more worrisome. This figure reveals a significant flaw in the work system.

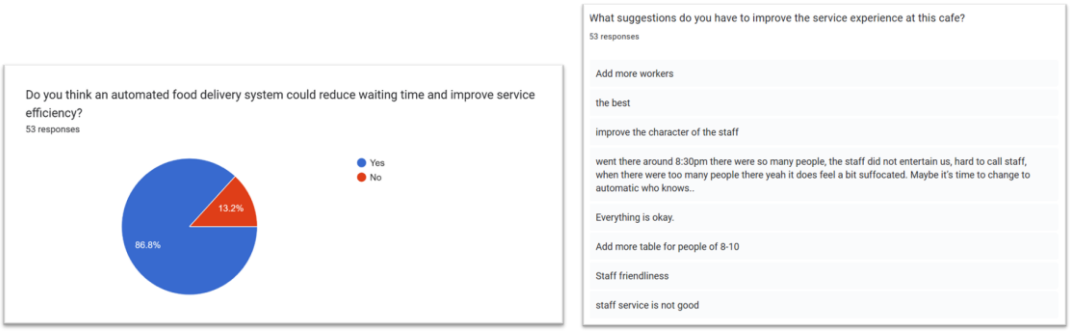

Figure 5. Analysis of the survey.

According to the questionnaire results, 86.8% of cafe customers feel an automated food delivery system (conveyor belt) could improve efficiency and minimize wait times, while 13.2% disagree. The agreement may have come from customer service difficulties, while the protesters are most likely regulars who are concerned about discomfort caused by modifications in the cafe's layout. Furthermore, the majority of respondents believe the cafe should improve their staff manners as most of the respondents stated they are being rude.

4. Novelty and uniqueness

Several key features were included as follows:

- **Smart Ordering System:** Customers will place food orders using a QR code system, which are then automatically sent to the kitchen for preparation.
- **Conveyor Belt Distribution System:** Customers will receive food via the conveyor system, where it will be delivered effectively without the need for employees.
- **Pickup Label:** With the help of clear label pickup, customers can easily pick up their meals without the help from the staff.

In order to maintain consistent performance while adhering to food safety regulations, coordination with kitchen staff will also be established to control the conveyor speed as well as the flow of food preparation.

5. Benefit to mankind

B. To improve service speed during peak hour

During busy times, staff juggle plenty of tables, sometimes slowing things down. Food moves faster when conveyor belts bring dishes straight to customers,cutting through crowds and smoothing steps. This setup cuts delays, keeps service moving, gives meals a smoother arrival.

C. To enhance customer satisfaction through an efficient and modernised system

Conveyor belts in cafes often make customers feel better about their visit. When food arrives, alerts help staff get orders right quicker, smoother, and satisfaction grows. This kind of update fits today's trend, sleek, high-tech spots where tech meets coffee.

6. Innovation and entrepreneurial impact

The Smart Food Conveyor System addresses the long waiting times and workload among the staff of the café. It provides an efficient and organized food distribution method using a conveyor belt system that delivers meals directly to customers. Digital ordering and clear label of pickup improve the order accuracy and reduce congestion. It also minimizes manual food handling which allows workers to focus on quality control and food preparation to

increase overall productivity. A survey conducted at the cafe indicated strong consumer interest in faster food service and automated delivery systems. It is time to improve how food services operate by embracing new technology to enhance efficiency and customer satisfaction as this system has the potential to improve customer experiences.

7. Potential commercialization

The Smart Food Conveyor System has high potential for commercialisation as it can be introduced to cafés, restaurants, food courts, university cafeterias, and quick-service food businesses that aim to improve service efficiency and reduce reliance on manual food delivery. This system is especially suitable for small and medium-sized food and beverage businesses that experience high customer volume during peak hours, as it helps minimise waiting time, reduce staff movement congestion, and improve order accuracy. By integrating the conveyor belt with the existing QR ordering system, businesses can create a more organised and modern service flow without fully replacing human workers. The product can be commercialised through customised installation packages based on café layout, maintenance services, and future upgrades such as automated sensors, order tracking, and table notification systems. With increasing demand for faster, cleaner, and technology-driven dining experiences, this innovation has strong market value and can help food service operators enhance customer satisfaction, improve productivity, and strengthen their competitive advantage.

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Sihat GO+: An Innovative Business Concept for the High-Demand Kuala Lumpur Food Market

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ABSTRACT
Sihat Go+ is a healthy grab-and-go food service idea which offers sustainable, nutritious and convenient meals to the urban customers in Kuala Lumpur. The idea emphasizes on providing nutritious, personalized meals in bowl for busy professionals, as well as people who care about fitness and are mindful of their health. The concept is a response to growing consumer interest in dietary health and the need for fast-food offerings without sacrificing nutritional values. This proposed business operation combines modular menu design, portion control, green packaging and a low-cost AI-based menu recommendation system to promote personalization and improve operational efficiency. Unique value propositions, such as build-your-own healthy bowls, plant-based offerings, QR-code ordering and enterprise wellness programs, enable Sihat Go+ to stand apart from traditional fast-food and fast-casual rivals. Socioeconomically, Sihat Go+ creates the opportunity to eat healthier, contributes to sustainable consumption by not using plastic in the packaging, and creates job opportunities in the food service sector. For the environmental aspect, it brings about responsible procurement and assists with waste reduction. From a commercialization perspective, the idea scales really well through corporate subscriptions, mobile kiosks, mall-based stores, and catering services to position Sihat Go+ as a highly competitive and sustainable business model in Malaysia's growing food service industry.

Keywords: Personalized healthy meals, Grab-and-go, Menu innovation, AI-powered ordering

1. Product Description
Sihat Go+ is a healthy, quick-bite food service concept developed as a convenient, healthy, and sustainable meal solution for the urban community. The product offering lies in the form of customizable healthy bowls and functional drinks of balanced nutrition made from natural, fresh and quality ingredients. The customers are able to create their own bowl with a variety of proteins, carbs, vegetables, and sauces to choose from according to their individual preference. The protein sources on the menu include chicken, fish, beef, as well as tofu for vegetarians. In addition, Sihat Go+ offers healthy drinks such as cold-pressed juices, detox drinks, and protein shakes. This healthy drink menu is to cater to the hydration needs of the customers. To increase convenience and customer satisfaction, Sihat Go+ features QR-ordering and a hassle-free artificial intelligence menu recommendation system that help identify appropriate food choices according to the fundamental lifestyle details of each individual customer. The meal is packed in environmentally supportive, plastic-free packaging to meet the demand for sustainability. In a fast-paced urban living, Sihat Go+ provides a convenient food solution for health-conscious customers.

2. Sihat GO+ Logo and Photos of Product

Figure 1. Sihat Go+ logo.

Figure 2. Proposed menu.

3. Novelty and uniqueness

Sihat Go+ has a unique healthy grab-and-go concept that integrates ideas of personalized healthy meal, technology, and sustainability. Its flexible menu architecture enables customers to create personalized healthy meals according to their required serving portion size and preferred combination of ingredients. This increases nutritional control to a significant extent compared to standard fast food. The innovative part of the business model lies in the incorporation of a simplified AI-driven personalized menu recommendation system through a QR code ordering platform, which implements personalized recommendations through a rule-based approach at a relatively low development cost. This increases the efficiency of the ordering and improves the ordering completion experience of the customers. Furthermore, the innovative incorporation of sustainable packaging solution, subscription-based healthy meal plan, and corporate wellness program service offering all enhance the distinct value proposition of the Sihat Go+.

4. Benefit to mankind

To instill better eating habits through readily available balanced meals catered to the needs of modern urban living, Sihat Go+ improves the overall welfare of communities. Healthy and better controlled food intake helps reduce the risk of health issues, such as obesity and diabetic, etc. The goal of environment conservation and sustainability can be achieved through the use of plastic-free and eco-friendly packaging. Sihat Go+ also helps create jobs and stimulate economic growth by partnering with local suppliers. Through Sihat Go+'s corporate wellness plans and subscription services, higher productivity can be expected for the participating companies. It is clear that Sihat Go+ is an entity to bring about favorable social, health, environmental, and economic impacts.

5. Innovation and Entrepreneurial Impact

With the integration of technology, sustainability, and customer-centric designs to create a viable meal service ecosystem, Sihat Go+ is committed to innovation. The use of a simplified AI menu recommendation system, manifests the adoption of technology by small-to-medium scale businesses in a novel and cost-effective manner, encouraging technology adoption in the food service industry. Its subscription service-oriented business approach is innovative both operationally and financially to enhancing the sustainability of the business. In terms of entrepreneurial impact, the proposed Sihat Go+ promotes a viable and easily adaptable business model for small-to-medium enterprises which aims for not only profitability but also social and environmental responsibilities. This proposal aims to inspire responsible and sustainable true entrepreneurship which can also protect the environment and give back to the communities when making profits.

6. Potential commercialization

The business strategy of Sihat Go+ is scalable and flexible, and hence, there is great commercialization potential. This business model could be developed and adapted in various ways: catering services, food carts at events, and grab-and-go kiosks in shopping malls, etc. An important factor, of course, is the enhanced financial stability this business model can provide by attracting funding from investors through its corporate wellness programs and food subscription services. Well-designed digital ordering, modular food components, and standardized food recipes facilitate an efficient replication strategy across multiple locations with controlled business expenses. In fact, due to the global growing consumer demand for convenient, sustainable, and healthy food, the commercialization value of this proposal goes beyond Malaysia. Once this business model proves successful, the formula can be used for the global market. The commercial potential of Sihat GO+ is significant, and beyond the border.

7. Acknowledgment

The team members of Sihat Go+ would like to express our heartfelt gratitude to all individuals and organizations who have supported and contributed to the success of this project. First and foremost, we extend our deepest appreciation to Miss Flora Shumin Chang, our lecturer and academic advisor, for her unwavering guidance, encouragement, and insightful feedback throughout the development of this project. The analytical skills we acquired in her class, including problem-solving and decision-making skills, have been honed by this project, especially in determining the viability of enterprises in the food service industry. Our appreciation also goes to Universiti Teknologi MARA (UiTM), Puncak Alam, for providing the academic environment,

resources, and platform to carry out this project. Lastly, we thank our families and friends for their continuous support and motivation.

8. Researchers' Biography

Muhammad Hakimi bin Kamarul Zaman is a Master's student in Hospitality Management at Universiti Teknologi MARA (UiTM). He has experience in hospitality operations, food service management, and business administration, supported by an academic background in Culinary Arts Management. His interests focus on operational efficiency and service quality in the hospitality industry. He has published a journal article in the Gading Journal for the Social Sciences, examining social and psychological factors influencing coffee consumer preferences in Malaysia.

Flora Shumin Chang is a lecturer with the Faculty of Hotel & Tourism Management, UiTM Puncak Alam Campus. A committed hospitality and tourism management educator with track record for consistently engaging students in stimulating and relevant activities/programs. Dedicated to individual student success and comprehensive understanding. Known for personable demeanor and strong work ethic.

Jazira Anuar is a senior lecturer in Faculty of Hotel and Tourism Management at Universiti Teknologi MARA, recognized for her strong contributions to academic innovation and applied research. Majoring in Hospitality Management, she has led and collaborated on numerous innovation projects, earning a Diamond Award alongside multiple gold, silver, and bronze medals in national and international invention and design competitions. Her more than 30 innovation projects span on food product development, hospitality service tools and inclusive solutions for People with Disabilities (PWDs). As an active scholar, she has produced a substantial body of publications in hospitality technology, service quality, work-based learning, and sustainable practices, with over 194 Google Scholar citations and h-index 6. Through research grants, journal publications, and industry-linked projects, she consistently connects academic knowledge with real-world hospitality advancements.

S.E.C.U.R.E Apps

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ABSTRACT
In today's dynamic labour market, effective employability assessment is crucial for matching individual competencies with employer needs. Conventional assessment methods have predominantly relied on static questionnaires to evaluate employability skills, which often fail to capture real-time readiness and practical alignment with organizational expectations. With the advancement of digital technologies, there is a growing need for more interactive and adaptive assessment solutions. This study introduces a digital employability assessment application designed to support employees in evaluating their skills and preparedness prior to job interviews. The application enables structured self-assessment and facilitates comparison with employer evaluations conducted during the interview process. By integrating both perspectives, the system provides a more comprehensive understanding of employability attributes and helps identify gaps between perceived and expected competencies. The digital platform enhances the accuracy and timeliness of employability analysis, contributing to a more efficient and transparent recruitment process. Transitioning from traditional questionnaire-based tools to an application-driven approach addresses the limitations of earlier assessment methods and aligns with contemporary hiring practices. This study demonstrates the potential of digital assessment tools to improve employability evaluation and strengthen alignment between job seekers and employers.

Keywords: Employability, Conventional method, Application, Digital, Recruitment

1. Product Description
The employability application is a digitally driven system developed to support contemporary recruitment and candidate evaluation processes. It integrates an interactive self-assessment instrument adapted from Baker et al. (2017), allowing candidates to reflect on and report their employability-related skills in a structured digital environment. Upon completion, the system produces automated feedback that outlines individual competency profiles, identifying both strengths and development needs. During the interview phase, employers can independently record their assessments within the same platform, enabling systematic comparison between candidate self-evaluations and employer judgments. This comparative functionality supports clearer interpretation of employability alignment and skill gaps. The application features an intuitive interface and an integrated dashboard that presents summarized insights and tailored recommendations for users. By transforming conventional assessment practices into a centralized digital format, the platform improves efficiency, transparency, and consistency in hiring decisions. The S.E.C.U.R.E. application further assists employers by providing access to candidate

questionnaire responses, offering deeper insight into employability levels and enhancing role-fit evaluation throughout the recruitment process.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

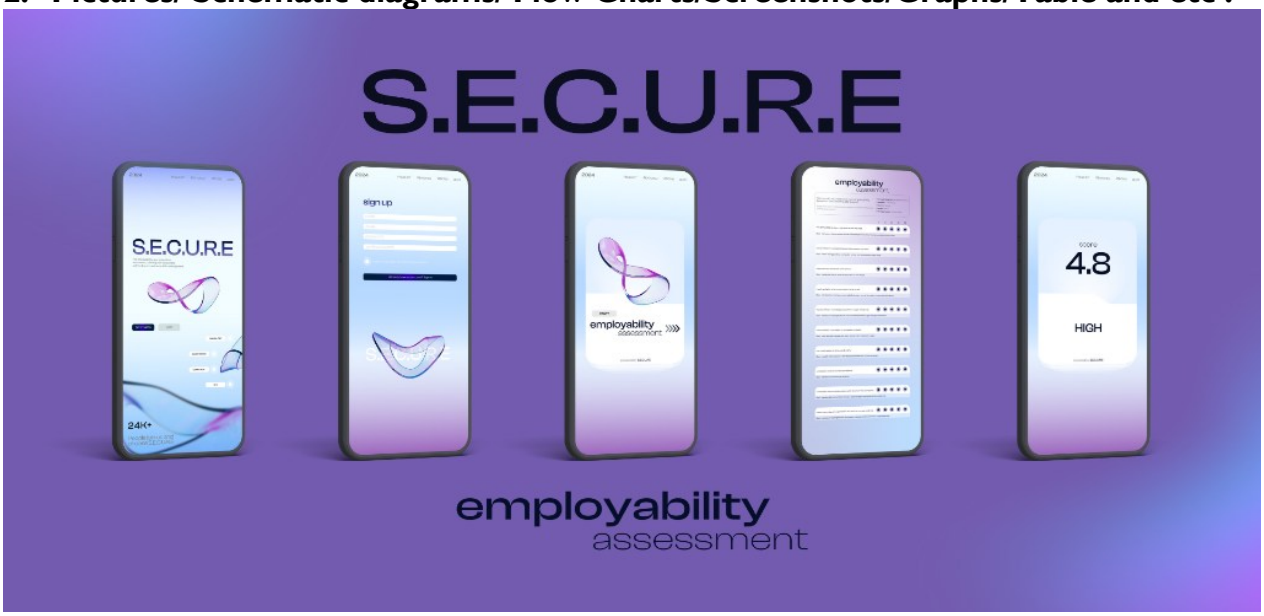


Figure 1. S.E.C.U.R.E Apps.

3. Novelty and uniqueness

The employability application demonstrates originality by effectively addressing the evolving requirements of today's workforce while moving beyond the constraints of traditional assessment methods. Instead of relying on static, form-based evaluations, the system offers an interactive and real-time assessment framework that delivers a more holistic view of candidate competencies. By incorporating structured self-assessment tools, the application encourages individuals to critically reflect on their employability readiness and skill profiles. A notable innovation of the platform is its ability to combine candidate self-assessments with employer evaluations captured during interview sessions. This integrated, dual-perspective approach enables simultaneous consideration of self-perceived capabilities and external assessments, providing clearer insight into skill alignment and identifying potential gaps. The use of real-time data and customized feedback enhances the consistency and accuracy of employability evaluations while promoting greater transparency throughout the recruitment process. Additionally, the application's adaptable structure and user-friendly interface distinguish it from conventional assessment tools, making it well suited to contemporary hiring environments. Overall, the application represents a forward-thinking digital solution designed to support more informed decision-making in an increasingly dynamic job market.

4. Benefit to mankind

The employability application provides meaningful benefits to society by enhancing fairness, efficiency, and transparency in recruitment and workforce development. It enables individuals to better understand their skills and employability readiness through structured self-assessment and personalized feedback, supporting continuous learning and career progression. For employers,

the application offers a more objective and systematic approach to candidate evaluation, helping to reduce bias and improve job–skill matching. This leads to more effective hiring decisions, higher workforce productivity, and improved employee retention. At a broader societal level, improved employability assessment contributes to addressing skills mismatch and unemployment by aligning individual capabilities with labour market needs. The standardized and digital nature of the application promotes equal opportunities by ensuring consistent evaluation criteria across candidates. Overall, the application supports sustainable workforce development, economic growth, and social inclusion by strengthening the connection between human potential and employment opportunities.

5. Innovation and Entrepreneurial Impact

The project promotes innovation and entrepreneurial impact by introducing a digital employability assessment platform that modernizes traditional recruitment and skill evaluation practices. By integrating real-time self-assessment and employer feedback within a single system, the application encourages data-driven decision-making and continuous improvement in talent management. Its scalable and adaptable design supports adoption across industries, enabling organizations, startups, and institutions to customize employability assessments based on specific workforce needs. The project fosters an entrepreneurial mindset by empowering individuals to take ownership of their skill development and career readiness through actionable insights and personalized feedback. Within institutions and industry, the application stimulates innovation by demonstrating how digital tools can enhance transparency, efficiency, and competitiveness in hiring processes. Furthermore, the platform has commercial potential as a software-based solution that can be expanded into workforce analytics, training recommendations, and talent development services, contributing to a sustainable culture of innovation and entrepreneurship.

6. Potential commercialization

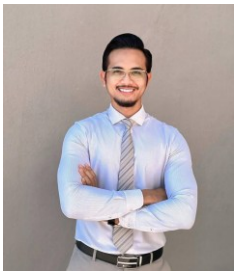
The employability application has strong potential for commercialization as a scalable digital solution for recruitment and workforce development. It can be offered as a software-as-a-service (SaaS) platform to employers, recruitment agencies, educational institutions, and training providers seeking data-driven employability assessment tools. Customizable assessment modules, analytics dashboards, and benchmarking features can be packaged into tiered subscription models to meet diverse organizational needs. The application may also be integrated with existing human resource management systems, learning platforms, and job portals to expand market reach. Additional revenue streams could be generated through premium features such as advanced analytics, skill-gap diagnostics, and tailored training recommendations. With increasing demand for transparent and efficient hiring solutions, the application is well positioned for adoption across multiple industries. Its digital nature enables cost-effective scaling and international deployment, supporting sustainable commercialization and long-term business growth while contributing to improved workforce alignment.

7. Acknowledgment

The authors would like to express their sincere appreciation to all individuals whose support and contributions made this study possible.

8. Researchers' Biography

Nur Syazwani Zulaikha Binti Safwan is a Doctoral student in the field of Sports Management at the Faculty of Sports Science and Recreation, Universiti Teknologi MARA, Seremban Campus, Negeri Sembilan, Malaysia. Her research focuses on sports management and human resource management.



Dr. Mohamad Firdaus Ahmad is a Senior Lecturer at the Faculty of Sports Science and Recreation, Universiti Teknologi MARA (UiTM), Seremban, Negeri Sembilan, Malaysia. His academic expertise lies within the social sciences, with a particular focus on sport management, sports policy, human resource management, and graduate employability.

Sign-Talk AR: Enhancing Inclusive Education Through Augmented Reality-Enabled Kinesthetic Learning

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ABSTRACT

Sign-Talk AR is a social innovation created to bridge the communication gap between the hearing and Deaf communities. The project was born out of a simple observation: learning sign language from static books or 2D posters is incredibly difficult because it lacks the movement and depth that the language requires. To solve this, I designed a system that combines traditional physical flashcards with Web-based Augmented Reality. The core advantage of this tool is its simplicity. Unlike most modern tech, it doesn't require a bulky app download. Users simply point their smartphone at a card, and a 3D avatar instantly appears to demonstrate the sign. This makes the learning process interactive and kinesthetic, allowing someone to see the exact hand shapes from every angle. The socio-economic impact of this project is rooted in inclusivity. By making sign language easier to learn, we can reduce the isolation felt by the Deaf community and support global goals for reduced inequalities. From a commercial perspective, Sign-Talk AR has huge potential in schools, corporate offices, and even government service counters like hospitals. It is a low-cost, scalable solution that turns a complex language into an engaging, everyday experience for everyone.

Keywords: Augmented Reality, Sign Language, Inclusive Education, Social Innovation, Kinesthetic Learning

1. Product Description

Sign-Talk AR is a groundbreaking educational tool that bridges the gap between static learning and the fluid, spatial nature of Sign Language. By pairing physical flashcards with a "Zero-Install" Web-AR architecture, it eliminates the need for bulky app downloads, allowing any smartphone user to instantly project a 3D digital avatar into their environment. While traditional 2D books struggle to convey the movement inherent to signing, this interactive avatar demonstrates precise hand gestures and facial expressions in a three-dimensional space. (**Figure 1** illustrates the seamless flow from scanning a card to viewing the AR avatar, while **Figure 2** displays the prototype flashcard layout.) This multi-sensory approach transforms complex linguistic training into an accessible, inclusive experience, ensuring that sign language education is as dynamic and vibrant as the community it represents.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

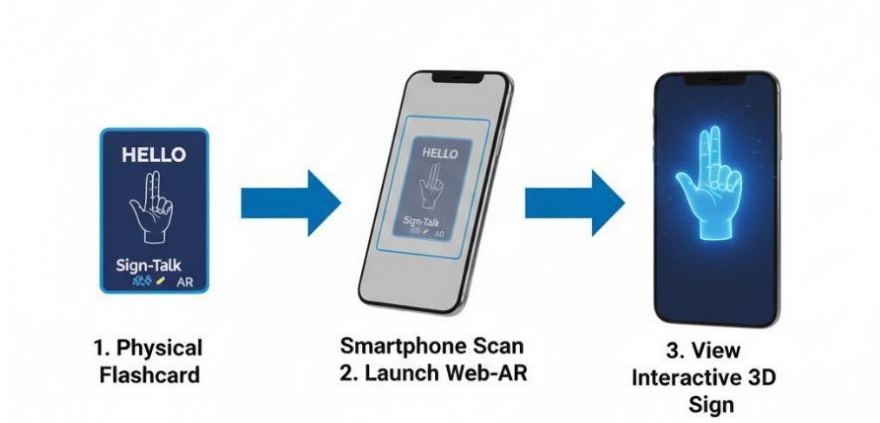

Figure 1. User Interaction Flow from Physical Card to AR 3D Avatar Display.

Figure 2. Prototype Layout of the Sign-Talk AR Flashcard Set.

3. Novelty and uniqueness

The primary novelty of Sign-Talk AR lies in its spatial interactivity and its "Zero-Install" Web-AR deployment. Traditional Sign Language resources are limited by the two- dimensional nature of paper or flat video screens, which often lead to confusion regarding hand depth and orientation. Sign-Talk AR allows learners to rotate and view the 3D avatar from 360 degrees, providing a comprehensive understanding of each sign. Furthermore, while most AR educational tools require high-storage mobile applications, our project utilizes a web browser-based trigger. This makes the technology inclusive for users with low-end devices or limited storage, effectively democratizing high-tech educational tools. The unique combination of physical tactile learning (flashcards) and digital kinesthetic feedback creates a superior "Dual Coding" memory effect, which is not found in standard language learning apps. This synergy ensures that the product is not just a digital gimmick but a robust pedagogical tool that respects the linguistic complexity of the Deaf community.

4. Benefit to mankind

Sign-Talk AR offers a significant contribution to social inclusivity by dismantling the communication barriers that isolate the Deaf and Hard-of-Hearing (DHH) community. By making Sign Language learning more accessible and less intimidating for the hearing public, it fosters empathy and understanding within society. In educational settings, it supports inclusive classrooms where DHH students and their peers can interact more fluidly. In public service sectors, such as healthcare and law enforcement, it provides a rapid tool for officers and medical staff to learn basic emergency signs, potentially saving lives in critical situations. Ultimately, this project supports the United Nations' Sustainable Development Goals (SDG 4 and 10) by ensuring quality, equitable education and reducing inequalities, creating a world where no one is left behind due to a lack of a shared language.

5. Innovation and Entrepreneurial Impact

This project promotes a culture of innovation by showcasing how "phygital" (physical + digital) products can be developed with low overhead costs but high social value. It encourages students and local innovators to look beyond traditional software development and explore browser-based AR as a viable medium for social entrepreneurship. Within the institution, Sign-Talk AR serves as a case study for interdisciplinary collaboration between electrical engineering, design, and social sciences. By adopting an agile development mindset, the project demonstrates that social problems can be solved through tech-driven entrepreneurship. It inspires a shift from being mere technology consumers to being technology creators, proving that inclusive tools can be both socially impactful and commercially viable.

6. Potential commercialization

Sign-Talk AR has strong commercial viability across three primary markets. First, the B2B sector includes private and public schools looking for interactive STEM and inclusive education tools. Second, the B2G (Business-to-Government) sector presents opportunities to supply government service counters, such as hospitals, police stations, and immigration offices, with "Emergency Sign Kits" to improve public service accessibility. Finally, the B2C market targets parents and hobbyists interested in early childhood development and language learning. The production cost is kept low as it primarily involves printed materials and web hosting, allowing for a high-profit margin. With the global rise in DEI (Diversity, Equity, and Inclusion) initiatives, Sign-Talk AR is well-positioned for international licensing and distribution as a subscription-based or physical product-service system.

7. Acknowledgment

I would like to express their deepest gratitude to Dr. Nur Aida binti Kipli for her invaluable supervision, guidance, and authorization throughout the development of this project. Her expertise and support have been instrumental in bringing this innovation to life. We also wish to extend our appreciation to Universiti Teknologi MARA (UiTM) for the opportunity to participate in the i-TIEC 2026 competition, allowing us to showcase our work on such a prestigious platform.

8. Researchers' Biography

Dr. Nur Aida binti Kipli, a seasoned senior lecturer at Universiti Teknologi MARA (UiTM) Sarawak, specializes in Political Sciences, particularly Sarawak politics, political theories, comparative politics, and policy studies. With over two decades of academic experience, she instructs a variety of courses spanning Politics, Malaysian Politics, International Relations, Development Administration, and Public Relations. Holding a Ph.D. in Political Science from the University of Malaya and a Bachelor's degree from the International Islamic University Malaysia (UIAM), she previously served as Senior Principal Assistant Director in the Education Malaysia Division, Department of Higher Education. Her expertise extends to media engagements during elections, making her a much sought-after commentator on both local and national platforms.

Austin Carlos bin Bos is a dedicated Master of Administrative Science (by Research) student at Universiti Teknologi MARA (UiTM), where he specializes in the intersection of social innovation and administrative technology. A homegrown talent, Austin previously earned his Bachelor of Administrative Science and Diploma in Public Administration from UiTM. While his core research in Master focuses on Consociational Theory and the Kuching City of Unity case study, he has expanded his academic reach into social entrepreneurship. As the innovator of Sign-Talk AR, Austin applies his administrative expertise to bridge communication gaps, proving that unity and inclusivity can be achieved through accessible, tech-driven solutions.

Smart Campus Parcel Management System: A Digital Self-Service Solution to Enhance Efficiency and Student Satisfaction

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ABSTRACT

The Smart Campus Parcel Management System is a digital self-service platform aimed at improving efficiency and student satisfaction in handling parcel deliveries on university campuses. This system was created to address the rising number of students engaging in online shopping, resulting in overcrowding, lengthy wait times, and ineffective manual management of parcels at campus pickup locations. The suggested system allows students to monitor, arrange, and retrieve their packages via a unified digital platform supported by intelligent lockers and automated alerts. The system reduces delivery delays and lessens staff workload by incorporating real-time tracking, self-service package collection, and secure access capabilities. Its main benefit is enhancing convenience, security, and operational efficiency in comparison to conventional parcel collection methods. From a socio-economic standpoint, the system enhances the quality of campus services, reduces time spent by students and staff, and facilitates better management of campus logistics. From an environmental perspective, it aids in minimizing unnecessary courier trips and repeated delivery efforts, leading to reduced carbon emissions. The Smart Campus Parcel Management System shows significant commercialization prospects via collaborations with universities, courier services, and its adaptable implementation in various educational institutions. Overall, the SCPMS presents a scalable and secure self-service innovation that enhances operational efficiency. It also improves students satisfaction, and supports the development of a smarter and more sustainable campus ecosystem.

Keywords: Smart Campus, Parcel Management System, Digital Self-Service, Smart Lockers, Student Satisfaction

1. Product Description

The Smart Campus Package Management System is a digital self-service tool aimed at improving the efficiency, security, and convenience of package retrieval in university housing areas. The system mainly serves students residing in campus housing, particularly those who often receive packages from online retail platforms, while also aiding residential college personnel and university administration. The system is made up of four primary elements. The Mobile/Web Application enables students to get notifications about parcels, check parcel status, and retrieve pickup verification codes. Smart Lockers function as secure automated storage solutions that efficiently hold packages and allow for self-service pick-up. The Payment Verification System and QR/Barcode ensure that only permitted users can access lockers via

a defined verification process, including an optional digital payment feature for applicable service fees. The Automated Notification System notifies students right away when packages arrive, minimizing ambiguity and unnecessary inquiries. By removing lengthy lines and restricted counter hours, students are able to pick up packages when it suits them. Simultaneously, staff responsibilities are lessened, enabling greater attention to critical administrative functions. In general, the system provides a quicker, safer, and more effective parcel management experience for campus communities.

2. Flow Charts

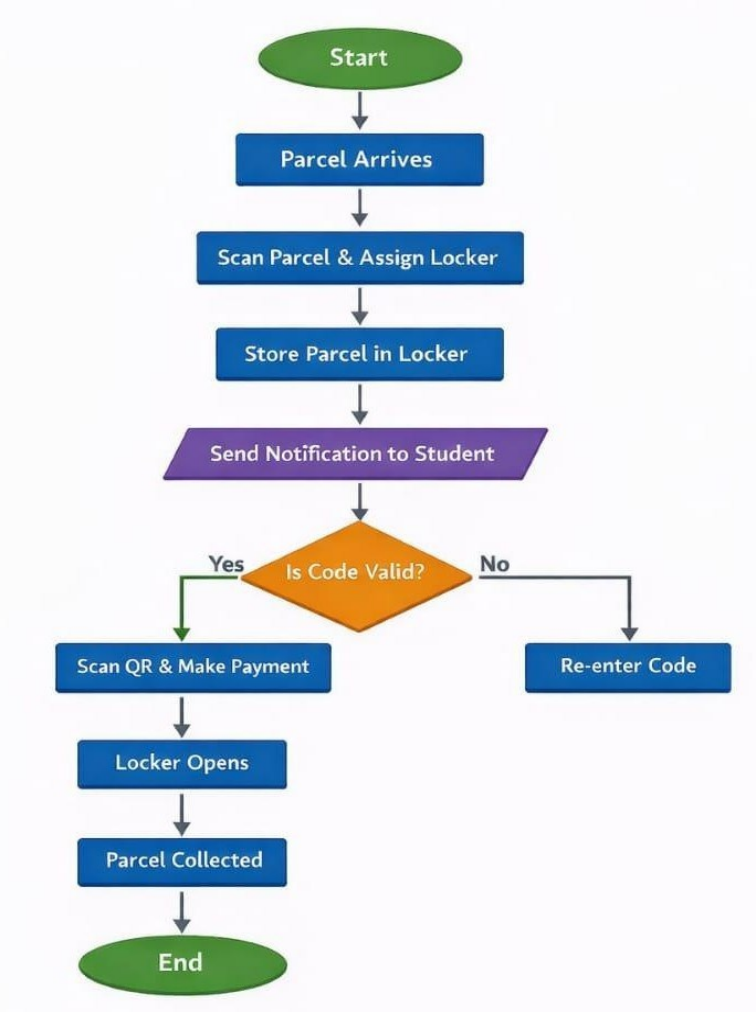

Figure 1. Flowchart of Self-Service Parcel Pickup Vending Machine System.

3. Novelty and uniqueness

The novelty of this proposed system lies in its secure, payment-based self-service parcel pickup mechanism designed specifically for a campus environment. Most existing parcel hubs rely on manual counter-based collection, where staff members verify parcels using tracking numbers or students' identification before handing them over. This approach is time-

consuming, prone to human error, and often results in congestion at the service counter. In contrast, this proposed system automates the entire parcel collection process through a controlled access mechanism with an accountability trail, ensuring that every parcel pickup is properly verified and recorded without staff involvement. Before a locker can be accessed, users must complete a sequential verification process that includes a pickup code validation step, followed by QR or barcode verification, and payment confirmation. This layered verification enhances security and prevents unauthorized access. Additionally, the system features an automated notification system that immediately informs students when their parcel has been stored, reducing uncertainty and unnecessary inquiries. By minimizing manual handling and human intervention, the system improves operational efficiency and provides a more organized pickup process. Overall, this system offers a more reliable, structured, and efficient solution compared to traditional manual parcel hub systems.

4. Benefit to mankind

The Digital Self-Service Parcel Pickup Solution benefits mankind in several ways: it enhances quality of life by providing a quicker and more convenient method of collecting parcels, reducing time spent waiting and alleviating daily stress, and promoting better time management for busy people. The solution is also beneficial in terms of increasing efficiency and productivity in various fields, such as education and health, through a reduction in human error and an improvement in processes. Moreover, it benefits mankind in terms of safety and security through a reduction in lost, stolen, or misplaced parcels. The solution also benefits mankind in terms of technological advancement through the encouragement of smart service systems and technological advancement in society. Finally, it benefits mankind indirectly in terms of sustainability through a reduction in unnecessary congestion and repeated handling of parcels, which in turn reduces energy consumption and emissions.

5. Innovation and Entrepreneurial Impact

The Digital Self-Service Parcel Pickup Solution promotes innovation by introducing automated parcel lockers, QR or barcode-based verification, and cashless payment systems into the campus environment. This approach replaces inefficient manual parcel collection processes, reducing congestion, saving time, and improving the overall user experience. From an entrepreneurial perspective, the project demonstrates how everyday operational challenges within a community can be transformed into practical, technology-driven solutions with strong scalability potential. The system creates opportunities for collaboration with higher education institutions, logistics service providers, and smart campus developers. At the same time, it encourages an entrepreneurial mindset among students by highlighting value creation, cost efficiency, and service innovation. Overall, the project contributes to the development of a more innovative and entrepreneurial culture within the institution and the broader logistics and facilities management industry.

6. Potential commercialization

The Digital Self-Service Parcel Pickup Solution has great commercialization potential as it is not limited to the university setting but can also be used in offices, apartments, hospitals, and shopping malls. The product can be sold as a whole package, including software, smart lockers, and scanning devices. It can be offered as a service through the Software as a Service (SaaS) model, where the organization would have to pay a fee for the usage of the system. It can

also be further commercialized through the partnership of courier services and property developers, as the system would benefit them through improved service delivery. Moreover, the data analytics feature of the system can also be commercialized, making the product a sustainable business model.

7. Acknowledgment

First and foremost, we wish to convey our heartfelt thanks to Madam Nur Dalila Adenan for her invaluable guidance, support, and encouragement during the entire process of developing this project. Their knowledge, valuable input, and helpful critique have been vital in assisting us in polishing our concepts and guaranteeing the quality and significance of this project. We would also like to express our heartfelt gratitude to our classmates and friends who offered their help, shared insights, and provided encouragement during the research and writing journey. Their teamwork and support have been incredibly inspiring and have played a major role in the successful achievement of this project. We also express our sincere gratitude to the staff and management of Kedai Isiswa, UiTM Dungun, for their valuable insights and guidance on campus parcel management systems, aiding our understanding of the operational challenges and possible solutions. Finally, we are extremely thankful to our family for their constant support, patience, and understanding, which have enabled us to invest the essential time and energy into this project. Their support has been a wellspring of strength and inspiration throughout the entire journey. We genuinely appreciate the efforts of all these individuals and organizations, whose support made this project achievable.

8. Researchers' Biography

Muhammad Danish Bin Abdul Wahib is a Bachelor of Business Administration (Hons.) in Operations Management at Universiti Teknologi MARA (UiTM), Cawangan Terengganu, Kampus Dungun. Having completed his Diploma in Business Management, he has acquired good analytical and problem-solving skills, and his interest in enhancing efficiency and quality has grown even stronger. His interest in smart automation and digital technologies to simplify processes, improve security, and enhance user experience has become his passion. This innovation has led him to develop systems that are user-friendly and efficient in solving various problems that arise in daily operations.

Syaza Shamimi binti Ahmad Shajari obtained her Diploma in Business Management before pursuing her Bachelor of Business Administration in Operations Management at UiTM Dungun. Her focus is on operational efficiency, process optimization, and service management. She is particularly interested in applying operations management principles and digital solutions to improve service delivery. Her research explores innovative methods to streamline operations, reduce inefficiencies, and enhance user satisfaction. By integrating theoretical knowledge with practical applications, she aims to support efficient, reliable, and sustainable operational practices within campus and organizational settings.

Nur Farisya Farhana binti Halim obtained her Diploma in Business Studies (Transportation) before continuing her Bachelor of Business Administration in Operations Management at UiTM Dungun. Her keen interest in logistics, transportation systems, and operational efficiency drives her to enhance campus services. Her research investigates digital self-service parcel collection options to tackle issues like lengthy wait times, mistakes in manual handling, and dissatisfaction among students. Utilizing expertise in automation, workflow enhancement, and service design, she seeks to develop effective, efficient, and sustainable solutions for campus parcel management that connect theoretical knowledge with practical applications.

Wan Nuralieya Binti Wan Hanaffi is a business student at Universiti Teknologi MARA (UiTM), Cawangan Terengganu, Kampus Dungun, currently pursuing a Bachelor of Business Administration (Hons.) in Operations Management. Building on her Diploma in Accounting, she combines strong analytical skills with a keen interest in practical solutions that improve efficiency, security, and user experience. She focuses on using smart automation and technology to make processes easier, while designing simple, user-friendly systems that solve real-world operational challenges.

Nur Dalila Adenan is a Senior Lecturer at Universiti Teknologi MARA (UiTM), Cawangan Terengganu Kampus Dungun, Terengganu , Malaysia. She holds a Master of Business Administration (MBA) and specialises in Business and Management. She is actively involved in innovation and student development. She is particularly involved in guiding students for innovation projects and competitions at various levels. She also coordinates business start-up consulting initiatives in collaboration with external agencies to support entrepreneurship and practical business implementation.

Assessing Multilevel Determinants of Food Choice Behaviour Among University Students: The Moderating Role of Food Allergy

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ABSTRACT
University students' food choice behavior is shaped by a complex interaction of personal, social, environmental, and societal factors. However, existing studies have largely examined these influences in isolation and have rarely considered how a health condition such as food allergy alters these relationships, particularly within the university context in developing countries. This study aims to assess the roles of intrapersonal, social, physical, and societal influences on food choice behavior among Malaysian university students, with food allergy examined as a moderating variable. Using a quantitative cross-sectional design grounded in the Social Ecological Model, data were collected through a validated questionnaire and analyzed using Partial Least Squares Structural Equation Modelling (PLS-SEM). The findings reveal that intrapersonal, social, and physical environmental factors significantly influence food choice behavior, while societal factors show no direct effect. Importantly, food allergy significantly moderates the relationships between intrapersonal and social factors with food choice behavior, highlighting how health-related constraints reshape decision-making processes. This study contributes novel empirical evidence by integrating a health-specific moderator into a multilevel behavioral framework. The findings offer practical insights for universities, foodservice providers, and policymakers in designing safer, more inclusive campus food environments, supporting Sustainable Development Goal 3 on good health and well-being.

Keywords: Food choice behavior; Food allergy; University students; Social Ecological Model; PLS-SEM

1. Product Description
This study presents an evidence-based behavioral framework designed to understand how university students make food choices under the influence of multiple environmental layers, while explicitly accounting for food allergy as a moderating health condition. The framework integrates intrapersonal factors (e.g., knowledge, habits, self-efficacy), social environmental factors (e.g., peers and family), physical environmental factors (e.g., food availability, accessibility, and labelling), and societal factors (e.g., media and cultural norms). Unlike conventional models, this innovation embeds food allergy as a moderator rather than treating it solely as a background characteristic. The analytical approach uses PLS-SEM to capture complex interactions and predictive relationships. The resulting model functions as a diagnostic and planning tool for higher education institutions, enabling targeted interventions such as allergen-aware food provision, risk communication strategies, and student-centered nutrition education.

2. Conceptual Framework

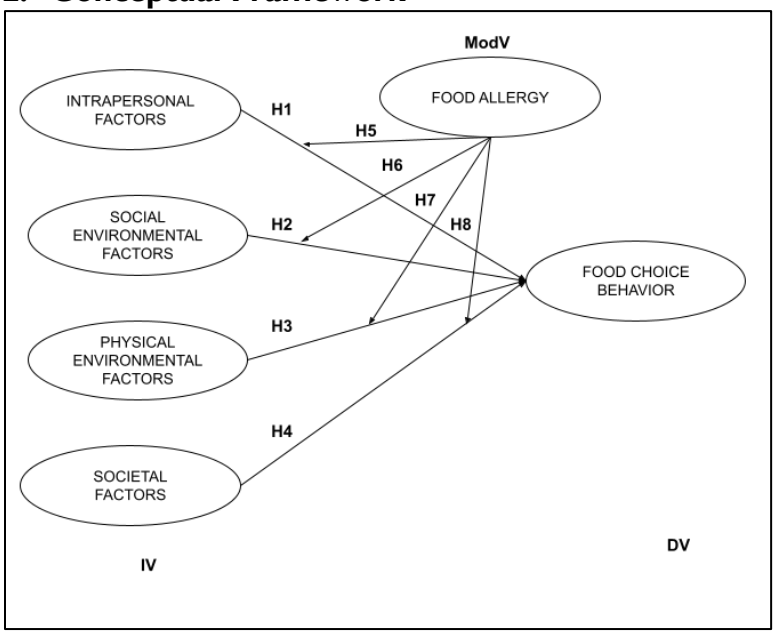

Figure 1. Conceptual framework of Allergy-Moderated Behavioral Environmental Resource model (AMBER). Note: This figure illustrates the interplay between intrapersonal, social, physical environment, and societal factors influencing food allergy management and choices. Adapted from "Towards Sustainable Food Systems: Exploring the impact of food allergies on health and well-being in university settings," by A. H. Aziz et al., 2024, Proceedings of the AcE-Bs2024Langkawi.

Figure 1 presents the proposed conceptual framework, illustrating the hypothesised direct effects (H1–H4) of multilevel environmental factors on food choice behaviour, as well as the moderating effects of food allergy (H5–H8) on these relationships. The framework is grounded in the Social Ecological Model and prior empirical literature, ensuring both theoretical robustness and practical relevance.

3. Novelty and Uniqueness

The novelty of this study lies in its integration of food allergy as a moderating variable within the Social Ecological Model of food choice behavior among university students. While previous research has examined food choice determinants or food allergy impacts independently, this study is among the first to empirically demonstrate how food allergy reshapes the strength of relationships between intrapersonal and social environmental factors and food choice behavior in a higher education setting. The study further distinguishes itself by adopting a large Malaysian sample and applying PLS-SEM to test complex multilevel interactions simultaneously. By revealing that food allergy amplifies the influence of personal and social factors but not physical or societal factors, the study offers a nuanced understanding that challenges assumptions of uniform environmental influence. This contextual and health-sensitive modelling approach represents a significant advancement over traditional one-dimensional analyses.

4. Benefit to Mankind

This study directly contributes to improved health and well-being by generating actionable insights for protecting university students with food allergies, a population at heightened risk due to increased independence and exposure to unsafe food environments. The findings support the development of safer campus dining systems, improved allergen labelling, and targeted nutrition education programs. By identifying key leverage points for intervention, the study aids universities and policymakers in reducing food allergy-related risks, enhancing dietary safety, and promoting inclusive food environments. These outcomes align with Sustainable Development Goal 3 by supporting preventive health strategies and improving quality of life for individuals managing food allergies.

5. Innovation and Entrepreneurial Impact

The study promotes innovation by translating behavioral research into practical solutions for campus food systems. Its framework can be commercialized as a decision-support model for universities, foodservice operators, and catering companies to assess allergen risk and student behavior patterns. The model encourages an entrepreneurial mindset by demonstrating how data-driven insights can inform service design, policy development, and niche food markets such as allergen-free products. By bridging academic research and operational decision-making, the study fosters a culture of innovation within higher education and the foodservice industry.

6. Potential Commercialization

The findings of this study have strong commercialization potential through consultancy services, training modules, and digital assessment tools for universities and foodservice providers. The behavioral model can be packaged into an institutional audit tool to evaluate allergen safety readiness and student food choice behavior. It may also support the development of allergen-aware menu planning systems or certification programs for campus dining facilities. These applications provide scalable opportunities for collaboration between academia, industry, and public institutions.

7. Acknowledgment

The author gratefully acknowledges the support and guidance provided by academic supervisors and Universiti Teknologi MARA. Appreciation is also extended to all respondents who participated in this study.

8. Researchers' Biography

Ainul Hayati Abdull Aziz is a Postgraduate Student in Food Service Management at UiTM Permatang Pauh, Pulau Pinang. Her research interests focus on food choice behaviour, food allergies, student health and well-being, and sustainable food systems, particularly within university settings. She has published studies on the impact of food allergies on health and sustainability in higher education and on caffeine consumption and its effects on university students' academic performance. Her work employs quantitative methods, including structural equation modelling, to address contemporary food and nutrition challenges.

Dr. Norrina Din is a Senior Lecturer in Hospitality and Tourism, specializing in food safety, consumer behavior, gastronomy innovation and education. Her scholarly work focuses on bridging the gap between academic theory and industry practice to drive innovation. Dr. Norrina shapes excellence in hospitality pedagogy and research. Her commitment to integrating real-world applications into the curriculum ensures a dynamic, forward-thinking learning environment that prepares students for the evolving global tourism landscape.

Dahlan Abdullah is a lecturer at the Faculty of Hotel and Tourism Management, Universiti Teknologi MARA (UiTM) Pulau Pinang. He holds a Master's degree in International Hospitality Management from Strathclyde University, UK. He is currently undertaking his PhD study program under Graduate School of Business, Universiti Sains Malaysia (USM). He has published in various indexed journals, conference proceeding and books. His area of research interest includes service marketing, technology management, and hospitality management.

Sesuap

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ABSTRACT

The Sesuap project introduces a social media application prototype that integrates short-form recipe video sharing with e-marketplace and food delivery functionalities. Designed in response to the growing popularity of video-based platforms and increasing dependence on digital food services, the application aims to streamline the transition from food inspiration to execution within a single platform. Sesuap was innovated to address the lack of diversity, accessibility, and actionable features in existing recipe video platforms. The application allows users of all skill levels to engage with simple, user-generated cooking videos, enhanced by dietary information, optional written instructions, and AI-assisted content generation through "*Chefy AI*". *Chefy AI* automatically detects ingredients, generates dietary details, suggests recipe alternatives, and provides personalised guidance, reducing misinformation and improving usability. The integrated e-marketplace enables users to purchase ingredients or order meals directly, while promoting local stores and creating delivery job opportunities. Sesuap's key advantages lie in its seamless content-to-commerce flow, AI-driven support, and inclusive design. The platform has positive socio-economic potential by supporting local markets, encouraging digital participation, and enhancing everyday cooking experiences. Its scalable features indicate strong prospects for commercialisation within the digital food and lifestyle ecosystem.

Keywords: Social media application, short-form recipe videos, e-marketplace integration, Artificial intelligence (AI), digital food ecosystem

1. Product Description

Sesuap is an all-in-one social media application designed for discovering, sharing, and acting on food content through short-form recipe videos. Inspired by the ease and engagement of video-based platforms, Sesuap allows users to explore simple, user-generated cooking videos that are accessible to individuals of all skill levels. Each post may include dietary information, ingredient lists, and optional written instructions to support informed and inclusive cooking experiences. A key feature of Sesuap is its AI assistant, Chefy AI, which automatically detects ingredients used in videos, generates dietary details, and offers recipe suggestions or alternatives based on user preferences and restrictions. Users can also interact with Chefy AI to receive personalised cooking guidance or ideas using available ingredients. In addition, Sesuap integrates an e-

marketplace that enables users to purchase ingredients or order prepared meals directly from the platform. This feature supports local stores, increases digital visibility for small businesses, and creates delivery opportunities. By combining entertainment, convenience, and technology, Sesuap delivers a seamless food discovery and execution experience within a single application.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

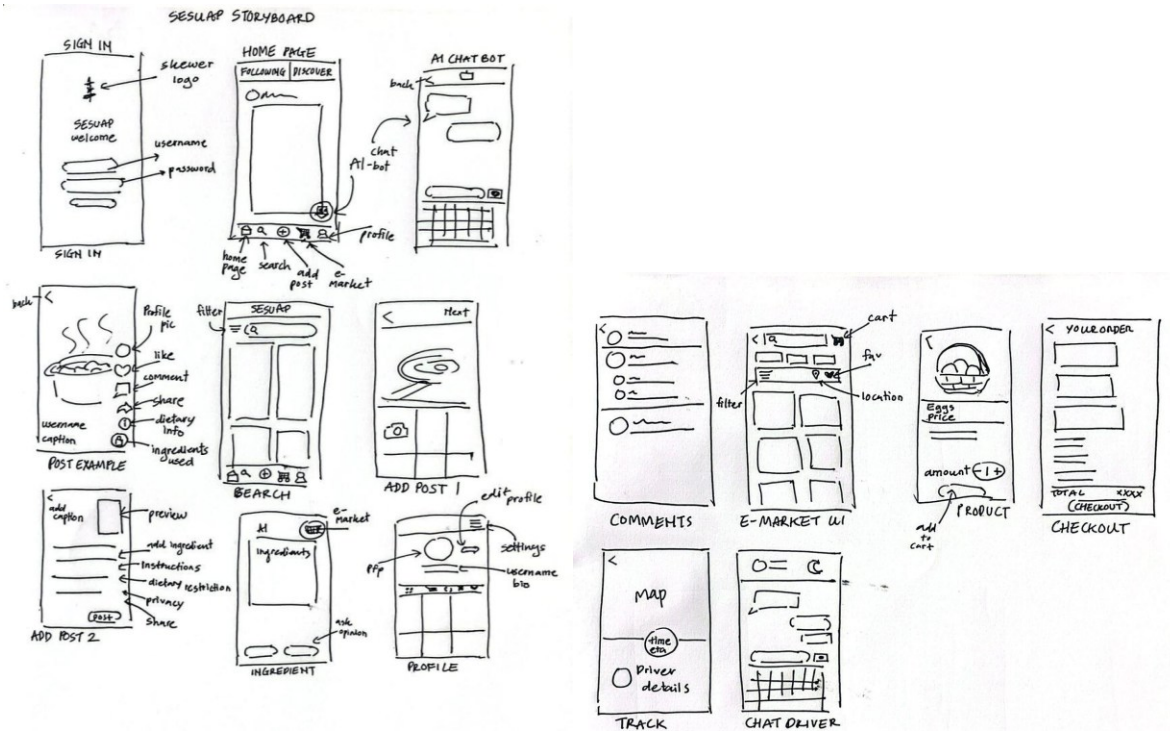

Figure 1. Social media prototype storyboard/draft.

As depicted in **Figure 1**, the Sesuap application's procedural flow originates from the login page, which in the application is equipped with registration/sign-up mechanisms to accommodate user account generation. One of the main purposes of social media is to share information, Sesuap has a home page where users can see or watch content from other users.

3. Novelty and uniqueness

The Sesuap project distinguishes itself by evolving beyond a standard social media platform into a specialized "Culinary OS" that closes the loop between inspiration and consumption. While platforms like TikTok offer entertainment and apps like Grab provide delivery, Sesuap is novel in its seamless fusion of these functions specifically for the food niche. Its primary uniqueness lies in the integration of Chefy AI, a context-aware assistant that automates the tedious aspects of content creation. Unlike generic platforms, Sesuap uses AI to auto-detect ingredients directly from video frames and generate structured dietary data, effectively eliminating the friction of manual entry for creators while ensuring viewers receive accurate, actionable information. Furthermore, the application introduces a hyper-local e-marketplace that bridges the "inspiration

gap." Rather than forcing users to search external apps for ingredients, Sesuap allows for an instant transition from watching a recipe to purchasing the exact components from local vendors. This ecosystem doesn't just prioritize convenience; it uniquely supports local economies by giving small supermarkets a digital storefront. By combining automated metadata generation, real-time AI culinary coaching, and a closed-loop commerce system, Sesuap offers a specialized, high-utility experience that general-purpose social media simply cannot replicate.

4. Benefit to mankind

The Sesuap project offers a profound benefit to mankind by transforming the kitchen from a place of stress into one of accessible, community-driven creativity. By bridging the gap between digital inspiration and physical execution, it empowers people of all skill levels to cook nutritious meals through streamlined AI guidance and short-form education. This doesn't just simplify dinner; it fosters a healthier society by prioritizing dietary transparency and reducing food waste through intelligent, pantry-based recipe suggestions. Beyond the individual, Sesuap revitalizes local economies by providing small-scale vendors with much-needed digital visibility and creating flexible job opportunities for delivery drivers. It effectively collapses the distance between a "good idea" and a "home-cooked meal," ensuring that healthy eating is no longer a luxury of time but a streamlined reality. Ultimately, by merging entertainment with commerce and AI, Sesuap enriches human connection through shared culinary experiences while supporting a sustainable, locally-focused food ecosystem.

5. Innovation and Entrepreneurial Impact

Sesuap drives innovation by dismantling the silos between content, commerce, and AI-driven automation. By converting passive entertainment into an active marketplace, it transforms casual creators into culinary micro-entrepreneurs who can monetize their skills effortlessly. The integration of Chefy AI lowers the barrier to entry for content production, automating technical metadata so creators can focus on culinary craft rather than data entry. Furthermore, the platform catalyzes local entrepreneurship by providing small-scale vendors and traditional grocers with a sophisticated digital storefront, leveling the playing field against retail giants. It builds a sustainable ecosystem for delivery drivers while encouraging a "fail-fast" culture for home cooks testing market demand for their unique recipes. Ultimately, Sesuap creates a vibrant environment where technical innovation directly fuels economic opportunity, empowering individuals to turn kitchen expertise into scalable, community-supported business ventures.

6. Potential commercialization

The commercial viability of Sesuap lies in its integrated revenue ecosystem, which successfully bridges the gap between social media engagement and logistics. Its primary monetization strategy includes transaction commissions from the e-marketplace, where every ingredient purchased or meal ordered generates revenue. Local supermarkets and global food brands can leverage targeted advertising and sponsored content, reaching high-intent users at the exact moment of culinary inspiration. Furthermore, the platform can implement a "freemium" model, offering subscription-based access to advanced "*Chefy AI*" features like personalized health analytics, automated grocery budgeting, or exclusive professional masterclasses. The scalability is further enhanced by its data-driven insights; Sesuap captures valuable consumer trends and purchasing habits, offering immense value for market research within the F&B industry. By transforming the

"recipe-to-table" journey into a frictionless digital experience, Sesuap is positioned to disrupt the food-tech market while fostering sustainable, hyper-local economic growth.

7. Acknowledgment

The group would like to express sincere appreciation to En. Muhammad Fadhli Abdul Rahman, the course lecturer, for his guidance, support, and constructive feedback throughout the development of this project. His insights and encouragement were invaluable in shaping the direction and quality of the work. Appreciation is also extended to the project group members for their cooperation, commitment, and teamwork during the design and development process. Special thanks are given to friends and peers who provided helpful suggestions and moral support. Finally, heartfelt gratitude is expressed to family members for their continuous encouragement and understanding throughout the completion of this project.

8. Researchers' Biography

Balqis Batrisyia Hairul is a second-year Bachelor's degree student at Universiti Teknologi MARA (UiTM), Shah Alam, currently pursuing Instructional Communications and Training. She has a strong interest in digital media, content development, and user-centred communication design. Through academic projects, she has gained experience in social media strategy, multimedia storytelling, and instructional content creation. Her work reflects a focus on combining communication theory with practical digital applications to enhance user engagement and learning experiences.

Jannahthin Aleeya Afandi is a second-year Bachelor's degree student at Universiti Teknologi MARA (UiTM), Shah Alam, currently pursuing Instructional Communications and Training. She is deeply passionate about digital media and the art of user-centric communication. Through her academic journey, she has mastered the nuances of social media strategy, multimedia storytelling, and the creation of impactful instructional content. Ultimately, her work is about more than just content; it's about refining how people connect and learn in a digital-first world.

Haura Tsabitah Nurhidayah is a third-year Bachelor's degree student at Universitas Pendidikan Indonesia (UPI), majoring in Communication Science, and is currently doing a semester exchange programme at Universiti Teknologi MARA (UiTM) Shah Alam. She is appealed to how social media can affect how humans act and think on a daily basis. She has done research that discusses the way social media become a medium for citizens to express their political opinion and how social media can affect people' opinions on political figures and policies. Her works tell about how social media and preferences can affect people' lives and minds.

Muhammad Fadhli Abdul Rahman is a lecturer in the Instructional Communication and Training programme at the Faculty of Communication and Media Studies, Universiti Teknologi MARA (UiTM). He has accumulated nine years of experience teaching in higher education. He earned a Master's degree in Instructional Multimedia from Universiti Sains Malaysia (USM). His academic and research interests encompass instructional design, game-based learning, multimedia development, web-based learning, instructional communication, and digital media. Over the past nine years, he has consistently earned recognition at international innovation competitions, reflecting his ongoing commitment to advancing educational innovation and technology-enhanced learning.

UiTM Bus Campus Transportation Application

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ABSTRACT

UiTM Bus is a campus transportation application designed to improve the daily commuting experience of students at Universiti Teknologi MARA (UiTM) Shah Alam. The application was developed to address common transportation issues such as uncertain bus arrival times, long waiting periods, lack of route information, overcrowding, and inefficient time management among students. UiTM Bus Campus Transportation Application integrates real-time GPS tracking, updated bus schedules, estimated time of arrival (ETA), live passenger capacity, and route visibility into a single, user-friendly platform that is accessible through the existing MyStudent app. The main advantage of UiTM Bus Campus Transportation Application lies in its ability to reduce uncertainty and waiting time while enhancing punctuality, safety, and convenience for students. Its unique features include real-time tracking for buses A to G, live capacity updates, notification alerts, a past rides feature, and a student forum that encourages information sharing and community participation. This application contributes positively to the socio-economic environment of the campus by improving transportation efficiency, reducing congestion, and supporting smoother daily routines. In terms of commercialization, UiTM Bus Campus Transportation Application has strong potential to be expanded to other UiTM campuses and adapted for use in other universities, making it a scalable and sustainable digital transportation solution.

Keywords: UiTM Bus Campus Transportation Application, campus transportation, real-time bus tracking, student mobility, smart campus

1. Product Description

UiTM Bus Campus Transportation Application is a smart campus transportation application designed to support students of Universiti Teknologi MARA (UiTM) Shah Alam in managing their daily bus travel more efficiently. The application aims to reduce uncertainty, waiting time, and inconvenience by providing accurate and real-time information related to campus bus services. UiTM Bus Campus Transportation Application offers key features such as real-time GPS-based bus tracking for Bus A to Bus G, estimated time of arrival (ETA), live passenger capacity, route maps, and updated schedules. Through this platform, students can also receive notifications and announcements related to delays, route changes, or special bus operations. The application includes a past rides feature that allows users to review previous trips and access driver information in cases where items are accidentally left on the bus. In addition, UiTM Bus Campus Transportation Application incorporates a forum feature designed for sharing and community contribution, where students can post comments, reports, or warnings regarding bus delays,

capacity, or route conditions. This creates a shared reference space similar to a social media platform. To enhance user engagement, the application includes a reward system that provides points, badges, or ranks for contributing useful information.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

Figure 1 illustrates the prototype storyboard of the UiTM Bus application, showing the main interface layout and key functional components designed to support student transportation needs.

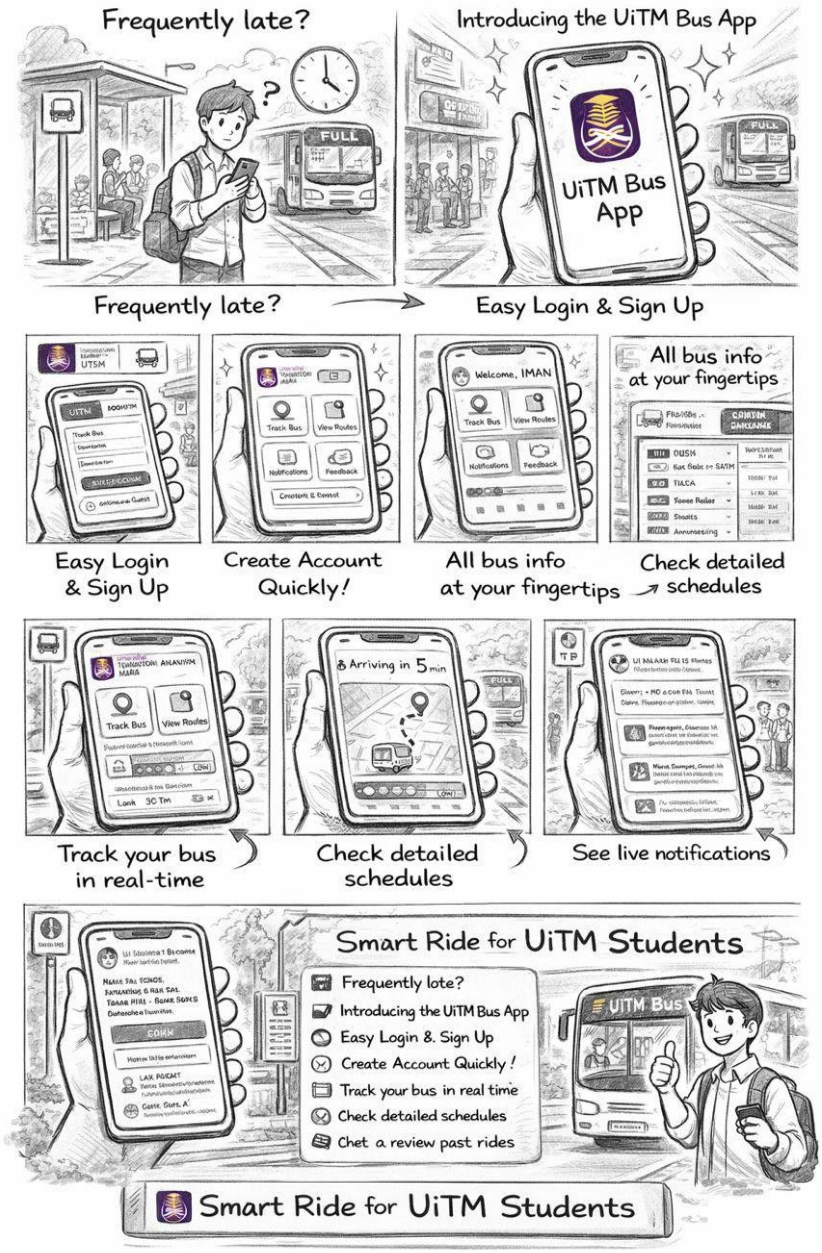


Figure 1. Storyboard of the UiTM Bus application.

Table 1. AOF Method – UiTM Bus Campus Transportation Application .

Title	Description
Primary Activity	The main activity of the UiTM Bus Campus Transportation Application system is to help students plan and manage campus transportation efficiently. Students can track buses (Bus A–G) in real time, check schedules, routes, stop locations, and view the estimated time of arrival (ETA). They can also see live bus capacity and receive notifications about arrivals, delays, or changes. This helps reduce waiting time, avoid overcrowding, and reach destinations on time.
Social Objects	The app includes several important objects: GPS tracker (to send real-time bus location), digital route map (to help plan routes), alert object (for arrival, delay, and route changes), ETA object (predicts arrival time), capacity object (shows how full the bus is), and feedback object (allows students to report issues and give suggestions).
Core Feature Set	The system provides real-time tracking for Bus A–G, bus schedules, ETA, and live capacity. It also sends notifications and alerts about delays or changes. Other features include a forum for students to share updates, a past rides feature to find driver info if items are lost, and a reward/ranking system to encourage active contributions.

Table 2. Design for Collective Intelligence.

Aspect	Explanation
Core Idea	Design for collective intelligence focuses on how apps support human interaction and shared decision-making (Gregg, 2010). When many students use the UiTM Bus app, the shared information becomes more accurate and useful for everyone.
Student Contributions	Features like feedback and issue reporting allow students to share real-time problems such as delays, overcrowding, and technical issues. This ensures the system reflects real campus conditions.
Shared Data & ETA	Student reports improve service updates, notifications, and ETA displays. For example, if one student reports a full bus, others can check capacity and choose another route or time.
GPS & Management Response	GPS tracking plus student reports help UiTM management respond faster with announcements on delays, route changes, or disruptions.
Forum & Social Network	The forum allows students to post comments, warnings, and advice, creating a collaborative information network.

Aspect	Explanation
Community Interaction	Chat features let students discuss schedules, share tips, coordinate travel, and review past rides if items are lost.
Rewards & Motivation	Points, badges, and rankings motivate students to contribute useful information and stay active in the community.

Table 3. Design for Sign Up.

Aspect	Explanation
Core idea	To make the registration process simple, inclusive, and low-effort so that new users can sign up quickly without confusion or frustration.
Simplicity & Easy Use	The sign-up flow is straightforward with clear steps, allowing first-time users to register easily.
Role-Based Registration	Users can select their role (Student / Staff, UiTM / Non-UiTM), ensuring relevance and clarity during registration.
Multiple Sign-In Options	Users can sign up using username and password or Google sign-in, reducing barriers to entry.
Minimal Required Information	Only essential details (name, email, role, institution, password) are requested to avoid overwhelming users.
Visual Consistency	Colours, layout, and typography remain consistent with the rest of the app, ensuring a smooth transition into the platform.
Navigation Support	Prompts such as "Already have an account? Log In" help users move easily between sign-up and login pages.
First-Time User Experience	The sign-up design creates a positive first impression and encourages users to continue using the app.

Table 4. Design for Ongoing Participation.

Aspect	Explanation
Core idea	To ensure that there is continuous user engagement. This is done by promoting user participation over time. The UiTM Bus Campus Transportation Application is designed to encourage students to participate continuously.
Contribution-Based System	Students can contribute through the use of the UiTM Bus Campus Transportation Application using all the features to make it easier.

Aspect	Explanation
Achievement & Ranking System	UiTM Bus Campus Transportation Application levels, badges, and ranks, such as "Top Contributor" or milestone achievements, motivate the students to continue their engagement in order to receive recognition and prestige in their community.
User Profile & History	Users have the ability to have personalized profiles, which enable them to keep track of their ride history, contribution history, and progress in achieving their goals.
Social Validation (Likes & Visibility)	Features such as likes, contribution count, and highlighted helpful posts in the UiTM Bus Campus Transportation Application motivate the user to contribute. Being recognized by other students motivates the user to contribute.
Forum & Continuous Updates	The discussion forum allows daily interactions between users to share information regarding the bus conditions. Since the transportation conditions keep changing daily, the students log in to access the latest updates and additional information.
Incentives & Retention Strategy	The UiTM Bus Campus Transportation Application system rewards frequent users with points, badges, or special recognition. This motivates frequent usage and helps transform the application from a simple information source to a dynamic and self-sustaining student community.

3. Novelty and uniqueness

The novelty of UiTM Bus Campus Transportation Application lies in its integration of real-time campus transportation services into a single, community-driven digital platform tailored specifically for UiTM students. Unlike conventional bus tracking applications that focus only on location and schedules, UiTM Bus Campus Transportation Application combines GPS-based real-time tracking, estimated time of arrival (ETA), live passenger capacity, and route visibility with interactive social features. This integrated approach allows students not only to receive information but also to actively contribute to the accuracy and usefulness of the system. A key unique aspect of UiTM Bus Campus Transportation Application is its forum feature, which functions as a shared information space like a social media platform. Through this feature, students can post real-time updates, reports, and warnings regarding bus delays, overcrowding, or route conditions, enabling collective intelligence and peer-supported decision-making. In addition, the inclusion of a reward system that offers badges, or ranks for useful contributions encourages continuous participation and sustained user engagement. Another distinctive element is the integration of UiTM Bus Campus Transportation Application into the existing MyStudent app, eliminating the need for a separate application and ensuring accessibility and familiarity for users. This combination of real-time technology, social interaction, and system integration makes UiTM Bus Campus Transportation Application a unique and innovative solution for campus transportation management.

4. Benefit to mankind

UiTM Bus Campus Transportation Application contributes to the wellbeing of users and the wider community by improving the efficiency, safety, and accessibility of campus transportation. By providing real-time bus tracking, estimated time of arrival (ETA), and live passenger capacity information, the application reduces uncertainty, long waiting times, and overcrowding, allowing users to plan their journeys more effectively. This leads to better time management, reduced stress, and improved punctuality among students. From a broader perspective, UiTM Bus Campus Transportation Application supports smoother traffic flow and more organized transportation systems within the campus environment, contributing to a safer and more sustainable mobility ecosystem. The community-based forum feature promotes cooperation, shared responsibility, and collective intelligence, enabling users to exchange accurate, real-time information for mutual benefit. By integrating transportation services into a digital platform, UiTM Bus Campus Transportation Application encourages smart mobility practices that can be adopted by other institutions, ultimately supporting the development of smarter, more connected communities.

5. Innovation and Entrepreneurial Impact

UiTM Bus Campus Transportation Application promotes innovation by applying digital technology and social web principles to address real-world transportation challenges within a university environment. By integrating real-time GPS tracking, live passenger capacity, and user-generated updates into a single platform, the project demonstrates how technology-driven solutions can improve efficiency and user experience. The inclusion of interactive features such as a student forum and reward-based contribution system encourages creative problem-solving, collaboration, and continuous improvement among users. From an entrepreneurial perspective, UiTM Bus Campus Transportation Application fosters a culture of innovation by highlighting the potential of scalable digital services. The system can be expanded to other UiTM campuses or adapted for use in different educational institutions, creating opportunities for partnerships with transport operators and service providers. This project also nurtures entrepreneurial thinking among students by exposing them to product development, user engagement strategies, and value creation through digital platforms, supporting the growth of innovation-driven initiatives within the institution and beyond.

6. Potential commercialization

UiTM Bus Campus Transportation Application has strong commercialization potential as a scalable digital transportation solution for educational institutions. Although initially designed for Universiti Teknologi MARA (UiTM) Shah Alam, the system can be expanded to other UiTM campuses and adapted for use in universities, colleges, and large institutional environments with similar transportation needs. The application's integration of real-time GPS tracking, passenger capacity monitoring, and community-driven updates makes it a valuable service for improving transport efficiency and user satisfaction. Commercial opportunities may include partnerships with campus transport operators, licensing the platform to other institutions, or offering customized features based on institutional requirements. Additional value-added services, such as data analytics for route optimization and service performance monitoring, can further enhance its commercial appeal. By leveraging existing digital infrastructure and a familiar user base,UiTM Bus Campus Transportation Application demonstrates potential as a sustainable and market-ready smart mobility solution.

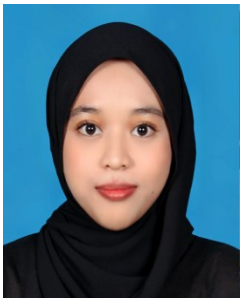
7. Acknowledgment

The group would like to express their sincere gratitude to En. Muhammad Fadhli Abdul Rahman, the course lecturer, for his continuous guidance, valuable advice, and constructive feedback throughout the completion of this project. His knowledge, support, and encouragement played a significant role in improving the quality and direction of this work. The group also wishes to acknowledge all project members for their strong cooperation, dedication, and teamwork during the planning, design, and development stages of the project. Their commitment greatly contributed to the successful completion of this study. In addition, appreciation is extended to friends and peers who provided useful suggestions, feedback, and moral support along the way. Finally, the group would like to express heartfelt thanks to their family members for their patience, understanding, and continuous encouragement throughout the project.

8. Researchers' Biography

Nor Aafreen Nazeeha Binti Faisal is a second year Bachelor's degree student at Universiti Teknologi MARA (UiTM), Shah Alam, currently pursuing Instructional Communications and Training. She has strong interest in digital media, content development, and instructional design, particularly in creating user-centered and technology-based solutions. Her academic work reflects an interest in applying communication strategies and digital tools to improve learning experiences and everyday systems. Through project-based learning, she continues to develop skills in research, content planning, and digital innovation, with a focus on practical applications that benefit users and the community.

Nur Iman Nazihah Binti Mohammad is a second year Bachelor's degree student at Universiti Teknologi MARA (UiTM), Shah Alam, currently pursuing Instructional Communications and Training. Academic interests include communication technology, media planning, and digital platform development, with a focus on improving efficiency and user experience through digital solutions. Coursework and project involvement reflect an ability to apply communication principles and problem-solving skills in practical contexts. Ongoing academic projects support the development of research, system design, and digital innovation skills within collaborative learning environments.



Nur Umaira Wahida Binti Sukimin is a second year Bachelor's degree student at Universiti Teknologi MARA (UiTM), Shah Alam, currently pursuing Instructional Communications and Training. Academic interests include user experience design, digital systems, and information management, with particular attention to how technology can support daily activities and decision-making. Academic work reflects an interest in developing structured, user-friendly digital solutions that respond to real-world needs. Through coursework and group projects, skills in research, analysis, and digital application development continue to be strengthened.

Muhammad Fadhli Bin Abdul Rahman is a lecturer at Universiti Teknologi MARA (UiTM), Shah Alam. His academic interests include user experience design, digital systems, and information management, with particular attention to how technology can support daily activities and decision-making. He's passionate about how technology can make our daily lives easier and help us make better decisions. He focuses on creating digital solutions that are simple, structured, and user-friendly, and through his teaching and research, he's constantly exploring new ways to improve how we interact with technology.

LingoCrowd

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ABSTRACT

Pronunciation and vocabulary are fundamental components of communicative competence in English as a Second Language (ESL). However, many primary-level ESL learners face difficulties in mastering pronunciation due to limited exposure to the International Phonetic Alphabet (IPA) and insufficient engaging, technology-integrated learning tools. To address this gap, LingoCrowd is introduced as an edtech innovation and commercialisable learning solution that integrates phonetic instruction with play-based learning and digital support. The product comprises a three-level phonetics card game focusing on consonants, vowels, minimal pairs, and diphthongs. Each card is embedded with a QR code linking to audio pronunciation, definitions, and contextualised examples, enabling scalable multimodal and self-directed learning across physical and digital platforms. By combining repetition, interaction, and gamification, LingoCrowd enhances learner engagement while creating a market-ready educational product. User testing and survey findings indicate positive learner perceptions, improved vocabulary awareness, increased pronunciation confidence, and high satisfaction. From an entrepreneurship perspective, LingoCrowd demonstrates strong commercial potential through scalable production, adaptable content levels, and applicability for schools, tuition centres, and independent learners. The innovation positions LingoCrowd as a promising prototype with potential for classroom adoption and future development into a marketable ESL learning product.

Keywords: International Phonetic Alphabet, pronunciation, vocabulary, game-based learning, ESL

1. Product Description

LingoCrowd is an educational card game developed to support ESL learners' understanding of IPA, pronunciation accuracy, and vocabulary development. The game is structured into three progressive levels, each targeting specific phonetic elements, including consonants, short and long vowels, minimal pairs, and diphthongs. Players engage in interactive gameplay while repeatedly encountering phonetic symbols and their corresponding words. A key feature of LingoCrowd is the integration of QR codes on each card, which provide access to audio pronunciation, word meanings, and example sentences. This feature enables learners to independently verify pronunciation and reinforce vocabulary learning beyond the physical gameplay. Designed primarily for primary-level learners, the game can also be adapted for secondary students and

beginner ESL learners. Its compact format, clear rules, and technology-enhanced support make it suitable for classroom use, small group activities, or home-based learning.

2. Project Development

Figure 1 illustrates the Gantt chart outlining the project development process, including design, validation, production, and testing stages. The chart demonstrates systematic planning and time management throughout the project lifecycle. **Table 1** presents the estimated production cost for one complete set of LingoCrowd, highlighting its affordability and feasibility for large-scale production.

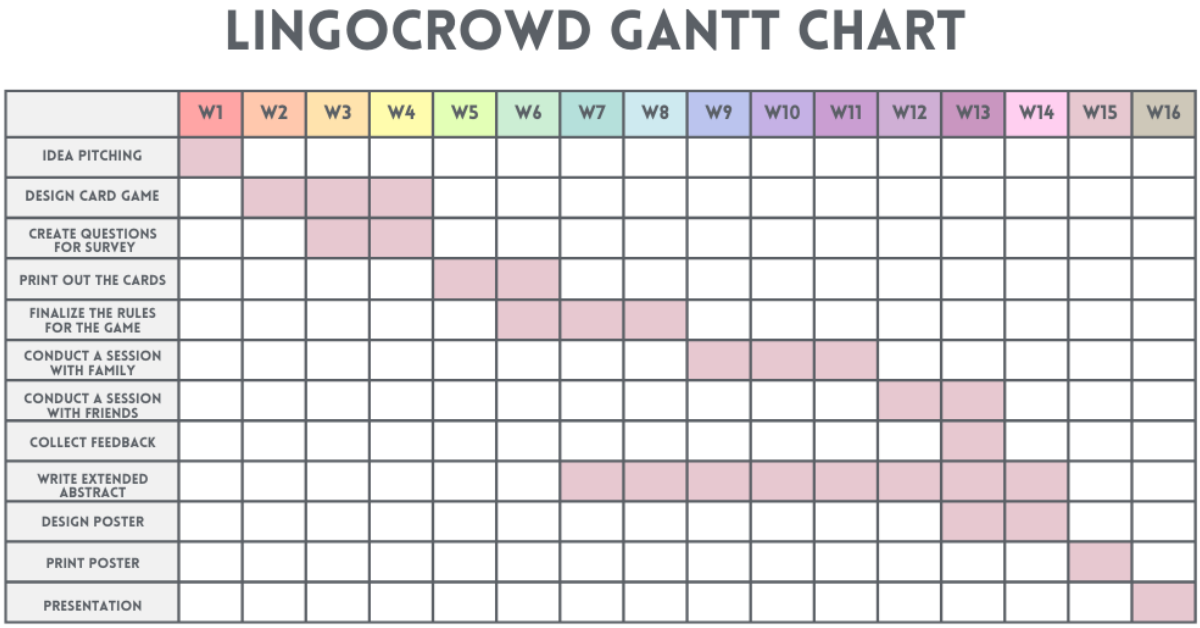

Figure 1. Gantt Chart of LingoCrowd project development.

Table 1. Cost of producing one set of LingoCrowd.

ITEM	PRICE
Logo design	RM30.00
Game Cards	RM66.60
Packaging box	RM17.63
Instruction & Rule cards	RM3.80
TOTAL COST	RM118.03

3. Novelty and uniqueness

The novelty of LingoCrowd lies in its integration of IPA-based phonetic instruction with game-based learning and QR-code technology. Unlike conventional pronunciation materials that rely heavily on drills and textbooks, LingoCrowd offers an interactive, learner-centred approach that promotes active participation and repeated exposure. The three-level structure allows learners to progress gradually, catering to different proficiency levels. Additionally, the QR code feature extends learning beyond the cards by providing immediate access to audio pronunciation and contextualised vocabulary support. This combination of physical gameplay and digital reinforcement distinguishes LingoCrowd from traditional ESL pronunciation tools and enhances its effectiveness as a modern learning resource.

4. Benefit to mankind

LingoCrowd helps improve English language learning by making pronunciation and vocabulary acquisition more accessible and engaging for ESL learners. By reducing anxiety associated with pronunciation practice and encouraging learning through play, the game supports learner confidence and motivation. Teachers benefit from an alternative instructional tool that complements existing curricula, while learners gain opportunities for independent and collaborative learning. Ultimately, the project promotes clearer communication skills, which are essential for academic success and social interaction in a globalised society.

5. Innovation and Entrepreneurial Impact

The project promotes innovation by combining educational content with gamification and digital technology. LingoCrowd encourages creative approaches to language teaching and learning while demonstrating how educational products can be transformed into marketable innovations. From an entrepreneurial perspective, the project nurtures skills in product development, cost analysis, user testing, and market awareness. It also supports a culture of educational entrepreneurship by addressing a real learning need through an innovative, scalable solution.

6. Potential commercialization

LingoCrowd has strong commercialization potential within the ESL education sector. The game can be marketed to schools, tuition centres, parents, and educational retailers as an affordable pronunciation support tool. Its modular design allows for future expansion, such as additional card packs or digital enhancements. With increasing demand for interactive and technology-supported learning materials, LingoCrowd is well-positioned for wider distribution both locally and internationally.

7. Acknowledgment

The author would like to express sincere gratitude to Assoc. Professor Dr. Geraldine De Mello for her valuable guidance and continuous support throughout the development of this project. Appreciation is also extended to all participants involved in the gameplay sessions and surveys for their meaningful feedback.

8. Researchers' Biography

Farah Amni Binti Mohamad Fadzil is an undergraduate student at Universiti Teknologi MARA (UiTM), Cawangan Melaka, specialising in English language studies. Her academic interests include pronunciation, phonetics, game-based learning, and educational material development. She is particularly interested in creating innovative teaching tools that enhance learner engagement and confidence in English communication.

Geraldine d/o John Philip De Mello is an Associate Professor at the Academy of Language Studies, Universiti Teknologi MARA Melaka. She holds a Degree in Law from the University of East London and Masters and PhD in English Language from Universiti Putra Malaysia. She has been with UiTM Melaka since 1997 and is now on contract. Her research interests are in Genre Analysis, English Language Teaching, English for Specific Purposes and Sociolinguistics.

Mohammad Nor Afandi bin Ibrahim (PhD) has been teaching for more than 30 years at both secondary and tertiary levels in Malaysia and is currently attached to Universiti Teknologi MARA, Melaka Branch, Malaysia. He co-wrote a coursebook on Malaysian University English Test (MUET) and a number of journal articles. His main research interests includes SFL, academic writing, genre and EAP/EOP/ESP/EPC (English for Professional Communication).

Startsheet: Digital English Worksheet for Kindergarten

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ABSTRACT
The lack of engaging, age-appropriate, and readily available English learning resources for kindergarten motivated the creation of Starsheet, an inventive collection of digital English worksheets intended to help early English learning. This project aims to assist teachers and parents by providing interactive worksheets covering fundamental English skills such as vocabulary, grammar, reading, writing, and spelling. Starsheet was created using a methodical procedure that included determining learning challenges, creating worksheet content, editing and proofreading, gathering user feedback, and constantly enhancing the materials. According to user feedback, the worksheets are interesting, useful, and suitable for kindergarten students. In terms of socio-educational impact, Starsheet encourages young children's active learning and early language development. Additionally, the concept has great marketing potential through social media advertising, digital distribution, and prospective partnerships.
Keywords: English worksheets, educational innovation, early language learning

1. Product Description
Starsheet emphasizes the development of fundamental English skills, such as reading, writing, spelling, basic grammar usage, and vocabulary recognition. Each worksheet set is structured by topic, with two to four pages per set, allowing learners to practice their abilities progressively without cognitive overload. The worksheets include vibrant illustrations, unambiguous directions, and captivating exercises. One of Starsheet's unique features is that every worksheet has a QR code that connects to digital content that includes instructional support for parents and teachers, usage guidelines, and learning advice. These QR-linked resources provide ideas for reinforcement to help kids learn. The product's simple digital accessibility allows flexible application in both home and classroom learning settings. The quality and relevancy of the information are continuously improved by incorporating user comments.

2. Flow Charts & Screenshots
Worksheet Development Process

Figure 1 illustrates the overall workflow of the STARSHEET, which begins with identifying kindergarten students' learning obstacles. This is followed by the creation of worksheets using the Canva app, editing and proofreading with the help of friends, gathering feedback based on the survey, improving the material, and finally promoting the initiative online.

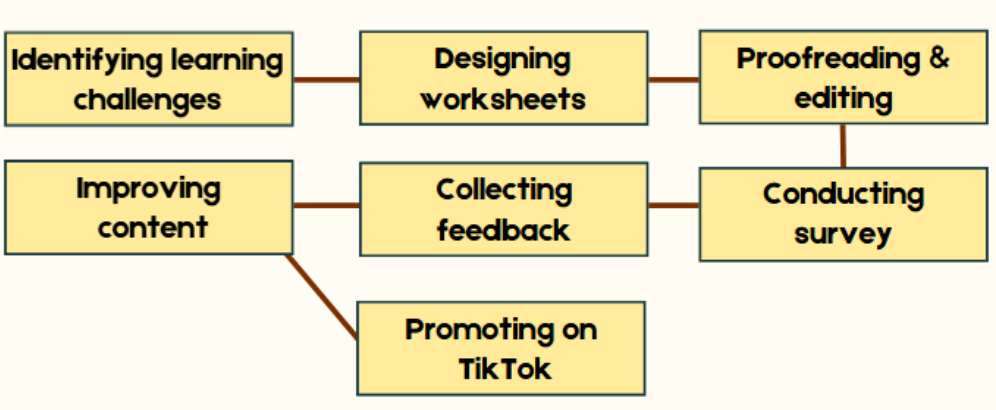

Figure 1. Flowchart of the Starsheet worksheet development process.

Feedback Summary

Figure 2 is a summary of user feedback on Starsheet worksheets, showing that most parents and teachers found the worksheets suitable, engaging, and likely to be reused. In terms of feedback, respondents mentioned that they liked the graphics and overall design of the worksheets. Some suggested adding more exercises to further enhance learning**.**

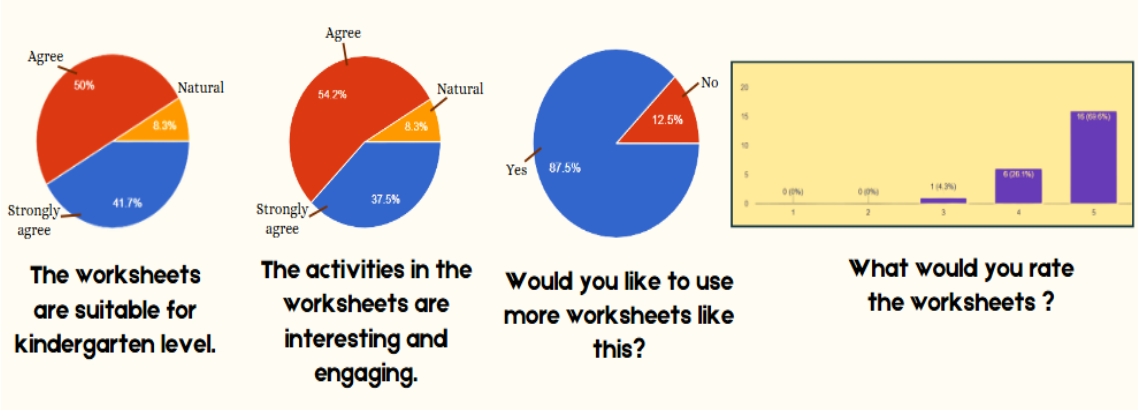

Figure 2. Summary of user feedback on Starsheet worksheets.

3. Novelty and uniqueness

The combination of interactive design, early English content, and digital accessibility created especially for kindergarten students is what makes Starsheet unique. In contrast to traditional printed worksheets, Starsheet incorporates easy activities and captivating graphics to promote active engagement. The worksheets are useful and user-centered because they are based on actual learning difficulties encountered by young students. The addition of QR codes to every worksheet is a noteworthy feature that facilitates assisted learning both at home and in the classroom by giving parents and instructors instant access to advice. Additionally, parents and teachers may easily access the digital format, which lessens reliance on physical materials. This combination of interaction, accessibility, and learner-focused design distinguishes Starsheet from traditional English worksheets.

4. Benefit to mankind

Starsheet helps kindergarteners build their English language skills early on, which benefits society. Children's communication abilities are enhanced, and they are better prepared for formal education when they are exposed to good English learning resources at a young age. The worksheets also help parents and teachers by offering practical, ready-to-use educational materials. Starsheet promotes excellent learning habits at a young age by making learning fun and engaging. Long-term, this helps young learners achieve higher educational results.

5. Innovation and Entrepreneurial Impact

Starsheet promotes innovation by incorporating digital resources into early childhood education and converting conventional worksheets into interactive learning experiences. Entrepreneurially, Starsheet uses social media sites like TikTok to promote to a larger audience and provide useful digital marketing techniques. The project encourages people to investigate technology-driven learning solutions by cultivating a culture of content production, digital entrepreneurship, and educational innovation.

6. Potential commercialization

Starsheet's potential for commercialization as a digital educational product is substantial. The worksheets are available for purchase as downloadable bundles. Digital distribution and social media marketing reduce operational costs while expanding market reach. Future partnerships with educational institutions, kindergartens, and tuition centers could increase their commercial value even more. It is also possible to create additional worksheet series to accommodate various learning levels.

7. Acknowledgment

I would like to express my sincere appreciation to my project supervisor, Madam Nurhamizah Ishak, for her guidance and support throughout the development of this project. I am also grateful to all the respondents who provided valuable feedback and suggestions, which contributed greatly to the improvement of Starsheet.

8. Researchers' Biography

Zulyya Madina Binti Zamri, a final-year Diploma student in English for Professional Communication at Universiti Teknologi MARA. I have a keen interest in education, digital learning, and creative content development. My passion lies in developing innovative learning resources that make education engaging and accessible for young learners. Through this project, I combined interactive design, early English content, and digital tools to address real learning challenges faced by kindergarten students.

Development of Hesi Mobile for Measuring Household Economic Stress

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ABSTRACT
Economic stress in the households is increasingly becoming an issue because of the escalating cost of living, income instability, and escalated financial burdens. Nevertheless, the current methods of measuring household financial situations tend to be disjointed, survey-based and do not provide real-time access to households and decision-makers. This project presents a mobile-type application known as HESI Mobile and the application aims to quantify the stress in the house economies using the Household Economic Stress Index (HESI). HESI Mobile is an index which combines important economic indicators, which are: income stability, expenditure burden, debt pressure, savings adequacy and employment security, into a normalized index framework. Mobile interface allows households to enter the corresponding financial information and receive an immediate HESI score that will then categorize the level of economic stress in the household, which is low, moderate, or high. Continuous monitoring will also be supported by the application as the users will be able to track the changes in household economic stress through the course of time. This is the innovation that HESI Mobile has to offer since it can convert complicated indicators of the economy into one, understandable index that can be used to recognize a threat to fiscal stability early. The application has great socio-economic advantages because it enhances financial awareness of households and assists policymakers and social institutions in making data-driven interventions. As a financial well-being and economic monitoring tool, HESI Mobile has good commercialization potential due to its scalable and digital structure and flexible structure of indexes.

Keywords: Household Economic Stress, Economic Stress Index, Mobile Application, Financial Vulnerability, Socio-Economic Monitoring

1. Product Description
HESI Mobile is an application that evaluates and tracks economic stress in households with the help of a structured and data-driven method that utilizes a mobile phone. The software enables individuals to fill in important details about their household finances such as monthly earnings, core and non-core spending, debt obligations, availability of savings and employment. Based on these inputs, the system calculates a Household Economic Stress Index (HESI) score that categorizes households as having low, moderate, or high economic stress. It is an easy to use and convenient interface on the application to make it accessible to all categories of users

regardless of their socio-economic status. After passing through the assessment, users get immediate feedback in the form of a stress level rating, an overview of the result, and a simple financial advice depending on the results. This allows family to have a better idea of their economic status and what their vulnerability may be early enough. In technical terms, HESI Mobile employs a standardized index framework that integrates multiple economic indicators into a single composite score. Historical data can be as well stored in the application and users can see the transformation of their economic stress level in course of time. HESI Mobile is not only a self-assessment tool to the households but also a possible data source to researchers, policymakers, and social agencies who would like to know the household financial stress patterns.

2. Workflow Overview of HESI Mobile.

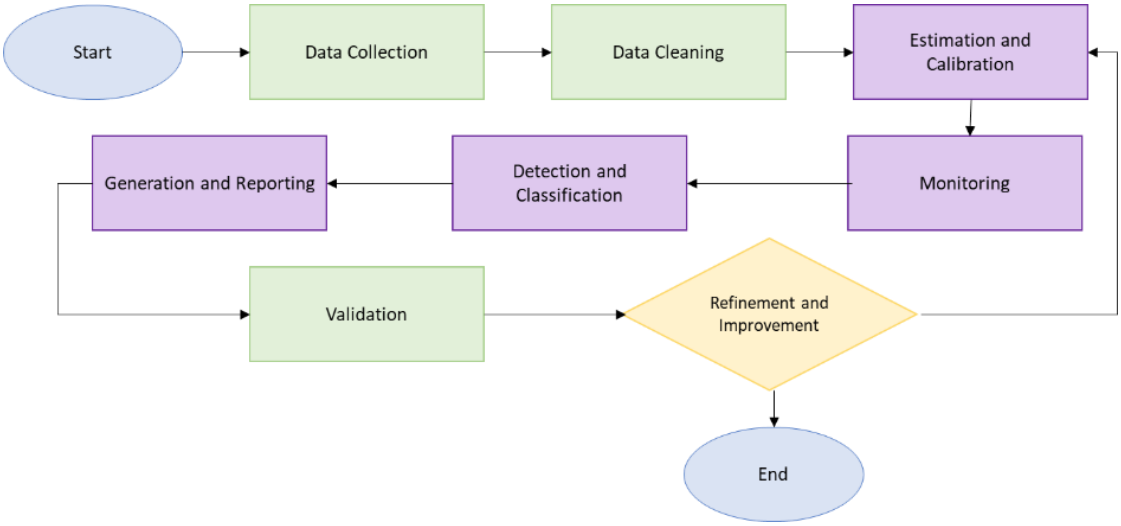

Figure 1. Workflow of Household Economic Stress Assessment in the HESI Mobile Application.

3. Novelty and uniqueness

The innovation of HESI Mobile consists in the creation of a mobile-based Household Economic Stress Index that is composed of layers of household financial indicators in one standardized and interpretable index. Contrary to current financial evaluation instruments, which are more concerned with budgeting or monitoring finances, HESI Mobile concentrates on the processing of economic stress, which gives a clue on financial vulnerability at a family level in its early stages. The HESI Mobile is the only index that takes the major economic aspects such as income stability, expenditure burden, debt pressure, savings adequacy and employment security into consideration in a structured index. The coordinated measure will allow a more detailed determination of household economic status than the disjointed or single-indicator analyses. The application serves to simplify the level of stress classification by translating rather complicated economic information to be easy to understand by the user who may not have a background in economics or finance. The other unique characteristic of HESI Mobile is that it has real time self-assessment and constant monitoring over a mobile platform. The application enables households to follow the changes in their economical strains over time to enhance proactive financial insight and early intervention. Also, the HESI Mobile can create aggregate data insights, which could be used in research, policy evaluation, and more specific socio-economic support. All these characteristics

make HESI Mobile a new and expandable solution to gauge economic stress in the household in an online world.

4. Benefit to mankind

HESI Mobile has huge advantages to society as it enhances awareness and knowledge of economic stress in the household. The application allows households to assess their personal financial situation by using a convenient and easy mobile application that allows the household to know about its financial vulnerability early while it still remains within the confines of economic hardship. This heightened awareness helps in improving financial decision-making and proactive financial management by households. On a bigger scale, HESI Mobile will be able to support policymakers, social agencies, and non-governmental organizations by giving them aggregated information on household economic stress trends. This knowledge may be used to allocate the available monetary aid, social protection schemes, and economic interventions in a more focused and effective manner. As HESI Mobile allows identifying and tracking early signs of household economic pressure, it can help curb financial instability, enhance household stability, and lead to overall socio-economic well-being. Finally, the application aids the initiatives of inclusive economical growth and increased financial stability of communities.

5. Innovation and Entrepreneurial Impact

HESI Mobile fosters innovation by changing the process of economic stress estimation to a usable, digital and user-oriented tool. Through the project, the translation of economic indicators and index-based analysis into a mobile phone application that can tackle real world financial problems of households is shown. Combining the economic theory with mobile technology, HESI Mobile promotes the interdisciplinary innovation in economics, data analysis, and development of digital applications. As an entrepreneur, HESI Mobile presents a replicable digital product that can be used in a variety of industries, such as the household financial well-being, social protection, and policy support. The application cultivates entrepreneurial thinking because it recognizes the economic stress of a household as a marketable issue and suggests a technologically-based solution that has a social effect. In addition, HESI Mobile can promote the growth of innovation-based entrepreneurship in academic and community environments, as it can be a prototype of digital financial assessment tools in the future. The project is part of developing an innovative, problem-solving, and social entrepreneurship culture among stakeholders and students.

6. Potential commercialization

HESI Mobile has great possibility of being commercialized as a digital financial well-being and economic measurement tool. It could be provided on a freemium or subscription basis as a mobile service to households with simple economic stress screening with optional advanced options like in-depth financial data, past trend analysis and custom recommendations. Besides, HESI Mobile may be commercialized by institutional collaborations with the government agencies, the financial institutions, the non-governmental organizational and the social welfare agencies to conduct the economic monitoring of large-scale households and address the interventions programs. The data that will be brought together and made anonymous by the application could be used to provide research and policy analysis services as well, which will form new sources of revenue. HESI Mobile, with its mobile platform that is scalable and an index framework that can be tailored, can be expanded in various regions and social-economic settings. This makes the application a long-term commercial and socially sustainable digital product.

7. Acknowledgment

The authors wish to thank Universiti Teknologi MARA (UiTM) most sincerely, as it gave them the necessary academic support and facilities to carry out this project. The authors also recognize the efforts, collaboration, and support of all individuals and parties which have helped in development and successful execution of the HESI Mobile application either directly or indirectly.

8. Researchers' Biography

Nurul Raudhah Binti Norramadan is a Master of Science (Business Management) student at Universiti Teknologi MARA (UiTM), Johor Branch, Pasir Gudang Campus. She has a strong interest in financial analysis and economic policy, focusing on quantitative and analytical methods in financial research. Through her postgraduate studies, she aims to become a competent researcher and contribute meaningfully to the field of finance. Her growing commitment to advancing financial knowledge is reflected in her academic work and practical contributions.

Dr. Suhana Mohamed is a Senior Lecturer of Finance from the Faculty of Business and Management at UiTM. Dr. Suhana has twenty-six (26) years of experience in academia and industry, where she has pioneered several works relating to Finance and Education. Dr. Suhana has been actively involved in investment research, mainly real estate finance, where she concentrated on real estate investment research. Recognizing her outstanding contributions to research and community services, Dr Suhana had received several prestigious awards inclusive from Women Icon. She devoted her passion and life to knowledge transfer, and supporting many exciting projects for UiTM.

Dr. Fatin Farazh Yaacob is an Economics lecturer at the Faculty of Business and Management, Universiti Teknologi MARA (UiTM) Segamat Campus since June 2020. Dr. Fatin Farazh holds a Bachelor of Business Economics from UiTM Shah Alam and a Master's and Ph.D. in Economics from Universiti Putra Malaysia. Her research interests focus on natural resource and environmental economics. Through teaching and research, Dr. Fatin Farazh aims to contribute meaningfully to the field of economics.

Dr. Siti Norbaya Binti Mohd Rashid is a Senior Lecturer at the Faculty of Business and Management, Universiti Teknologi MARA (UiTM) Puncak Alam Campus since January 2009. Dr. Siti Norbaya holds a Ph.D. in Business Administration, an MBA, and a BBA (Hons) in Finance from UiTM. Her research interests include financial management, investment, financial planning, banking institutions, corporate finance, and derivatives. Through her teaching and research, Dr. Siti Norbaya strives to advance financial knowledge and contribute to innovation in economics and business.

TEP-SME: A Hyperlocal Collaborative Ecosystem for Resilient SME Clusters

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ABSTRACT

TEP-SME is a digital ecosystem designed to transform isolated Small and Medium Enterprises (SMEs) into collaborative, resilient clusters. It addresses the "SME Isolation Crisis" characterized by high operational costs and labour fragility by quantifying social capital through a proprietary "Trust Score". Using a mobile-first platform, neighbouring businesses can pool procurement orders to access wholesale pricing, share trained staff during peak hours via a legal framework, and consolidate last-mile logistics. The innovation utilizes Social Exchange Theory to incentivize pro-social behaviour, turning "neighbourliness" into a measurable and commercially valuable asset. This builds community resilience, particularly for B40 and M40 entrepreneurs, by reducing operational expenditure (OPEX) and fostering job stability. With the global shift toward ESG compliance, TEP-SME offers significant commercialization prospects as a "Neighbourhood Operating System" for urban commercial hubs like Pasir Gudang, Johor Bahru or Kuala Lumpur.

Keywords: SME Collaboration, Social Capital, Resource Pooling, Hyperlocal Logistics, ESG

1. Product Description

TEP-SME is a hyperlocal Resource-Pooling and Trust-Management platform. The product features three integrated modules: the **Trust Score Dashboard**, **Dynamic Staff-Swap**, and **Neighbourhood Bulk-Buy**. The Trust Score uses a weighted algorithm (Reliability, Reciprocity, and Engagement) to unlock financial perks for businesses, as detailed in table 1 and the formula for the Trust Score Calculation as **Figure 1**. The Staff-Swap module utilizes smart contracts and micro-insurance to allow legal labour sharing between unrelated entities, solving the retail labour paradox. Furthermore, the platform automates "Milk-Run" logistics by aggregating small orders from multiple neighbourhood shops into a single delivery route, as illustrated in **Figure 2**. This reduces last-mile costs and urban carbon footprints by 20-30%. The product integrates seamlessly into existing POS workflows to capture real-time social and economic data, providing SMEs with the data-driven advantages of large-scale corporations while maintaining their independent identity. The application snippet shows in **Figures 3,4** and **5.**

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

Table 1. Trust Score Rate.

Pillar	What it Measures	Example Actions	Weight
Commercial Reliability	Financial and operational trust.	Paying for bulk orders on time; ensuring "shared staff" arrive punctually.	50%
Social Reciprocity	Willingness to help others without immediate profit.	Lending a spare generator; sharing a supplier contact; providing free mentorship.	35%
Ecosystem Engagement	Platform health and activity.	Responding to "Help Wanted" pings; participating in neighbourhood business polls.	15%

$$TS = (w_1 \cdot R) + (w_2 \cdot S) + (w_3 \cdot E)$$

Where:

- R = Reliability Index (0–100)
- S = Social Reciprocity Index (0–100)
- E = Engagement Index (0–100)
- w = Weightage (e.g., 0.50, 0.35, 0.15)

Figure 1. Trust Score Calculation Method.

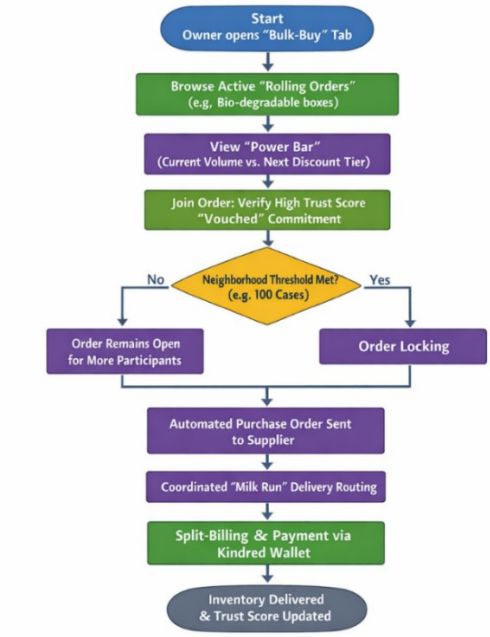

Figure 2. The process Flow of The System.

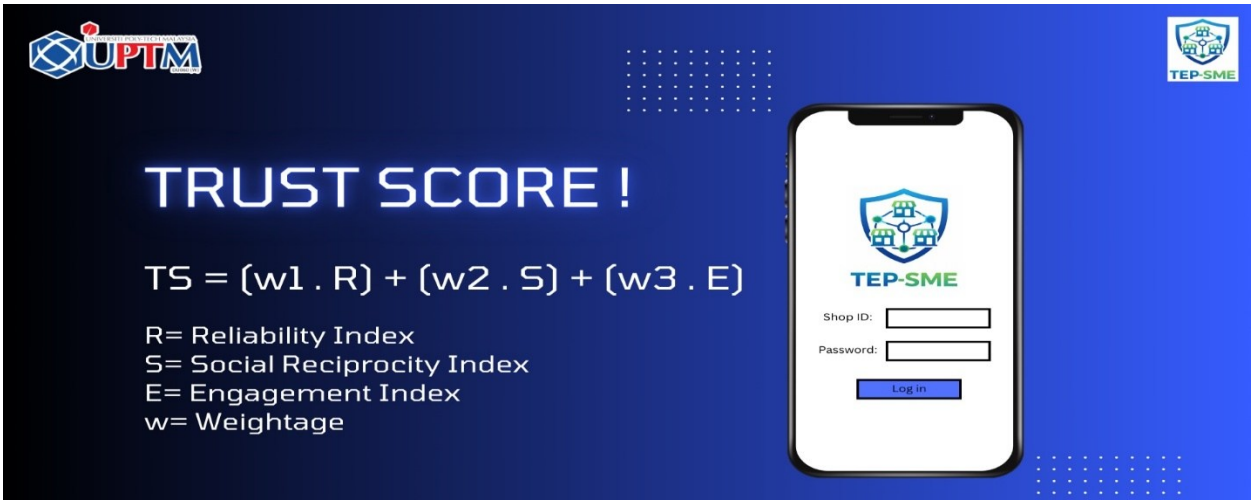

Figure 3. Application Snipped – Credential landing page.

Figure 4. Bulk-Buying Listing & Payment channel .

Figure 5. Labor-Swap and Kindered Wallet.

3. Novelty and uniqueness

The primary novelty of TEP-SME lies in its "Quantified Social Capital" engine. Unlike traditional B2B marketplaces that are purely transactional, TEP-SME is the first to treat "trust" as a functional currency within the logistics and retail sectors. It introduces a unique legal and insurance-backed framework for inter-company labour sharing, a major innovation for the SME market. While cooperatives have historically existed, this platform digitalizes "Reciprocal Altruism" through AI-driven matching and blockchain-backed reliability. It shifts the business paradigm from zero-sum competition to "Coopetition," where the survival of the neighbourhood ecosystem directly benefits the individual shop owner.

4. Benefit to mankind

TEP-SME provides significant social utility by preserving the "soul" of local high streets and ensuring the economic survival of B40/M40 entrepreneurs against global e-commerce dominance. By stabilizing local jobs through labour-sharing, it reduces underemployment and improves the quality of life for retail workers. Environmental benefits are realized through the significant reduction in delivery vehicle movements, lowering urban noise and emissions in residential zones. Ultimately, it rebuilds the social fabric of communities by incentivizing businesses to solve local problems collectively.

5. Innovation and Entrepreneurial Impact

This project promotes an "Ecosystem Entrepreneurship" culture by teaching owners to expand the economic "pie" through collaboration rather than just competing for it. It empowers small owners with the data analytics and purchasing power of large corporations, levelling the playing field. By providing a safety net through community-backed trust, it encourages bolder innovation and reduces the risk associated with business entry in the local industry.

6. Potential commercialization

The platform targets the massive SME market in high-density urban zones. Revenue streams include tiered subscriptions for "Cluster Insights," transaction fees on bulk-purchase savings, and lead-generation for ESG-focused micro-finance providers. The "Trust Score" creates a high-moat data asset that banks can utilize for alternative credit scoring. Partnerships with Municipal Councils for tax-rebate integration provide a scalable path to regional market dominance.

7. Acknowledgment

We would like to acknowledge the support of Supervisor from Institute of Graduate Studies (IGS, UPTM) thru out studies and development of this innovation.

8. Researchers' Biography

Mr. Mohamad Yusuf Mislam is a PhD Candidate at Universiti Poly-Tech Malaysia (UPTM). Graduated from Universiti Sains Malaysia (USM) with Bachelor of Housing, Building and Planning (Architecture) and Master of Business Administration from Berjaya University College (BUC). His area of studies is employee satisfaction, technology adoption, logistic operation, process automation and facilities management. He has 10 years working experience in project management, facilities management and business management from retails, banking, highway and logistic industries. Mr. Yusuf is the team leader for this project by managing the whole project process, timeline and main correspondent.

Mr. Desmond Leong Chen Hui graduated from UNITAR International University with Master of Information Technology and Bachelor of Industrial Electronics Technology from Universiti Teknikal Malaysia Melaka (UTEM). Currently working as Automation Manager in a metrology and instrumentation companies. Results-driven and detail-oriented professional with over 6 years of experience in metrology industry. Demonstrated expertise in data analysis, application development, and instrument calibration, with a proven track record of delivering exceptional results in ERP deployment. Mr. Desmond is a technical advisor and software developer for this project.

Puan Nur Azureen Azha graduated from Universiti Sains Malaysia (USM) with Bachelor of Housing, Building and Planning (Architecture) and Master of Technical and Vocational Education from Universiti Tun Hussein Onn Malaysia (UTHM). She has 7 years working experience in interior design, project management, retails and education industries. Currently working as freelance designer and drafter while waiting for placement for teaching from Education Service Commission (SPP). Puan Azureen act as market researcher and documentation specialist for this project.

Melo-C Massage Bar Innovation

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ABSTRACT

This project aims to develop an innovative product based on natural materials known as the Melo-C Massage Bar, formulated using watermelon rind extract and sugarcane bagasse as an eco-friendly alternative cosmetic product. The development of this product supports sustainability initiatives by utilizing agricultural waste that may otherwise contribute to environmental pollution. Watermelon rind extract was selected due to its high antioxidant and vitamin C content, while sugarcane bagasse functions as a natural exfoliating agent. The product development process involved raw material collection, drying, grinding, formulation using a shea butter base, and evaluation of physical stability and sensory characteristics. The second objective of this study was to assess user perception and the effectiveness of the Melo-C Massage Bar among consumers. Evaluation was conducted through a questionnaire survey to examine perceptions of product quality and added value, as well as basic effectiveness tests on skin moisture and texture after use. The findings indicate a high level of user acceptance, with respondents reporting positive effects on skin softness, natural aroma, and the uniqueness of the massage effect. The overall perception recorded a mean score of 4.62, product effectiveness achieved a mean score of 4.44, and sustainability and eco-friendliness attained the highest mean score of 4.76. Furthermore, Life Cycle Assessment (LCA) analysis demonstrated that the reuse of sugarcane bagasse could reduce carbon emissions by 1.13 tCO_2e per tonne of waste reused. Overall, the Melo-C Massage Bar shows strong potential as an effective and sustainable cosmetic innovation.

Keywords: *sugarcane bagasse, watermelon rind extract, agricultural waste, exfoliation, eco-friendly*

1. Product Description

The Melo-C Massage Bar is an innovative eco-friendly personal care product developed using natural and sustainable ingredients derived from agricultural waste. The product is formulated with watermelon rind extract (*Citrullus lanatus*) and sugarcane bagasse, which function as key active components in providing skin care benefits while supporting environmental sustainability. Watermelon rind extract is rich in antioxidants and vitamin C, contributing to skin revitalization, cooling effects, and overall skin health. Sugarcane bagasse serves as a natural exfoliating agent that gently removes dead skin cells without causing irritation, offering a safer alternative to synthetic microbeads commonly found in commercial exfoliating products. The formulation is based on a shea butter soap base, which provides deep moisturization and helps maintain skin softness after use. The incorporation of sweet almond oil enhances the emollient properties of the product,

improving skin hydration and elasticity. In addition, natural essential oils are added to deliver a refreshing aroma and a relaxing massage experience. The bar is designed with a textured surface to enhance the massage effect, promoting better blood circulation and muscle relaxation during application. The Melo-C Massage Bar is free from synthetic chemicals and microplastics, making it suitable for daily use and environmentally responsible consumption. Overall, the product represents a sustainable cosmetic innovation that integrates effectiveness, user comfort, and green practices, while offering a value-added solution for modern eco-conscious consumers.

2. Methodology, Results & Discussion

Figure 1. Production Method.

The production process begins with material preparation, where all raw materials and active ingredients are accurately measured and prepared under hygienic conditions to ensure formulation consistency. Next, during the melting process, the base material is gently heated using controlled temperature to achieve a uniform liquid state without degrading sensitive compounds. Once melted and slightly cooled, active ingredients such as plant extracts, essential oils, or natural exfoliants are incorporated and mixed thoroughly to ensure even distribution. The mixture is then poured into molds and allowed to solidify under controlled conditions to achieve the desired shape and structural stability. Finally, the product undergoes a curing process and quality control, where it is inspected for hardness, texture, weight consistency, and overall quality before being approved for packaging and commercialization.

This section presents the research findings obtained from product testing and user feedback on the Melo-C Massage Bar. The analysis was conducted based on the average mean scores for each evaluation aspect, including texture, fragrance, exfoliation effectiveness, skin moisturization, design, and overall satisfaction.

Table 1. Mean Score of Melo-C Massage Bar.

Item	***Mean Score***	***Level***
Perception		
B1: I believe that products based on watermelon rind extract and sugarcane bagasse are innovative.	4.45	*High*
B2: I am confident that this product is safe to use as it contains natural ingredients.	4.45	*High*
B3: The design and appearance of the Melo-C Massage Bar are attractive.	4.77	*High*
B4: The fragrance of the Melo-C Massage Bar is suitable, long-lasting, and soothing.	4.71	*High*
B5 This product is suitable as an alternative to existing cosmetic products.	4.71	*High*
Effectiveness		
C1: I feel that my skin is softer after using this product.	4.35	*High*
C2: This product effectively helps remove dead skin cells.	4.35	*High*
C3: This product provides freshness and a relaxing sensation to the body.	4.61	*High*
C4: I observe positive changes in skin texture and moisture after use.	4.29	*High*
C5: Overall, I am satisfied with the effectiveness of the Melo-C Massage Bar.	4.58	*High*
Sustainability and Environmental Aspects		
D1: I agree that this product supports the reduction of agricultural waste through the use of sugarcane bagasse and watermelon rind.	4.87	*High*
D2: I prefer using environmentally friendly products compared to synthetic products.	4.65	*High*
D3: I believe that the use of waste materials in cosmetic products is a positive initiative.	4.58	*High*
D4: This product is suitable to be promoted as part of a green lifestyle.	4.94	*High*
D5 I would recommend eco-friendly products like this to friends and family.	4.77	*High*
Average Mean Score	4.61	*High*

Table 1 indicates that the Melo-C Massage Bar achieved a high overall acceptance level, with an average mean score of 4.61, reflecting strong positive user perception and satisfaction. Under the perception dimension, respondents rated the product as innovative, safe due to its natural ingredients, visually attractive, and suitable as an alternative to existing cosmetic products, with mean scores ranging from 4.45 to 4.77. In terms of effectiveness, users agreed that the product helps soften the skin, remove dead skin cells, provide freshness and relaxation, and improve skin texture and moisture, with consistently high scores between 4.29 and 4.61. The highest ratings were recorded under sustainability and environmental aspects, particularly the suitability of the product to be promoted as part of a green lifestyle (4.94) and its role in reducing agricultural waste through the use of sugarcane bagasse and watermelon rind (4.87). Overall, the findings demonstrate that the Melo-C Massage Bar is well-received not only for its functional performance and aesthetic appeal but also for its strong environmental value proposition.

Table 2. Carbon Emmission Parameters.

Parameter	***Unit***	***Assumption / Source***
Sugarcane bagasse usage per bar	5g	*Laboratory-scale formulation*
Total bars per year	10000/pilot	*Planned production output*
Open burning emission factor (EF)	1.181 tCO2/tan	*IPCC 2006*
Landfill emission factor (EF)	1.05tCO2/tan	*EPA methane (CH_4) factor, GWP = 28*
Processing emissions	0.05 tCO2/kWh	*TNB emission factor (2023)*
Transportation distance	50km	*Within Selangor region*

Table 2 outlines the key parameters and assumptions used to estimate the carbon emission impact of the Melo-C Massage Bar production. Each bar utilizes 5 g of sugarcane bagasse based on laboratory-scale formulation, with an estimated annual pilot production of 10,000 bars. The open burning emission factor is assumed at 1.181 tCO_2 per tonne according to IPCC 2006 guidelines, while landfill emissions are estimated at 1.05 tCO_2 per tonne based on EPA methane (CH_4) conversion with a Global Warming Potential (GWP) of 28. Processing emissions are calculated using an electricity emission factor of 0.05 tCO_2 per kWh based on TNB (2023) data. Transportation emissions are estimated based on an average distribution distance of 50 km within the Selangor region. These parameters form the basis for evaluating the potential carbon reduction achieved by diverting sugarcane bagasse and watermelon rind from conventional disposal methods into value-added cosmetic production.

Table 3. Carbon Emission Reduction Analysis (Carbon Avoidance Analysis).

Scenario	***Baseline Emissions (tCO_2e/tonne)***	***Processing Emissions (tCO_2e/tonne)***	***Emissions Avoided (tCO_2e/tonne)***	***Total Avoided (tCO_2e/tonne)***
100% Open Burning	1.181	0.05	1.131	0.0566
100% Landfill Disposal	1.05	0.05	1.00	0.05
70% Open Burning / 30% Landfill	1.144	0.05	1.094	0.0553

Table 3 presents the Carbon Avoidance Analysis, comparing baseline disposal emissions with emissions generated during processing to determine the net carbon reduction achieved by utilizing sugarcane bagasse in the Melo-C Massage Bar. Under the 100% open burning scenario, the baseline emission is 1.181 tCO_2e per tonne, and after deducting processing emissions of 0.05 tCO_2e per tonne, the net emissions avoided amount to 1.131 tCO_2e per tonne, resulting in a total avoided emission of 0.0566 tCO_2e based on the annual material usage. For the 100% landfill disposal scenario, the baseline emission is 1.05 tCO_2e per tonne, leading to 1.00 tCO_2e per tonne avoided after accounting for processing emissions, with a total avoided value of 0.05 tCO_2e. Meanwhile, the 70% open burning and 30% landfill scenario produces a weighted baseline emission of 1.144 tCO_2e per tonne, resulting in 1.094 tCO_2e per tonne avoided and a total avoided emission of 0.0553 tCO_2e. Overall, the findings demonstrate that diverting agricultural waste into value-added cosmetic production contributes to measurable carbon emission reductions across all disposal scenarios.

3. Novelty and uniqueness

The Melo-C Massage Bar is a novel personal care product that combines sustainability, natural ingredients, and multifunctional benefits. Unlike conventional exfoliating products that rely on synthetic microbeads and chemical additives, it utilizes watermelon rind extract (*Citrullus lanatus*) and sugarcane bagasse, both sourced from agricultural by-products. Watermelon rind extract is rich in antioxidants and vitamin C, promoting skin revitalization and providing a cooling effect, while sugarcane bagasse functions as a gentle, natural exfoliant that removes dead skin cells without causing irritation.

The product's formulation is unique, as it integrates these ingredients into a shea butter soap base, enhancing skin moisturization while delivering exfoliation. Its textured bar design supports massage effects, improving blood circulation and providing a relaxing sensory experience. Sweet almond oil and natural essential oils are incorporated to enhance hydration and offer a refreshing aroma, making the bar multifunctional.

From an environmental perspective, the Melo-C Massage Bar embodies eco-innovation by repurposing agricultural waste, reducing potential landfill or open-burning emissions, and aligning with circular economy principles. This combination of effectiveness, sensory appeal, and sustainability sets it apart from existing products, offering consumers a high-value, environmentally responsible skincare solution. Overall, the Melo-C Massage Bar demonstrates distinct novelty by merging functional skincare benefits with sustainable practices, establishing a unique position in the personal care and eco-friendly product markets.

4. Benefit to mankind

The Melo-C Massage Bar provides multiple benefits to mankind by combining personal care, wellness, and environmental responsibility. Its natural ingredients, including watermelon rind extract and sugarcane bagasse, offer safe and effective skin care, promoting exfoliation, hydration, and skin revitalization without the risks associated with synthetic chemicals or microplastics. The massage bar's texture design enhances blood circulation, reduces muscle tension, and provides a relaxing sensory experience, contributing to overall physical and mental well-being. Beyond personal health, the product supports sustainable living by repurposing agricultural by-products, reducing waste, and lowering carbon emissions associated with disposal or open burning. This promotes environmental consciousness among consumers while encouraging adoption of eco-friendly practices. By integrating functionality, wellness, and sustainability, the Melo-C Massage

Bar not only improves individual skin health but also fosters environmental stewardship, demonstrating tangible benefits to both mankind and the planet.

5. Innovation and Entrepreneurial Impact

The Melo-C Massage Bar exemplifies innovation by transforming agricultural waste into a value-added, eco-friendly personal care product. By integrating watermelon rind extract and sugarcane bagasse into a multifunctional massage soap, the project introduces a unique product that combines exfoliation, moisturization, and massage benefits while promoting sustainability. This approach challenges conventional cosmetic practices and demonstrates the potential for circular economy principles in product development. Entrepreneurially, the project encourages creativity and business thinking within the community and institution by showcasing how locally available natural resources can be commercialized into high-value, environmentally responsible products. It fosters a culture of innovation by inspiring students, researchers, and small businesses to develop solutions that are both marketable and sustainable. The Melo-C Massage Bar serves as a model for eco-conscious entrepreneurship, highlighting opportunities for product differentiation, green innovation, and responsible consumerism within the personal care industry.

6. Potential commercialization

The Melo-C Massage Bar demonstrates strong potential for commercialization as a sustainable and innovative personal care product. Its unique formulation, incorporating watermelon rind extract and sugarcane bagasse, differentiates it from conventional exfoliating products, appealing to environmentally conscious and health-focused consumers. The multifunctional benefits of exfoliation, moisturization, and massage enhance product value, while its eco-friendly and chemical-free attributes align with growing consumer demand for green and safe skincare products. Production scalability is feasible due to the availability of raw materials locally and the simplicity of the melt-and-pour formulation process. Marketing strategies can emphasize sustainability, wellness, and the use of agricultural by-products, creating a competitive advantage in both domestic and international personal care markets. Pilot production and positive consumer feedback indicate market acceptance, suggesting opportunities for partnerships with cosmetic retailers, e-commerce platforms, and wellness brands. Overall, the Melo-C Massage Bar is positioned as a commercially viable product with significant market potential.

7. Acknowledgment

Acknowledgement and sincere gratitude to all individuals and organizations who contributed to the successful development of the Melo-C Massage Bar. Special thanks are extended to the laboratory team for their technical support in product formulation and testing, as well as to the survey participants for providing valuable feedback on product perception and effectiveness. The project also acknowledges support from institutional management for facilitating resources and guidance throughout the research process. Finally, appreciation is given to all mentors and colleagues whose insights and encouragement have been instrumental in advancing the objectives of this study.

8. Researchers' Biography

Nurul Syamshida Binti Mokhtar is a Senior Lecturer and Head of the Strategic Planning Unit at Polytechnic Sultan Idris Shah, specializing in Business Administration. With over 23 years of teaching experience, she is actively engaged in research on sustainable investment, circular economy practices, and entrepreneurship. Nurul has developed several innovative eco-friendly products, including the Melo-C Massage Bar and V.Folia Powder, emphasizing the use of natural ingredients and agricultural by-products. Her work bridges academic research and practical applications, promoting environmentally responsible solutions. She continues to mentor students and collaborate with institutions to foster innovation, sustainability, and eco-conscious business practices within the community and industry

Nurauni binti Azahari is a Semester 4 student of Diploma in Islamic Finance at Politeknik Sultan Idris Shah, Sabak Bernam. She currently serves as a member of the Student Representative Council (Majlis Tertinggi Jawatankuasa Perwakilan Pelajar) for the 2026/2027 session. She is active in student leadership and has a strong interest in Islamic financial management and entrepreneurship. She hopes to become a successful entrepreneur and make a positive impact on society.

.Nur Farisha Raihanna binti Mohd Suzreen is a Semester 4 student of Diploma in Islamic Finance at Politeknik Sultan Idris Shah, Sabak Bernam. She currently serves as the Vice President of the Commerce Executive Club. She is active in student leadership and islamic entrepreneurship, demonstrating strong commitment and responsibility in her roles. She aspires to become a successful individual who contributes positively to society and achieves success in life.

Nuralyaa Binti Sharuddin, a student at Politeknik Sultan Idris Shah, Sabak Bernam, is taking the Diploma in Islamic Finance course in semester 4. Her highest leadership experience is as the secretary of the AdHoc Secretariat Club from 2024 to early 2026. She also enjoys participating in any program under the Polytechnic which includes most students at Sultan Idris Shah Polytechnic. In addition, she also has a strong interest in the field of Islamic finance including entrepreneurship. She hopes that the experience gained throughout the program she participated in will make her a successful person and also be able to spread a positive influence to society.

SportMate: A Digital Sports Platform for Social Interaction and Active Lifestyles

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ABSTRACT

SportMate is a mobile application designed to encourage active and social connected lifestyle solutions as it combats the typical challenges to sporting attendance: difficulty in seeking partners, lack of motivation, and limited access to organized sport activities. SportMate, created as a community-oriented digital platform, combines sports partner matching, sports facility search, court booking, in-app communication, and planning of physical activities for regular participation in indoor and outdoor sport. The application is user-centered, based on interaction, and integrates functionalities with social networks to increase participation and motivation. It stands out in combining social interactions, collective engagement, and practical sports management into one platform; chat, invitations, shared activities, ratings, and reviews are some of the available features to support collaboration and continued involvement of the users, as well as to help inform decision-making through collective input.

SportMate brings profound socio-economic and socio-environmental gains from the promotion of healthier lifestyles, commercialization, SportMate shows great promise due to court booking fees, tournament registration, partnerships with sports facilities, and potential for premium features, making it a scalable and sustainable digital platform for community-based sports participation.

Keywords: Mobile Application, Sports Participation, Social Interaction, Active Lifestyle

1. Product Description

SportMate is a community-based mobile application developed to encourage active lifestyles by connecting users with sports partners and simplifying access to sports facilities and activity planning. The platform allows users to discover nearby indoor and outdoor courts, match with individuals who share similar sports interests, communicate through in-app messaging, and organize group activities through an integrated booking system. In addition, SportMate incorporates social features such as activity invitations, user profiles, ratings, reviews, and a public content feed to encourage continuous engagement and informed decision-making. By combining social networking with practical sports management in one platform, SportMate addresses common barriers such as coordination difficulties and low motivation. The application is designed for students, working adults, and sports enthusiasts who seek a convenient, interactive, and

organized approach to maintaining regular physical activity while strengthening community connections.

2. Application Interface and System Flow

Figure 1. SportMate prototype storyboard.

3. Novelty and uniqueness

SportMate is a unique digital platform that combines social interaction with sports facility management. In contrast to traditional fitness or reservation apps, SportMate integrates real-time facility booking, in-app conversation, group planning, partner matching, and a social feed for sharing sports experience. This approach transforms sports participation into a community-driven activity rather than an individual task. The application also includes collective intelligence through user ratings, reviews, and activity preferences, enabling smarter venue selection and partner matching. Its design encourages continuous engagement through invitations, shared bookings, and content posting, creating a dynamic ecosystem that supports motivation, collaboration, and sustained physical activity.

4. Benefit to mankind

SportMate contributes to societal well-being by encouraging regular physical activity and reducing sedentary lifestyles through accessible and socially engaging sports participation. By simplifying the process of finding sports partners and facilities, the platform supports healthier daily routines and improves users physical and mental well-being. In addition, SportMate promotes social inclusion by connecting individuals with different backgrounds through shared sports interest, strengthening community relationships and peer motivation. The application also empowers users with informed choices through ratings and reviews, enhancing confidence in facility selection. Collectively, SportMate helps foster active communities, supports public health initiatives, and encourages sustainable lifestyle habits, making it a meaningful digital solution for improving quality of life.

5. Innovation and Entrepreneurial Impact

SportMate promotes innovation by integrating social interaction with sports management services such as partner matching, court booking, and activity planning within a single digital platform. The project demonstrates how mobile technology can be applied to solve real-world challenges related to physical inactivity and social disconnection through user-centered design. SportMate also contributes to a culture of entrepreneurship by creating opportunities for collaboration with sports facilities, local communities, and event organizers. The platform supports digital entrepreneurship by enabling service-based revenue models, encouraging student innovation, and providing a foundation for future expansion into tournaments, community programs, and premium features. Through this approach, SportMate fosters creative problem-solving, promotes entrepreneurial thinking among students, and supports the development of sustainable digital solutions within the sports and wellness industry.

6. Potential commercialization

SportMate has strong commercialization potential through multiple revenue streams, including court booking commissions, tournament registration fees, partnerships with sports facilities, and premium subscription features. Additional opportunities include in-app advertising, sponsored events, and referral programs. The platform's scalable digital model allows expansion across universities, urban communities, and recreational centers, increasing market reach and user adoption. By collaborating with local sports operators and wellness providers, SportMate can generate sustainable income while supporting community-based activities. With growing awareness of healthy lifestyles and digital services, SportMate is well-positioned to evolve into a profitable sports engagement platform that benefits both users and industry stakeholders.

7. Acknowledgment

The authors would like to thank Encik Muhammad Fadhli Bin Abdul Rahman for his guidance, insightful suggestions, and continuous support throughout the development of this project. His expertise and encouragement greatly assisted in refining the project direction and overall quality. Appreciation is also extended to all team members for their commitment, collaboration, and active contribution during the planning, design, and implementation stages. The authors additionally acknowledge friends and peers for their helpful feedback and motivation. Special thanks are given to family members for their understanding and constant encouragement, which provided valuable support throughout the completion of this project.

8. Researchers' Biography

Sharifah Nur Atiqah is a second-year Bachelor's degree student at Universiti Teknologi MARA (UiTM), Shah Alam, currently pursuing Instructional Communication and Training. Academic interests focus on user experience design, interface planning, and digital system development. Contributions include application layout structuring, user flow design, and visual organization for digital platforms. Academic projects support the development of design thinking, system planning, and the creation of user-friendly digital solutions that address practical needs.

Nur Raisyah Firhah Binti Ramzi is a second-year Bachelor's degree student at Universiti Teknologi MARA (UiTM), Shah Alam, currently pursuing Instructional Communication and Training. Academic interests include communication content development, media planning, and digital storytelling. Main contributions involve content writing, communication strategy, and documentation, with emphasis on delivering clear and engaging messages through digital platforms.

Hanis Afni Binti Mat Harun is a second-year Bachelor's degree student at Universiti Teknologi MARA (UiTM), Shah Alam, currently pursuing Instructional Communication and Training. Academic interests center on social interaction design, community engagement, and idea development. Contributions focus on concept generation related to social features, user participation, and collaborative activities, while strengthening skills in creative planning and project coordination.

Muhammad Fadhli Bin Abdul Rahman is a lecturer at the Faculty of Communications and Media Studies, Universiti Teknologi MARA (UiTM), with expertise in social web technologies and digital communication. Extensive academic supervision and guidance were provided throughout the course of this project, assisting students in research conceptualization, methodology development, system design, and the implementation of innovative solutions.

AI-QueenPreneurs - Students' Entrepreneurship Academic Integrity Framework Using Quintuple Helix Model

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ABSTRACT

The AI-QueenPreneurs is a pioneering Students' Entrepreneurship Academic Integrity Framework designed for the Malaysian context to curb academic misconduct among future entrepreneurs. It was developed using the Quintuple Helix Model, this innovation addresses the gap between current student behaviors and desired integrity standards. It integrates five subsystems—education, economy, environment, civil society, and politics—to create a multi-dimensional approach to ethical learning. Its uniqueness lies in the synergy between the five helices and the six core values of academic integrity: honesty, trust, fairness, respect, responsibility, and courage. Unlike traditional models, it utilizes AI-driven insights to identify gaps, prioritize resources, and foster evidence-based decision-making. Socio- economically, it cultivates a generation of high-integrity entrepreneurs, ensuring a sustainable, ethical business ecosystem in Malaysia. It minimizes "bad legacies" of misconduct, promoting a culture of transparency and public trust. For commercialization prospect, the framework offers high scalability as an interactive AI module and a standardized benchmarking tool for higher education institutions, government bodies, and industry players seeking to certify ethical entrepreneurship standards such as commercialize via SaaS subscriptions for universities, certification fees for ethical entrepreneur credentials, and licensing the AI modules to government bodies and private ed-tech firms for nationwide integration.

Keywords: academic integrity; entrepreneurs-leader, AI-QueenPreneurs; quintuple helix model

1. Product Description

AI-QueenPreneurs is a validated framework designed to bolster academic integrity among student entrepreneurs. Grounded in the International Center for Academic Integrity (ICAI) standards and the Quintuple Helix Model, it integrates five key pillars—academia, industry, government, civil society, and the natural environment—to align innovation with ethical and sustainable development. This innovation addresses the critical gap in student misconduct by offering a structured guideline that identifies integrity risks early through data-driven support. By synergizing the economic, political, and ecological systems, the framework ensures that knowledge production remains transparent and socially responsible. Empirically tested for validity and reliability, AI-QueenPreneurs functions as a scalable prototype ready for institutional pilot testing. Its core advantage lies in its ability to detect misconduct patterns early, allowing for targeted educational interventions. This flexible model is designed for seamless integration into future AI-enhanced academic monitoring systems, fostering a culture of honesty and "green" innovation. Ultimately, AI- QueenPreneurs empowers students to navigate complex entrepreneurial landscapes with courage and accountability, ensuring Malaysia's future business

leaders uphold the highest ethical standards in an increasingly digital and eco-conscious global economy.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

Flowchart Phases

Figure 1 illustrates the structured framework development process of AI-QueenPreneurs across two main phases. First phase establishes the theoretical basis from the International Center for Academic Integrity or ICAI model (2021) including six constructs such as honesty, trust, fairness, respect, responsibility, and courage. Besides, Quintuple Helix Model (2010) contains academia, industry, government, culture or media, and natural environment. Those elements embedded with Entrepreneurship context to produce students with excellent academic integrity. Second phase involves the framework development with assessment on robust validity and reliability. Finally, AI-QueenPreneurs framework demonstrates students' entrepreneurship academic integrity using quintuple helix model that can help to guide students properly to solve integrity issues.

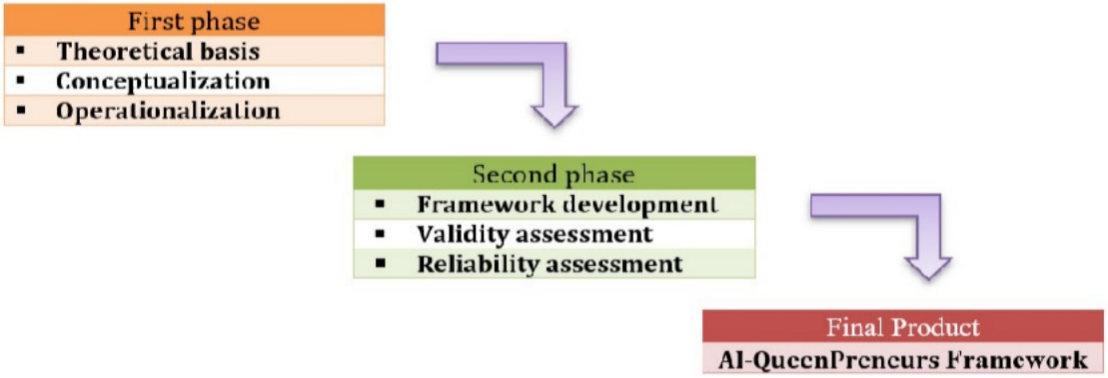

Figure 1. Flow chart AI-QueenPreneurs framework.

Figure 2. The AI-QueenPreneurs framework.

Figure 2. produced the AI-QueenPreneurs framework that integrates five subsystems such as education (academia) , economy (knowledge economic drivers), environment (natural environment), civil society (governance and social influence), and politics (culture) to create a

multi-dimensional approach to ethical learning. These framework is useful as a guidelines to identify integrity risk early in entrepreneurship sustainable development.

3. Novelty and uniqueness

The AI-QueenPreneurs Framework represents uniquely on a paradigm shift in entrepreneurship education by integrating the Quintuple Helix Model to address academic integrity. Moving beyond punitive measures, it creates a new novel holistic ecosystem that synergizes five pillars namely as academia, industry, government, culture, and the environment. By embedding ethics directly into the innovation process, the framework ensures student entrepreneurs operate within a collaborative network of shared moral responsibility. A key uniqueness is its status as a validated mechanism designed to bridge the gap between entrepreneurial pressure and academic transparency. AI-QueenPreneurs positions integrity as a competitive advantage, framing ethical conduct as a foundation for brand credibility and long-term sustainability rather than a restriction. Furthermore, the innovation incorporates the natural environment and social capital under the fifth helix into the entrepreneurial code of conduct. This elevates academic integrity from classroom compliance to global corporate responsibility. By aligning academic outcomes with sustainable real-world impact, the framework serves as a dynamic blueprint for higher education institutions. It provides an expert-backed roadmap to producing business-ready graduates equipped with a robust moral compass to lead honestly in a complex, digital-driven economy.

4. Benefit to mankind

The AI-QueenPreneurs Framework cultivates ethical leaders by embedding academic integrity into the entrepreneurial mindset, ensuring future pioneers prioritize transparency and social trust. This transition significantly reduces corporate fraud, intellectual property theft, and exploitative practices, fostering a more reliable global market where ethical practices enhance corporate reputation. Through the Quintuple Helix Model, the framework aligns economic growth with environmental and social sustainability. By integrating society and the natural environment as core pillars, it empowers students to develop innovations that address climate change and social inequality. This initiative transforms student ventures from academic exercises into missions for corporate social responsibility. Ultimately, mankind benefits from a stable, eco-conscious economic ecosystem where progress is measured by the long-term well- being of both the planet and its people.

5. Innovation and Entrepreneurial Impact

The AI-QueenPreneurs Framework transforms academic integrity from passive compliance into a dynamic strategic asset for student entrepreneurs. By integrating the Quintuple Helix Model, it bridges the gap between classroom ethics and the global marketplace, ensuring student-led ventures are built on authenticity. This empowers students to generate high-value, original intellectual property, replacing shortcuts with a rigorous standard of excellence essential for knowledge-based economies. The framework significantly enhances the invest ability and scalability of startups. Investors prioritize ventures with transparent operations. Graduates using this model possess a seal of integrity that signals reliability to venture capitalists. This fosters a ripple effect where student businesses can secure funding, navigate regulations, and build resilient global brands. Furthermore, the framework catalyzes a sustainable ecosystem by incorporating the fifth helix or the natural environment. AI-QueenPreneurs produces principled leaders who redefine the market through ethical sustainable value creation, driving genuine economic growth and social stewardship.

6. Potential commercialization

The AI-QueenPreneurs Framework offers significant commercialization potential by addressing the global demand for ethical standards in entrepreneurship. Firstly, it can be packaged as a proprietary educational syllabus or digital toolkit licensed to Higher Education Institutions (HEIs). This allows universities to provide professional certifications that signal ethical reliability to venture capitalists and recruiters. Secondly, a Software-as-a-Service (SaaS) platform can be developed to facilitate real-time interaction among Quintuple Helix stakeholders. This platform would feature automated tools to track a venture's *Integrity Score*, providing essential data-driven validation for incubators and accelerators. Finally, the framework serves as a high-level consultancy service for government agencies and corporations. As global markets shift toward ESG (Environmental, Social, and Governance) standards, AI-QueenPreneurs provides a ready-made blueprint for building sustainable innovation pipelines. By ensuring student ventures are socially responsible and academically sound, the framework transforms integrity into a marketable, high-value asset for the modern knowledge economy.

7. Acknowledgment

The authors would like to express their sincere appreciation to the academic experts who contributed to the AI-QueenPreneurs Framework. Their valuable feedback significantly strengthened the development and applicability of AI-QueenPreneurs innovation. Heartfelt thanks are due to our supervisor, whose continuous guidance and intellectual support were instrumental to this innovation. Furthermore, we are deeply grateful to the supporting institution for the resources and facilitation that made the implementation of this work possible.

8. Researchers' Biography

Rosidah binti Md Desa is a Master's student in Measurement and Evaluation at Universiti Kebangsaan Malaysia (UKM). Her research focuses on academic integrity among secondary school students in the era of artificial intelligence, particularly in AI-assisted learning and assessment contexts. She specializes in instrument development, construct validation, and educational measurement, with an emphasis on value-based assessment models grounded in integrity principles. Her work aims to develop empirically validated measurement tools that support ethical AI usage and sustainable academic practices within school environments.

Associate Professor Ts. Dr. Mohd Effendi @ Ewan Mohd Matore is a senior lecturer at Universiti Kebangsaan Malaysia (UKM) and Head of the University Research Group (KPU) in Educational Assessment. He specializes in educational measurement and evaluation, with expertise in psychometrics, instrument development, and quantitative research methodologies. His scholarly work focuses on construct validation, modern measurement models, and assessment design in educational settings. As a leading expert in measurement and evaluation, he has contributed extensively to research and innovation in assessment practices, supporting the development of valid and reliable educational measurement instruments.

Web-Based Personal Expenses Management System

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ABSTRACT

This project presents the development of a Web-based Personal Expense Management System designed to improve personal financial management and increase financial awareness in today's digital era. Although financial literacy is becoming more important, many people still record their expenses manually. This often leads to inefficiency, budgeting errors, and poor understanding of spending habits. To solve this problem, the proposed system provides a centralized and real-time platform where users can track their expenses easily. Users can categorize their spending, manage their account balances, and automatically generate financial summaries. The system is developed using lightweight client-side web technologies, making it easily accessible, fast, and simple to use without requiring complex installation. The platform also includes interactive data visualization features such as graphs and spending trend analysis. These features help users clearly see their financial patterns and make better budgeting decisions. Automated calculations instantly update total expenses, remaining balance, and overall spending status, encouraging more responsible financial behaviour from an innovation and entrepreneurship perspective, this system has strong potential for scalability and commercialization. It offers a low-cost and accessible digital financial solution, especially for students, young professionals, and underserved communities. Its web-based design allows easy customization, quick deployment, and future integration with advanced features such as predictive analytics, cloud storage, or mobile application expansion. By combining usability, affordability, and financial empowerment, this platform supports digital financial inclusion and provides a strong opportunity for startup development within the growing financial technology (fintech) industry.

Keywords: personal financial management, web-based application, expense tracking, financial literacy, digital budgeting

1. Product Description

Effective personal financial management remains a significant challenge for many individuals, particularly those who rely on manual recording methods or fragmented digital tools. Limited accessibility, inconsistent tracking habits and lack of financial visibility often result in poor budgeting decisions and reduced financial awareness. To address this gap, the proposed Expense Tracker is developed as a web-based financial management application designed to provide a simple, accessible and efficient platform for daily expense monitoring.

The system enables users to record, categorize and manage expenses in real time while automatically updating account balances and generating financial summaries. A key innovation of the platform is its offline functionality, allowing users to access and manage their financial data

without requiring continuous internet connectivity. This feature enhances accessibility and usability, particularly in areas with limited network coverage.

Interactive visual analytics, including weekly and monthly expenditure charts as well as category-based pie charts, provide users with meaningful insights into spending behaviour. Through its user-friendly interface and lightweight architecture, the system promotes better budgeting habits and supports improved financial decision-making. The platform is designed with scalability potential, making it suitable for further development into a broader digital personal finance solution within the growing financial technology ecosystem.

2. System Description

As illustrated in **Figure 1**, the system operates based on a structured flowchart that defines the overall logic and workflow of the financial management process.

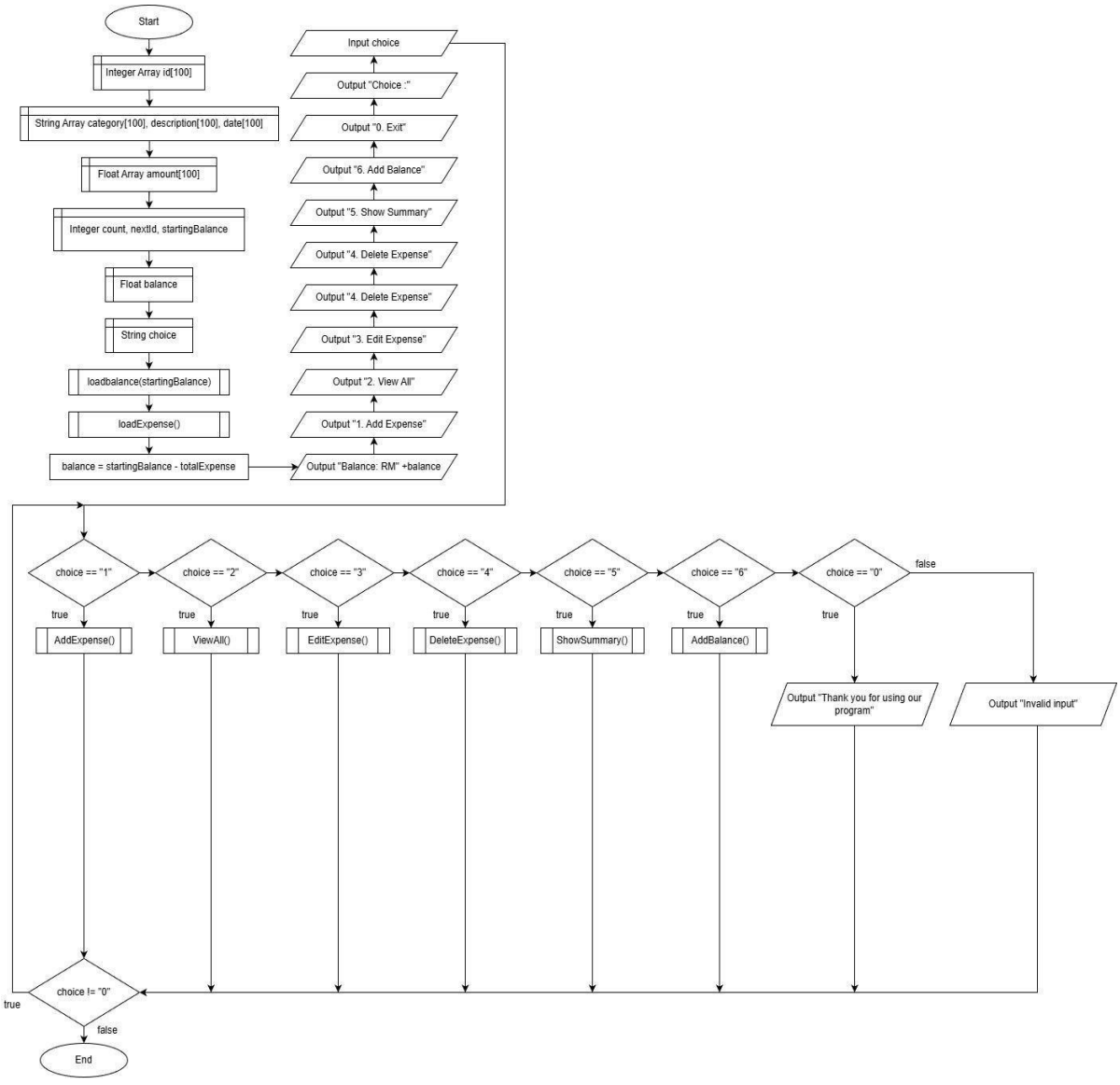


Figure 1. Flowchart of Financial Management System.

The application begins by initializing essential datas, including arrays for expense IDs, categories, descriptions, dates, and amounts. It also loads the user's starting balance and previously saved expense data. The balance is automatically calculated by subtracting the total expenses from the starting balance, ensuring accurate and real-time financial tracking. The system then displays a menu of options that allows users to interact with the application. These options include adding new expenses, viewing all expenses, editing or deleting existing records, displaying a financial summary, adding balance, and exiting the system. Each user choice triggers a specific function, such as AddExpense(), ViewAll(), EditExpense(), or DeleteExpense(), as shown in the decision-making structure of **Figure 1**. Invalid inputs are handled appropriately to maintain system reliability.

The user interface of the system is shown in figure below, which demonstrates the implementation of financial management features on the website using HTML. **Figure 2** presents the login interface, which includes fields for username and password. This allows registered users to securely access the system. The interface displays the starting balance and current balance, as shown in **Figure 3**, where users can see their starting balance and remaining balance to better understand their financial status. Each expense record includes action buttons that allow users to edit or delete entries for better data control. Additionally, the system provides an Add Balance feature that enables users to increase their available funds when necessary. Users can add expenses by entering the date, category, description, and amount, as presented in **Figure 4**. These expenses are then displayed in an expense list table, as shown in **Figure 5**. A Summary section presents key financial insights, such as monthly and weekly spending, as illustrated in **Figure 6**. **Figure 7** shows the category distribution in a pie chart, along with the remaining balance, total expenses, and overall financial status. The system also provides advice to users in the form of warnings and recommendations by tracking their expenses and displaying the highest, lowest, and average spending, as highlighted in **Figure 8**. To further enhance understanding, the system includes expense statistics presented in a pie chart, which visually represents the distribution of expenses across different categories.

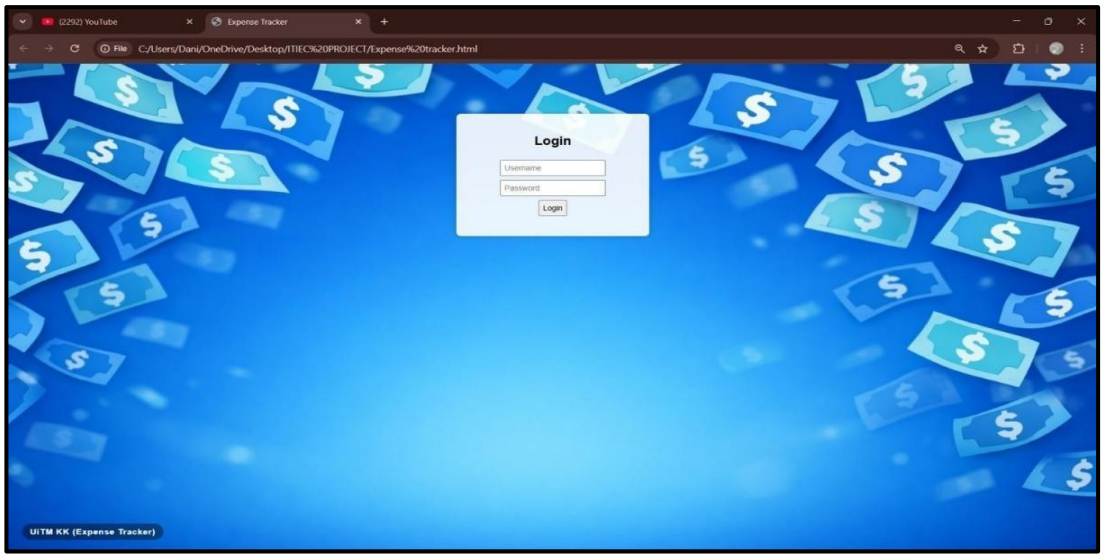


Figure 2. Login display .

Figure 3. Balance Display.

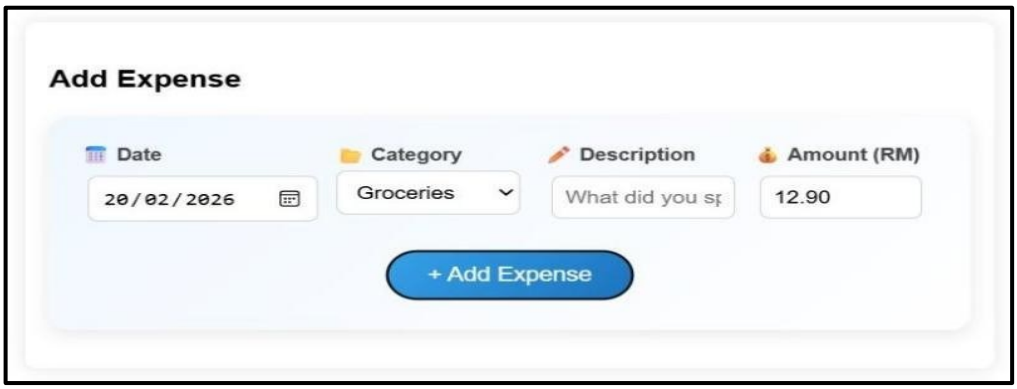


Figure 4. Add Expense Display.

Figure 5. Expense List Table.

Figure 6. Monthly and Weekly Spending Charts.

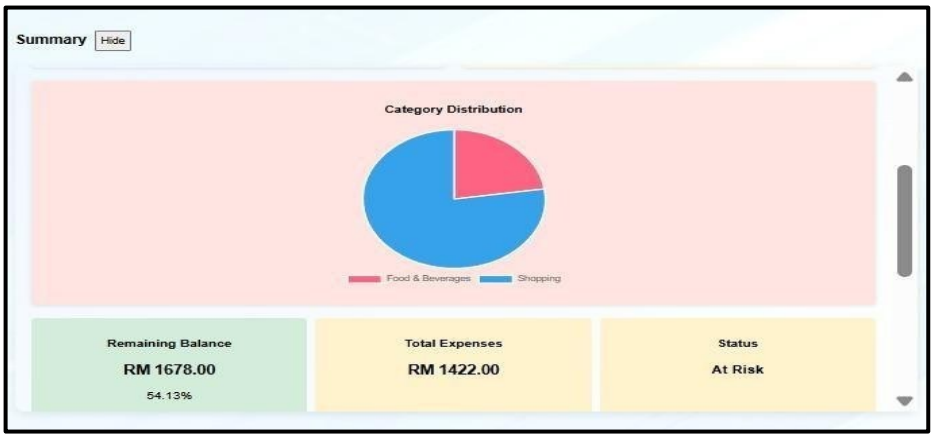


Figure 7. Category Distribution Pie Chart, Remaining Balance, Total Expenses and Status Display.

Figure 8. Warning, Recommendations, Highest, Lowest and Average Spending Display.

3. Novelty and uniqueness

The primary innovation of the proposed system lies in its transition from passive expense recording to active financial behaviour analysis. Unlike conventional expense tracking applications that merely document transactions, the system incorporates a structured financial status evaluation mechanism to assess users' spending patterns in real time. The system implements a three-level warning framework-Safe, At Risk, and Critical-which classify the user's financial condition based on their spending patterns and remaining balance. Each warning level is linked to targeted recommendations that help users manage their money more effectively and make better financial decisions. In addition to automated status monitoring, the platform integrates behavioural analytics features, including weekly and monthly expenditure summaries, category-based distribution charts, and statistical indicators such as highest, lowest, and average expenses. These analytics provide users with structured financial insights rather than simple transaction logs. By combining real-time monitoring, visual analytics, and advisory feedback, the system functions as a lightweight digital financial guidance tool. This proactive and advisory-oriented approach differentiates the platform from basic expense trackers, positioning it as a behaviour-aware personal financial management solution within the emerging digital finance ecosystem.

4. Benefit to mankind

This project promotes innovation by introducing a practical, technology-driven solution to everyday financial management challenges faced by individuals and small communities. By leveraging web-based technologies, the system demonstrates how simple yet effective digital tools can replace traditional manual processes, encouraging the adoption of innovative approaches to problem-solving. The Expense Tracker also contributes to a culture of entrepreneurship by showcasing the potential of developing user-centred applications that address real market needs. It can serve as a foundation for future enhancements such as premium features, data analytics services, or integration with financial platforms, inspiring students and developers to explore business opportunities in financial technology. Within institutions and communities, the project fosters entrepreneurial thinking by highlighting how digital solutions can be transformed into sustainable products, services, or startups that create value and improve quality of life.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by introducing a practical, technology-driven solution to everyday financial management challenges faced by individuals and small communities. By leveraging web-based technologies, the system demonstrates how simple yet effective digital tools can replace traditional manual processes, encouraging the adoption of innovative approaches to problem-solving. The Expense Tracker also contributes to a culture of entrepreneurship by showcasing the potential of developing user-centred applications that address real market needs. It can serve as a foundation for future enhancements such as premium features, data analytics services, or integration with financial platforms, inspiring students and developers to explore business opportunities in financial technology. Within institutions and communities, the project fosters entrepreneurial thinking by highlighting how digital solutions can be transformed into sustainable products, services, or startups that create value and improve quality of life.

6. Potential commercialization

The Expense Tracker has strong potential for commercialization as a user-friendly financial management tool designed for students, individuals, and small households. It can be introduced using a freemium model, where basic features are offered free of charge, while advanced functionalities such as detailed financial reports, cloud data backup, and in-depth spending analysis

are available through a paid subscription. In addition, the system can be customized and adapted for educational institutions, small businesses, or organizations to support more structured expense management. Its flexible web-based design allows for easy modification, branding, and scalability according to different user needs. With its simple interface, practical functionality, and low development cost, the application has strong potential to evolve into a competitive digital product that not only supports daily financial management but also creates sustainable revenue opportunities within the growing fintech market.

7. Acknowledgment

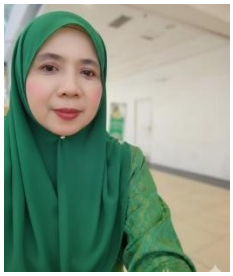
We would like to express our sincere appreciation to our advisor, Madam Norah Tuah, for her invaluable guidance, constructive advice, and continuous support throughout the development of this project. Her encouragement and insights have greatly contributed to the successful completion of this work. We are also deeply grateful to Universiti Teknologi MARA (UiTM) for providing the facilities, resources, and supportive learning environment that made this project possible. Finally, we would like to extend our heartfelt thanks to all individuals who contributed directly or indirectly to the success of this project. Their support and assistance are truly appreciated.

8. Researchers' Biography

A hmad Akmal Dinie bin Hamzria is a 1st semester student of Computer Science and Mathematics at Universiti Teknologi MARA. He served as the team leader for the Expense Tracker project and was responsible for the overall system development, implementation, and integration of key features. He coordinated team activities, ensured project progress, and oversaw the functionality and performance of the system.

Dayang Nurzahierah binti Awangku Mohd Shanizan is a 1st sem student of Computer Science and Mathematics at Universiti Teknologi MARA (UiTM). She contributed to the Expense Tracker project as the report writer and was responsible for researching ideas, gathering relevant information, and organizing project documentation to ensure clarity and completeness.

Nazrin bin Johan is 1st semester student of Computer Science and Mathematics at Universiti Teknologi MARA. He was responsible for project planning, contributing ideas, and assisting in the system development for the Expense Tracker project. His role included organizing project tasks and supporting the overall development process.



Madam Norah Tuah is a senior lecturer in the Faculty of Computer Science and Mathematics at Universiti Teknologi MARA (UiTM), Sabah Branch, Kota Kinabalu Campus. She holds a master of Engineering (Computer & Communication) and a Bachelor of Engineering in Electric, electronic & system from Universiti Kebangsaan Malaysia (UKM). Her primary research interest includes artificial intelligence, energy efficiency & wireless sensor network.

Literacy Travel Bag Innovation in Preschool Language and Literacy Learning Subject

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ABSTRACT

The Literacy Travel Bag is an interactive and portable educational kit developed to support preschool language and literacy learning for six-year-old children. The innovation is designed to transform conventional worksheet-based literacy instruction into a more engaging and hands-on learning experience. The product was developed in response to the limitations of traditional teaching methods that rely heavily on memorization and passive learning. The Literacy Travel Bag incorporates a spin wheel, colour-coded doors, syllable flashcards, a whiteboard writing surface, and a dice mechanism to structure turn-taking. Learners spin the wheel to obtain a syllable, select the corresponding-coloured door to retrieve another syllable card, combine both syllables to form a word, write the word on the whiteboard, and match it with the correct picture before spelling and pronouncing it. The main advantages of the product include its multi-sensory learning approach, portable wooden design, and structured game-based interaction that supports phonemic awareness, vocabulary development, and fine motor skills. This innovation contributes to improving early literacy readiness among preschool children, which is essential for strengthening foundational education and supporting long-term educational outcomes. The Literacy Travel Bag also presents commercialization potential as an innovative teaching aid for the preschool education sector and educational learning product markets.

Keywords: Multi-Sensory Learning, Preschoolers Literacy, Phonemic Awareness, Game-Based Learning, Interactive Educational Kit

1. Product Description

As Illustrated in **Figure 1**, the Literacy Travel Bag is a compact and portable teaching aid designed to enhance preschool language and literacy learning. It integrates a syllable spinner, colour-coded doors, syllable cards, and picture-word matching cards to create a structured, interactive, and playful learning experience suitable for six-year-old learners. Based on **Figure 2**, the activity begins when students spin the syllable spinner. After reading the displayed syllable, they identify the associated colour section, select a matching door, and retrieve a syllable card. Both syllables are then combined to form a meaningful word. Students proceed to find the corresponding picture card, spell the word, and pronounce it aloud. Turn-taking and cooperative participation encourage social interaction and peer learning, while also reinforcing self-confidence and communication skills. This multi-sensory approach supports the development of phonemic awareness, vocabulary acquisition, spelling skills, and pronunciation. Learners are encouraged to explore independently, and actively engage with the materials, making the learning process both

enjoyable and educational. The portable "travel bag" design ensures flexibility, allowing literacy activities to be conducted in any type of settings. Its durable, child-friendly materials provide longevity and adaptability across diverse learning environments. The Literacy Travel Bag is an innovative, practical, and engaging tool that effectively fosters early literacy competency, promotes interactive learning, and inspires a lifelong interest in reading and language development.

2. Pictures

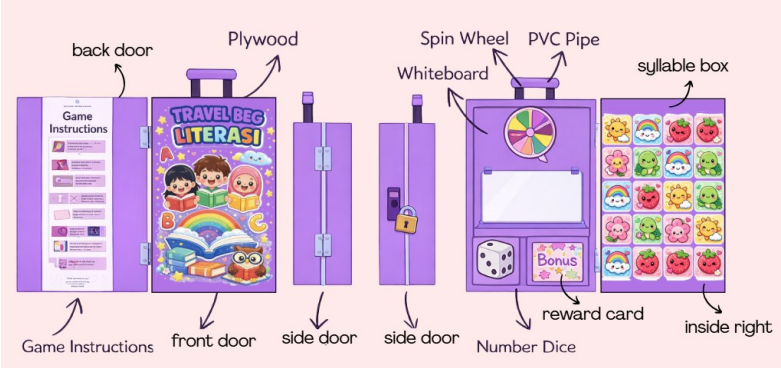

Figure 1. Early figure of final product.

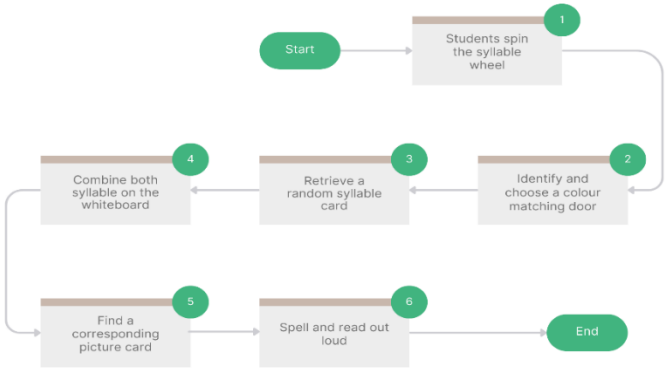

Figure 2. Game flow.

3. Novelty and uniqueness

The Literacy Travel Bag introduces a novel approach to preschool literacy learning by combining multi-sensory engagement, interactive word construction, and flexible portability. Unlike traditional worksheet-based methods, it engages learners through visual, auditory, and kinesthetics experiences, including spinning syllables, colour-coded matching, card manipulation, writing, and verbal pronunciation. This multi-sensory approach strengthens phonemic awareness, syllable recognition, vocabulary acquisition, spelling, and pronunciation while making learning enjoyable and memorable. The system allows children to actively construct words from syllables, promoting deeper understanding of language structures rather than passive memorization. Integrated turn-taking and cooperative mechanisms foster peer interaction, social skills, and collaborative problem-solving—features often missing in conventional literacy tools. Its portable "travel bag" design ensures flexibility, allowing activities to be conducted inside the classroom, at home, or in outdoor learning settings, making it highly adaptable to diverse environments.

Constructed with durable, child-friendly materials, the bag balances educational effectiveness with playful engagement, ensuring repeated use and longevity. Combining pedagogical innovation, interactive play, and practical portability, the Literacy Travel Bag represents a unique and commercially viable tool that enhances early literacy learning while promoting active participation, social interaction, and lifelong interest in language development.

4. Benefit to mankind

The Literacy Travel Bag contributes significantly to human development by fostering early literacy skills, which are fundamental for lifelong learning. By enhancing phonemic awareness, vocabulary, spelling, and communication skills**,** it equips preschool learners with the foundation for academic success and effective social interaction. The system promotes active participation, self-directed exploration, and peer collaboration**,** supporting social and emotional development while encouraging cooperative behaviour from a young age. Its portable design allows parents and caregivers to engage in literacy activities at home, strengthening home-school partnerships and fostering a culture of reading and learning within families. By providing an innovative, accessible, and engaging tool, the Literacy Travel Bag helps nurture confident, communicative, and literate individuals**,** thereby contributing to the development of a knowledgeable and skilled society, capable of lifelong learning and meaningful participation in the community.

5. Innovation and Entrepreneurial Impact

The Literacy Travel Bag exemplifies educational innovation by transforming traditional preschool literacy methods into an interactive, multi-sensory learning system. Its combination of visual, auditory, and kinaesthetic activities introduces a creative approach to early literacy, encouraging educators to adopt novel teaching strategies and rethink conventional classroom practices. From an entrepreneurial perspective, the product demonstrates commercial potential within the preschool education sector. Its portable design, durable materials, and structured yet playful methodology make it a market-ready educational tool suitable for schools, learning centres, and home-based programs. By integrating pedagogy with product design, the Literacy Travel Bag fosters a culture of innovation and entrepreneurship within the community and institutions. It inspires educators, parents, and aspiring entrepreneurs to explore educational product development, creating opportunities for start-ups, small businesses, and educational enterprises that contribute to the growth of the early childhood education industry.

6. Potential commercialization

The Literacy Travel Bag has strong potential for commercialization within the preschool education market. Its portable, durable, and user-friendly design makes it suitable for use in schools, learning centres, and home-based programs. The product addresses a growing demand for interactive and multi-sensory educational tools that engage young learners beyond traditional worksheets and textbooks. The structured yet playful activities, combined with its innovative approach to early literacy, position the Literacy Travel Bag as a unique offering that can differentiate educational suppliers in a competitive market. Manufacturers and distributors can market it as a ready-to-use, educational kit for teachers, parents, and caregivers, while also exploring digital or supplementary learning materials to enhance its value. By combining pedagogical effectiveness with practical portability, the Literacy Travel Bag creates opportunities for entrepreneurial ventures, start-ups, and educational enterprises**,** contributing to both the growth of early childhood education resources and the broader educational products industry.

7. Acknowledgment

The authors would like to express sincere appreciation to Akademi TVET Unirazak for providing academic support and facilities throughout this project. Special thanks are extended to the supervisor, preschool teachers and participating students for their continuous guidance and professional support and encouragement in completing this innovation project. Their contributions were invaluable in the development, testing, and completion of the Literacy Travel Bag project.

8. Researchers' Biography

Mohamad Firdaus Mohd Rusihan is a Pegawai Penilai at Akademi TVET Unirazak specializing in preschool teaching, early childhood pedagogy, curriculum design, and educational innovation. He actively supervises student projects that integrate practical teaching solutions with industry relevance.

Nik Sabariah Nik Abdullah is a Pegawai Pengesah Dalaman at Akademi TVET Unirazak with expertise in preschool curriculum, early childhood education management and instructional strategies. She supervises innovation-based academic projects aimed at enhancing preschool teaching quality.

Naz Rafisya Aqilah is a final-year student in the DKM Preschool Teaching and Education Administration programme at Akademi TVET Unirazak. Her academic interests include early literacy development, interactive learning strategies, and play-based pedagogy. She is passionate about designing creative teaching aids that enhance young children's language acquisition and cognitive development.

Nursyaliatie is a final-year student in the DKM Preschool Teaching and Education Administration programme at Akademi TVET Unirazak. She focuses on child-centred learning approaches and innovative instructional materials. Her work emphasizes improving literacy engagement through hands-on and experiential learning methods.

Neulearn: The Ultimate User-Friendly Interface for Smart Academic Management

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[1]Department of Educational Technology, Faculty of Education, Universitas Negeri Malang, Malang, East Java, Indonesia
[2]Department of Indonesian Language Education, Faculty of Letters, Universitas Negeri Malang, Malang, East Java, Indonesia
Corresponding author: zaaraafira2256@gmail.com

ABSTRACT

Neulearn: The Ultimate User-Friendly Interface for Smart Academic Management is an AI-integrated Learning Management System (LMS) designed to optimize academic management through intelligent automation and centralized digital infrastructure. Developed in response to the growing administrative burden faced by educators and the unintegrated use of external AI tools by students, Neulearn embeds artificial intelligence directly into the system to streamline academic workflows within a single unified platform. The platform's key features include an AI-Powered Educator Forum and an Automated Grading system capable of generating scores and detailed feedback aligned with instructor- uploaded rubrics. Additional capabilities encompass automatic class creation, secure examination management, and an integrated AI assistant (Copilot) that eliminates the need for external platforms. Native AI integration and intelligent video management further enhance operational efficiency. From a socio-economic standpoint, Neulearn broadens access to premium AI technology and improves institutional operational efficiency. Commercially, the platform is positioned as a sustainable B2B solution operating under an institutional licensing model, making it scalable and adaptable for educational institutions at various levels.

Keywords: Learning Management System; Artificial Intelligence; Educational Technology; Academic Management; EdTech Innovation.

1. Product Description

Neulearn: The Ultimate User-Friendly Interface for Smart Academic Management is an AI-integrated Learning Management System (LMS) engineered to optimize academic management intelligently and efficiently. The platform is built upon the development of an LMS ecosystem that seamlessly supports the activities of both educators and students within a unified digital environment. Neulearn operates through two main portals. The Educator Portal offers AI-powered features including automatic class creation via text description or visual input, rubric-based assignment grading automated by AI, individual task recapitulation, and an Exam Protector feature that restricts browser activity during examinations to uphold academic integrity. The Student Portal provides an integrated AI assistant (Copilot), eliminating the need for external platforms when seeking information. Additional features include AI-based video management, academic performance tracking (performance grade), structured assignment lists, and a systematic assessment extension submission system. With a comprehensive AI integration and an intuitive user-friendly interface, Neulearn delivers a modern academic management solution that is fully adaptive to the ongoing transformation of digital education.

2. System Flowchart, User Interface, and Feature Comparison

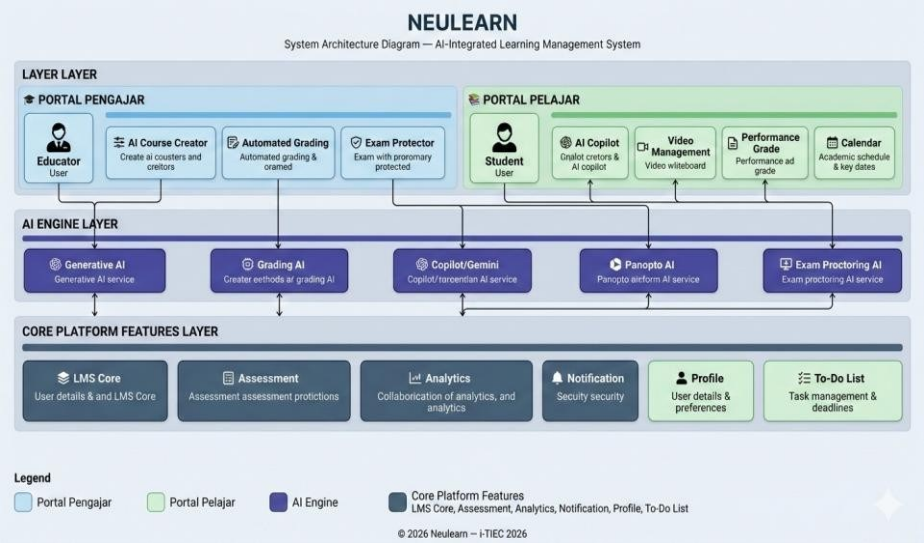

Figure 1. Neulearn Learning Management System Flowchart.

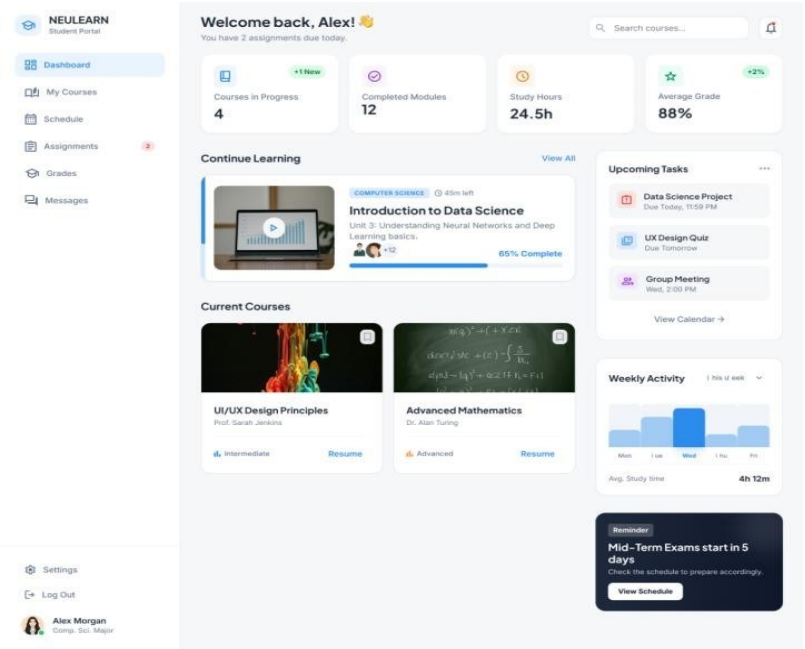

Figure 2. Neulearn User Interface Design.

Table 1. Feature Comparison of Neulearn, Conventional LMS, and Standard LMS.

Feature	***Neulearn***	***Conventional LMS***	***Standard LMS***
AI Course Creator (automatic material generation)	Available (Generative, instant)	Not available	Not available
Automated Grading with Explanation	Available (Rubric analysis + logical feedback)	Not available	Limited / Requires add-on
AI Assistant Integration (Copilot/Gemini)	Available (Native, no external platform required)	Not available	Not available
Intelligent Video Analysis	Available (Panopto integrated)	Not available	Limited / Requires add-on
Exam Protector (Browser locking)	Available	Not available	Limited / Requires add-on
Real-time Performance Dashboard	Available	Limited / Requires add-on	Available
Centralized Institutional License	Available (Enterprise license)	Available	Available

3. Novelty and uniqueness

The primary novelty of Neulearn lies in its integration of generative AI as a creative assistant for educators in developing teaching materials. Unlike conventional LMS platforms that merely serve as content repositories, Neulearn enables educators to instantly generate complete course components — including class descriptions, visual assets, brief assessments, and learning materials — based solely on a given topic input. This feature significantly reduces administrative workload and accelerates course preparation. A further distinction is the AI-Powered Educator Forum with its Automated Grading system. This feature enables AI to analyze student assignments based on instructor-uploaded rubrics, producing not only scores but also logical explanations aligned with rubric indicators, thereby enhancing the objectivity and transparency of assessment. Additionally, Neulearn offers native integration with advanced AI technologies such as intelligent video analysis (Panopto) and research assistants (Copilot/Gemini) within a single unified ecosystem, allowing students to engage in academic exploration without switching between external platforms. By delivering a cohesive and user-friendly AI experience, Neulearn transcends the conventional LMS model, functioning as a comprehensive digital academic infrastructure that integrates course creation, automated assessment, learning analytics, and research support in one structured platform.

4. Benefit to mankind

Neulearn contributes to democratizing access to premium Artificial Intelligence (AI) technology for students across diverse economic backgrounds. By embedding AI directly within the LMS, students no longer need to subscribe to additional platforms to obtain technology-driven academic support, effectively narrowing the digital divide and fostering a more inclusive and equitable learning environment. For educators, Neulearn significantly alleviates administrative workload through automated grading, task recapitulation, and AI-based classroom management.

This efficiency allows educators to redirect their time and energy toward personal interaction, character development, and the cultivation of students' critical thinking competencies. On a broader scale, Neulearn supports an adaptive, transparent, and quality-oriented digital education transformation, ultimately creating a productive and sustainable learning experience for society at large.

5. Innovation and Entrepreneurial Impact

Neulearn fosters a data-driven and technology-oriented educational culture within academic institutions. By integrating Artificial Intelligence into the academic management system, the platform introduces data-driven decision-making in learning evaluation, student performance monitoring, and classroom management, encouraging institutions to adapt to digital transformation in a systematic and innovative manner. From an entrepreneurial perspective, Neulearn creates opportunities for the emergence of a new EdTech ecosystem through a centralized licensing model that enables institutions to manage AI-powered services efficiently within a unified platform. This scheme promotes strategic collaboration between educational institutions and technology providers, simultaneously generating partnership-based business opportunities. Accordingly, Neulearn not only delivers technological innovation but also contributes to strengthening entrepreneurship within the education sector through a scalable and sustainable solution.

6. Potential commercialization

Neulearn is positioned as a Business-to-Business (B2B) solution targeting higher education institutions, schools, and corporate training providers. Its commercialization strategy centers on an institutional licensing model that enables centralized user management through annual or multi-year subscription schemes, offering high scalability and flexible implementation tailored to each institution's needs. The commercial value of Neulearn lies in the operational efficiency generated through AI- powered assessment automation, task recapitulation, and classroom management. These features deliver a measurable Return on Investment (ROI) for institutions, particularly in the form of time savings and a significant reduction in educators' administrative workload. Through an efficiency-driven approach and comprehensive AI integration, Neulearn holds strong market potential within the rapidly expanding global EdTech industry.

7. Acknowledgment

The authors would like to express their deepest gratitude to the supervising lecturer, Dr. Muhibuddin Fadhli, M.Pd., for the invaluable guidance, constructive feedback, and unwavering support provided throughout the development of this work. His expertise and dedication have been pivotal in shaping the direction and overall quality of this project. The authors also disclose that artificial intelligence (AI) tools were utilized in approximately 40% of the writing process, primarily for language refinement and translation purposes. All ideas, analyses, and conclusions presented in this work remain solely the original contribution of the authors.

8. Researchers' Biography

Alifia Shafarotuz Zahra is an active undergraduate student in the Educational Technology program at Universitas Negeri Malang. Her academic interests lie in learning content development, copywriting, and visual design, particularly in educational technology integration. She is a recipient of 3rd Place at the FIP JIP 2025 National Competition and a book-writing award published by Media Guru Indonesia. She also serves as a facilitator in student training programs and holds a position at the Regional Board of Ikatan Pelajar Muhammadiyah (IPM) Kota Batu. In the Neulearn project, she serves as the UI/UX Developer

Dayang Nurzahierah binti Awangku Mohd Shanizan is a 1st sem student of Computer Science and Mathematics at Universiti Teknologi MARA (UiTM). She contributed to the Expense Tracker project as the report writer and was responsible for researching ideas, gathering relevant information, and organizing project documentation to ensure clarity and completeness.

Valenia Citra Amartha is a fourth-year undergraduate student in the Educational Technology program at Universitas Negeri Malang. Her academic interests include graphic design and digital branding within educational technology. She has presented at the 4th International Conference on Educational Management and Technology and is actively engaged as a graphic designer at the ASEAN Youth Organization and Kejar Mimpi by CIMB Niaga. In the Neulearn project, she serves as the UI/UX Developer.

Zaara Safira is an undergraduate student in the Educational Technology program at Universitas Negeri Malang, specializing in interactive media development and 2D/3D animation. She has international collaboration experience in animation projects such as *Doggyland* and *Bob the Train*, and has contributed to a national literary modernization project with Kemendikbudristek. She holds a BNSP-certified competency as a 3D Junior Animator and serves as a practicum assistant for the Graphic and Visual Media Innovation course. In this project, she serves as the Team Leader.

Cognitrace

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ABSTRACT

This project introduces Cognitrace, an advanced AI-based pedagogical platform designed to combat the crisis of "instant answer dependency" among students. Designed using the Socratic framework and Lev Vygotsky's scaffolding theory, this innovation transforms the role of AI from a mere answering machine to a cognitive gatekeeper that prioritizes the process of understanding. The system's main uniqueness lies in its mandatory "Mind-Check" protocol, which blocks immediate assistance until users demonstrate initial efforts at problem-solving. Furthermore, the platform features an adaptive environment: Guider Mode for step-by-step guidance, Teach-Mode using the Feynman Technique, and Debater Mode for testing logical reasoning. Socially, Cognitrace fosters a resilient and intellectually strong generation capable of rational argumentation in a complex global era. Economically, the platform has substantial commercialization potential in the global EdTech market through subscription-based and institutional licensing models. By rewarding intellectual resilience through gamified engagement scores, Cognitrace ensures that human critical thinking remains the primary driver in an AI-supported world.

Keywords: Cognitrace, Socratic framework, scaffolding, Feynman Technique, critical thinking.

1. Product Description

Cognitrace is a sophisticated AI-driven pedagogical platform engineered to transform digital learning from passive consumption into active cognitive engagement. Addressing the crisis of "instant-answer dependency," this application functions as a Socratic personal tutor that prioritizes the journey of understanding over the final result. The system's architecture is anchored by the mandatory "Mind-Check" gateway, an "attempt-before-assist" protocol that blocks direct answers until the user submits their initial logic or draft solution. Upon analysis, the AI dynamically transitions between three specialized learning environments: Guider Mode: Employs scaffolding techniques to provide incremental hints, triggering "eureka moments" for struggling users without revealing the solution. Teach-Mode: Utilizes the Feynman Technique, where the user must explain the concept back to the AI, ensuring fundamental mastery rather than rote memorization. Debater Mode: A critical-thinking "stress test" where the AI challenges the user's reasoning through counter-arguments and "why" inquiries. The session concludes with a Synthesized Reflection and a Engagement Score, rewarding intellectual resilience and analytical depth. By integrating these advanced methodologies, Cognitrace ensures that human critical thinking remains the primary driver in an AI-enhanced world

2. Graph and Table About Frequency of Using AI and The Effect to Critical Thinking.

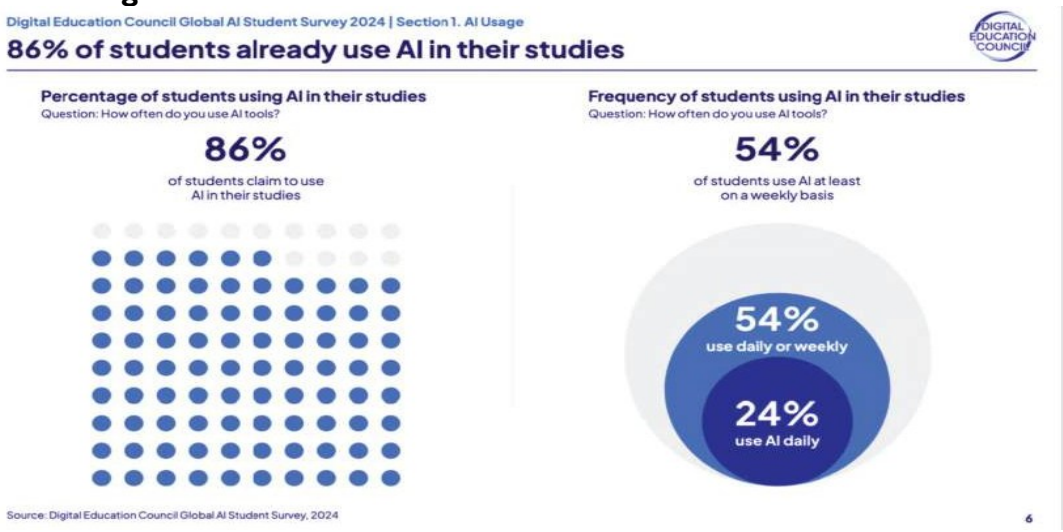

Figure 1. Percentage of the students using AI in their studies.

A survey by the Digital Education Council involving 3,839 university students from 16 countries found that 86% of students use artificial intelligence in their studies, with many using it frequently. On average, students use 2.1 AI tools, with ChatGPT being the most common (66%), followed by Grammarly and Microsoft Copilot (25% each). Students primarily use AI to search for information, check grammar, summarize texts, paraphrase documents, and create first drafts. However, despite the widespread use of AI, many students feel they lack sufficient AI knowledge and skills, and nearly half feel unprepared for an AI- driven workforce. Additionally, 80% believe their universities have not met expectations in integrating AI into education, leading students to call for more AI literacy courses, training for both students and faculty, greater involvement in AI-related decisions, and increased use of AI in teaching and learning.
Source : https://campustechnology.com/articles/2024/08/28/survey-86-of-students- already-use-ai-in-their-studies.aspx

Statement	Mean	Standard Deviation
AI dependency reduces my critical thinking ability	4.01	0.91
I am not sure about ethical boundaries of using AI in academic	3.48	0.79
University did not provide any ethical guidelines of using AI	3.45	1.06
I have not got any ethical awareness training in AI	3.7	0.93

Figure 2. Descriptive Analysis of Engineering Students Responses.

The study found that AI dependency and its potential to reduce critical thinking received the highest agreement from students (mean = 4.01), suggesting that many believe excessive reliance on AI may negatively affect their ability to think critically. Some students explained that AI can reduce mental effort when completing assignments, while others argued that using AI

still requires critical engagement, particularly when designing effective prompts to obtain accurate results. In addition, students expressed uncertainty about ethical boundaries related to AI use (mean = 3.48) and felt that their universities have not provided sufficient ethical guidelines (3.45) or awareness training (3.70) regarding AI usage. The relatively high standard deviation (1.06) for the statement about university guidelines also indicates significant differences in students' perceptions of the support provided by their institutions. Source : https://www.researchgate.net/publication/399094945_AI_as_a_Learning_Partner_Exploring_Ethical_Awareness_of_Engineering_Students

3. Novelty and uniqueness

Novelty offered by Cognitrace platform lies in its AI, which is not only used to provide instant answers, but also as a cognitive gatekeeper. Unlike other AI, the AI in Cognitrace functions as an assistant that helps improve critical thinking skills. Cognitrace AI does not provide instant answers. Therefore, the Cognitrace application adapts Lev Vygotsky's learning theory of caffolding. This adaptation is an effort to help users maximize their cognitive abilities. It does this by limiting access to answers until users demonstrate their initial understanding. In this way, users' cognitive abilities can become more critical. There is also a debate mode that employs the Socratic approach. The Socratic approach aims to explore understanding through continuous discussion by asking a barrage of questions. Users and Cognitrace AI will test each other's arguments. So, it can be seen that the innovation lies in AI acting as a thinking engine, not just an answer engine.

4. Benefit to mankind

By strengthening human critical thinking skills in an era of technological dependence, Cognitrace platform provides broad benefits to society. This innovation shifts the role of AI from simply providing answers to enhancing thinking skills. By building resilience in the face of mistakes, encouraging cognitive abilities, and maintaining rational arguments, Cognitrace can help build a foundation for critical thinking in society. In the long term, this innovation supports the formation of a generation that is not only academically intelligent, but also intellectually strong. This system contributes to shaping a generation capable of critical thinking, evaluation, and rational argumentation, not merely obtaining information instantly. This is relevant for the world of education, human resource development, and decision-making in society. By positioning AI as a cognitive coach, this innovation supports the creation of individuals who are reflective, adaptive, and resilient in the face of global complexity.

5. Innovation and Entrepreneurial Impact

Cognitrace emphasizes innovation that has the potential to be implemented in schools in the form of an AI-based learning platform that focuses on strengthening the thinking process. Through a cognitive and metacognitive psychology approach, Cognitrace provides a solution for reflecting on the thinking process, helping students learn to analyze mistakes, and gradually build understanding. Thus, this approach can create a more exploratory and interactive learning environment that improves students' critical thinking skills. From an entrepreneurial perspective, the implementation of Cognitrace in schools can develop students problem-solving and creativity skills, enabling them to achieve critical thinking independence. Thus, the implementation of the Cognitrace platform can open up collaboration between the education community, schools, and technology developers in creating an innovative and adaptive learning ecosystem. Therefore, it

can be concluded that Cognitrace has the potential to improve critical thinking skills and build an innovative generation with an entrepreneurial spirit.

6. Potential commercialization

Cognitrace has substantial commercialization potential within the fast-growing global EdTech industry, as digital learning and AI-assisted education continue to expand across schools and universities. The increasing adoption of intelligent platforms, evident in the global success of companies like Duolingo and Quizlet, demonstrates strong market demand for innovative academic solutions. Cognitrace can position itself as a premium academic AI platform that enhances learning efficiency, supports measurable academic improvement, and aligns with outcome-based education systems promoted by institutions worldwide. Its commercialization potential includes subscription-based models, institutional licensing agreements, and integration into university learning management systems. With scalable cloud infrastructure and opportunities for regional and global expansion, Cognitrace can penetrate emerging and developed markets alike, making it financially sustainable and competitively positioned in the evolving future of education technology.

7. Acknowledgment

The author would like to express his deepest gratitude to Diponegoro University for providing a supportive academic environment for innovation and research excellence. We extend our highest appreciation and gratitude to our supervisor, Ika Zenita Ratnaningsih, S.Psi, M.Psi, Ph.D, Psychologist, for her invaluable guidance, direction, and support throughout the development of Cognitrace. We also thank our colleagues for their input, as well as the organizers of the 3rd International Tinker Innovation S Entrepreneurship Challenge (i-TIEC 2026) for providing this platform to showcase our project. This work is a collaborative effort aimed at strengthening digital integrity and supporting sustainable education in the AI era.

8. Researchers' Biography

Farah Zahra Afifah is an undergraduate Psychology student at Diponegoro University, currently in her second semester. She is an active member of Islamic Psychology Development Study Group, where she explores the integration of contemporary psychological theories with Islamic perspectives. As an emerging scholar, she is committed to strengthening her critical thinking, academic writing, and research skills. She is eager to participate in scientific competitions and research initiatives to expand her academic exposure and contribute meaningfully to the advancement of the field of psychology.

Wilbert Silalahi is a Psychology student at Diponegoro University who is curious about what shapes human thoughts, emotions, and behavior. In his second semester, he is exploring psychological theories while reflecting on them through his Christian worldview. He enjoys asking questions, discussing ideas, and learning beyond the classroom. Wilbert is committed to growing as a young researcher by improving his critical thinking and writing skills. He hopes to join research projects and competitions to challenge himself, gain new insights, and contribute to the development of psychology.

Danish Alfarisy is an undergraduate Computer Engineering student at Diponegoro University, currently in his fourth semester. He actively participates in academic and organizational activities that explore the intersection of technology, data, and real-world problem solving. Danish is passionate about algorithm design, system architecture, and AI-driven innovation, particularly in developing intelligent systems with human-centered approaches. Through competitions and research collaborations, he aims to contribute to technological advancements that strengthen digital integrity and support sustainable development in the information era.

Smart Feeder: IoT-Based Automatic Pet Feeding and Water Monitoring System

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ABSTRACT

SMART FEEDER is an Internet of Things (IoT)–based automatic feeding system designed to monitor and control pet food and water supply in real time. This project was developed to address common problems faced by pet owners, such as irregular feeding schedules, inaccurate portioning of food, and lack of remote monitoring. The system integrates an automatic feeding mechanism with a mobile application using the Blynk platform, allowing users to monitor food and water levels anytime and anywhere. The system utilizes a load cell sensor to accurately measure the weight of pet food dispensed, ensuring precise portion control according to predefined settings. A servo motor is employed to automatically open and close the food container based on scheduled feeding times or manual control via the application. For water monitoring, an ultrasonic sensor is used to measure the water level in the drinking container, while a water pump draws water from a storage tank when the level falls below a specified threshold. SMART FEEDER offers advantages such as automation, real-time monitoring, ease of use, and improved pet care management. This innovation has the potential to enhance pet welfare, reduce owner workload, and provide commercial opportunities in the smart pet care industry.

Keywords: Smart Feeder, Internet of Things, Blynk Application, Load Cell Sensor, Automatic Pet Care

1. Product Description

SMART FEEDER is a smart pet feeding system that combines hardware and software components to provide automated feeding and monitoring. The system is controlled by a microcontroller programmed using the Arduino IDE, with the main control logic implemented in the *SMART_FEEDER*. The food dispensing mechanism uses a load cell sensor to measure the exact weight of food released, ensuring accuracy and consistency. A servo motor controls the opening and closing of the food outlet automatically based on feeding schedules. For water management, an ultrasonic sensor detects the water level in the pet's drinking bowl, and a water pump transfers water from a tank when required. All sensor data and control functions are synchronized with the Blynk mobile application, enabling real-time monitoring, notifications, and manual overrides. This system is designed to be reliable, efficient, and user-friendly for daily pet care.

Figure 1 Project View. It looks simple but multifunctional, with this project it can make it easier to maintain, especially the sophisticated automatic feeding which can be monitored.

2. System Overview and Application Interface

Figure 2. Monitoring Dashboard.

Figure 2 illustrates the interface of the SMART FEEDER mobile app developed using the Blynk platform. This app is designed to provide real-time monitoring and control of an automated pet feeding system. The interface displays the current food weight, measured by a load cell sensor, and the water level, detected by an ultrasonic sensor. These parameters allow users to continuously monitor the availability of food and water for their pets. Furthermore, the app

displays scheduled feeding times, allowing users to accurately manage feeding routines. A manual control option is also provided, allowing users to remotely activate the feeding mechanism when needed. The integration of real-time data visualization and remote control enhances user convenience and ensures effective pet care management.

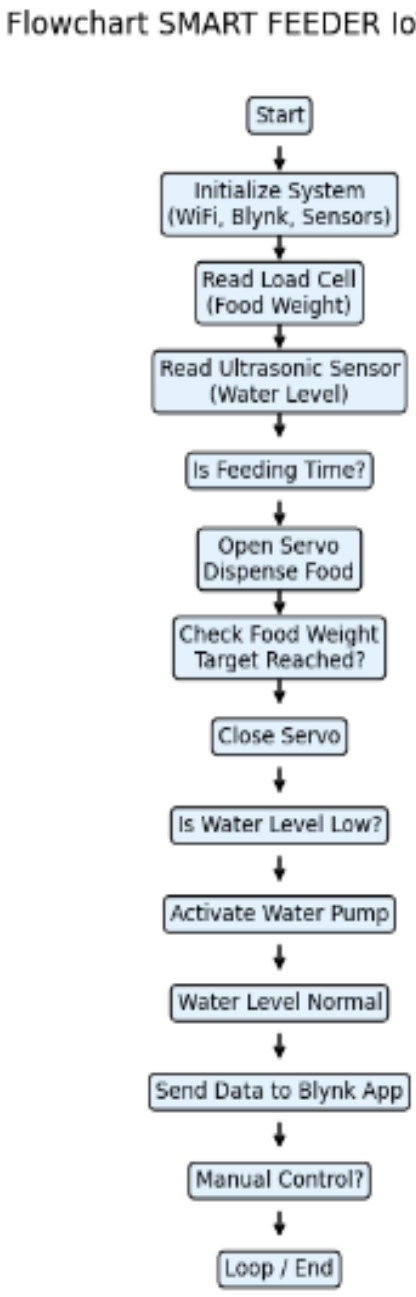

Figure 3 Flowchart

The flowchart illustrates the operational workflow of the SMART FEEDER IoT-based automatic pet feeding system. The process begins with the Start state, which indicates that the system is powered on and ready to operate. At the initialization stage, the system performs Initialize

System, where the microcontroller establishes a Wi-Fi connection, synchronizes with the Blynk cloud platform, and initializes all sensors and actuators. This step ensures that the system is ready for real-time monitoring and control. Next, the system reads the food weight through the Load Cell Sensor to determine the amount of pet food available. Simultaneously, the Ultrasonic Sensor measures the water level in the drinking container to monitor water availability. The system then checks whether the current time aligns with the predetermined feeding schedule through the "Is It Time to Feed?" decision process. If the condition is met, a servo motor is activated to open the food dispenser and dispense food. During this process, the system continuously monitors the food weight to ensure the target portion size is reached. Once the desired food weight is reached, the servo motor automatically closes to prevent overfeeding. After the feeding process, the system evaluates the water level using the "Is It Time to Feed?" decision process. The water pump is activated to refill the water container from the water tank. The pump stops automatically based on the predetermined settings in the coding. All collected sensor data and system status are then transmitted to the Blynk Mobile App in real time, allowing users to remotely monitor food weight, water level, and feeding status. Additionally, the system provides a Manual Control option, allowing users to override automatic operation through the mobile app if needed. Finally, the system enters a Loop state, continuously repeating the monitoring and control process to ensure consistent and reliable operation of the SMART FEEDER.

3. Novelty and uniqueness

The novelty of SMART FEEDER lies in its integrated approach to precise food weight measurement and automated water level management within a single IoT-enabled system. Unlike conventional automatic feeders that rely on time-based dispensing, SMART FEEDER uses a load cell sensor to ensure accurate food portions based on weight. Additionally, the combination of ultrasonic water level sensing and automatic water refilling enhances reliability and pet safety. The integration with the Blynk application provides real-time monitoring, remote control, and user-friendly visualization, making the system accessible even for non-technical users. This combination of accuracy, automation, and remote accessibility distinguishes SMART FEEDER from existing solutions.

4. Benefit to mankind

SMART FEEDER provides significant benefits by improving pet welfare and supporting responsible pet ownership. The system ensures pets receive food and water on time with accurate portions, reducing health risks associated with overfeeding or underfeeding. For pet owners, it reduces daily workload and provides peace of mind through remote monitoring. In a broader context, this system supports smart living concepts and demonstrates the practical application of IoT technology in everyday life, contributing to increased awareness and adoption of smart home solutions.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by applying IoT technology to solve real-world pet care problems. SMART FEEDER encourages interdisciplinary learning involving electronics, programming, and mobile application development. From an entrepreneurial perspective, the project demonstrates strong potential as a commercial smart pet care product, fostering creativity, problem-solving skills, and entrepreneurial thinking among students and developers.

6. Potential commercialization

SMART FEEDER has strong commercialization potential in the growing smart pet care market. The system can be developed into a consumer-ready product with customizable features, mobile application enhancements, and scalable cloud services. Potential customers include pet owners, pet shops, veterinary clinics, and smart home solution providers. With further refinement, the product could be marketed as an affordable and reliable smart feeder solution.

7. Acknowledgment

The authors would like to express their sincere gratitude to all individuals and institutions that provided guidance, support, and resources throughout the development of the SMART FEEDER project.

8. Researchers' Biography

Delon Dede Afdilah is a Student and Research Leader at the Smart_Feeder Project, specializing in intelligent technology. With over 2 years of experience, I contributed to the creation of this intelligent system project until it was ready to use. Our work is very good and widely useful among the community, with many publications and high-impact awards. I have won 3 gold medals in information technology competitions and 1 silver medal in graphic design competitions, including national and international Research Awards, which recognize its significant contribution in modernizing and securing electric power infrastructure.

Fathi Ahyar is a Student and Fellow in the Smart_Feeder Project, specializing in smart technology. With over two years of experience, I have contributed to the development of this smart system project until it is ready for use. Our work is excellent and widely beneficial to the community, with numerous publications and prestigious awards. I have won three gold medals in information technology competitions and one silver medal in a graphic design competition, including national and international Research Awards, which recognize my significant contributions to the modernization and security of electric power infrastructure.

Muhammad Irsan is a Student and Fellow in the Smart_Feeder Project, specializing in smart technology. With over two years of experience, I have contributed to the development of this smart system project until it is ready for use. Our work is excellent and widely beneficial to the community, with numerous publications and prestigious awards. I have won one gold medal in an information technology competition and one silver medal in a graphic design competition, including national and international Research Awards, which recognize my significant contributions to the modernization and security of electric power infrastructure.

Methylene Blue Removal via Unplanted Vertical Flow Constructed Wetland with Enriched Riverbank Soil

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ABSTRACT

This study investigates the removal of Methylene Blue (MB) by acclimatized soil microbes and evaluates its biodegradation efficiency in an unplanted vertical flow constructed wetland using riverbank soil enriched with vermicompost. A three-stage experimental were designed, comprising preliminary studies, microbial acclimation & adsorption, and cycled vertical flow operation with and without sucrose, to analyze biodegradation. Color removal, pH, UV–Vis absorbance (664nm), and COD were monitored. The biodegradation kinetics of MB were analyzed using a pseudo-first-order model, demonstrating a good kinetic fit and effective microbial degradation. The findings highlight the potential of unplanted, microbe-enriched constructed wetlands as a cost-effective and environmentally sustainable solution for dye-contaminated wastewater treatment. The unplanted, microbe-enriched wetland offers a low-cost, energy-efficient, and environmentally sustainable alternative for textile wastewater treatment, with potential socio-environmental benefits through pollution reduction and water resource protection. Its simple design and use of locally available materials indicate strong potential for scale-up and practical commercialization in developing and industrial regions for textile wastewater treatment.

Keywords: Abstract , Novelty and Uniqueness , Benefit to mankind , Innovation & Entrepreneurship , Potential Commercialization

1. Product Description

The product is a compact, modular, unplanted vertical flow constructed wetland designed for the biodegradation of dye-contaminated wastewater, specifically Methylene Blue. Wastewater passes through a multilayer system—bottom gravel, middle coarse sand, and top riverbank soil enriched with vermicompost—which supports acclimatized microbial consortia that actively degrade the dye under predominantly anaerobic, low-energy conditions. Optional sucrose supplementation can further stimulate microbial activity for enhanced removal. The system is lightweight, low-maintenance, and scalable, making it suitable for small and medium textile industries, rural communities, and decentralized wastewater treatment facilities. By efficiently removing toxic dyes, it contributes to SDG 6 (Clean Water and Sanitation), encourages sustainable industrial practices (SDG 12), and protects aquatic ecosystems (SDG 14). Its microbe-driven, chemical-free approach, combined with modular design and use of locally available materials, makes it a promising commercial solution for sustainable wastewater management.

2. Research Methodology & Results

Stage 1 Preliminary Studies

Preliminary studies were conducted for 7 days to establish a baseline of native soil microbial activity using riverbank soil (~750 g) enriched with 15 g vermicompost in six 1.5 L PET bottles. Treatments included 10 and 50 mg/L Methylene Blue with 1% sucrose and 50 mg/L without sucrose (control), under shaded anaerobic conditions at ~25 °C. Methylene Blue removal was assessed after 7 days by decolorization, pH, and UV–Vis absorbance at 664 nm, addressing Objective.

Table 1 Preliminary Results

Treatment	Initial pH	Average Final pH	Colour Changes
10 mg/L MB + 1% sucrose	6.23	4.38	Clear
50 mg/L MB + 1% sucrose	6.29	4.39	Light brown
50 mg/L MB	6.65	6.49	Blue-green

Using the initial pH as baseline, treatments with 1% sucrose showed significant pH drop and decolorization, while MB alone showed minimal change, indicating sucrose enhances microbial degradation (**Table** 1).

Stage 2 Acclimation & Adsorption Studies (Batch Experiment)

Adsorption Studies

To distinguish true biodegradation from adsorption, a portion of riverbank soil (~750 g) was sterilized in Pyrex clear bottles using a TOMY SX-500 autoclave at 121 °C for 1 hour. After autoclaving, the soil was allowed to cool to room temperature in a laminar flow hood before adding Methylene Blue solution. This sterilized soil was used as a control to determine non-biological removal. The bar graph below indicates the overall % removal of adsorption (**Figure 1**).

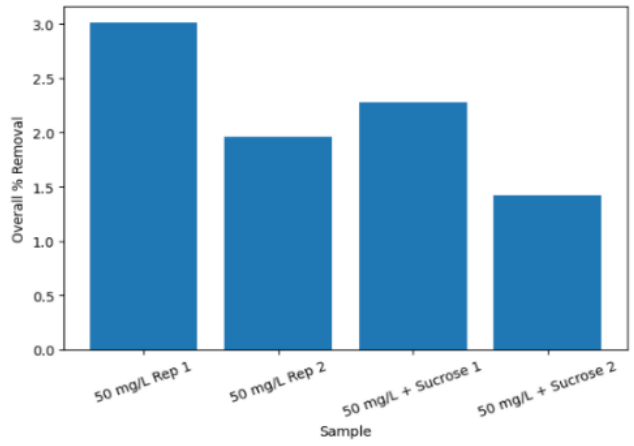

Figure 1 Overall % Removal of adsorption

Acclimation & Kinetic Studies

Stage 2 (~5 days) involved acclimating riverbank soil microbes with slight vermicompost enrichment at higher MB levels. Treatments included 50 mg/L MB and 50 mg/L MB with sucrose (both in duplicate). Experiments were conducted under shaded conditions at ~25 °C in a sealed

anaerobic system. Daily monitoring of MB removal was performed using UV–Vis absorbance at 664 nm, along with pH and discoloration, and the data were used to model microbial degradation kinetics. The following shows the Cumulative Removal Efficiency(%) of Batch Studies, where the Sucrose-amended system has higher removal efficiency than non amended system due higher microbial activity.(**Figure 2**).

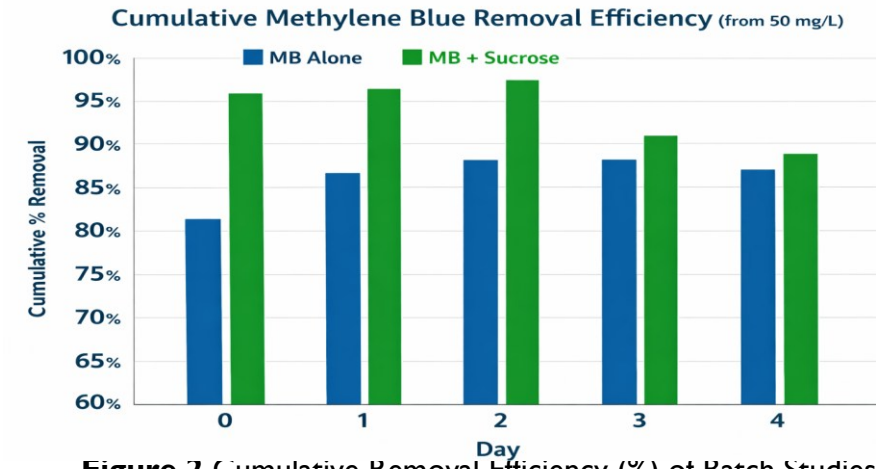

Figure 2 Cumulative Removal Efficiency (%) of Batch Studies

Stage 3 Cycled Vertical Flow Reactor Wetland Operations & Kinetics Study

Stage 3 used a PET bottle Vertical Flow Wetland with multilayer media. (**Table 2**) Acclimatized soil from Stage 2 was added, and influent containing 50 mg/L MB (2 replicates) and 50 mg/L MB with sucrose (2 replicates) was delivered via a calibrated plant dripper over 72 hours at 0.167 L/day (~2 drops/min, drop volume 0.0612 mL). The reactor operated under shaded, ambient conditions (~25 °C) in a predominantly anaerobic environment. The hydraulic retention time (HRT) was ~6 days, allowing sufficient contact for MB adsorption and biodegradation. MB concentration (UV–Vis at 664 and 290 nm), pH, color removal, and COD were monitored daily, with pseudo-first-order kinetics with rate constant(k) applied to determine the degradation rates using statistical analysis.

Table 2. Reactor Media .

Layer	Material	Height(cm)
Bottom	Small gravel	5
Middle	Coarse river sand	3
Top	Enriched riverbank soil with vermicompost	10.5

Stage 3 using the cycled vertical flow wetland (**Figure 3** with acclimatized soil removed 95–99% of Methylene Blue with sucrose (COD 20–60 mg/L, pH 6.8–7.2); 50–89% for MB alone (COD 100–139 mg/L). UV–Vis at 664 and 290 nm showed complete decolorization and efficient aromatic ring breakdown with sucrose. Pseudo-first-order (**Figure 5**) kinetics showed high, moderate, and low degradation rates across cycles, with sucrose maintaining faster, stable microbial activity(**Figure 4**) . Compared to literature CW3 (sand/gravel; 74% MB, ~44 mg/L COD), the enriched wetland performed superiorly in both MB and COD removal. In the cycled

vertical flow wetland, 50 mg/L MB alone removed 89–95% in early cycles but dropped to 50.8%, while 50 mg/L MB with sucrose maintained 95–98.8% removal. Rate constants increased from 0.25 to 0.78 day^{-1} with sucrose, and UV–Vis 290 nm plus 93.6% COD removal confirmed effective aromatic ring breakdown. The system shows potential for scale-up to treat textile dye wastewater efficiently.

Figure 3. Cycled Vertical Constructed Wetland Reactor.

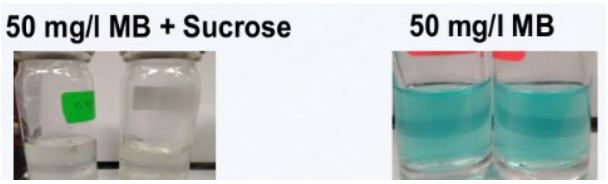

Figure 4 Discoloration Changes

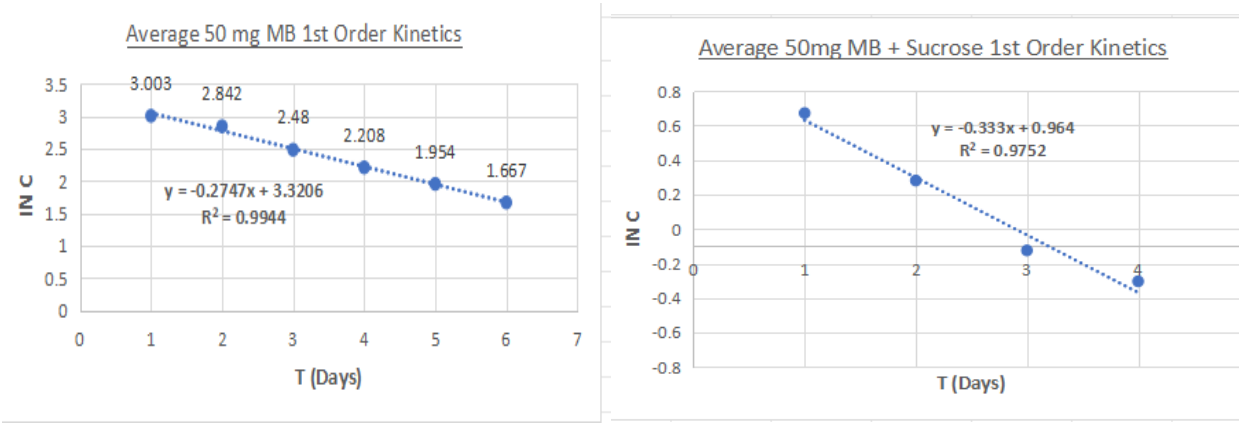

Figure 5 Pseudo First Order Kinetics

3. Novelty and uniqueness

For this project, the novelty lies in the construction of an unplanted, microbe-enriched vertical flow constructed wetland that relies on biodegradation rather than conventional treatment such as adsorption or chemical treatment for dye removal. Besides, unlike the traditional constructed

wetlands that depend on plantations and energy-intensive physicochemical processes or cultured microbial consortia, the system uses naturally acclimatized riverbank soil that has potential dye degraders enhanced with vermicompost to drive effective dye biodegradation under anaerobic, ambient conditions. This system also has very minimal adsorption that is negligible and predominantly lies on biodegradation. It distinguishes biodegradation from adsorption through sterilized soil controls, demonstrating that microbial activity is the primary removal mechanism, where the top layer is enriched riverbank soil with vermicompost, which is the main biodegradation medium, middle sand for microbial attachment and better hydraulic conductivity, and the bottom layer, small gravel for better draining. This arrangement enables prolonged contact between wastewater and microbial consortia, enhancing degradation efficiency without external aeration or chemical additives. Next, the addition of co-metabolism of sucrose as a carbon source adds operational flexibility This microbe-driven, low-energy and chemical-free approach, combined with its simple design and use of locally available materials, makes the system unique compared to existing dye treatment technologies and highlights its potential as a sustainable alternative for textile dye wastewater management.

4. Benefit to mankind

This project contributes to environmental protection and public well-being by providing a sustainable solution for dye-contaminated wastewater treatment according to SDG. Effective biodegradation of textile discharges (toxic dyes) which reduce water pollution and gives clean water, as well as minimizes risk to human health and aquatic system. The low-cost and energy-efficient design makes the system accessible to small and medium-scale textile industries that often lack advanced treatment facilities. By preventing untreated effluent discharge, the system supports cleaner water resources and safer downstream ecosystems, aligning with global sustainability goals. The use of natural microbial processes and locally available materials further reduces environmental footprints and sludge generation. Overall, the technology promotes responsible wastewater management, improves water quality, and supports sustainable industrial practices, benefiting both communities and the environment.

5. Innovation and Entrepreneurial Impact

For the innovation and Entrepreneurial aspect, this project bridges the gap between laboratory-scale microbial research and industrial application-oriented wastewater treatment. Instead of cultured microbial consortia , By translating complex biodegradation processes into a compact, nature-based technology, it offers a high-impact alternative to energy-intensive chemical treatments. The system is modular and scalable design as for prefabricated wetland modules or decentralised treatment kits .The plus and play scalability allows small and medium sized enterprises (SMEs) to upgrade and expand the treatment capacity in phases, matching their production, scalable market without heavy upfront capital investment.. The system also promotes a circular economy by utilizing locally sourced riverbank soil and vermicompost to transform raw earth into a high-performance bio-filter, while the treated effluent can be reclaimed for non-critical industrial reuse.The system offers low operational costs by eliminating expensive membranes and chemical dosing, while acclimatized native microbes ensure high resilience to environmental variations. Treated effluent can be safely reused for non-critical industrial applications, supporting SDG 6 and SDG 12. The modular design enables innovative business models, such as "Treatment-as-a-Service," and by helping industries meet strict environmental

discharge standards, it fosters sustainable problem-solving and green technology leadership, contributing to SDG 14 (Life Below Water).

6. Potential commercialization

As for the commercialization, the system has strong potential as a low-cost, modular wastewater treatment reactor or solution for dye-contaminated effluents. This can be scaled and packaged as compact wetland units for small textile industries, rural enterprises, and decentralized wastewater treatment facilities. The utilization of inexpensive, locally available materials and minimal energy reduces installation and operational cost which increases market feasibility. Commercial opportunities include on-site treatment units, customizable wetland modules, and maintenance-light treatment solutions for industries with limited technical expertise. The eco friendly design is another plus as it increases adoption potential in regions which face strict environmental discharge standards .Thus with appropriate scaling and design optimization , the system can developed into sustainable green commercial product for industrial applications and community wastewater management.

7. Acknowledgment

The author gratefully acknowledge the guidance and support of the project supervisor and the facilities provided by the host institution. Appreciation is also extended to laboratory staff and colleagues for their assistance during experimental work.

8. Researchers' Biography

Misha Anandan Naidu is a final-year, final-semester Bachelor of Science (Hons) in Applied Chemistry student at Universiti Teknologi Petronas (UTP) major in Sustainable Chemistry and minor in Petrochemistry . She has gained practical experience as a chemist in the Production team at Ranhill SAJ and in the Failure Analysis department at Infineon Technologies Sdn Bhd. Her research interests focus on environmental sustainability, particularly microbial biodegradation and wastewater treatment, aiming to develop practical and eco-friendly solutions for industrial effluents.

ChM. Ts. Dr. LIM JUN WEI (CSci, CChem, CEnv) was conferred with the Bachelor of Science (Hons) degree in Chemistry from Universiti Sains Malaysia in year 2009. He later received his Ph.D. qualification in Environmental Chemistry from the same university in year 2013. Currently, he is affiliated with the Department of Applied Science, Universiti Teknologi PETRONAS, serving as the Cluster Head of Applied Chemistry program. His major research interests are insect-based biological compounds, bioremediation of organic solid wastes and wastewaters, microalgal biofuels, and green hydrogen. Accordingly, he has published more than 400 research papers inclusive of book chapters of late.

Automated Retractable Hanger Rack with Handy Smart Drying Control

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ABSTRACT

The Automated Retractable Hanger Rack with Handy Smart Drying is an IoT-based solution designed to address common challenges in household clothes drying, particularly unpredictable weather conditions and limited user presence at home. The system is built around an ESP32 microcontroller integrated with a DHT22 humidity sensor, rain sensor, and light-dependent resistor (LDR) to monitor environmental conditions in real time. Based on predefined thresholds, the system automatically retracts or extends the hanger rack using a servo motor, while a DC fan assists the drying process when clothes are brought indoors under humid or rainy conditions. User interaction and monitoring are enabled through the Blynk IoT platform, while Telegram notifications provide instant alerts for rain detection, high humidity, and nighttime conditions. From a socio-economic perspective, the system reduces the risk of damp clothes, unpleasant odors, and repeated washing, contributing to improved household hygiene and time efficiency for working individuals. Additionally, the low-cost design and scalable IoT architecture present strong commercial potential for smart home applications, offering an affordable and practical solution suitable for modern lifestyles.

Keywords: Automated Hanger Rack, Smart Drying System, ESP32, IoT, Blynk

1. Product Description

The Automated Retractable Hanger Rack with Handy Smart Drying Control is an intelligent IoT-based clothes drying system designed to simplify household laundry management while protecting clothes from environmental factors. Powered by an ESP32 microcontroller, the system integrates multiple sensors, including a DHT22 humidity sensor, rain sensor module, and light-dependent resistor (LDR), to continuously monitor ambient conditions in real time. A compact servo motor is employed to automatically extend or retract the hanger rack based on detected rainfall, high humidity, or low-light (nighttime) conditions, ensuring optimal drying while safeguarding garments from damage or moisture accumulation. A 5V DC fan is incorporated to accelerate drying when clothes are retracted indoors while still damp, preventing unpleasant odors and prolonged dampness. Users can choose between automatic and manual control modes via the Blynk IoT platform, which displays real-time sensor readings, visual status indicators, and allows remote operation of the rack and fan. Critical conditions trigger instant notifications through Telegram, providing alerts for rain detection, low humidity, or nighttime events. By integrating automated sensor-driven control, wireless monitoring, and remote interaction, the system enhances drying efficiency, reduces manual supervision, and offers a practical, user-friendly solution that aligns with modern smart home lifestyles.

2. Methodology and Result

The system architecture is shown in **Figure 1**. The ESP32 microcontroller serves as the central processor, receiving real-time data from the DHT22 humidity sensor, rain sensor, and LDR light sensor. When environmental conditions exceed defined thresholds, the ESP32 automatically operates the servo motor to extend or retract the hanger rack and controls the DC fan to assist drying. The green LED indicates system status, while sensor readings and rack operation are sent to the Blynk IoT app, with important events triggering Telegram notifications for remote monitoring. The system control flow is shown in **Figure 2**. After startup, the ESP32 enters a continuous loop, reading values from the DHT22 humidity sensor, rain sensor, and LDR light sensor. The system evaluates whether any readings exceed their thresholds. If rain is detected, humidity is high, or it is nighttime, the servo motor retracts the hanger rack and the DC fan turns on to help drying. If conditions are normal, the rack extends and the fan switches off. The green LED shows system status, while all data and rack conditions are updated to the Blynk app and important alerts are sent via Telegram.

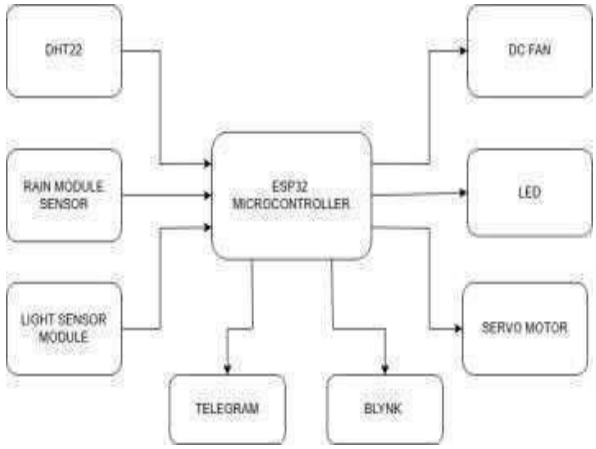

Figure 1. Block Diagram of Automated Retractable Hanger Rack with Handy Smart Drying Control.

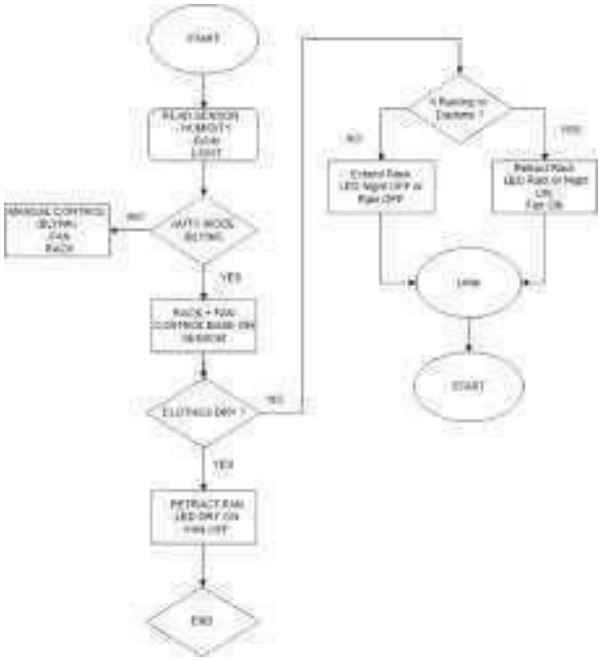

Figure 2. Flowchart of Automated Retractable Hanger Rack with Handy Smart Drying Control.

The Telegram notification methodology enables real-time user alerts for critical system events is shown in **Figure 3**. The ESP32 connects to a Telegram bot via a secure Wi-Fi and HTTPS connection. During operation, data from the DHT22 humidity sensor, rain sensor, and LDR light sensor are continuously monitored and compared with predefined threshold values. When a condition such as rain detection, high humidity, or nighttime is identified, the ESP32 sends a corresponding alert message through the Telegram Bot API. To avoid repeated notifications, a

flag-based control mechanism is implemented so that messages are sent only when a new event occurs. This method ensures timely, reliable, and efficient remote monitoring of the hanger rack system.

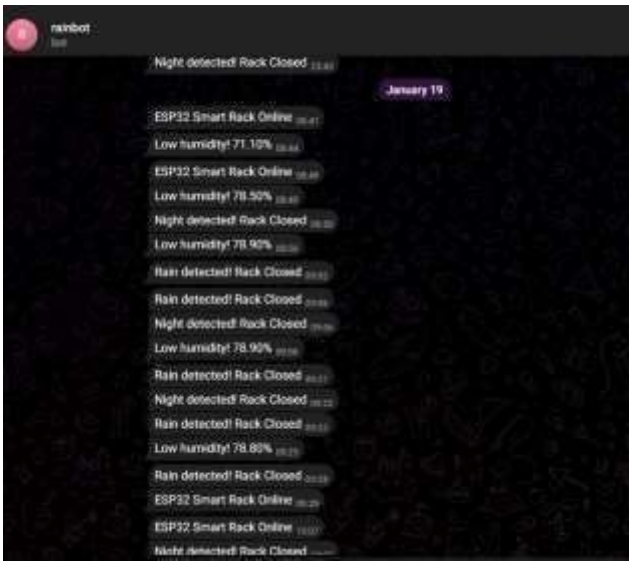

Figure 3. Telegram Notification of Automated Retractable Hanger Rack with Handy . Smart Drying Control

3. Novelty and uniqueness

The Automated Retractable Hanger Rack with Handy Smart Drying Control differentiates itself from conventional clothes drying methods by integrating real-time environmental sensing, automated actuation, and IoT-based remote monitoring, a combination rarely found in affordable home drying solutions. Traditional racks rely entirely on manual operation, leaving users unable to respond to sudden changes in weather or indoor humidity, which can result in damp clothes or unpleasant odors. This system utilizes a DHT22 humidity sensor, rain sensor, and LDR light sensor to continuously assess environmental conditions and automatically control a servo motor to extend or retract the hanger rack. A DC fan assists in drying clothes when necessary, while the green LED indicates system operation. Users can also interact with the system through the Blynk IoT app, enabling both automatic and manual control, and receive instant alerts via Telegram notifications. By combining automation, remote monitoring, and adaptive feedback, the project transforms a simple drying rack into a smart, data-driven home appliance that enhances drying efficiency, protects garments, and provides a convenient, user-friendly solution for modern households.

4. Benefit to mankind

The Automated Retractable Hanger Rack with Handy Smart Drying Control provides significant benefits by addressing common household challenges related to clothes drying, particularly for busy individuals and those living in areas with unpredictable weather. By automating the monitoring and protection of garments, the system reduces the risk of damp

clothes, unpleasant odors, and potential fabric damage, improving hygiene and convenience. Remote monitoring via the Blynk IoT app and real-time Telegram notifications allow users to manage laundry without constant supervision, saving time and effort. Its affordability and easy installation make smart drying accessible to a wide range of households, including those with limited resources. By combining automation, environmental sensing, and IoT connectivity, this project enhances domestic efficiency, minimizes manual labor, and promotes healthier, more convenient lifestyles, transforming a simple drying rack into a practical, modern smart home solution.

5. Innovation and Entrepreneurial Impact

This project transforms a conventional clothes drying rack into a smart, automated IoT system. Using DHT22 humidity, rain, and LDR light sensors with an ESP32, it monitors environmental conditions in real time and automatically controls a servo motor to extend or retract the rack, while a DC fan aids in drying clothes. Unlike traditional racks requiring manual intervention, this system offers sensor-driven automation, remote control via the Blynk app, and instant Telegram notifications, enhancing convenience and efficiency. The use of affordable, widely available components makes it scalable and accessible, suitable for smart homes, rental properties, or small businesses. By reducing manual effort, improving drying efficiency, and integrating IoT connectivity, this project provides a practical, marketready solution that encourages the adoption of automation in daily domestic life.

6. Potential commercialization

The Automated Retractable Hanger Rack with Handy Smart Drying Control demonstrates strong commercial potential, driven by growing demand for smart home appliances and convenient household solutions. With a low production cost of approximately RM101, the system can be competitively priced, making it accessible to a wide range of consumers compared to other smart home devices that are often more expensive. The product appeals to busy households, apartment dwellers, and small businesses seeking efficient, automated drying solutions. Additionally, its IoT integration, remote monitoring via Blynk, and realtime Telegram alerts offer unique value, enhancing user convenience and usability. The modular design allows for easy scaling of production and potential future upgrades, such as integration with other smart home ecosystems or premium analytics features. These factors collectively provide a sustainable business model and a viable commercial opportunity in the rapidly expanding smart home market.

7. Acknowledgement

I would like to sincerely thank Puan Norbaiti binti Sidik, my project supervisor, for her continuous guidance, advice, and support throughout this project. Her insights and encouragement were invaluable in completing the work successfully. I also wish to thank my family and friends for their moral support and motivation during this process. Finally, I extend my appreciation to everyone who contributed, directly or indirectly, to the development and completion of this project.

8. Researchers' Biography

Muhammad Fairuz Bin Jasman is a final-year student at the Centre for Electrical Engineering Studies, Universiti Teknologi MARA (UiTM), Pasir Gudang Campus. His research interests include embedded systems, smart home automation, and Internet of Things (IoT) applications. This project, Automated Retractable Hanger Rack with Handy Smart Drying, was developed as his Final Year Project to enhance household laundry efficiency and convenience through sensor-driven automation and IoT connectivity. He is passionate about creating practical, userfriendly technology solutions that improve daily life and promote the adoption of smart home innovations.

Mrs Norbaiti Binti Sidik received her first formal education at government primary school, Sekolah Kebangsaan Batu Lima in Sik Kedah. The second foundation, her academic journey was laid at Arabic high school established as Maktab Mahmud Alor Setar, Kedah Darul Aman. Her studies continued at Universiti Kebangsaan Malaysia in Bandar Baru Bangi Selangor right after completed 1 year Science Matriculation Certificate at Science Matriculation Centre, Ipoh Perak Darul Ridzuan. She graduated her Bachelor Engineering Degree in Electrical, Electronics and System within 3 years from Universiti Kebangsaan Malaysia, Bandar Baru Bangi Selangor Darul Ehsan and she further developed her academic and professional skills by obtaining Master Engineering Degree in Communication and Computer also from the same university in 2002. She is very committed, passionate and dedicated in education line who is now a senior lecturer and having experienced more than 15 years in teaching & learning and lecturing at Electrical Engineering Studies, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, Johor Darul Takzim.

Dr. Nor Affida M. Zin is a Senior Lecturer at UiTM Pasir Gudang Campus. She holds a Ph.D in Advanced Optical Networking, focusing on deterministic and time-sensitive services in Passive Optical Network. She has authored numerous high-impact journal articles and conference papers on PON technology. She is actively collaborating with academia and industry to enhance PON frameworks and developments in Malaysia.

Ruang EduSains E-Learning: An Innovation in Web-Based Digital Learning Platform to Improve Science Understanding at the High School Level

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ABSTRACT

The transformation of education in the era of Society 5.0 encourages the use of digital technology as an integral part of the learning process. Ruang EduSains E-Learning is a web-based learning platform designed for senior high school students, focusing on Mathematics, Biology, Chemistry, and Physics. This platform is developed to address the need for a learning system that is easily accessible, flexible, and aligned with current digital advancements. Ruang EduSains E-Learning serves as a solution to the limitations of conventional learning, which is often constrained by time and space. Its design integrates systematically structured learning materials, interactive instructional videos, and quizzes as evaluation tools to measure students' levels of understanding. This approach aims to promote independent learning, increase student engagement, and strengthen comprehensive mastery of science concepts. The uniqueness of this platform lies in its presentation of interdisciplinary science learning within a single integrated digital ecosystem, supported by a user-friendly interface and a feedback-based evaluation system. The implementation of Ruang EduSains E-Learning is expected to have a positive impact on equitable access to education, the improvement of science learning quality, and learning cost efficiency. From a sustainability perspective, this platform has promising commercialization opportunities through partnerships with educational institutions, schools, and the development of subscription-based services within the educational technology industry.

Keywords: E-Learning, EduSains Space, Digital Learning, High School Science, Web-Based Platform

1. Product Description

Ruang EduSains is a web-based e-learning platform designed to support senior high school students through structured learning objectives, interactive materials, instructional videos, and formative assessments in the form of quizzes and educational games. Each learning module begins with clear learning objectives to help students understand the competencies they are expected to achieve before engaging with the content. Learning materials are presented in a concise and student-friendly format, supported by video explanations that simplify complex topics and enhance understanding. After completing the materials, students participate in quizzes and game-based activities to evaluate their comprehension while maintaining motivation and interest in learning. The platform features a simple and intuitive interface, allowing students to easily navigate between objectives, materials, videos, and

assessments. Ruang EduSains can be accessed via a web browser, making it suitable for both classroom learning and independent study environments. If you would to access our product, please click the following link https://s.id/RuangEduSainsE-learning .

2. Pictures Ruang EduSains E-Learning An Innovation in Web-Based Digital Learning Platform to Improve Science Understanding at the High School Level

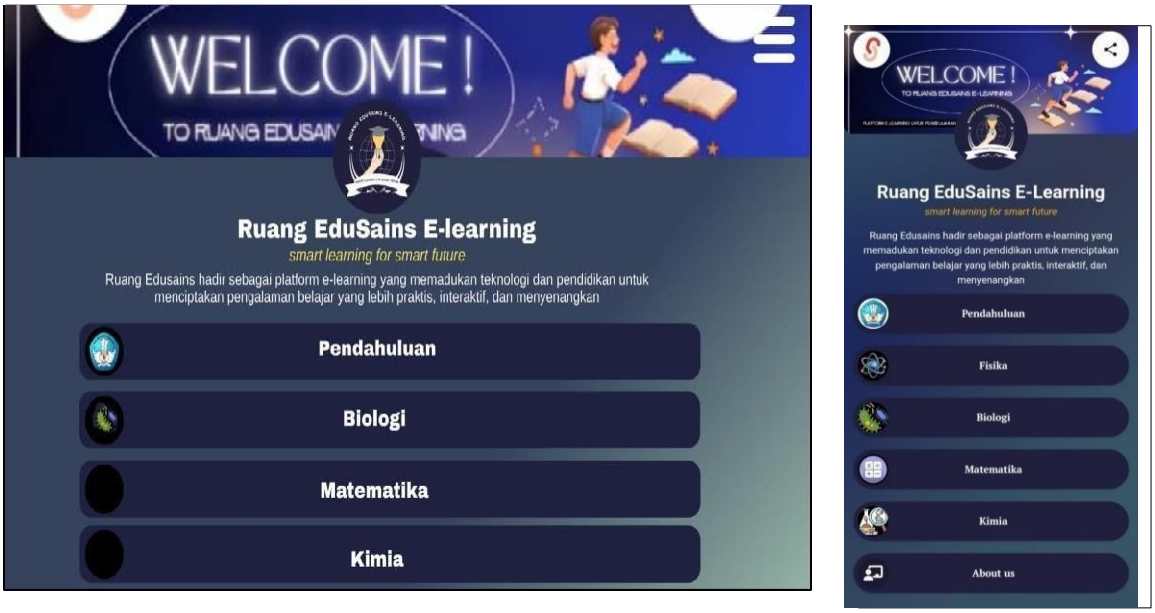

Figure 1. Halaman web Ruang EduSains.

Figure 2. Fitur E-learning.

Figure 3. logo E-learning.

The main interface of the Ruang EduSains platform can be seen in Figure 1. The web page presents a simple and intuitive user interface design with a primary navigation menu consisting of Introduction, Biology, Mathematics, and Chemistry. This structure is designed to facilitate students in accessing learning materials according to their selected field of study. The modern visual design and systematic layout support user convenience in exploring learning features independently as well as within a classroom learning context.

The learning features available in the Ruang EduSains platform are shown in **Figure 2**. The figure illustrates the senior high school learning structure, which includes Chemistry, Biology, Mathematics, and Physics. Each subject is equipped with learning materials, interactive videos, and evaluative quizzes. The learning flow is systematically designed, beginning with the presentation of learning objectives, followed by material delivery, and concluding with evaluation through quizzes or educational games. This feature integration supports an interactive and feedback-based learning approach.

The visual identity of the Ruang EduSains platform is presented in **Figure 3**. The logo represents the concept of modern digital education, featuring a graduation cap symbolizing education and orbit elements representing the integration of scientific disciplines within a unified digital ecosystem. This visual identity strengthens the image of Ruang EduSains as an innovative technology-based science learning platform that adapts to the development of the Society 5.0 era.

3. Novelty and uniqueness

The rapid development of digital technology demands learning platforms that not only provide instructional content but also guide students in understanding learning objectives and processes in a systematic manner. Ruang EduSains is a web-based e-learning platform designed to address these needs through a structured and interactive learning approach. The novelty of this platform lies in the presentation of learning materials that are concise yet comprehensive, delivered through an attractive visual design that facilitates students' understanding of scientific concepts. Each learning module begins with clearly defined learning objectives, followed by interactive materials, explanatory videos, and formative assessments in the form of quizzes and educational games within an integrated learning flow. Another distinctive feature is its ease of access through a web browser with a simple and intuitive interface, making Ruang EduSains effective for both classroom-based learning and independent study in the digital era.

4. Benefits to mankind

Ruang EduSains benefits students by providing a more engaging and accessible learning experience that support different learning styles. Through videos, reading materials, and interactive games, learners are encouraged to actively participate in the learning process, leading to improved understanding and motivation. For educators, Ruang EduSains offers as practical digital tool to deliver structured content while monitoring student progress effectively. On a broader level, the platform supports digital literacy development and promote inclusive education by enabling flexible access to learning resources regardless of location.

5. Innovation and Entrepreneurial Impact

Ruang EduSains E-Learning is a web-based learning platform innovation specifically designed for the senior high school level, covering Mathematics, Biology, Chemistry, and Physics. This platform represents a transformation from traditional learning systems to a digital system aligned with the development of Society 5.0. Ruang EduSains provides structured learning materials, interactive instructional videos, and evaluative quizzes, all presented through a modern, responsive, and user-friendly design to create an engaging and non-monotonous learning experience. From an entrepreneurial perspective, this project fosters edupreneurship innovation through the utilization of digital technology, opens opportunities for collaboration with educational institutions, and cultivates a creative and adaptive culture within the digital education industry. This innovation contributes to improving learning quality while strengthening a technology-based entrepreneurial ecosystem.

6. Potential commercialization

Ruang EduSains E-Learning has strong positive commercial potential in line with the increasing demand for digital learning platforms at the senior high school level. This service can be developed through subscription-based models for students and schools, as well as institutional partnerships with educational organizations. Structured learning materials, instructional videos, and evaluative quizzes serve as added value that enhance the quality of the platform. Furthermore, commercialization opportunities are expanded through the provision of specialized content, academic mentoring programs, and training for educators in utilizing the platform. This platform also plays a significant role in improving students' understanding of digital learning systems that can be accessed anytime and anywhere. Therefore, Ruang EduSains is suitable for both classroom- based instruction and independent learning environments. Its flexible digital system enables broad user reach without requiring high operational costs. As the demand for science education continues to grow, Ruang EduSains has the potential to become a competitive and economically sustainable edutechnology product.

7. Acknowledgment

The author would like to express our sincere gratitude to our institution, supervisors, and peers for the guidance, support, and euncouragement throughout the development of the Ruang EduSains project. We also extend our appreciation to all individuals who provided valuable feedback and contributions that helped improve the quality of this work.

8. Researchers' Biography

Priharti Ningrum Harahap is a young woman known for her active participation and outstanding achievements in various competitions. Her involvement began during her senior high school years and has continued into her university life. She has consistently achieved Gold rankings in the competitions she has participated in, reflecting her dedication and excellence. In addition to her academic and non- academic achievements, she is actively involved in campus organizations such as the Student Executive Board (BEM), the Indonesian National Student Movement (GMNI), as well as several external organizations outside the campus.

Luthfia Azzahra is a university student currently pursuing higher education. She has a strong interest in drawing and design, which she actively develops through both academic and non-academic activities. In addition, she participates in various competitions, including Musabaqah Tilawatil Qur'an (MTQ) and academic Olympiads. She is also actively involved in community and campus activities, such as participating in competitions, joining the Student Executive Board (BEM), and being a member of the Student Association of her study program

Bisma Salsa Fitri Lubis is a university student recognized for his expertise in the field of computer science. He is known for his critical and analytical thinking skills within both the campus environment and the surrounding community. His critical perspective enables him to actively contribute ideas and solutions to various academic and social issues.

Laili Habibah Pasaribu, S.Pd., M.Pd. is a lecturer at the University of Labuhanbatu. She is well known for her strong social awareness and high level of concern for her students' academic and personal development. She has also played an active role in the development of the Ruang EduSains digital learning platform, demonstrating her commitment to advancing technology-based education

Metalfuse PRO: Democratizing Sustainable Metal 3D Printing for SME Adoption

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ABSTRACT

Laser powder bed fusion (L-PBF) additive manufacturing (AM) is established as an advanced manufacturing process to fabricate end-use metallic components for critical applications in the automotive, biomedical, and aerospace industries. The layer-wise build approach of these AM technologies enables the parts with complex geometries and tunable properties to be manufactured with significant waste reductions, in contrast with conventional casting, forming, and machining processes. However, these processes require high investment and operational costs due to the combined use of high-power heat source, as well as complex and proprietary machinery and software, making it out-of-reach for small and medium entrepreneurships (SMEs). Hence, here we propose a low-cost AM approach based on fused filament fabrication (FFF) to fabricate similar metallic components through a 3-step printing-debinding-sintering process using entry level desktop 3D printers and commercially available electrical furnace which we named as MetalFuse Pro. The primary objective of this invention is to rapidly fabricate metallic components with significantly cheaper overall costs (50-90%), but with comparable properties as L-PBF AM, capable of meeting industrial performance standards. Finally, the goal is to establish MetalFuse Pro as an affordable and sustainable AM process for SMEs to cater to high quality metal parts production for end applications in the aforementioned industries.

Keywords: MetalFuse Pro; low-cost; additive manufacturing; metallic components; SMEs

1. Product Description

MetalFuse Pro is an innovative additive manufacturing solution that enables the rapid production of metallic components at significantly lower costs. Designed to match the quality of parts produced by laser-based AM technologies, MetalFuse Pro offers a cost-effective alternative without compromising performance. MetalFuse Pro supports the fabrication of complex, customized parts that meet industrial-grade specifications, making it ideal for applications requiring precision, durability, and flexibility.

2. Method and Process

Method and Process

Figure 1 illustrates the overall workflow for metal additive manufacturing via Fused Filament Fabrication (FFF). In this process, a polymer binder is mixed with metallic powder particles (65 – 85 wt.%) and bound together in filament form as the feedstock material, and then extruded through a heated nozzle onto the print area of the 3D printer to form the required objects which initially design using any Computer Aided Design (CAD) software. As the polymer binder helps to enhance the flowability of the filament during the printing stage, the polymer binder is then removed from the metallic part through thermal treatments via a debinding process, resulting in a binder-free structure. Finally, the brown part is sintered close to the melting point of the material to create a fully dense metallic part which in results having a relative density that is more than 90%. FFF process of metallic materials can be considered similar to metal injection molding (MIM) and powder metallurgy (PM), such that the main distinction between them is that compacting and molding are MIM and PM processes, rather than freeform fabrication in FFF during the shaping stage.

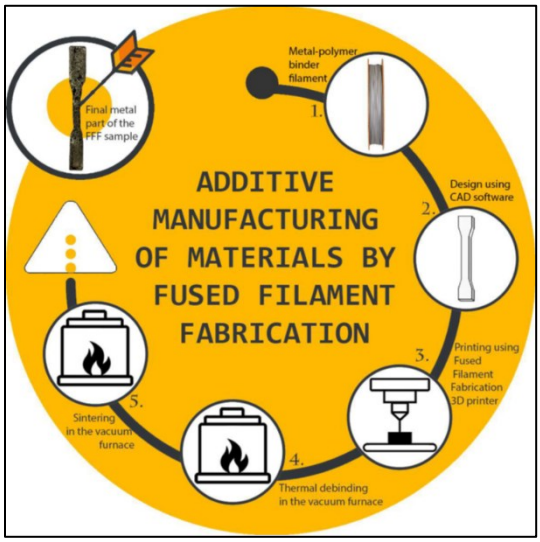

Figure 1. Complete Process Workflow of Additive Manufacturing of Metals/Alloys using Fused Filament Fabrication (FFF) - Copyright by our team (CRLY2023W01580).

The debinding process involved heating the furnace at a rate of 1°C/min to 204°C for 2 hours, then ramping the temperature up to 427°C over a 2-hour period, where it was held for 2 hours to eliminate the polymer binder from the green part. This process is intended to completely remove the PLA binder as the degradation of the PLA binder is around 360°C to 380°C. After debinding, the sintering process was continued using the same furnace by ramping the temperature up to 593°C for 1 hour and 30 minutes, then to the desired sintering temperature of 1260°C within 2 hours and held at this temperature for 4 hours. Finally, the sintered samples are left in the furnace to be air-cooled. The overall debinding and sintering thermal cycle are depicted in **Figure 2**.

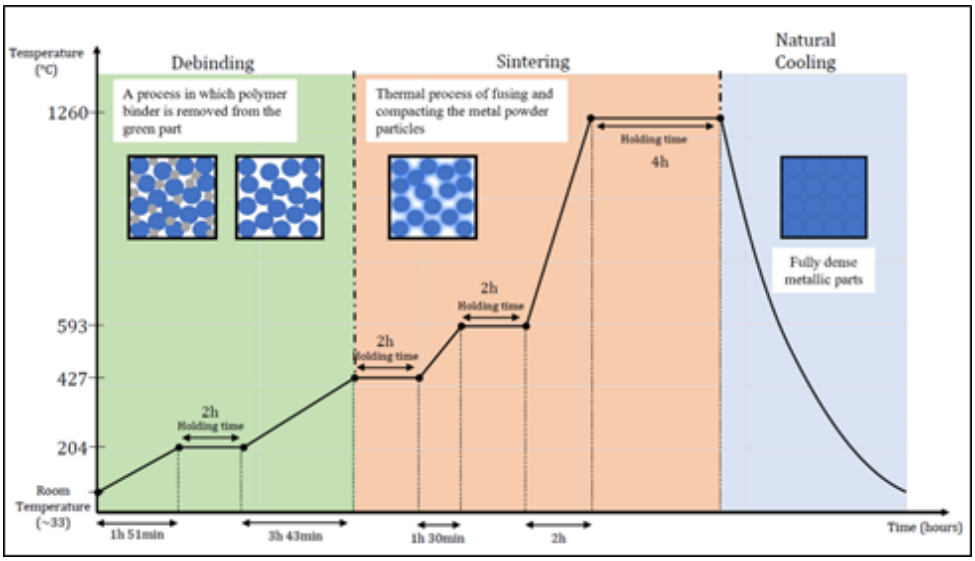

Figure 2. Debinding and sintering thermal cycle for 316L stainless steel fabricated by MetalFuse Pro process - Copyright by our team (CRLY2022W05719).

3. Results

A fully metallic 316L stainless steel (316L SS) specimens were successfully fabricated via MetalFuse Pro. The specimens were produced through a three-step cycle consisting of 3D printing, thermal debinding, and sintering. During the printing stage, green parts were fabricated at extrusion temperatures ranging from 195 to 220 °C. The results indicate that the temperature profile applied during the 3D printing stage significantly affects the final properties of the sintered components, particularly their relative density and hardness as exhibits in **Figure 3**. Among the investigated conditions, a nozzle temperature (T_n) of 200 °C yielded the best overall performance, achieving the highest relative density (97%) and hardness (292 HV), as well as the finest average grain size (~47 μm) after sintering. The average grain sizes were revealed in **Figure 4**.

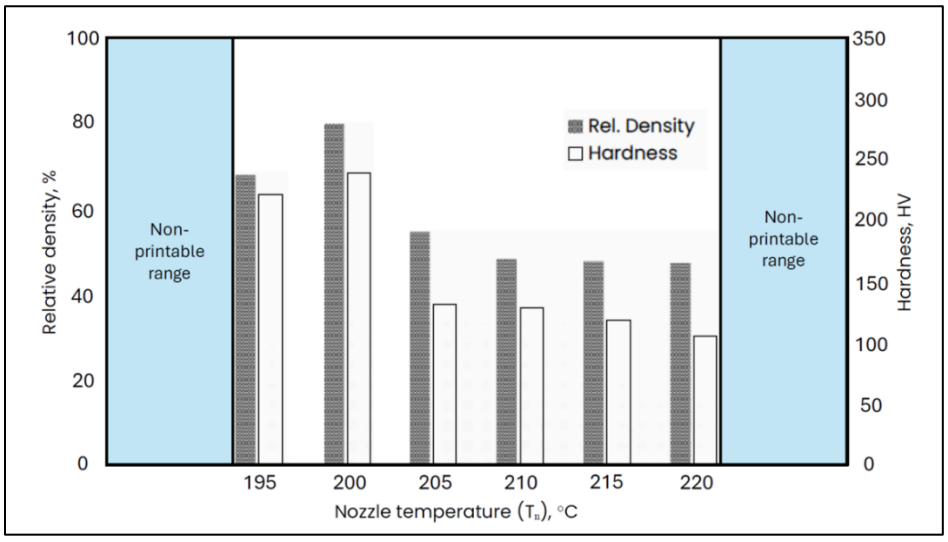

Figure 3. Processing Window of 316L Stainless Steel Specimens Additively Manufactured by MetalFuse Pro - Copyright by our team (CRLY2025W08408).

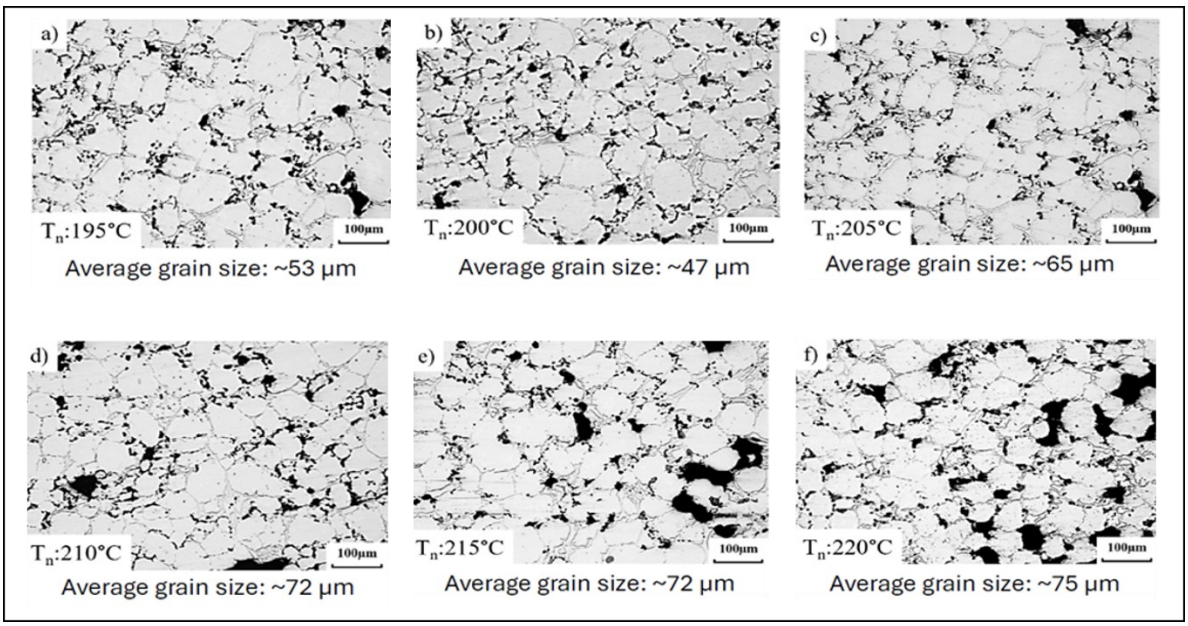

Figure 4. Average Grain Size obtained based on the Processing Window of 316L Stainless Steel Specimens Additively Manufactured by MetalFuse Pro - Copyright by our team (CRLY2025W08408).

Table 1 presents the relative density and hardness of post-sintered Inconel 718 specimens fabricated using the MetalFuse Pro technique at different nozzle processing temperatures (210–290 °C). The results indicate a clear dependence of densification and mechanical performance on processing temperature. Relative density increases from 66.81% at 210 °C to a maximum of 92.34% at 290 °C. A similar trend is observed for hardness, which rises from 122 HV to 188 HV at 290 °C. The significant improvement observed at higher temperatures confirms that the process enables effective microstructural control through temperature optimization. Moreover, the results indicate that the MetalFuse Pro technique is capable of producing components with tunable mechanical properties, achieving densification and hardness levels comparable to those obtained through conventional manufacturing routes.

Table 1. Relative density and hardness values of post-sintered Inconel 718 specimens at different processing temperature using MetalFuse Pro technique. Copyright by our team (CRLY2025W08409).

Nozzle Temp. / ***Sintered Properties***	***210°C***	***230°C***	***250°C***	***270°C***	***290°C***
Densification level (%)	66.81	70.39	71.97	68.74	92.34
Hardness value (HV)	122	135	146	132	188

Comparison with Other Manufacturing Processes

Figure 5 compares the hardness and yield strength of 316L stainless steel fabricated via Casting, L-PBF, and MetalFuse Pro processes. The results show a clear improvement in mechanical performance from conventional casting to additive manufacturing routes. MetalFuse Pro shows the highest performance among the three methods, achieving hardness and yield strength of 252 HV and 805 MPa respectively. This indicates superior densification and microstructural refinement, resulting in enhanced strength and hardness. Overall, the comparison confirms that MetalFuse Pro not only matches but exceeds the mechanical performance of conventional casting and is competitive with, or superior to, L-PBF for 316L SS components.

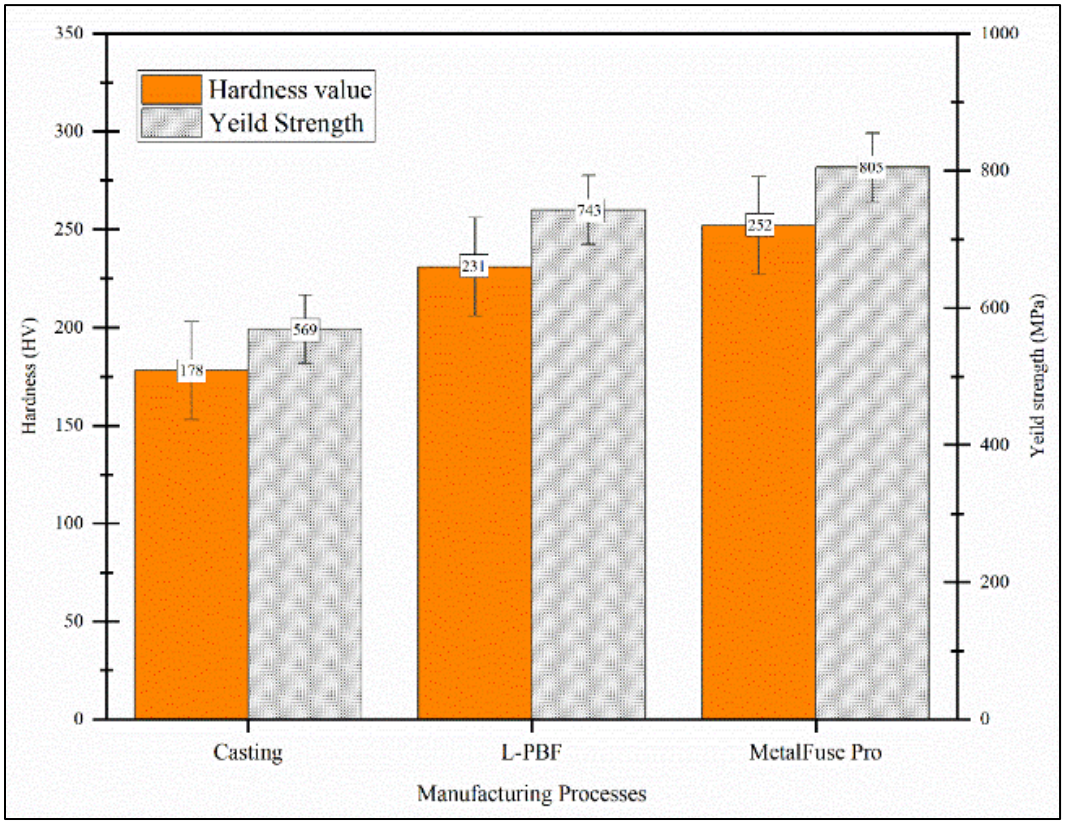

Figure 5. Comparison of yield strength and hardness value between casting, L-PBF and MetalFuse Pro manufacturing processes for 316L SS.

4. Novelty and uniqueness

MetalFuse Pro introduces a cost-effective, sustainable, and accessible approach to metal additive manufacturing (AM) by integrating low-cost fused filament fabrication (FFF) with an innovative debinding and sintering process. This system democratizes metal AM by delivering industrial-quality metallic parts using desktop 3D printers and standard electric furnaces, making it ideal for small and medium enterprises (SMEs). The following are the key novel features:

i. ***Innovative manufacturing approach***: Unlike established laser-based AM systems, particularly L-PBF AM, MetalFuse Pro utilizes a 3-step print–debinding–sintering technique to fabricate dense, high-quality metal parts.

ii. ***Economical Process Ecosystem:*** Operates on entry level commercial FFF 3D printers and commonly available sintering equipment, drastically reducing capital and operational costs compared to L-PBF between 50% to 90%.
iii. ***High Performance at Low Cost:*** Achieves mechanical properties comparable to L-PBF components, enabling high-performance applications in automotive, biomedical, and aerospace sectors.
iv. ***SME-Oriented Solution:*** Designed specifically to empower SMEs by removing the financial and technical barriers of metal AM, expanding access to advanced manufacturing capabilities.
v. ***Sustainable and Green Solution:*** The process promotes reduced material waste, safer operational conditions, and sustainable manufacturing practices, supporting circular economy goals in metal part production.

5. Benefit to mankind

MetalFuse Pro offers a transformative solution for sustainable and inclusive industrialization by enabling affordable metal additive manufacturing through desktop-based FFF. Unlike conventional L-PBF system, MetalFuse Pro uses a simple three-step process - printing, debinding, and sintering through commercially available FFF 3D printers and electric furnaces.

i. This makes advanced manufacturing accessible to small and medium enterprises (SMEs), educators, and innovators, directly supporting **SDG 9 (Industry, Innovation, and Infrastructure)** by promoting resilient and inclusive technological growth.
ii. The system reduces material waste, lowers energy consumption, and minimizes dependence on high-cost, proprietary equipment, aligning with sustainable production practices **SDG 12 (Responsible Consumption and Production).**
iii. Furthermore, MetalFuse Pro encourages open collaboration between academia, industry, and communities, promoting knowledge exchange and capacity building in developing regions - supporting **SDG 17 (Partnerships for the Goals)**. By decentralizing production democratizing access to metal 3D printing, this project not only accelerates industrial innovation but also fosters equitable access to advanced technologies, contributing to a more sustainable and inclusive future.

6. Innovation and Entrepreneurial Impact

MetalFuse Pro delivers a transformative innovation in metal additive manufacturing by **overcoming the high cost and technical barriers** associated with conventional laser-based systems. By integrating low-cost FFF with an optimized print–debinding–sintering process, the technology enables the production of industrial grade metallic components using desktop 3D printers and standard electrical furnaces. This innovation **achieves mechanical properties comparable** to L-PBF AM while significantly reducing capital investment, operational complexity, and material waste, supporting sustainable manufacturing practices. From an entrepreneurial perspective, MetalFuse Pro **democratizes access to metal 3D printing for SMEs**, enabling them to fabricate high-value metal parts in-house, reduce reliance on outsourcing, and accelerate product development cycles. The technology opens scalable commercialization pathways through equipment sales, consumables, printing services, and training platforms. By empowering SMEs to participate in advanced manufacturing sectors, MetalFuse Pro fosters inclusive industrial growth, strengthens innovation ecosystems, and contributes to a more sustainable and accessible future for metal manufacturing

7. Potential commercialization

MetalFuse Pro has strong commercialization potential through multiple pathways:

i. MetalFuse Pro can be offered as an affordable desktop metal 3D printing system bundled with optimized filaments and thermal post-processing tools, targeting SMEs, educational institutions, and R&D laboratories.
ii. This project can generate recurring revenue through the sale of 3D printing and post-processing services. It also holds value as a training platform for technical education for additive manufacturing companies.
iii. MetalFuse Pro addresses a market gap for low-cost, high-performance metal part production in automotive, biomedical, and aerospace sectors.

Furthermore, MetalFuse Pro team has secured several copyrights (CRLY2022W05719, CRLY2023W01580, CRLY2025W08408, CRLY2025W08409, CRLY2025W08410). This shows that our team remains deeply committed to the continued development of this research, aiming to deliver greater value through technological refinement, broader accessibility, and long-term contributions to the additive manufacturing.

8. Acknowledgment

The project members acknowledge the support and guidance from our collaborators and industry experts who contributed valuable insights to this project. Special thanks to PrecisionPro Edutech (Malaysia) and The Virtual Foundry (USA) for providing financial assistance and material resources for this research work.

9. Researchers' Biography

Nur Hidayah Musa is currently a postgraduate student (Ph.D) in Mechanical Engineering at Universiti Teknologi Malaysia, specializing in advanced manufacturing and material extrusion. Her research focuses on the fabrication of metallic components using Fused Filament Fabrication (FFF), with notable achievements including multiple national and international innovation awards for the "MetalFuse Pro" technology. She holds professional certifications in SOLIDWORKS and AutoCAD, and her work has been published in ISI and Scopus-indexed journals. Nur Hidayah is passionate about sustainable, cost-effective manufacturing technologies that can be accessible to small and medium enterprises.

Muhammad Hariz Zubir is currently a postgraduate student (Ph.D) in Mechanical Engineering at Universiti Teknologi Malaysia, specializing in 4D printing of polymeric and polymer composite smart materials via FFF and Vat photopolymerization additive manufacturing processes. As a former engineer at Sony EMCS, Hariz gained practical expertise in engineering design, manufacturing systems, and problem-solving in high-precision industrial environments. With a strong combination of industrial experience and academic research, Hariz is well-equipped to contribute effectively across multiple domains, including process optimization, product development, and applied engineering solutions.

Ir. Ts. Dr. Shahir Mohd Yusuf is a Senior Lecturer in Mechanical Precision Engineering at MJIIT, Universiti Teknologi Malaysia. He holds a Ph.D. in Mechanical Engineering from the University of Southampton, UK. His research focuses on additive manufacturing, severe plastic deformation, and process–structure–property relationships in metallic and smart materials. He has published extensively in high-impact journals and received numerous awards for innovations in metal 3D printing. As a principal investigator of multiple national grants, he also serves as a reviewer, guest editor, and STEM education advocate. Ir. Ts. Dr. Shahir is actively developing cost-effective metal AM technologies and sustainable smart material solutions.

Dr. Rahayu Emilia Mohamed Khaidir is a Senior Lecturer at the Faculty of Applied Sciences, Universiti Teknologi MARA (UiTM) Sarawak. She earned her Ph.D. in Materials and Structural Engineering from Universiti Teknologi Malaysia and her M.Phil. in Advanced Materials from Universiti Putra Malaysia. Her research focuses on smart magnetorheological materials and sustainable carbon quantum dots nanomaterials synthesized from agricultural waste. Dr. Rahayu has authored over 15 ISI-indexed publications and received multiple national and international innovation awards. With over 470 citations and an h-index of 11, her work demonstrates strong impact in the fields of materials science, nanotechnology, and green innovation.

DINS Q-Laundry: A Smart Queue Management System for Enhancing Operational Efficiency in Self-Service Campus Laundries

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ABSTRACT
A smart self-service laundry queue management system called DINS Q-Laundry was created to reduce wait times and improve campus laundry operations. The system enables users to check machine availability, obtain digital queue numbers, receive real-time notifications, and make cashless payments via a mobile application. Operationally, the system applies capacity planning and service process improvements to enhance workflow efficiency. From the economic perspective, the approach enhances students' productivity, time management, and overall university experience. In term of society and the environment, it reduces congestion, cut down on wasteful energy use, and encourages effective machine use. Through institutional collaborations and licensing approaches, the concept can be implemented in universities, residential collages, hostels, and commercial self-service laundromats, giving it considerable marketing potential.

Keywords: Smart self-service, queue management, capacity planning, mobile application, wait time.

1. Introduction
DINS Q-Laundry is a proposed smart self-service laundry solution designed to improve efficiency and reduce operational problems faced by users at self-service campus laundry facilities, particularly at public university. Currently, users experience long waiting times due to insufficient machine availability and inefficient washing operations, especially during peak hours such as evenings and weekends. Through a mobile application, DINS Q-Laundry allows users to check machine availability, take queue numbers digitally, receive real-time updates, and make cashless payments. The system also assists laundry operators in monitoring machine usage and managing operations more effectively.

2. System Design and Application Features
The method that will be used to solve the problem is to create an online application that can make it easier for users to use the machine. The main components in the apps are a queue system based on first-come, first-served (FCFS) digital queue mechanism integrated into a mobile application. The application workflow as follows:

1. The application is accessed by scanning a QR code shared through social media platform such as WhatsApp. The application is then download, and access is granted either through user registration or guest mode.
2. Next, the type of machine required, either a washer or a dryer, is selected through the application interface.
3. After a machine selection is completed, the system will generate and displays an estimated waiting time based on machine availability.
4. A notification is automatically sent by the system 10 minute before the allocated turn to inform that machine will soon to be available
5. Also 5-minute grace period is provided after allocated time. If the machine is not use within the period, then turn will automatically cancelled and reassigned to the next user
6. Users can choose to pay with card or e-wallet.
7. After users make payment, the start button can be pressed to activate the selected machine.

(1) (2) (3) (4) (5)

(6) (7)

Figure 1. Application Workflow Prototype.

3. Analysis

This analysis aims to address the issue of long waiting times. The findings show that most respondents are students from one of public university. Therefore, a Google Form was created to identify students' needs and expectations. The form is being distributed through the One of public university collage group to collect relevant feedback. A study involving 100 respondents from one of public university identifies significant problems related

to waiting and queuing times. As shown in **Figure 2**, 93% of respondents do laundry two to three time per week, resulting in a considerable amount of time spent on this activity. In term of queue duration, **Figure 3** indicates that 59% of respondents wait more than 30 minutes for a turn to do laundry. These results highlight a strong demand for reduced waiting times and the implementation of queuing system to improve students' daily routines.

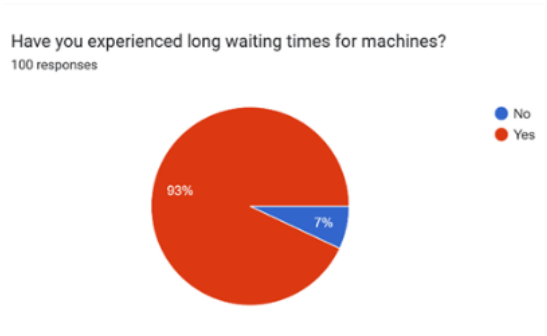

Figure 2. Frequency of Laundry Usage.

Figure 3. Waiting Time Duration.

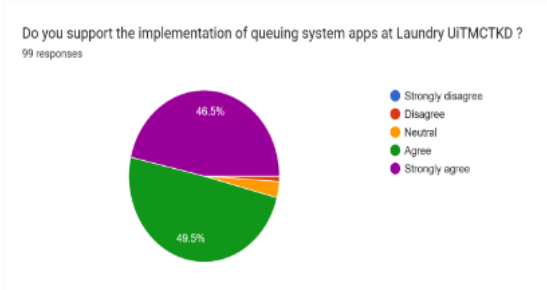

Figure 4. Support for Queue Application.

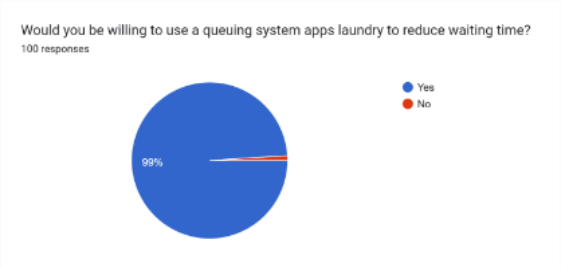

Figure 4. Acceptance Level Among Students.

The results in **Figure 4** indicate that 96% of respondents support the implementation of queuing system application at the one of public university laundry, with usage peaking during weekends. **Figure 5** shows that nearly 100% of respondents agree with the implementation of this application among one of public university users, particularly students, indicating strong acceptance of the new system compared to the existing method. The implementation of a comprehensive queuing system application such as DIN Q-Laundry can effectively reduce waiting times and improve efficiency. Therefore, one of public university can collaborate with relevant parties, including staff and the Student Affair Department (Hal Ehwal Pelajar), to enhance student welfare within the university.

4. Novelty and uniqueness

The novelty of DINS Q-Laundry lies in the implementation of a structured and digital queue management system within a campus laundry setting. Unlike the existing method, which requires users to wait physically without clear queue arrangements, DINS Q-Laundry introduces a first-come, first-served (FCFS) system with real-time monitoring. The inclusion of notification alerts and an automatic cancellation feature after a grace period further enhances operational efficiency and ensures fair service for all users.

5. Benefit to mankind

DINS Q-Laundry benefits students by reducing long waiting times, minimizing overcrowding, and improving overall user satisfaction when using laundry facilities. The system allows users to manage their time more efficiently without needing to remain at the laundry area. Additionally, it creates a more organized and comfortable environment while supporting digital and cashless transaction practices within the campus.

6. Innovation and Entrepreneurial Impact

The DINS Q-Laundry system demonstrates how operations management strategies such as queue management, capacity planning, and service process improvement can be applied to solve daily operational problems. The innovation encourages the use of digital applications to enhance service delivery and provides opportunities for future entrepreneurial development, particularly in smart service systems and campus-based solutions.

7. Potential commercialization

DINS Q-Laundry has potential to be implemented not only at one of public university but also at other universities, residential colleges, hostels, and self-service laundromats. The system can be commercialized through collaboration with educational institutions or laundry operators. With further enhancement, it may be expanded to include advanced monitoring systems and broader operational analytics.

8. Acknowledgment

The team would like to thank to Madam Nur Dalila Adenan for her guidance and support throughout the completion of this project. The thank is also extended to the Faculty of Business and Management, University Teknologi Mara Cawangan Terengganu Kampus Dungun, and all students who participated in the questionnaire survey.

9. Researchers' Biography

Nuriman Husna Binti Mohd Rizal is a first-year student in the Bachelor of Operation Management (Honor) at University Teknologi MARA Cawangan Terengganu Kampus Dungun. She is from Kedah. She has graduate in Diploma in Business Study for 2 and half years. Her academic interest includes operation management, service process improvement, and efficiency in service systems. She was actively involved in the development of the DINS Q-Laundry project, particularly in identifying operational issues, data collection, and analysis related to queue management and service efficiency.

Nurul Najwa binti Zainal Abidin is currently pursuing a bachelor's degree in Operations Management at Universiti Teknologi MARA (UiTM) Cawangan Terengganu, Campus Dungun.She has a strong foundation in accounting and business principles through to her Diploma in Accounting. She was born in Perak and currently lives in Ipoh, Perak. She aims to further develop her knowledge and skills in operations management to support her future professional career.

Nur Dini binti Abdul Mutalib is an undergraduate student in the Bachelor of Operations Management programme at Universiti Teknologi MARA (UiTM), Cawangan Terengganu, Dungun Campus. She previously completed her Diploma in Business Management, which helped her build a solid understanding of business-related concepts. She is currently based in Selangor. With a strong interest in operations and management, Nur Dini is motivated to continuously improve her skills and knowledge to support her future career development.

Noor Syazila binti Rugani is currently pursuing a Bachelor's Degree in Operations Management at Universiti Teknologi MARA (UiTM) and holds a Diploma in Banking, which has provided her with a strong foundation in finance and business operations. She is an active member of Commander Kesatria UiTM, where she develops leadership, discipline, and teamwork skills, and she is committed to further enhancing her knowledge in operations management to support her future professional career.

A1: Scalable Energy Management System (S.E.M.S) with Hall Effect Current Detection

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ABSTRACT

In line with the National AI Technology Action Plan 2026-2030, Smarthomes have been gaining traction over the years with the improvements in technological advancements. However, it cannot be denied that energy is still required to operate such a home. That is where Scalable Energy Management System (S.E.M.S) comes in to manage the amount of energy used throughout the home and detect and notify any abnormal energy consumption within the home by contrasting with the daily average energy consumption for certain appliances. The key thing that sets this proposed system apart from other energy management systems is the utilization of TinyML and Hall Effect to constantly detect energy usage of an appliance at home. Hall Effect sensors will be installed throughout the cable lines to ensure detection of energy usage and a monitoring system will receive the data from these sensors and notify the owners on real time energy usage while also acting as home security. By using this energy management system, energy savings will increase due to optimised usage. For commercialization, due the increase in smart home demands, owners will definitely require an energy management system and this one is relatively affordable due to the use of Hall Effect sensors.

Keywords: Energy Saving, Hall Effect, Management System, Smart Home, Energy Consumption.

1. Product Description

Scalable Energy Management System (S.E.M.S) is a miniature low-power palm sized control server for energy management, smart home and anomaly detection based on TinyML. TinyML is a novel form of low-power AI to run and perform real-time decisions or data feedback based on sensor analytics and user pattern recognition while eliminating the power, data safety and latency limitations of web-based solutions, paired with a simple
mini server raspberry pi layer for use with a user-friendly application to monitor energy use, set preferences and control appliances. S.E.M.S. can be installed into any household or facility with appliances and electricity, works by analysing data from various sensors connected to the main computer, as seen in **Figure 1.** S.E.M.S. is able to intelligently optimize energy consumption based on usual usage patterns, while being able to detect anomalous deviation in baseline power draw to indicate potential issues with the appliances before problems occur. Besides that, users can opt to use S.E.M.S. for household safety applications. For example, gas sensors can be used to detect if a fire or unusual burning is happening in the house, alerting the user before calling the fire department in case no response is obtained.

2. Schematic Diagrams and Operational Flow Charts

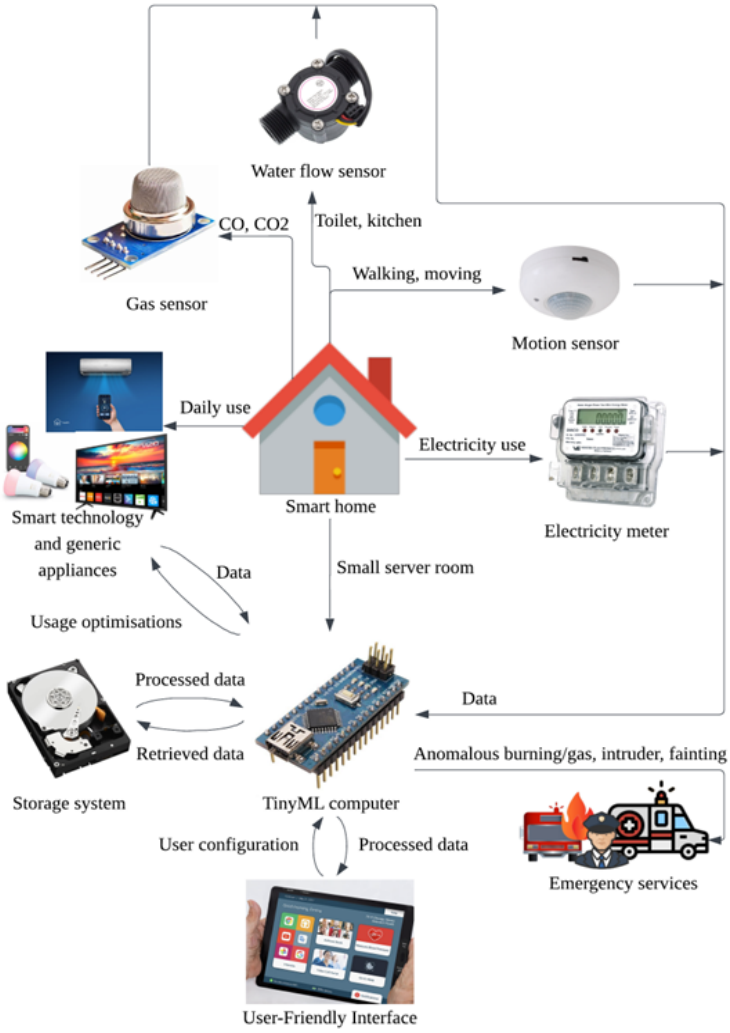

Figure 1. Overall working concept flowchart for applications within a smart home.

System overview

- **User-computer interaction**
  - Users tune and set preferences on a user-friendly interface
  - The entire setup will feature low power draw
  - Data is stored discreetly in a storage drive
  - The system can be controlled over the web (if the user configures it) via a local encrypted portal

- **Energy management system**
  - Optimises energy use based on user usage pattern and preferences
  - Uses sensors to obtain appliance usage data or integration with external applications (i.e., for air conditioning)
  - Data obtained from the sensors are collected and stored for model training and as a historical record

- Processed data is acted upon by the computer to deliver real-time usage optimisations
- Alerts the user of anomalous power draw

- **Home safety**
  - Integrated with energy and non-energy monitoring sensors like gas sensors or motion sensors
  - Unusual activity due to the presence of excess CO_2 gas, power draw or unusual movement detection outside of the usual pattern will result in the computer alerting the user
  - Significantly unusual energy usage patterns will trigger an anomaly warning
  - The user can decide to allow the computer to automatically make appropriate decisions when no response is obtained (ie. calling the fire department)
  - If the user opts in, they can allow the computer to track usual household activities and alert if unusual behaviour is detected (similar to google being able to know when you start going to work)

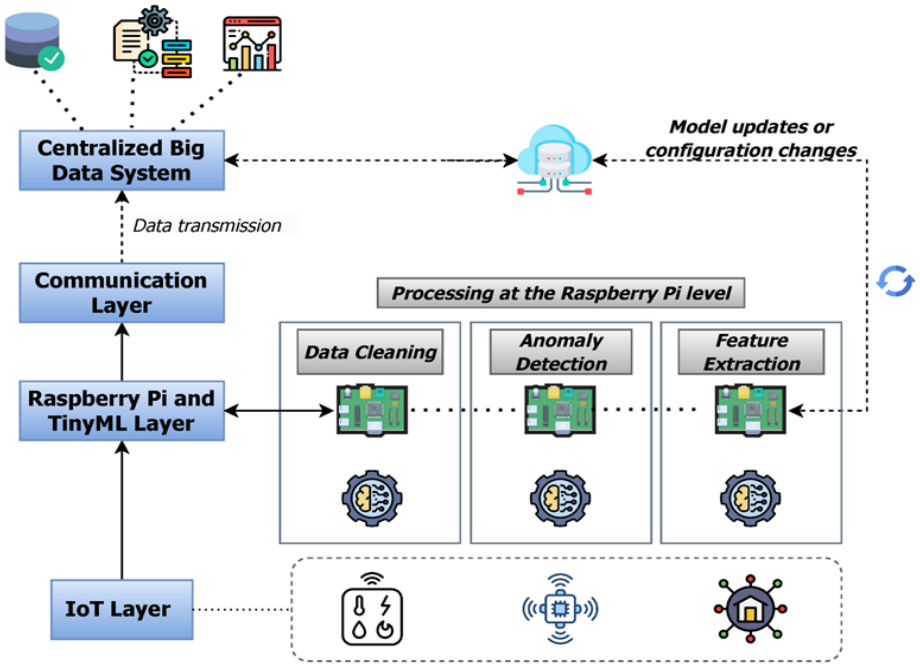

Figure 2. High-level overview of the innovation's data management system obtained from: Karras, A., Giannaros, A., Karras, C., Theodorakopoulos, L., Mammassis, C. S., Krimpas, G. A., & Sioutas, S. (2024). TinyML Algorithms for Big Data Management in Large-Scale IoT Systems. *Future Internet*, *16*(2), 42. https://doi.org/10.3390/fi16020042.

Software operation

Figure 2 describes how each component layer, from sensors and IoTs to the TinyML thinking layer, with higher-level data processing by the Raspberry Pi, mutually interacts.

- **IoT/sensor layer**
  - Obtains data from surroundings or connected appliances and feeds data to the TinyML layer either through bluetooth or via an array of wires
  - Can be any compatible sensor which has been calibrated for use.
  - Ie. gas, motion sensors or the dedicated Hall effect current measurer.

- **TinyML layer**
  - Operates as the "brain" for the innovation to detect anomalies and provide optimisations to power usage
  - The model is trained on prehistoric household data
  - TinyML is unable to continuously train itself while running and requires model updates to occur while the system is not running
  - TinyML processes the data from the sensors and sends it to the Raspberry Pi layer

- **Raspberry Pi layer**
  - Further processes the data and displays it on a centralised big data system (i.e., user interface)
  - Works as a low-power server and mini standalone computer to run applications and web portals.

- **User interface (communication and big data layer)**
  - Simple and easy to use
  - Displays all relevant power uses, average power draw and projected monthly power draw, energy savings, etc.
  - Interfaces with local electrical power supply apps (like myTNB) to provide data on electricity fees

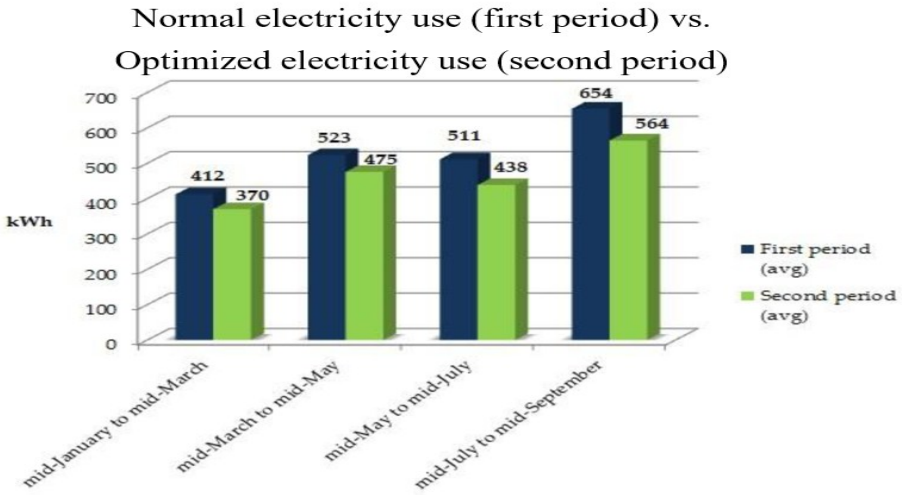

Figure 3. Energy savings obtained by using optimisations from a cloud-based Home Energy Management System (HEMS), retrieved from Machorro-Cano, I., Alor-Hernández, G., Paredes-Valverde, M. A., Rodríguez-Mazahua, L., Sánchez-Cervantes, J. L., & Olmedo-Aguirre, J. O. (2020). HEMS-IoT: A Big Data and Machine Learning-Based Smart Home System for Energy Saving. *Energies*, *13*(5), 1097. https://doi.org/10.3390/en13051097.

Kategori Tarif	Unit	Kadar Baharu (1 Julai 2025)
Domestik Am		
Untuk jumlah penggunaan 1,500 kWj dan ke bawah sebulan		
Caj Tenaga - Untuk semua kWj	sen/kWj	27.03
Caj Kapasiti - Untuk semua kWj	sen/kWj	4.55
Caj Rangkaian - Untuk semua kWj	sen/kWj	12.85
Caj Peruncitan	RM/bulan	10.00
Nota: 1. Untuk jumlah penggunaan 600 kWj dan ke bawah sebulan, Caj Peruncitan dikecualikan. 2. Untuk jumlah penggunaan 600 kWj dan ke bawah sebulan, Caj AFA dikecualikan. 3. Untuk jumlah penggunaan 1,000 kWj dan ke bawah sebulan, pengguna layak menerima Insentif Cekap Tenaga.		

Bagi jumlah penggunaan (kWj) sebulan	Unit	Kadar (1 Julai 2025)
1 - 200	sen/kWj	-25.0
201 - 250	sen/kWj	-24.5
251 - 300	sen/kWj	-22.5
301 - 350	sen/kWj	-21.0
351 - 400	sen/kWj	-17.0
401 - 450	sen/kWj	-14.5
451 - 500	sen/kWj	-12.0

Figure 4. Current general TNB tariff rate and incentive rate effective from 1st July 2025.

By using example literature data from a similar innovation as seen in **Figure 3** and electricity tariff rates as seen in **Figure 4,** assuming energy usage is not inclusive of ToU uses, HEMS-IoT is able to save a maximum of 90 kWh bimonthly from mid-July to mid-September. Assuming energy usage for a day is equal across 60 days of a month,

Daily power saving = 90/60
= 1.5 kWh/day

Extrapolating for 30 days,
Monthly energy savings = (1.5 kWh/day)*(30day/month)
= 45 kWh/month

However, to calculate cost savings, the monthly usage rate needs to be taken into consideration.

For unoptimised power usage,
654/2 = 327 kWh/month
By referring TNB's tariff rate (assuming no ToU tariff)
The bill for the month will be:
Power usage*electricity tariff rate - energy efficiency incentive
(327kWh*(27.03+4.55*12.85)cent/kWh - 327kWh(17)cent/kWh)/100 = RM 89.70

For optimised power usage,
564/2 = 282 kWh/month
The bill for the month will be:
Power usage*electricity tariff rate - energy efficiency incentive
(282kWh*(27.03+4.55+12.85)cent/kWh - 282kWh(22.5)cent/kWh)/100 = RM 61.84

Thus effectively saving RM27.86 for the selected month. Assuming energy usages are even throughout the year, annual electricity bill savings are 27.86*12 = RM334.32

However, it should be noted that the above data is obtained from a similar concept as S.E.M.S. but is based on cloud infrastructure and interfacing with only IoTs; thus, energy savings may not be as effective as S.E.M.S. with lower power draw and real-time optimisations.

3. Novelty and uniqueness

As of 2026, the concept of web-based home energy management systems for IoT (HEMS-IoT) has been around since 2020, and only one hotel-based energy management system offered by Infinia from 2024 onwards exists. There is a lack of affordable, localised and scalable solutions for housing applications to simultaneously perform energy management and anomaly detection for household safety. Besides that, HEMS-IoT employs a web-based approach, while S.E.M.S. runs entirely local, low latency and data safe working with bleeding edge TinyML AI infrastructure which is currently not available in the market for this application. Other than that, the use of Hall Effect sensors to measure current flow of electrical appliances regardless if the appliance is connected to the internet or not is also novel as other solutions involve using a power plug with energy measuring devices built in. The use of Hall effect sensors makes it easier for users to set up the product non-invasively, while having an intuitive user interface to pair hall effect sensors to the app. Besides that, S.E.M.S. features anomaly detection which is not offered by Infinia, which functions by using external sensors (ie. gas sensors) to detect anomalous behaviour, alerting the user of potential issues.

4. Benefit to mankind

S.E.M.S solves the issue of the lack of clarity in power consumption making energy management simple and effective. With its unique trait of being scalable, the target consumer can range from typical homeowners to large-scale businesses in handling the energy consumption. The primary benefit of this device is to save cost in energy as homeowners can identify where electricity is being consumed and take action to reduce unrequired energy consumption. This monitoring system can also alert and prevent fluctuations in energy consumption due to malfunctions to give homeowners better control and assurance. Other than financial benefits, the device strives for environmentally friendly living by reducing total energy consumption and carbon footprint. With its easy setup and user-friendly interface, homeowners do not need technical knowledge to begin optimising their living space. S.E.M.S empowers homeowners to make smarter decisions, save money, and manage their energy efficiently and sustainably.

5. Innovation and Entrepreneurial Impact

The S.E.M.S. transforms intelligent infrastructure by replacing manual controls with proactive, habit-driven optimization. By employing "invisible" management and self-regulation, it fosters innovation and transforms residences into adaptable spaces that cater to both the upscale "Quiet

Luxury" market and the essential healthcare industry. By identifying typical variations for seniors and those with disabilities, S.E.M.S. questions conventional home-care approaches and generates new income possibilities for "Smart City" developers and healthcare professionals. It also promotes an entrepreneurial environment by providing a scalable platform for integrating third-party services, like energy retailers with emergency responders, enabling the system to optimize electrical appliance usage to cut operating costs and alert first responders to any anomalies found in senior users' habits. By connecting social technology with high-end lifestyle automation, S.E.M.S. drives a transformative shift in the industry toward human-centered, self-sufficient living solutions that enhance personal freedom and overall energy efficiency.

6. Potential commercialization

The Scalable Energy Management System (S.E.M.S.) is the next step in smart infrastructure, going beyond manual controls to proactive, habit-based optimization. By learning individual routines, the system creates a seamless "hands-free" environment for its users by providing advanced home management by autonomously monitoring patterns desired by developers and "Smart City" planners to offer a more comfortable living experience to its users. This system is suitable for users who are disabled or are senior living operators and home healthcare providers, where the system is able to detect deviations such as a stove left on or a missed morning routine, allowing seniors to live independently longer. Additionally, built on a flexible architecture, S.E.M.S. combines energy efficiency with personalized control. Whether optimizing energy use in large homes or providing subtle management, it turns a residence into a responsive environment that provides the quiet luxury of invisible autonomous management that premium buyers can expect.

7. Acknowledgment

We would like to thank our project advisor, DR. NUR HAFIZAH AB HAMID, for providing us with valuable insights and information throughout this project, and our sincerest gratitude to our parents who have shown unwavering support throughout this project.

8. searchers' Biography

Brian Chan Jin Xian is a Bachelor of Chemical Engineering undergraduate at Universiti Teknologi Malaysia. He's a "Jack of all trades" with interdisciplinary experience and hobbies in a variety of fields, often solving problems with a pattern recognition based approach by applying solutions and concepts from other fields. He is determined to apply sustainable energy technologies to solve the problems of tomorrow.

Beh Jien Chern is a Bachelor of Chemical Engineering undergraduate at Universiti Teknologi Malaysia. He is passionate about using artificial intelligence to solve real-world problems and create technologies to support better living , smarter decision-making and more inclusive digital experiences.

Melvin Siew Zhi Yi is a Bachelor of Chemical Engineering undergraduate at Universiti Teknologi Malaysia (UTM). He is a curious individual who is keen on solving real world problems with a more sustainable approach. He is keen on the utilization of technology and software to help in managing problem solving, data analysis and data collection to ensure a better tomorrow.

Muhammad Aqeel Bin Mohamad Arif is a Bachelor of Chemical Engineering undergraduate at Universiti Teknologi Malaysia (UTM). He is eager to learn and yearns to delve deeper into research to gain a better understanding of the scientific side of life to hopefully apply it for the betterment of society

Resorb – Potential Recovered Adsorbent from Alum-Sludge

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ABSTRACT

Water treatment sludge contains significant amounts of hazardous substances such as heavy metals and residual coagulants, which pose environmental concerns and increased management costs. RESORB is an initiative project focusing on the innovative recycling the alum-sludge to transform it into valuable product thereby reducing the financial burden associated with disposal for the water treatment operator. RESORB has a potential serve as a sustainable and cost-effective adsorbent for the dye removal from polluted water. To improve the properties of alum-sludge as an effective adsorbent, the sludge undergoes modification through a chemical activation by sodium hydroxide (NaOH). The alum-sludge obtain were dried to remove the moisture content and crushed to certain size particle. The modification process further continued calcined at high temperature for 2 hours in limited oxygen condition to improve surface area, porosity and functional group. The activated alum-sludge was be examined using spectroscopy and Scanning Electron Microscopy (SEM) to evaluate its physicochemical properties. To determine the adsorption potential, the activated sludge was applied in Methylene Blue (MB) removal. The investigation demonstrated a reduction in dye concentration due to adsorption. This innovation contributes to environmentally friendly by reducing sludge disposal and reducing dye pollution in water bodies. From socio-economic perspective, this offers cost effective alternative to commercial adsorbents and shows strong potential for large-scale use and commercial application in waste treatment.

Keywords: Alum-sludge, chemical activation, adsorbent, dye removal

1. Product Description

RESORB is an alternative adsorbent from a development process of a sustainable, low-cost adsorbent derived from alum-sludge, a byproduct generated from water treatment plants. Alum sludge is rich in aluminum oxides and hydroxides due to the coagulation-flocculation process during water treatment. Alum-sludge practically disposed in landfills which may leads to high disposal cost and environmental concern. To address this issue, this project introduces an initiative to recycle alum-sludge into a valuable adsorbent, transforming waste into a useful product. The adsorbent was prepared using standard methods, including drying, particle size reduction, chemical activation and thermal treatment. These processes were applied to enhance the surface area, porosity and functional groups of the sludge, improving its adsorption performance. The activated alum-sludge shows potential adsorbent for dye removal with methylene blue used as a model pollutant. Experimental findings indicate that the modified sludge exhibits effective adsorption capacity, demonstrating its suitability for wastewater treatment applications. Overall, the findings confirm that alum sludge can be successfully recycled into a

low-cost, sustainable and efficient adsorbent. This offer the environmentally friendly alternative to commercial adsorbent while reducing sludge disposal problems.

2. Schematic diagrams

Figure 1 shows the schematic diagram of development process in producing the alum-sludge adsorbent from water treatment plants, the chemical activation process and the application of potential alum-sludge adsorbent.

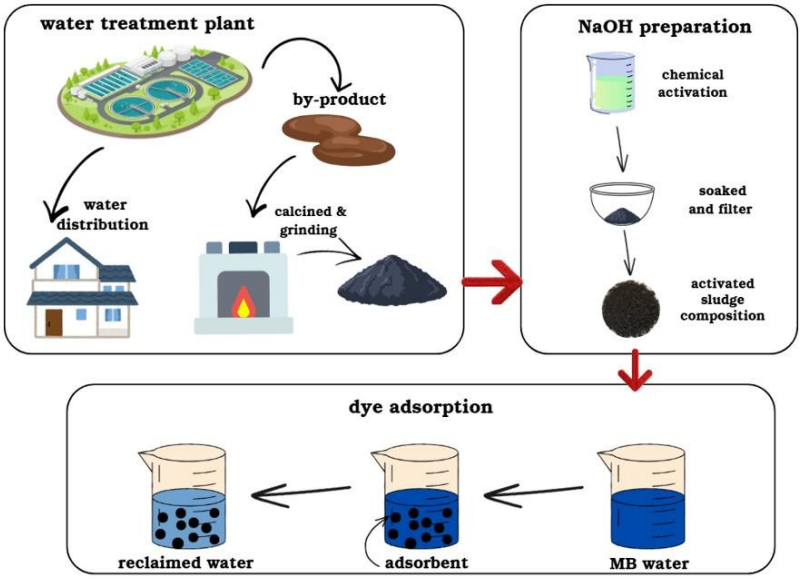
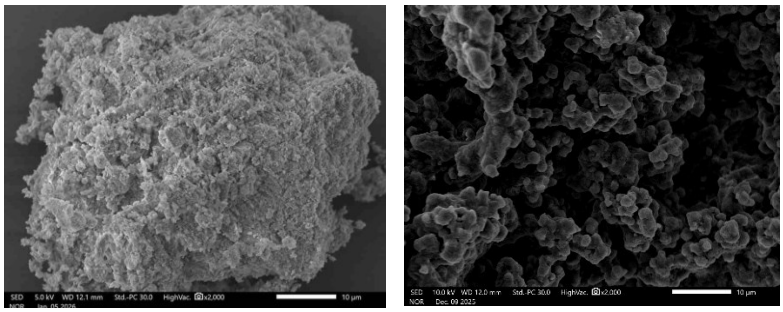


Figure 1. Flowchart preparing and producing process of activated alum-sludge.

Scanning Electron Microscopy (SEM) is employed to compare the surface structure of the developed adsorbent before and after chemical activation. **Figure 2** showed the existence of mesoporous size in activated alum-sludge. During the activation, the process did not change the surface structure or pore size of the adsorbent.



(a) (b)

Figure 2. SEM image for (a) inactivated alum-sludge and (b) activated alum-sludge.

Figure 3 illustrated the application of developed adsorbent (RESORB) in Methylene Blue (MB) removal. The inactivated alum-sludge exhibited poor dye removal performance due to limited surface activity and adsorption sites. After the sludge is modified by chemical activation, it showed significant in reduction in dye solution, indicating higher adsorption efficiency. However, due to the certain limitation, the adsorbent showed good adsorption only at low dye concentration.

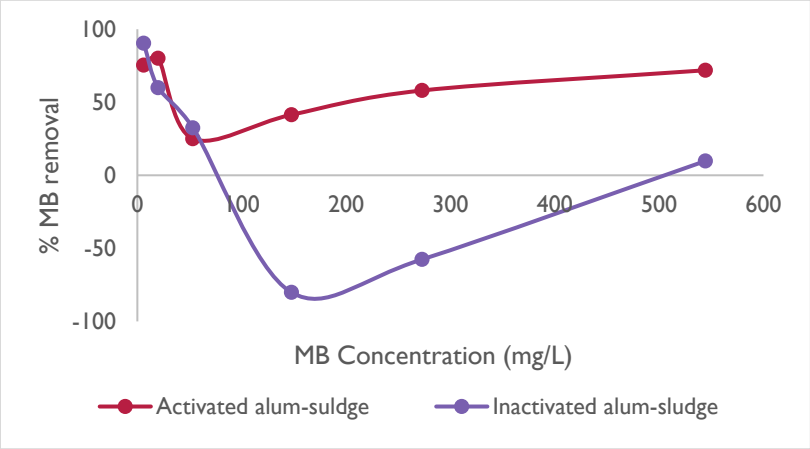


Figure 3. Percentage of Methylene Blue (MB) dye removal by inactivated and activated alum-sludge.

3. Novelty and uniqueness

This innovation introduces a novel approach to converting alum-sludge from water treatment plants into a renewable adsorbent material. The product converts a commonly discarded waste into a value-added adsorbent, reducing reliance on landfill disposal which frequently imposes significant financial burdens on water treatment operators. Its uniqueness lies in the integration of waste recycling and water treatment which offering a sustainable solution that addresses both environmental pollution and sludge management issues. The adsorbent demonstrates potential performance in dye removal application, highlighting its practical applicability, sustainability and low-cost benefits compared to conventional adsorbents particularly for industries with low-concentration dye effluents.

4. Benefit to mankind

This project provides significant benefits to water treatment plant operators by offering an alternative solution for alum-sludge management. Instead of relying on costly landfill disposal expenses while addressing environmental concerns. The recycled sludge can be commercialized as adsorbent material, creating additional revenue opportunities for water treatment facilities. Furthermore, the availability of cost-effective and sustainable adsorbent supports industries in wastewater treatment application, its also contributing to cleaner water resources and improved environmental protection. Overall, this innovation promotes sustainable waste management, cost reduction and economic value creation which bring benefits both industry stakeholders and society.

5. Innovation and Entrepreneurial Impact

The development of alum-sludge adsorbent demonstrated significant entrepreneurial potential by turning an industrial waste product into renewable and marketable products. This new idea gives new business opportunity to provide alternative adsorbents to expensive commercial adsorbents especially for industries facing dye effluent challenges. Utilizing the sludge resource, the product offers promising prospect as sustainable, manufactured green adsorbent and reducing the dependency on imported and expensive materials.

6. Potential commercialization

The alum-sludge adsorbent offers a potential commercialization to certain industries and company. As for water treatment plants, they can generate revenue by supplying by-product alum-sludge as a value-added adsorbent, turning a disposal burden into a profitable resource. For small or start-up companies, the adsorbent represents a marketable green technology with scalable production potential, targeting dye industries require affordable wastewater treatment solutions.

7. Acknowledgment

The authors extend their heartful gratitude to Faculty of Chemical Engineering, UiTM Cawangan Johor Kampus Pasir Gudang for the excellence facilities provided and to everyone especially the laboratory staff for their invaluable participation, supports and cooperation throughout this project.

8. Researchers' Biography

Noor Liyana Binti Mazelan is a final year diploma student in chemical engineering at the Faculty of Chemical Engineering, UiTM Cawangan Johor Kampus Pasir Gudang. She has demonstrated strong teamwork skills and ability to work effectively under pressure. She is motivated to develop her research skills and gain further experience in engineering-related studies.

Hurin Ein Binti Mohd Rizal is a final year diploma student in chemical engineering at the Faculty of Chemical Engineering, UiTM Cawangan Johor Kampus Pasir Gudang. She is a person who actively contributes and participates to group projects and very independent. She is interested in pursuing study as an environmental engineering student on her degree journey.

Siti Hajar Anaziah Muhamad is currently a senior lecturer in the Faculty of Chemical Engineering at UiTM Cawangan Johor Kampus Pasir Gudang. She holds a Master of Engineering in Chemical Engineering, which she obtained from Universiti Kebangsaan Malaysia (UKM). Her academic and research interests lie in environmental engineering and science, with a particular emphasis on sustainable environmental management and pollution control.

Design and Development of a Plant Monitoring and Watering System Based on Soil Moisture and Temperature Sensing

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ABSTRACT

Maintaining proper plant watering schedules can be challenging due to busy lifestyles, often resulting in overwatering or underwatering that negatively affects plant health. This paper presents the design and implementation of an automated plant monitoring and watering system using a microcontroller integrated with soil moisture, temperature, and light sensors. The system continuously monitors environmental conditions and automatically initiates irrigation when the soil moisture level falls below a predefined threshold. Real-time data, including soil moisture and temperature, are displayed on an OLED screen for local monitoring. Additionally, remote monitoring and control are supported via a smartphone or computer, enabling users to observe plant conditions and manage watering conveniently. The proposed system enhances efficiency, reduces manual intervention, and promotes water conservation. By ensuring optimal growing conditions, the system supports healthy plant growth and demonstrates potential for application in smart home automation and urban gardening systems.

Keywords: Automatic plant watering, Microcontroller-based system, Plant monitoring system, Soil moisture sensor,

1. Product Description

The Plant Monitoring and Watering System is an innovative IoT-based solution designed to simplify plant care and ensure healthier growth. Powered by the ESP32 microcontroller, the system integrates soil moisture, temperature, and light sensors to continuously monitor environmental conditions. When the soil becomes too dry, the system automatically activates a water pump through a relay while triggering a buzzer to alert the user. An OLED display provides instant local feedback, showing real-time sensor readings, while remote access via the Blynk application allows users to monitor and control the system from their smartphone or computer. To enhance usability, sensor data is also logged into Google Sheets, enabling users to track plant conditions over time. The system supports three modes of operation: automatic watering, manual activation through a switch, and remote control via Blynk, offering flexibility for different user preferences. By combining automation, real-time monitoring, and remote accessibility, this project reduces the effort required for plant care, prevents overwatering or underwatering, and promotes efficient water usage. Compact, reliable, and user-friendly, it is suitable for home gardening, small greenhouses, and educational projects, bridging the gap between traditional plant maintenance and modern smart technology.

2. Block Diagram and Flowchart of The Project

The block diagram in **Figure 1** illustrates how the plant monitoring and watering system operates. Soil moisture, temperature, and light sensors measure the plant's conditions and send data via Wi-Fi to the ESP32 microcontroller, which acts as the system's brain. Based on these readings, the microcontroller decides whether to activate the water pump and buzzer when the soil is dry. An OLED display provides real-time feedback on moisture and temperature, while the system also transmits status updates to a remote interface, allowing users to monitor and control the plant care process from their phone or computer.

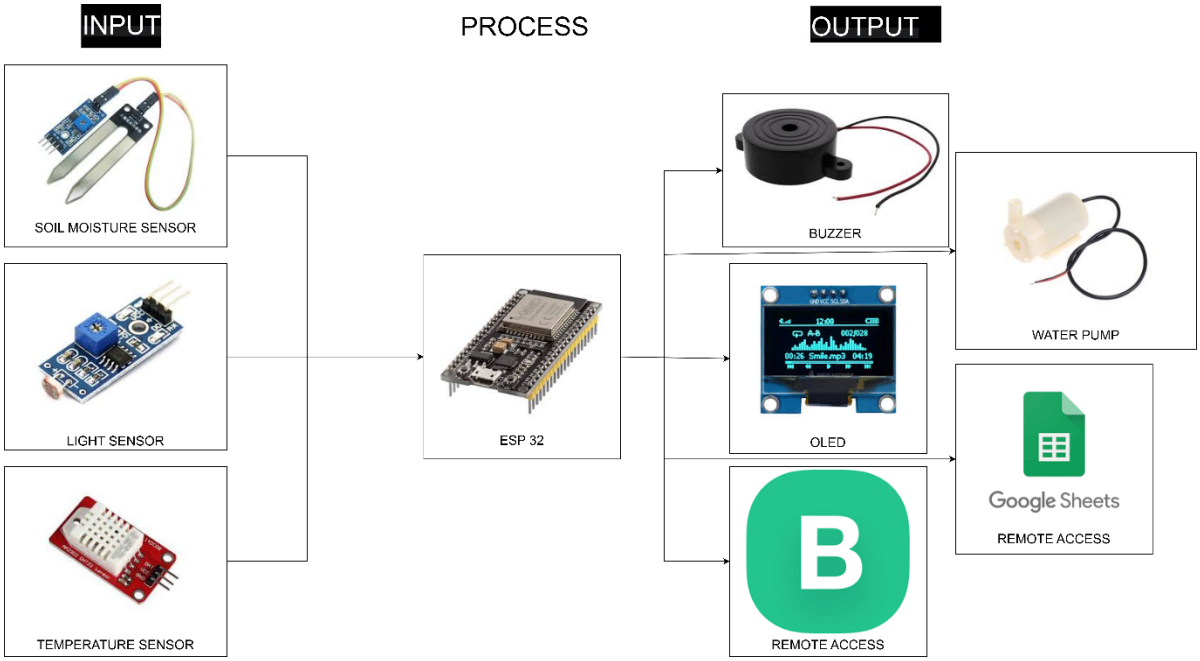

Figure 1. Block diagram of Plant Monitoring and Watering System with Soil Moisture and Temperature Sensing.

The flowchart in **Figure 2** shows the step-by-step process of how the system works. It starts by connecting microcontroller to the Wi-Fi and then, reading the soil moisture, temperature and light from the sensors. The readings are then displayed on the OLED screen. Next, the system checks if the soil moisture is below a set threshold. If the soil is too dry, the microcontroller triggered the buzzer and activated the water pump to water the plant. If the soil is still moist enough, the pump stays off. The system then sends the updated data to the remote interface and repeats the process continuously, ensuring the plant always receives the right amount of care without needing much attention from the user.

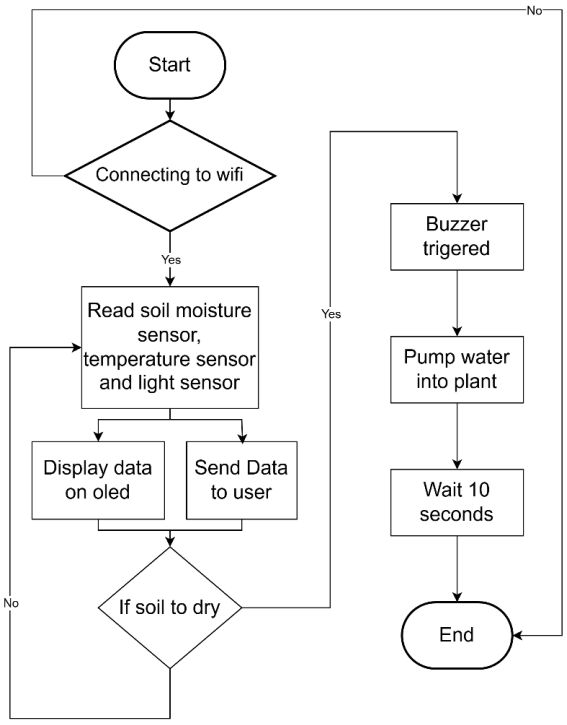

Figure 2. Flow chart of Plant Monitoring and Watering System with Soil Moisture and Temperature Sensing.

Figure 3 shows that simulation for this system that was made by using Wokwi Potentiometer were used as substitution for soil moisture since in Wokwi there is no soil moisture.

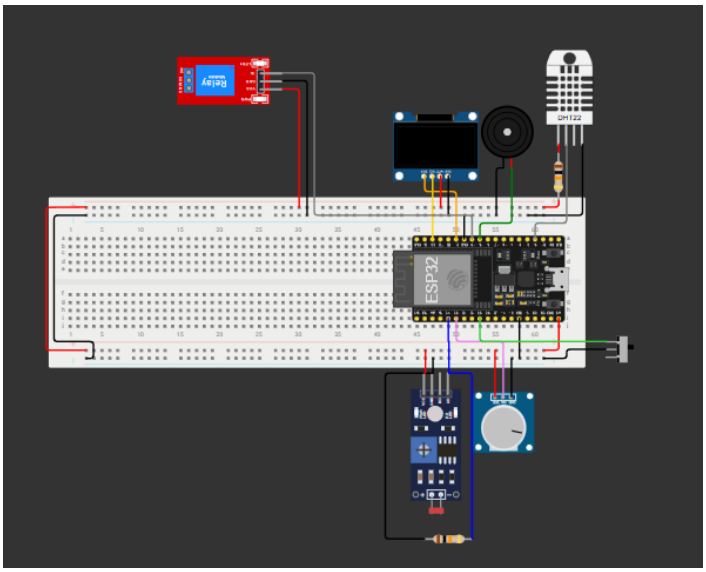

Figure 3. Simulation for the proposed system.

3. Novelty and uniqueness

The novelty of the Plant Monitoring and Watering System lies in its ability to combine local real-time feedback with remote IoT accessibility in one compact design. Unlike many existing systems that rely solely on cloud platforms or basic manual control, this project integrates an OLED display to provide immediate sensor readings of soil moisture, temperature, and light directly near the plant. At the same time, it enables remote monitoring and control through the Blynk application and Google Sheets, ensuring flexibility for users to access data and manage watering from anywhere. Another unique aspect is its multi-mode operation**,** offering automatic watering based on sensor thresholds, manual activation via a physical switch, and remote control through a mobile app. This versatility makes the system adaptable to different user needs and reliable even with unstable internet connections. The use of the ESP32 microcontroller enhances efficiency by combining Wi-Fi connectivity with powerful sensor integration, while maintaining affordability and simplicity. By bridging gaps between complex cloud-based systems and overly basic designs, this project delivers a balanced, user-friendly solution **t**hat promotes water efficiency, reduces plant care effort, and ensures healthier growth. Its compactness and accessibility make it especially suitable for home gardening, small greenhouses, and educational applications.

4. Benefit to mankind

The Plant Monitoring and Watering System offers clear benefits to mankind by making plant care easier, more efficient, and sustainable. By automating irrigation through soil moisture, temperature, and light sensors, it ensures plants receive the right amount of water, reducing stress for busy individuals while promoting healthier growth. This system also supports environmental sustainability by conserving water and preventing waste, contributing to responsible resource management. The integration of an OLED display for local feedback and remote monitoring via Blynk and Google Sheets makes technology accessible to everyday users, bridging the gap between advanced IoT solutions and simple household needs. Beyond personal convenience, the system can be adapted for small-scale farming, urban gardening, and educational purposes, encouraging innovation and awareness of smart technologies. Ultimately, it improves quality of life, supports greener living, and fosters sustainable practices that benefit both individuals and communities.

5. Innovation and Entrepreneurial Impact

The Plant Monitoring and Watering System promotes innovation by integrating IoT technology with practical, everyday plant care, offering a solution that is both affordable and user-friendly. Its novelty lies in combining local OLED feedback with remote monitoring through Blynk and Google Sheets, ensuring accessibility even for non-technical users. This approach encourages creative problem-solving and demonstrates how advanced technology can be applied to simple, real-life challenges. From an entrepreneurial perspective, the project highlights opportunities for commercialization in smart home products, urban gardening, and small-scale agriculture. By showcasing a compact, scalable design, it inspires students and communities to explore technology-driven ventures that address sustainability and convenience. Within the institution, it fosters a culture of entrepreneurship by motivating peers to develop innovative solutions that merge electronics, IoT, and environmental care, ultimately contributing to industry growth and encouraging future startups in smart systems and sustainable living.

6. Potential commercialization

The Plant Monitoring and Watering System demonstrates strong commercialization potential due to its affordability, simplicity, and adaptability. By integrating IoT technology with everyday plant care, the system addresses a clear market need among busy individuals, households, and small-scale farmers who struggle with consistent plant maintenance. Its compact design, multi mode operation (automatic, manual, and remote), and dual feedback system (OLED display and mobile/cloud monitoring) make it attractive to both tech-savvy users and general consumers. The use of low-cost components such as ESP32, sensors, and OLED ensures that production can be scaled at minimal expense, making the product accessible to a wide audience. Beyond home gardening, the system can be marketed to educational institutions for IoT training, urban agriculture projects, and small greenhouse operators. With growing interest in smart home devices and sustainable living, this project has the potential to evolve into a commercially viable product line.

7. Acknowledgment

I would like to express my deepest gratitude to my project supervisor for their invaluable guidance, support and valuable feedback throughout the development of this project. Her insights and encouragement really played a crucial role in shaping the outcome of my project. I am also sincerely thankful to my family for their constant support and motivation and to my faculty members who offered their assistance and shared their knowledge wherever possible. Their contributions really help in overcoming challenges and completing my project successfully.

8. Researchers' Biography

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The Imtcs Hub (Integrated Multi-Tier Cooling System): A Smart Vertical Solution for Rapid Cooling and Operational Efficiency

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ABSTRACT

The cooling stage represents a significant bottleneck in yellow noodle production, as conventional methods require approximately ten minutes per batch and result in uneven cooling, hygiene concerns, and inefficient space utilization. The Integrated Multi-Tier Cooling System (IMTCS) is introduced as an innovative vertical conveyor design that incorporates high-velocity airflow and IoT-based thermal control. Transitioning from horizontal lines to a multi-tier vertical configuration reduces human contact and substantially decreases the required factory floor space. Preliminary findings demonstrate that IMTCS increases production throughput, maintains consistent noodle texture, and enhances hygiene compliance. This innovation provides a scalable solution for small and medium-sized enterprises (SMEs) seeking improved productivity and operational efficiency in food manufacturing.

Keywords: yellow noodles, cooling system, conveyor, operations management, innovation

1. Product Description

The process of manufacturing yellow noodles is divided into several major processes, which start with the mixing and boiling process followed by the cooling and packaging process. The cooling process can be considered the most significant as it determines the texture, safety, and the overall quality of the product. Currently, every process of cooling is done manually or using simple fans and normally takes approximately ten minutes per batch. As the demand of production rises, it might result in a bottleneck of this stage since noodles cannot be packed until they are cooled. The problem with limited space in the factories is also that long cooling lines are hard to install and the amount of manual control that is done on a frequent basis also poses the question of hygiene and consistency. To alleviate this predicament, the introduction of the Integrated Multi-Tier Cooling System (IMTCS) as a radical method on the yellow noodle processing is to be used. The system incorporates a vertical, multi-level conveyor with powerful airflow and temperature sensors to achieve better and more controlled cooling. The system can be used to enhance productivity by minimizing physical contact and using as much space as possible to ensure the quality and cleanliness of yellow noodles are not compromised.

2. Methodology

The IMTCS will be designed for enhancing the cooling stage when making noodles at factory. This technology aims at creating an efficient cooling system that consumes less time and space.

- Prototype Design: A vertical multi-tier conveyor will be designed to allow for maximum cooling with minimal floor space. The speed of this conveyor will be adjustable depending upon noodle thickness and moisture.
- Cooling System: Industrial fans and air knives ensure a constant high-speed air flow, which helps in rapidly cooling noodle temperature after boiling, thus preventing moisture formation.
- Sensor Integration: IoT thermal sensors will monitor in real time, and the temperature will automatically adjust the conveyor speed to reach the perfect packaging temperature for the noodles.

Additionally, prototype design will be evaluated in terms of compatibility with the production facilities and hygiene standards that require less change in the layout.
Lastly, cooling time per run/cycle and differences in temperature per run/cycle, throughput rates, and space efficiency of the system shall be tested to assess the effectiveness of the system for industrial applications.

The primary objectives are as follows:
1. Reduce cooling duration from 10 minutes to 5 minutes by employing high-velocity air knives, resulting in a 50% increase in heat dissipation efficiency.
2. Optimize factory floor space through a vertical zig-zag configuration, thereby maximizing cubic space and minimizing the production footprint.
3. Integrate Internet of Things (IoT) real-time monitoring by utilizing thermal sensors to automatically regulate conveyor speed, which ensures consistent product quality and precise temperature control.
4. Enhance hygiene and regulatory compliance by minimizing human contact via automated workflows, thereby supporting adherence to Halal and MeSTI standards.

3. Analysis of Current Operation

Figure 1. Manual Horizontal Cooling Layout.

Company currently utilizes a process-oriented layout in which boiled noodles are cooled manually on large horizontal tables. This stage represents the primary bottleneck, requiring 10

minutes per batch and occupying significant floor space. Manual handling also increases the risk of contamination and inconsistent texture. Additionally, power outages that halt the cooling fans can result in overcooked products and elevated internal failure costs.

Figure 4.2.1: The Innovation (3D Model)

Figure 2. The Innovation (3D Model) .

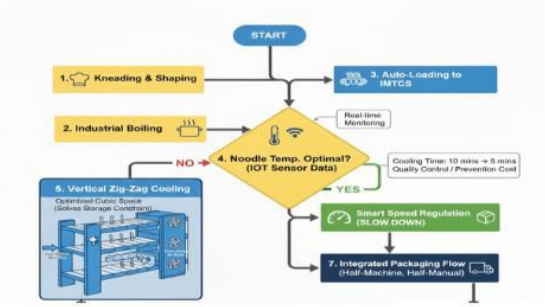

Figure 4.2.2: Operational Flowchart

Figure 3. Operational Flowchart .

Proposed IMTCS Operational Sequence.

The Integrated Multi-Tier Cooling System (IMTCS) implements an automated, vertical zig-zag flow to enhance production efficiency. The operational sequence is as follows:

1. Preparation and Boiling: Flour and ingredients are kneaded and shaped before entering the industrial boiler.
2. Automated Loading: After boiling, noodles are conveyed directly into the IMTCS unit, eliminating manual handling.
3. Multi-Tier Cooling: Noodles move through vertical zig-zag tiers, where high-velocity air knives reduce cooling time from 10 minutes to 5 minutes.
4. IoT Monitoring and Regulation: Integrated thermal sensors monitor noodle temperature. If the temperature remains elevated, the conveyor speed is automatically reduced (Smart Speed Regulation) to ensure optimal cooling.
5. Direct Packaging: Cooled noodles are immediately transferred to the packaging line, maintaining a continuous flow from raw material to finished goods.

Impact on Space and Quality Management

Table 4.3.1 Comparison of Current & Proposed IMTCS.

Criteria	Current	IMTCS (Innovation)
Cooling Time	10 Minutes	5 Minutes
Space Usage	Horizontal (Extensive)	Vertical (Optimized)
Quality Control	Risk of unevenness	IoT Automated
Labor	High Dependency	Minimal

The adoption of a vertical layout represents a strategic optimization of the factory's cubic space. Reclaiming the floor area previously occupied by cooling tables enables company to reorganize workflow and increase production capacity. Furthermore, the enclosed stainless-steel design functions as a preventive measure within the framework of Total Quality Management (TQM), thereby enhancing hygiene standards and facilitating compliance with Halal and MeSTI requirements.

4. Novelty and uniqueness

Integrated Multi-Tier Cooling System (IMTCS) addresses operational bottlenecks in noodle production by reducing cooling time by 50 percent and optimizing factory floor space through a vertical zig-zag design. Integration of IoT thermal sensors ensures consistent product quality and compliance with Halal and MeSTI safety standards. This cost-effective innovation offers significant commercialization potential for small and medium-sized enterprises seeking to improve production efficiency and manufacturing competitiveness. The novelty of the Integrated Multi-Tier Cooling System (IMTCS) lies in its ability to transform the conventional noodle cooling process from a manual, horizontal, and space-consuming operation into a smart, automated, and vertical cooling system. Unlike traditional cooling methods that rely on open tables and basic fans, IMTCS applies a multi-tier zig-zag conveyor design that maximizes vertical space while maintaining continuous product movement. This makes the system especially suitable for small and medium-sized food manufacturers with limited factory floor area. A unique feature of IMTCS is the combination of high-velocity airflow and IoT-based thermal monitoring. The use of air knives enables faster and more uniform heat dissipation, reducing cooling time from 10 minutes to 5 minutes. At the same time, IoT thermal sensors monitor noodle temperature in real time and automatically regulate conveyor speed to ensure that the product reaches the ideal packaging temperature. This smart control mechanism helps maintain consistent noodle texture, reduce overcooling or undercooling, and improve overall product quality. Another distinctive aspect of IMTCS is its contribution to hygiene and food safety. By minimizing human contact during the cooling stage, the system reduces contamination risks and supports compliance with Halal and MeSTI standards. Its enclosed stainless-steel structure also promotes cleaner production practices and easier maintenance.

5. Benefits to mankind

The Integrated Multi-Tier Cooling System (IMTCS) provides meaningful benefits to society by improving the safety, quality, and efficiency of yellow noodle production. By reducing manual handling during the cooling process, the system lowers the risk of contamination and supports better food hygiene, which is important for protecting consumer health. The use of automated cooling and IoT thermal monitoring ensures that noodles are cooled evenly and consistently before packaging, helping to maintain product texture, freshness, and overall quality. In addition, IMTCS benefits workers by reducing dependency on repetitive manual tasks, creating a cleaner and safer working environment. The faster cooling process also reduces production delays, allowing food manufacturers to meet customer demand more effectively. For small and medium-sized enterprises (SMEs), this innovation supports business sustainability by improving productivity, minimizing product defects, and reducing operational losses. Overall, IMTCS contributes to a more efficient, hygienic, and reliable food manufacturing process that benefits consumers, workers, businesses, and the wider community.

6. Innovation and Entrepreneurial Impact

The IMTCS demonstrates strong innovation impact through its smart vertical cooling concept, which transforms the conventional horizontal and manual cooling method into an automated, space-saving, and technology-driven system. Its multi-tier zig-zag conveyor design maximizes the use of vertical factory space, while high-velocity airflow reduces cooling time from 10 minutes to

5 minutes. The integration of IoT thermal sensors further enhances the system by enabling real-time temperature monitoring and automatic conveyor speed regulation, ensuring consistent product quality and operational control. From an entrepreneurial perspective, IMTCS has strong commercialization potential, particularly for SMEs in the food manufacturing sector. Many small noodle producers face challenges such as limited factory space, high labor dependency, inconsistent product quality, and hygiene compliance requirements. IMTCS directly addresses these challenges by offering a practical, scalable, and cost-effective solution. The system can help businesses increase production capacity, reduce waste, improve compliance with Halal and MeSTI standards, and strengthen their competitiveness in the market. Furthermore, the innovation creates opportunities for business expansion through prototype development, equipment customization, licensing, and potential collaboration with food processing machinery suppliers. As demand for efficient and hygienic food production continues to grow, IMTCS has the potential to become a marketable technology that supports modernization in Malaysia's food manufacturing industry and beyond.

7. Potential Commercialization

The IMTCS effectively addresses key constraints related to time, space, and labor, positioning it as a highly scalable solution for the food industry. Its capacity to reduce product loss and ensure consistent quality supports its readiness for patenting and commercial expansion.

8. Researchers' Biography

Zainati Amni Binti Zaki is a student of Operations Management at Universiti Teknologi MARA (UiTM). She also holds a Diploma in Halal Management. Her project focuses on improving the efficiency of the noodle cooling process through the Integrated Multi-Tier Cooling System (IMTCS). The main objective of this project is to reduce cooling time, minimize production bottlenecks, and enhance overall operational efficiency. The project is conducted with her group members in collaboration with Muslim Food Industry, Kuala Terengganu.

Nur Qistina Idayu binti Azha is a Semester 3 undergraduate student in Operations Management at Universiti Teknologi MARA (UiTM). She has a keen interest in the study of business operations, particularly in improving organizational efficiency and performance. She is committed to developing her knowledge and skills in management and aspires to contribute meaningfully to the operations and business sector in the future.

Shafaezza Mohd Yusof is a student of Operations Management at Universiti Teknologi Mara (UiTM). Her project focuses on how to shorten the cooling process of the noodles which know as Integrated Multi-tier Cooling System or IMTCS..she doing this project with ther group members at Muslim Food Insdustry at Kuala Terengganu

Nurul 'Aqilah binti Ibrahim is a student at Universiti Teknologi MARA, pursuing studies in Operations Management. Her academic interests focus on process optimization, operational efficiency, and innovative system design within industrial and manufacturing environments. She is currently involved in a research project which explores the application of vertical cooling technologies to enhance performance, space utilization, and efficiency in modern operational systems.

Nur Aisyatul Balqis Binti Mohd Khairol is a student of Business Operations and Management at Universiti Teknologi Mara (UiTM). Her project focuses on how to shorten the cooling process of the noodles which know as Integrated Multi-tier Cooling System or IMTCS..she's enjoying doing this group project with their group members at Muslim Food Insdustry at Kuala Terengganu.

Gold Price Prediction Using Lstm and News Sentiment Analysis

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ABSTRACT
Forecasting gold prices is challenging due to market volatility influenced by macroeconomic indicators, geopolitical events, and investor sentiment. This project presents an intelligent gold investment prediction system that integrates Long Short-Term Memory (LSTM) time-series forecasting with financial news sentiment analysis to enhance short-term decision-making. Historical daily gold prices are modelled using LSTM to capture nonlinear temporal patterns, while sentiment polarity scores extracted from financial news headlines using the VADER sentiment analyzer represent market mood. A rule-based decision engine combines predicted price movement and sentiment polarity to generate interpretable investment signals such as BUY, HOLD, or SELL. The system is delivered through an interactive dashboard that visualizes forecasted prices, sentiment trends, prediction accuracy, and recommendation signals in a user-friendly format. Experimental evaluation demonstrates that the LSTM-based model achieves low MAE and RMSE values and outperforms traditional ARIMA models. User acceptance testing and surveys involving real gold investors confirmed the system's practicality, clarity, and usefulness in supporting investment decisions. The solution demonstrates strong potential as a scalable fintech decision-support tool that bridges advanced analytics with real-world investor needs.

Keywords: Gold price prediction, LSTM, sentiment analysis, financial forecasting, dashboard

1. Product Description
The proposed product is an AI-driven gold investment decision-support system designed to assist investors in identifying short-term market opportunities. It integrates two key components: an LSTM-based time-series forecasting model and a financial news sentiment analysis module. Historical daily gold price data are processed to predict next-day price movement, while sentiment scores derived from financial news headlines capture investor psychology and external market influence. A rule-based decision engine interprets the predicted price direction alongside sentiment polarity to generate actionable investment signals (BUY, HOLD, or SELL). These outputs are visualized through an interactive Power BI dashboard that presents current and predicted prices, expected percentage change, sentiment classification, forecast accuracy, and trend indicators. The dashboard emphasizes clarity and accessibility, enabling both novice and experienced investors to interpret insights without technical expertise. By transforming complex machine learning outputs into simple, actionable guidance, the system functions as a practical investment analytics product rather than a standalone prediction model.

2. System Architecture, Dashboard Output and Performance Evaluation
Figure 1 illustrates the overall workflow of the proposed gold investment prediction system. The process begins with data collection and preprocessing of historical gold prices and financial

news headlines. Sentiment analysis is then performed to extract market sentiment polarity, which is integrated with the LSTM-based time-series forecasting model. The predicted price output and sentiment score are combined using a rule-based decision logic to generate interpretable investment signals. Finally, the results are evaluated and visualized through an interactive dashboard to support investor decision-making. **Figure 2** presents the main Gold Investment Prediction Dashboard, which displays the current gold price, predicted next-day price, expected percentage change, market sentiment, and investment signal. The dashboard consolidates forecasting and sentiment insights into a single interface, enabling users to quickly interpret market conditions and recommended actions. **Figure 3** shows the same dashboard with a filtered date range, demonstrating the system's capability to support flexible temporal analysis and customized user exploration.To validate the effectiveness of the forecasting model, performance evaluation was conducted using standard regression metrics. **Table 1** summarizes the Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE) achieved by the LSTM model in comparison with CNN-LSTM and ARIMA approaches. The results indicate that the proposed LSTM-based model delivers significantly lower prediction errors than traditional statistical methods, confirming its suitability for short-term gold price prediction.

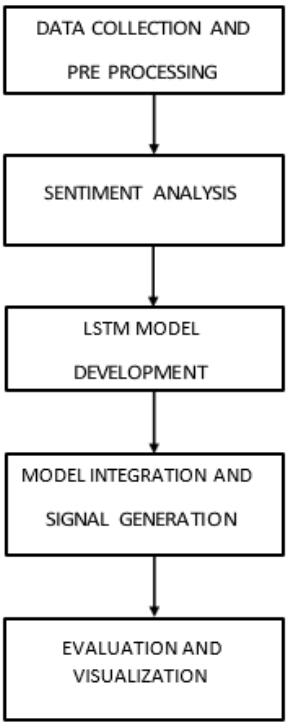

Figure 1. Gold price prediction system workflow using LSTM and news sentiment analysis.

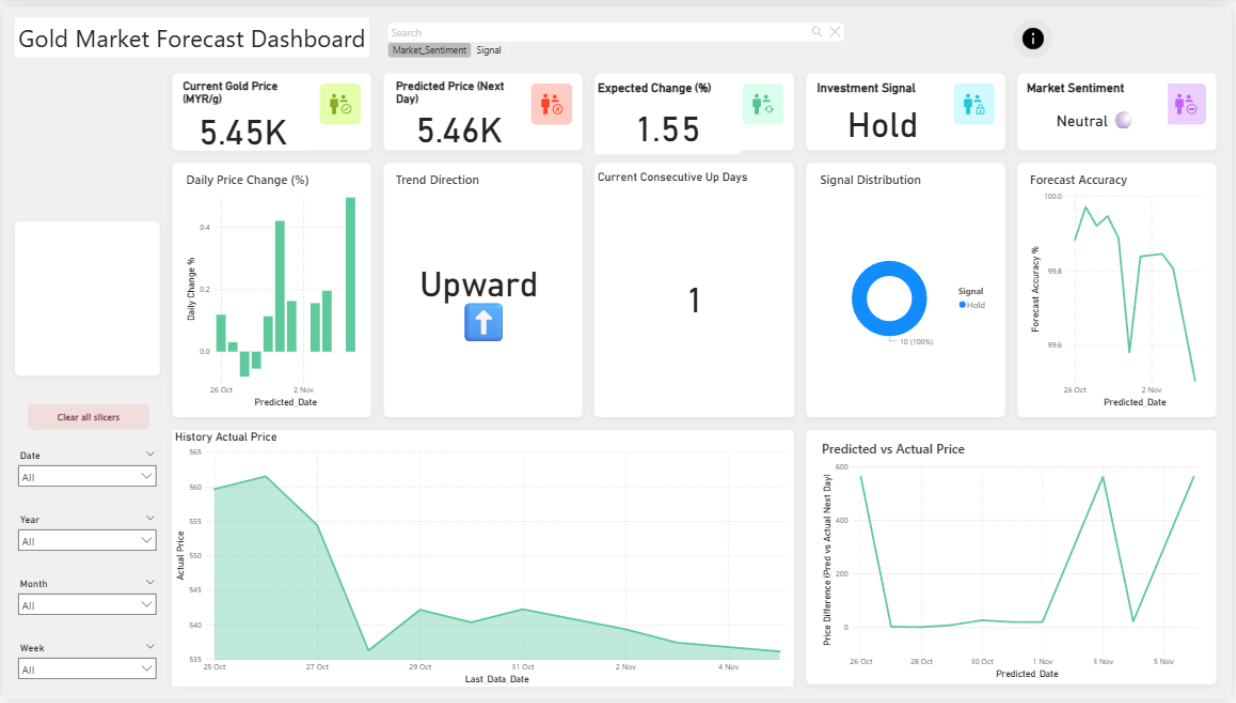

Figure 2. Gold Investment Prediction End Outcome Dashboard.

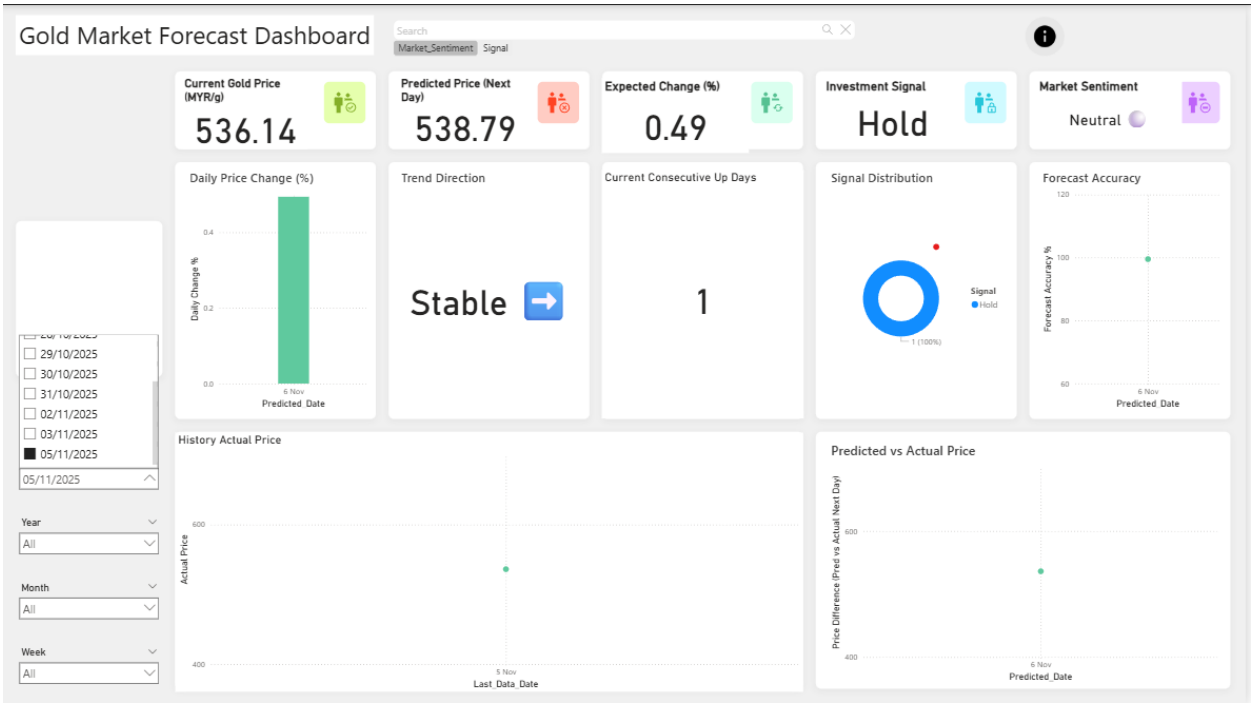

Figure 3. Gold Investment Prediction End Outcome Dashboard with Filtered Date,.

Table 1. Performance Comparison Analysis.

Metric	LSTM	CNN-LSTM	ARIMA
Mean Absolute Error (MAE)	0.008641	0.009025	94.02186
Root Mean Squared Error (RMSE)	0.011554	0.012142	115.23661

3. Novelty and uniqueness

The novelty of this project lies in its unified integration of deep learning, sentiment analysis, and decision-support logic within a single investor-oriented platform. Unlike conventional gold forecasting systems that rely solely on historical price trends, this solution incorporates qualitative sentiment signals to capture market psychology and news-driven shocks. The use of LSTM enables effective modelling of nonlinear and long-term dependencies in volatile financial time series.Furthermore, the system goes beyond prediction by embedding a rule-based recommendation engine that converts forecasts and sentiment polarity into interpretable BUY, HOLD, or SELL signals. The integration of these components into an interactive dashboard enhances transparency and usability, distinguishing the project from purely technical forecasting models. This combination of predictive accuracy, interpretability, and real-user validation makes the solution unique in both technical design and practical application.

4. Benefit to mankind

This project benefits society by empowering investors with clearer, data-driven insights into gold market behaviour. By simplifying complex analytics into understandable signals, the system reduces uncertainty and supports more confident investment decisions, particularly for novice investors. User studies confirmed that centralized visualization of price trends, sentiment, and recommendations improves financial literacy and reduces reliance on speculation. In the long term, such intelligent decision-support tools promote responsible investing, better risk management, and improved financial planning, contributing to healthier personal and community-level financial outcomes.

5. Innovation and Entrepreneurial Impact

The project demonstrates innovation by transforming advanced machine learning and NLP techniques into a practical fintech solution. Its dashboard-based delivery model illustrates how AI research can be productized into accessible decision-support tools. Entrepreneurially, the system can evolve into a subscription-based analytics platform, integrated trading assistant, or investment advisory dashboard. It promotes a culture of innovation by encouraging applied AI development and bridging academic research with real-world financial technology applications.

6. Potential commercialization

The system has strong commercialization potential as a fintech decision-support product for individual investors, financial advisors, and investment platforms. It can be deployed as a web-based dashboard or integrated into existing trading systems. Future enhancements include real-time data feeds, automated alerts, portfolio tracking, and cloud-based scalability. Revenue models may include subscription services, premium analytics features, or enterprise licensing. Its modular architecture also allows expansion to other commodities, stocks, or cryptocurrency markets.

7. Acknowledgment

The author would like to express sincere appreciation to the supervisor for continuous guidance and support. Gratitude is also extended to Universiti Teknologi PETRONAS for providing facilities and resources, as well as to participating investors who contributed valuable feedback during system evaluation.

8. Researchers' Biography

Nur Khairina Abdul Halim is a Bachelor of Computer Science (Hons) graduate from Universiti Teknologi PETRONAS with a strong interest in data analytics, artificial intelligence, and machine learning. She has hands-on experience in time-series forecasting, sentiment analysis, and dashboard development through academic projects and an industry internship at NXP Malaysia. Her work focuses on transforming complex analytical models into practical decision-support tools using Python, Power BI, and machine learning techniques. She has also contributed to AI and IoT projects involving predictive modelling, computer vision, and system automation, with an emphasis on real-world usability and impact.

Shakirah Binti Mohd Taib is a Senior Lecturer under the Faculty of Science, Management & Computing at Universiti Teknologi PETRONAS. Her research interests include Data Science, Machine Learning, Knowledge Management Technology, and E-learning/M-learning. She is actively involved in teaching, research, and academic supervision, contributing to the development of innovative computing solutions and digital learning environments. Her work focuses on applying data-driven techniques and intelligent systems to enhance knowledge management and support effective decision-making. She is committed to advancing computing education while nurturing students' analytical, problem-solving, and technical skills to prepare them for challenges in the rapidly evolving digital and technological landscape.

Pill Dispensing and Monitoring System with Biometric Access

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ABSTRACT

The Pill Dispensing and Monitoring System is a smart healthcare technology that allows for secure and automated medication management. It is controlled by ESP32 as the primary controller and employs dual biometric fingerprint sensors to guarantee that only authorized users have access to their medicine, while an LCD screen shows instructions and status updates. A Real-Time Clock (RTC) monitors the precise medication schedule and controls a servo motor to automatically distribute pills at specified times. The system also uploads intake data to Google Sheets via the Wi-Fi module, allowing caregivers to track medication history remotely. This project provides a significant socio-economic impact by reducing healthcare costs associated with medication errors and improving the independence of the elderly. Furthermore, with its cost-effective modular design and the rising global demand for home-based healthcare, the system holds high commercialization prospects for the medical device market

Keywords: Pill Dispensing, Medication Management, Healthcare Automation

1. Product Description

The Pill Dispensing and Monitoring System with Biometric Access is a smart healthcare device designed to automate and secure medication management. The system integrates dual fingerprint biometric authentication to ensure that only authorized users can access prescribed medication. It uses a Real-Time Clock (RTC) to schedule precise medication times, an LCD display to show instructions and system status, a buzzer for reminders, and a servo motor to dispense pills automatically. The system also records medication intake data and uploads it to Google Sheets via Wi-Fi (ESP32), enabling remote monitoring by caregivers or healthcare professionals.

2. System Architecture and Design.

Figure 1 illustrates the block diagram of the system, detailing the interaction between input sensors, the ESP32 processing unit, and output actuators. The logical flow of the medication dispensing process, from time checking to data logging, is mapped out in **Figure 2**. The physical hardware assembly is shown in the system prototype in **Figure 3**, while the real-time cloud-based logging of medication status ("Taken" or "Missed") can be seen in the website output displayed in **Figure 4.**

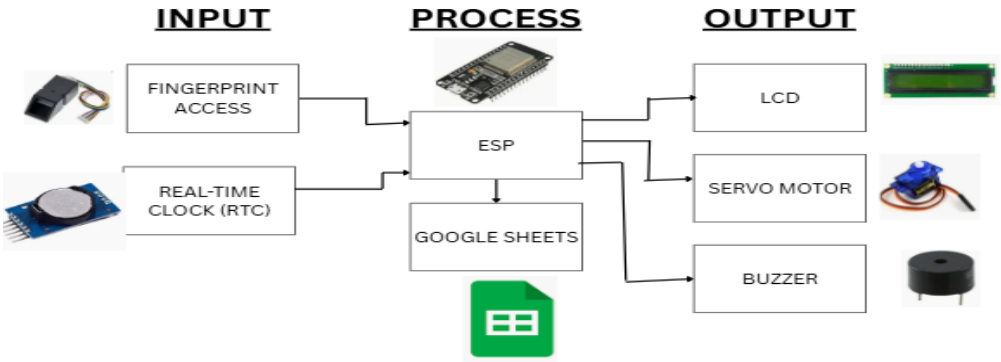

Figure 1. Block Diagram of the System.

Figure 2. System Flow Chart.

Figure 3. System Prototype.

DATE	STATUS	USER	TIME
Sat, Nov 15, 2025	Missed a dose	User A	12:38:30
Sat, Nov 15, 2025	Missed a dose	User B	12:40:30
Thu, Nov 27, 2025	Missed a dose	User A	16:30:30
Thu, Nov 27, 2025	Taken	User A	16:36:12
Thu, Nov 27, 2025	Taken	User A	16:50:12
Thu, Dec 4, 2025	Taken	User A	11:30:12
Wed, Jan 7, 2026	Taken	User A	22:08:11
Wed, Jan 7, 2026	Taken	User A	22:13:07
Wed, Jan 7, 2026	Taken	User A	22:20:07
Wed, Jan 7, 2026	Taken	User A	22:29:11
Wed, Jan 7, 2026	Taken	User A	22:37:06
Wed, Jan 7, 2026	Taken	User B	22:47:06
Wed, Jan 7, 2026	Missed a dose	User A	22:50:30
Wed, Jan 7, 2026	Missed a dose	User B	22:52:30
Wed, Jan 7, 2026	Taken	User A	22:59:07
Wed, Jan 7, 2026	Missed a dose	User B	23:00:30
Fri, Jan 9, 2026	Taken	User A	12:19:05
Fri, Jan 9, 2026	Taken	User B	12:27:10

Figure 4. Website Output.

3. Novelty and uniqueness

The novelty of this innovation lies in its holistic integration of biometric security, automated dispensing, and cloud-based monitoring within a single compact system. Unlike conventional pill dispensers that rely on manual access or simple reminder alarms, this system introduces fingerprint-based authentication as a core safety feature, effectively preventing unauthorized access and medication errors. The inclusion of real-time data logging and wireless connectivity further differentiates the system, as it enables transparent monitoring of patient compliance without requiring complex or costly healthcare platforms

4. Benefit to mankind

This innovation provides substantial benefits to society by addressing critical challenges in medication adherence and patient safety. It is particularly beneficial for elderly individuals, patients with chronic illnesses, and users who require strict medication schedules. By automating reminders and dispensing while enforcing biometric verification, the system significantly reduces the risk of missed doses, overdosing, and incorrect medication intake. Furthermore, the ability for caregivers to remotely monitor medication history improves clinical oversight and reduces caregiver stress.

5. Innovation and Entrepreneurial Impact

From an innovative standpoint, the system demonstrates the effective application of embedded systems, Internet of Things (IoT) technology, and biometric authentication to solve real-world healthcare problems. The project shows how affordable hardware components and cloud-based platforms can be combined to produce a functional and scalable healthcare solution. Entrepreneurially, this innovation has strong potential to be developed into a market-ready product, supporting the growth of smart healthcare startups and technology-driven enterprises. Its modular design allows for future enhancements such as mobile application integration, AI-driven adherence analysis, and connectivity with hospital information systems, making it adaptable to evolving healthcare demands.

6. Potential commercialization

The Pill Dispensing and Monitoring System with Biometric Access has high commercialization potential due to increasing global demand for home-based healthcare and elderly care solutions. The system is designed using cost-effective and readily available components, enabling scalable manufacturing and competitive pricing. It can be commercialized for use in homes, hospitals, clinics, nursing homes, and assisted living facilities. With further refinement in industrial design, regulatory certification, and user interface optimization, the product could be positioned as a smart medical device offering secure, automated, and connected medication management. Its ability to reduce healthcare risks while supporting remote monitoring makes it highly attractive for both local and international healthcare market.

7. Acknowledgment

I want to thank my project supervisor for their crucial direction and assistance during the project's progress. Her insights were helpful in molding the outcome of my project. I am also grateful to my family for their support, and to my faculty colleagues for sharing their knowledge.

8. Researchers' Biography

Danish Zahirul Iqbal Bin Zainalabidin is a final-year student of the Diploma in Electrical Engineering (Electronic) at UiTM. He has excelled in numerous subjects, including Microprocessor Systems, Electronics, and Digital Systems. He plans to pursue his engineering degree in 2026.

Dr. Fadila Mohd. Atan is a senior lecturer at Universiti Teknologi MARA (UiTM) Pasir Gudang specializing in optical and photonic systems. She receives her PhD in electrical engineering and since then has been actively working in her field. Her work primarily explores dynamics bandwidth allocation, network layer security, and integration of innovative approaches in engineering education.

Nur Asfahani Ismail has been serving as a lecturer at UiTM Pasir Gudang since 2014. She obtained her PhD in Optical Fibre Communication from Universiti Teknologi Malaysia (UTM) in 2025. Over the years, she has guided numerous students in their final year projects and earned recognition from the university for her contributions. Her research interests focus on IoT-based systems and machine learning.

Dr. Nor Affida M. Zin is a Senior Lecturer at UiTM Pasir Gudang Campus. She holds a Ph.D in Advanced Optical Networking, focusing on deterministic and time-sensitive services in Passive Optical Network. She has authored numerous high-impact journal articles and conference papers on PON technology. She is actively collaborating with academia and industry to enhance PON frameworks and developments in Malaysia.

LUMy: A Virtual Reality-Based Universal Design for Learning Innovation to Enhance Self-Advocacy and Inclusive Sexuality Education for Students with Intellectual Disabilities

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ABSTRACT
This project proposes and evaluates LUMy, a virtual reality (VR) sex education intervention for adolescents with mild intellectual disability (IQ 50-70) aged 12–18, who face a 3.5–4 times greater risk of sexual victimization. Guided by the Universal Design for Learning (UDL) framework, LUMy is a user-centered, multisensory prototype developed via conceptual prototyping to ensure inclusivity, enhance self-advocacy, and improve awareness. An exploratory quantitative approach with pre-test and post-test confirmed the intervention's effectiveness. The project's socio-environmental impact is realized through advancing inclusive education, bridging cognitive accessibility gaps, and contributing to the long-term safety and empowerment of millions of vulnerable children worldwide. Its commercialization prospects are strong, as the single core product is deliverable across special, inclusive, and general secondary schools, facilitates highly cost-efficient scaling (a key socio-economic benefit), and recurring revenue through an institutional licensing and program-based distribution model.

Keywords: Sex education, virtual reality (VR), mild intellectual disability

1. Product Description
LUMy is a Virtual Reality-based sex education and self-advocacy development intervention designed specifically for children with mild intellectual disability (IQ 50-70, ages 12-18). Recognizing that this population faces 3.5-4 times higher risk of sexual victimization yet lacks accessible education, LUMy combines immersive VR technology with Universal Design for Learning principles to deliver inclusive, interactive sex education that systematically cultivates self-advocacy skills, enabling children to assert bodily autonomy, recognize rights violations, communicate boundaries, and advocate for their own safety and wellbeing. To achieve this, the LUMy employs a multisensory approach integrating visual, auditory, and motor elements, which is systematically organized into four structured stages: self-identification, puberty education, personal hygiene, and boundary maintenance. Students practice social scenarios in a safe virtual environment, motivated by a reward system of points and trophies. Furthermore, the intervention includes a practical pocketbook with QR codes to support sustained learning. Beyond special needs, LUMy is a single core product adoptable by special, inclusive, and general secondary schools by aligning content delivery with learners mental age rather than institutional

labels, ensuring essential protective knowledge is effectively applied to lead safer, autonomous, and fulfilling lives.

2. Visual Aids and Data

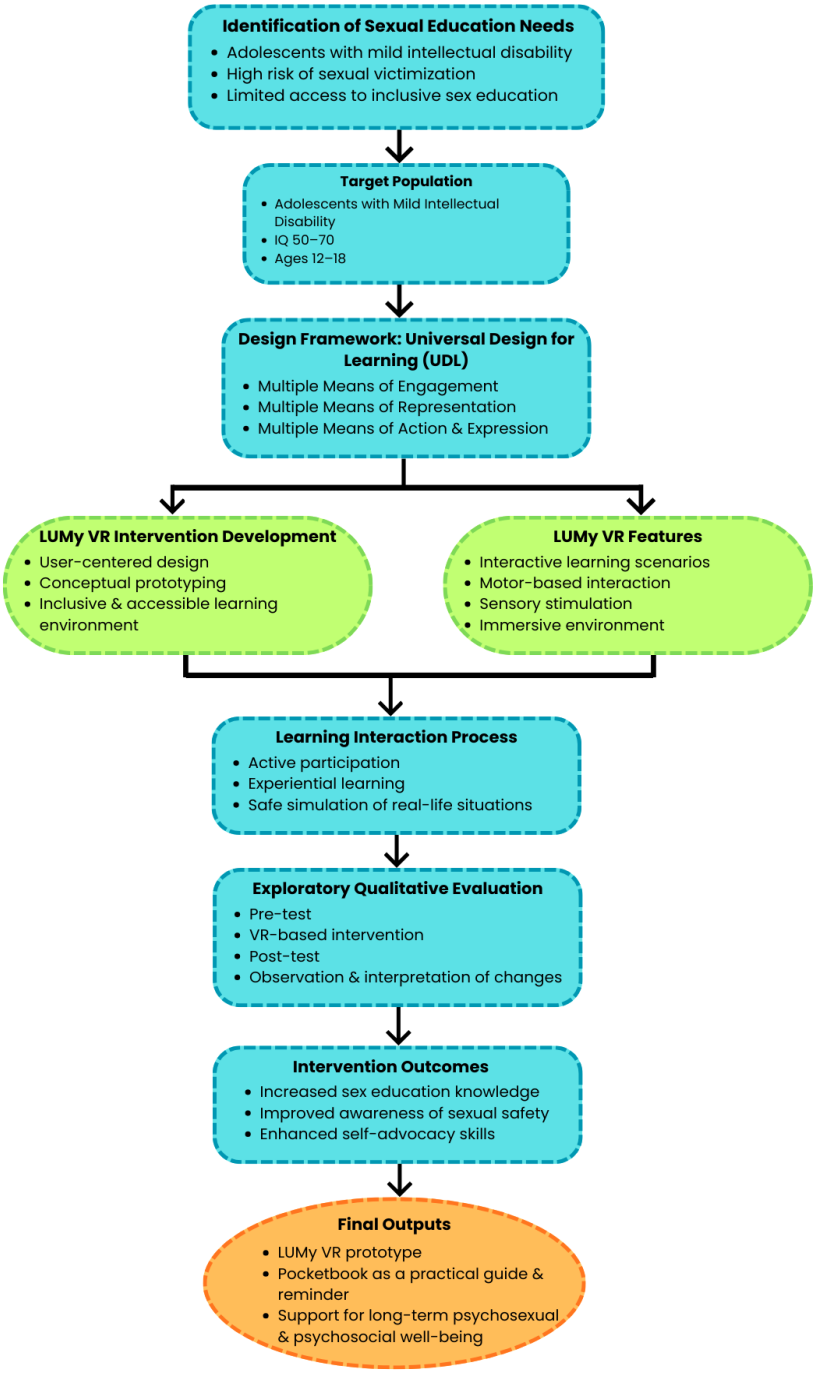

Figure 1. Conceptual flow of the LUMy virtual reality sex education intervention based on Universal Design for Learning.

Table 1. Market Segmentation and Scalability Model of LUMy.

Aspect	Description
Market Segmentation	LUMy is designed as a single core product that can be adopted by special schools, inclusive schools, and general secondary schools by aligning content delivery with learners' mental age rather than institutional labels.
Scalability and Cost Efficiency	By segmenting users based on mental age rather than institutional categories, LUMy operates on a single core system with adjustable pedagogical parameters, reducing the need for institution-specific product variants and enabling cost-efficient scaling across diverse school settings.
Institutional Adoption	Implementation requires teacher training, curriculum integration, and contextual adaptation, embedding LUMy into school systems and increasing switching costs.
Competitive Barrier	The combination of pedagogical design, age-appropriate personalization, and institutional support materials creates barriers to entry that extend beyond access to VR technology

Figure 2. LUMy Virtual Reality prototype.

Figure 3. LUMy Companion Pocketbook.

3. Novelty and uniqueness

LUMy introduces a substantial novelty by transforming sex education for children with mild intellectual disabilities from abstract, textual methods into concrete, immersive simulation experiences. The primary uniqueness of this innovation lies in the integration of the Universal Design for Learning (UDL) framework, which ensures that all content remains inclusive and accessible regardless of the users' cognitive limitations. Unlike conventional media, LUMy employs a multisensory approach involving visual, auditory, and motor components to facilitate various learning styles for students with special needs. This innovation systematically divides the learning process into four structured stages: self-identification, puberty, personal hygiene, and boundary maintenance. These stages allow children to practice complex social scenarios within a safe, controlled virtual environment. Furthermore, the explicit focus on self-advocacy is a unique value-add rarely found in general sexual education curricula. The implementation of a virtual reward system, including points and trophies, enhance emotional engagement, which is crucial for successful cognitive interventions in this population. This combination of advanced technology and user-centered design positions LUMy as a pioneer in inclusive digital literacy.

4. Benefit to mankind

Adolescents with intellectual disabilities face profound vulnerabilities in sexual abuse prevention due to critical gaps in recognizing body privacy, distinguishing appropriate touch, and articulating uncomfortable experiences. Educational intervention findings reveal these developmental barriers significantly increase their susceptibility to sexual violence (Januarti et al., 2023). LUMy addresses these challenges through immersive VR technology that enhances protective knowledge and self-advocacy capabilities, competencies difficult to achieve through conventional educational approaches. The pocket book as a practical guide facilitates sustained support from parents, educators, and caregivers, creating a replicable framework globally. This study generates critical empirical evidence on design principles, content adaptation, and implementation protocols, providing foundations for researchers to develop targeted interventions across diverse contexts. Beyond special needs populations, LUMy demonstrates scalability for adolescent sexual education in regular school. LUMy fundamentally advances inclusive education by demonstrating how emerging technologies bridge cognitive accessibility gaps, contributing to safer, and autonomous lives for millions of children worldwide.

5. Innovation and Entrepreneurial Impact

LUMy's entrepreneurial potential lies in its developmental efficiency and highly scalable ecosystem. Utilizing the Millealab cloud platform enables high quality 3D content creation without advanced coding skills, which significantly reduces production costs and accelerates time-to-market. Innovation is further demonstrated through a dual-output strategy: an immersive VR experience using Meta Quest 2 and a practical physical pocketbook for sustainable learning. This pocketbook includes QR codes linking to additional digital resources, creating a comprehensive long-term support model for parents and educators. Strategically, LUMy employs a measurable pre-test and post-test evaluation system to provide essential empirical evidence of effectiveness. By directly addressing the urgent need to protect children with intellectual disabilities, who face a 3.5-4 times higher risk of sexual victimization–LUMy offers a high value, socially responsible solution. Its capacity for replication ensures massive impact and economic viability.

6. Potential commercialization

As shown in **Table 1**, LUMy is an educational innovation with strong commercial potential driven by broad market segmentation and efficient scalability. By adopting a mental-age–based approach and Universal Design for Learning, a single core product can be implemented across special schools (SLB), inclusive schools, and general secondary schools, reducing production and content differentiation costs. Its institutional value is further strengthened through high switching costs, as adoption involves teacher training, integrated learning modules, and contextualized implementation that embed the product into school systems. In addition, the combination of VR-based real-life scenarios, age-appropriate personalization, and institutional support materials creates a clear barrier to entry, as replication requires substantial expertise, time, and resources beyond technology alone. Supported by an institutional licensing and program-based distribution model, LUMy enables recurring revenue and a clear expansion pathway from individual schools to larger educational and child protection programs, reinforcing its long-term commercial sustainability.

7. Acknowledgment

The authors would like to express their sincere gratitude to Rudi Cahyono, M.Psi., Psikolog, as the supervising lecturer, for his guidance, valuable feedback, and academic support throughout the development of this study. Appreciation is also extended to the Faculty of Electrical Engineering, Universiti Teknologi MARA Johor Branch, Pasir Gudang Campus, for providing institutional support and facilities that enabled the implementation of the LUMy virtual reality intervention. Special thanks are given to the participants and their guardians for their cooperation and involvement. This work was presented as part of the 3rd International Thinker Innovation & Entrepreneurship Challenge (iTIEC) 2026.

8. Researchers' Biography

Naura Nasywa Hidayatulloh is a fourth-semester undergraduate student at the Faculty of Psychology, Universitas Airlangga, with a strong interest in child and developmental psychology. She has been actively involved in community-based programs and international youth exchanges with Junior Chamber International in Malaysia and Thailand. Through her internship at the Indonesian Navy Psychology Service, she gained practical experience in educational and clinical psychology settings. She has published five anthology books and was awarded 1st Place Outstanding Student of the Faculty of Psychology, Universitas Airlangga (2024). She is also a recipient of the Indosat Ooredoo Hutchison Scholarship (2021–2024).

Faiz is a distinguished young researcher in Psychology with a specialized focus on behavior modification, intervention design, and mental health advocacy. His strategic leadership is evidenced by his tenure as the Head of the Research and Science Division at UKM Penalaran, where he actively drives academic excellence and scientific rigor. A prolific participant in national innovation competitions, Faiz has consistently demonstrated his expertise in bridging technology and psychology, most notably as the Chief Research Officer (CRO) for "Curhatorium", a project that earned a Bronze Medal at the 38th PIMNAS.

Zahra Ariqasari is a fourth semester Psychology student at Universitas Airlangga with a strong interest in mental health, educational psychology, and broader psychosocial issues. She enjoys exploring how psychological concepts relate to everyday life and social challenges, especially through research and writing. Zahra actively participates in scientific writing and innovation competitions, and was part of a winning team for a paper on the experiences of individuals living with schizophrenia. In addition, she is currently involved in exploring projects related to the practical application of educational psychology.

Angelica Mulyana Putri is a fourth-semester undergraduate student in the Faculty of Psychology with a strong interest in inclusive education and developmental psychology. She has experience in academic writing, having won a writing competition focused on schizophrenia survivors. She also completed an internship at the Social Services Office, where she worked in the field of developmental psychology, conducting behavioral therapy for children with special needs and providing basic counseling support. Her interests include technology-based psychological interventions, self-advocacy, and psychosocial well-being for vulnerable populations.

Gas Guard Pro Monitoring Powered by Solar

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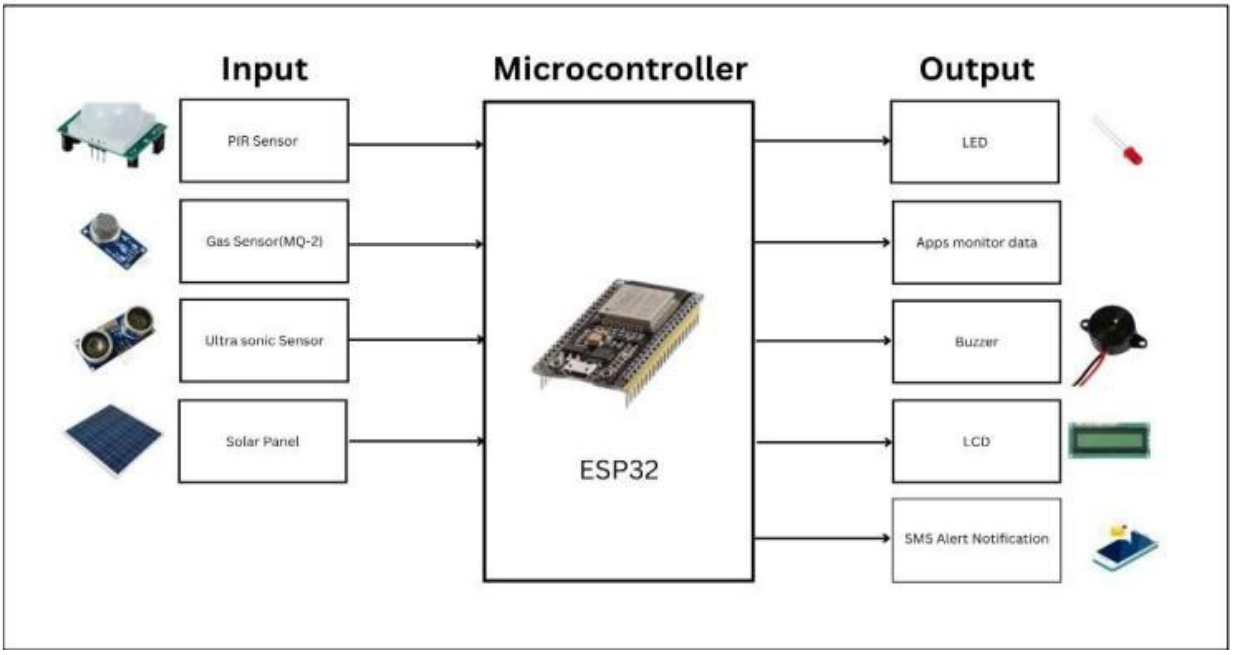
ABSTRACT
Gas Guard Pro Monitoring is a smart safety system designed to detect gas leaks and suspicious activity around gas pipelines. The project addresses the critical risk of undetected leaks and human interference, which can lead to fires or explosions. Utilizing an MQ-2 gas sensor, a PIR motion sensor, and an ultrasonic sensor controlled by an ESP32 microcontroller, the system monitors gas levels and movement simultaneously. Its unique advantage lies in a dual-sensor verification system (ultrasonic and PIR) that distinguishes human presence from other movements to reduce false alarms. Additionally, the system is powered by solar energy with a rechargeable battery, enabling operation in remote areas without grid electricity. The device provides real-time alerts via a buzzer, LED, and mobile push notifications through the Blynk app. This innovation impacts socio-economic safety by preventing industrial accidents and offers high commercial prospects for residential and industrial pipeline monitoring, providing an affordable and eco-friendly solution for early warning detection.

Keywords: Gas detection, pipeline safety, ESP32, real-time monitoring, solar-powered system

1. Product Description
Gas Guard Pro Monitoring System is a safety solution powered by solar energy, created to supervise gas pipelines in time. It combines an ESP32 microcontroller with an MQ-2 gas sensor to identify dangerous leaks such as LPG and methane. To improve security, it applies a two-stage detection approach using an ultrasonic sensor to sense object proximity and a PIR sensor to verify human presence, separating real threats from false triggers. The system includes a 16x2 LCD for on-site status display and links to the Blynk mobile app through Wi-Fi for remote push notifications and data logging. A built-in buzzer and LED system deliver immediate local alarms during critical events. Its solar-powered design guarantees continuous operation in remote areas without reliable electricity.

2. Block Diagram, Flow Charts and Schematic diagrams
Figure 1 shows the block diagram of the system. It begins with the input section, where four main components continuously monitor the environment. The MQ-2 gas sensor detects the presence of harmful gases such as LPG, methane, or smoke. After that, the ultrasonic sensor checks for any object or movement within a certain range, and if any is detected, the PIR (Passive Infrared) sensor confirms whether the movement is caused by an animal or a human. These three sensors provide critical data to the ESP32 microcontroller, which is the brain of the system. The solar panel provides power to the ESP32 and all connected components, making the system energy-efficient and capable of operating in areas without reliable electricity. Once the ESP32

processes the input data, it controls the output components based on the conditions detected. If a gas leak or nearby human activity is confirmed, the system activates a buzzer and LED to provide immediate local alerts. At the same time, the LCD shows the gas level and status (e.g., Safe, Warning, or Danger). The ESP32 also sends real-time data to a mobile application for remote monitoring and, if needed, triggers an SMS alert notification to inform users or safety personnel even when they are not nearby. This entire flow helps ensure quick detection, accurate human



confirmation, and timely alerts to prevent gas-related hazards effectively.
Figure 1. Block Diagram of the System.

Figure 2 shows the flowchart of the Gas Guard Pro Monitoring System, which starts by checking the gas sensor to see if there's any dangerous gas in the air. If the gas level is high, the system then checks for movement using the ultrasonic sensor. If something is moving nearby, it continues by checking the PIR sensor to confirm if it's an animal or a human. If a human or animal is detected, the system will turn on the buzzer and LED as a warning and show a message on the screen saying "!! DANGER/LEAK – Evacuate Now!". If no human and an animal are detected but gas is still present, it still gives a warning, showing "Gas Detected – Check Pipe!!" on the screen. In both situations, the system will also send all the data to the user's phone through the app. If there is no gas leak, the system still checks the area for any movement using the ultrasonic sensor. If it detects movement, it will use the PIR sensor again to see if it's a person. If a human is detected, it shows "Object near pipe – Check Now!" on the screen and sends the information to the phone. But if neither an animal nor a human is found, it just shows the current gas value and distance from the ultrasonic sensor without any warning. Also, if the ultrasonic doesn't detect motion but the PIR sensor does, it still shows the gas value and distance, just for monitoring purposes. No matter what happens, the system will keep sending updates to the phone and continue running to keep monitoring the area.

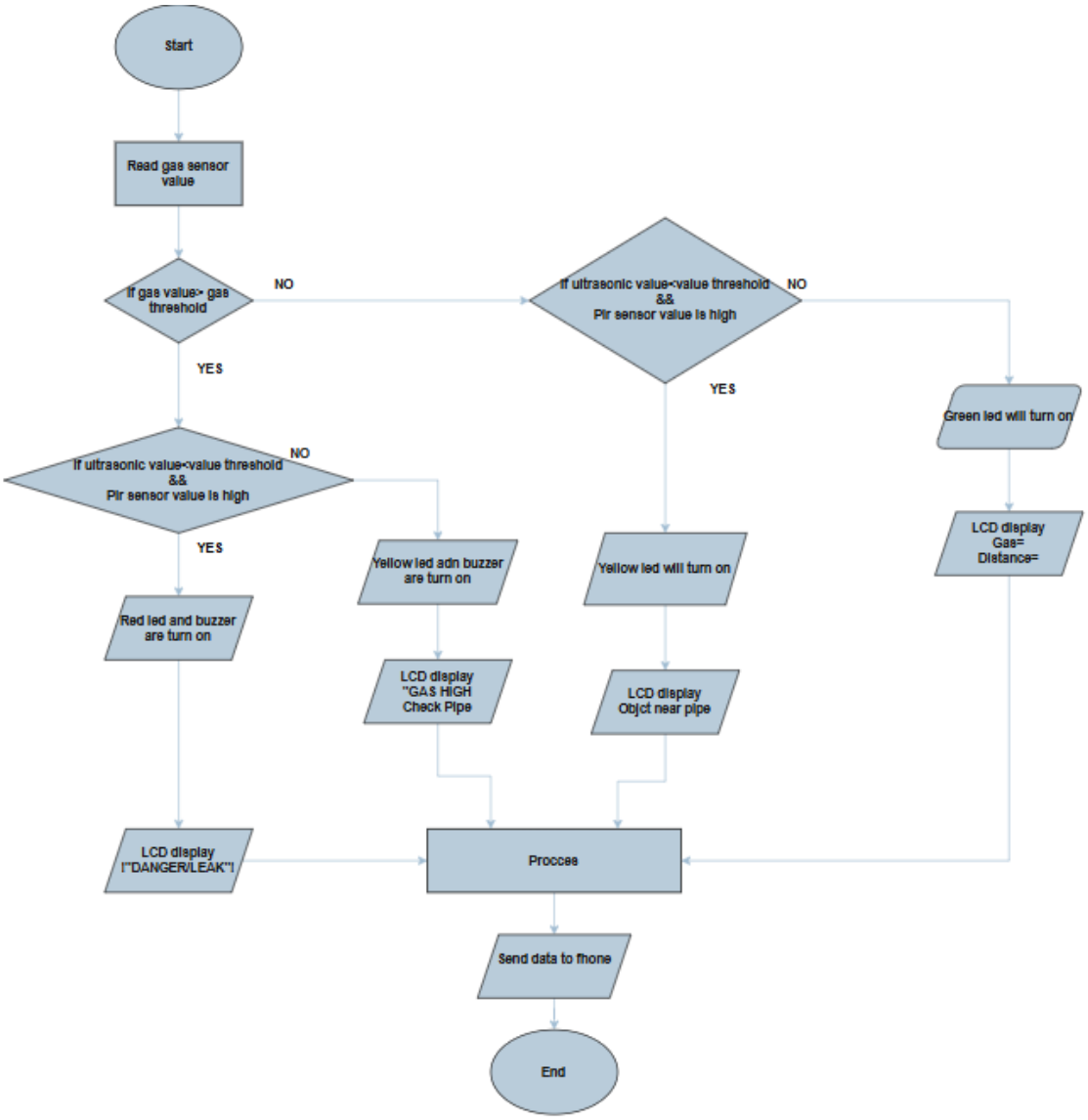


Figure 2. Flow Chart.

Figure 3 shows the schematic diagram for the Gas Guard Pro Monitoring System. It shows how all the components are connected to the ESP32 microcontroller. This system utilizes multiple sensors to detect the presence of gas and humans, then issues a warning via a buzzer, LED, and LCD screen. In this circuit, the LED and buzzer are connected to the ESP32. When the system detects danger, both the LED and buzzer will turn on to give a warning. A resistor is used to protect the LED from too much current. The circuit also includes the MQ-2 gas sensor, which reads the gas level in the environment. It is connected to the ESP32 to help the system know when there is a gas leak. The ultrasonic sensor is used to check if there is any movement nearby, and it is connected to two pins on the ESP32 (one for sending the signal and one for receiving it). The PIR sensor is used to detect if the movement is from a human. It sends a signal to the ESP32 when it senses human motion. Lastly, the LCD is connected to the ESP32 using I2C communication. It shows messages like gas value, warning alerts, and movement detection in real

time. This setup allows the system to give early warnings and show information clearly when there is a gas leak or if someone is nearby.

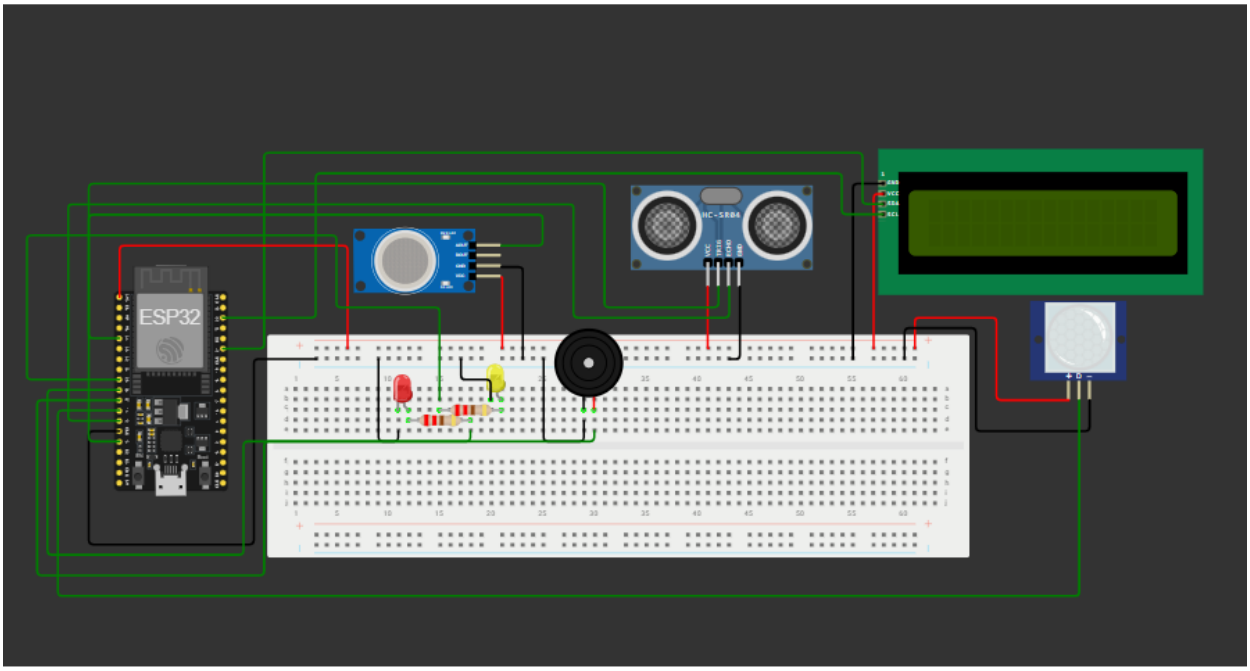


Figure 3. Schematic diagram.

3. Novelty and uniqueness

The novelty of the Gas Guard Pro Monitoring System lies in its intelligent combination of multi-sensor validation and renewable energy integration, which enhances gas pipeline safety. Unlike conventional gas detectors that rely solely on gas concentration thresholds, this system introduces a dual-sensor validation logic, utilizing both an ultrasonic sensor and a PIR sensor. The ultrasonic sensor first detects the presence of nearby objects or movement, while the PIR sensor confirms whether the detected movement is caused by a human. This two-stage approach significantly reduces false alarms that are commonly triggered by animals, environmental movement, or random disturbances. In addition, the system integrates an ESP32 microcontroller with IoT capability, enabling real-time monitoring and instant alerts through a mobile application. This allows users to receive notifications regardless of their location, improving response time during emergencies. Another key uniqueness of this project is its solar-powered design. The inclusion of a solar panel and rechargeable battery enables continuous operation in remote or off-grid locations where a conventional power supply is unavailable. By combining intelligent sensing, human verification, wireless communication, and sustainable energy, Gas Guard Pro offers a more advanced and reliable solution compared to existing standalone gas detectors. This integrated design represents a meaningful innovation in gas safety monitoring systems.

4. Benefit to mankind

The Gas Guard Pro Monitoring System provides significant benefits to society by improving safety in both residential and industrial environments. Early detection of gas leaks helps prevent serious accidents such as fires, explosions, and health hazards, thereby protecting lives and property. The integration of motion and human presence detection further enhances security

by alerting users to unauthorized or suspicious activity near gas pipelines. The system's ability to send real-time notifications through a mobile application ensures that users are informed immediately, even when they are not physically present at the site. This allows faster emergency response and timely corrective action. Furthermore, the use of solar energy promotes environmental sustainability and ensures uninterrupted operation during power outages or in remote areas. Overall, the system contributes to public safety, environmental protection, and peace of mind by providing a reliable, efficient, and eco-friendly gas monitoring solution.

5. Innovation and Entrepreneurial Impact

Gas Guar Pro demonstrates innovation by combining IoT technology, intelligent sensing, and renewable energy to address real-world safety challenges. By using low-cost components such as the ESP32 and commonly available sensors, the Gas Guard Pro Monitoring System proves that effective safety solutions can be developed affordably without compromising performance. This approach encourages innovation among students and young engineers to design practical solutions using accessible technology. From an entrepreneurial perspective, the project highlights strong potential for commercialization as a smart safety product. It shows how engineering knowledge gained in the classroom can be transformed into a market-ready solution capable of saving lives. The system promotes technological self-reliance by reducing dependence on expensive imported safety equipment. Overall, the project inspires a mindset of innovation, problem-solving, and entrepreneurship within the institution and community.

6. Potential commercialization

The Gas Guard Pro Monitoring System has strong potential for commercialization in both residential and industrial safety markets. In smart home applications, the system provides continuous gas monitoring and real-time mobile notifications, improving household safety and user awareness. Its ability to detect gas leakage and confirm human presence makes it suitable for homes with gas storage, kitchens, and small commercial premises. For industrial use, particularly in oil, gas, and utility sectors, the system can be deployed to monitor remote or restricted pipeline areas where safety supervision is limited. The integration of IoT connectivity enables centralized monitoring and faster emergency response. Additionally, the solar-powered operation allows the system to function independently in locations without reliable electrical infrastructure. Its scalable and modular design supports future expansion and customization based on specific safety requirements. Overall, Gas Guard Pro presents a practical and adaptable solution with high commercial relevance in modern safety monitoring applications.

7. Acknowledgment

I would like to express my deepest and most sincere appreciation to my project supervisor, Ts. Shakira Azeehan Binti Azli, for her continuous guidance, patience, and unwavering support throughout the entire duration of this research. Her valuable technical insights, constructive feedback, and encouragement played a vital role in shaping the direction of this project and in refining the safety mechanisms of the system. Her dedication and commitment greatly motivated me to complete this work with confidence and determination. I would also like to extend my sincere gratitude to the Faculty of Electrical Engineering, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, for providing the necessary laboratory facilities, equipment, and a conducive learning environment that made the development and testing of this project possible. The support and resources provided were essential to the successful completion of this research.

8. Researchers' Biography

Muhamad Syazwan Bin Norkani is an Electrical Engineering student at Universiti Teknologi MARA, Pasir Gudang Campus, currently completing his Diploma. He specializes in integrating Internet of Things (IoT) technology with power systems, specifically for safety monitoring. His academic work focuses on designing automated solutions for disaster prevention to enhance public safety in vulnerable environments. Syazwan is committed to applying engineering principles to real-world problems. He aspires to develop innovative, sustainable solutions that address infrastructure challenges and positively impact communities.

Ts. Shakira Azeehan Binti Azli obtained her Diploma in Electrical Engineering (Power) from UTM Kuala Lumpur, Bachelor of Engineering (Electrical) (Hons) and MSc. in Engineering (Electrical Power) from UTM Skudai. Currently, she serves as a lecturer at UiTM Cawangan Johor Kampus Pasir Gudang in Power Department. Her main research interests are power system and high voltage.

Dr. Ts. Siti Aminah Nordin is a lecturer who is currently working at UiTM Pasir Gudang. She received her B. Eng (Hons) of Electronic Engineering and a Master's in Electrical Engineering from Universiti Teknologi MARA (UiTM) Shah Alam, in 2010 and 2014, respectively. In May 2014, she joined UiTM Pasir Gudang as a teaching staff. She is currently working towards a Ph.D. degree in microwave and radio frequency at Universiti Teknologi MARA Shah Alam, Malaysia. Her research interests include microwave filter, antenna, and electromagnetic wave.

Generator Air Conditioning 4R (Recycle, Reuse, Reduce & Reform)

Muhamad Abdullah Bin Ismail, Nur Fatin Farhana Binti Ramli, Muhammad Adib Adham Bin Mohama Jami, Muhammad Darwisy Irfan Bin Zulkefli,
[1]Technologies of Refrigeration and Air Conditioing studies, Kolej Vokasional Shas Kuala Lipis, Pahang

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ABSTRACT

The GENac4R system is an environmentally driven innovation that applies the principles of Recycle, Reuse, Reduce, and Reform to generate renewable electrical energy by harnessing waste heat from air conditioners. By recycling and reusing thermal energy, the system reduces heat emissions that contribute to global warming, while reforming air conditioner performance through extended superheat duration. Utilizing a thermoelectric generator based on the Peltier Effect, the device converts heat flux between two materials into usable electricity, producing 215–240V/6A for electrical and electronic devices and 5V–12V DC for battery charging. Integrated subsystems—including battery charging, hot and cold piping with copper tubes for efficient heat conduction, and a control system for monitoring and regulation—ensure reliable operation without compromising air conditioner performance, thereby offering a sustainable and efficient energy solution.

Keywords: Aair conditioning system, renewable electricity, 4R sustainability, energy efficiency, green innovation, battery charging

1. Product Description

This product is designed to generate a secondary renewable energy source while reducing contributions to global warming. It produces electrical energy of 215–240V/6A, equivalent to up to 1440W, derived from the air conditioning system, allowing users to access free electricity for powering electrical and electronic devices as well as charging batteries. The system integrates several subsystems, including a battery charging unit, hot and cold piping, and a control system. At its core, a thermoelectric generator utilizing the Peltier Effect creates heat flux between two different materials, with hot and cold junctions enabling direct power generation from air conditioner heat. The generated electricity is connected to the battery charging system to supply 5V–12V DC for battery charging, while the control system monitors and regulates operations. The air conditioner serves as the primary source, with its released heat redirected through copper piping—chosen for its excellent thermal conductivity—to the Peltier module. Careful consideration is given to maintaining air conditioner performance, ensuring that modifications do not interfere with its normal operation.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

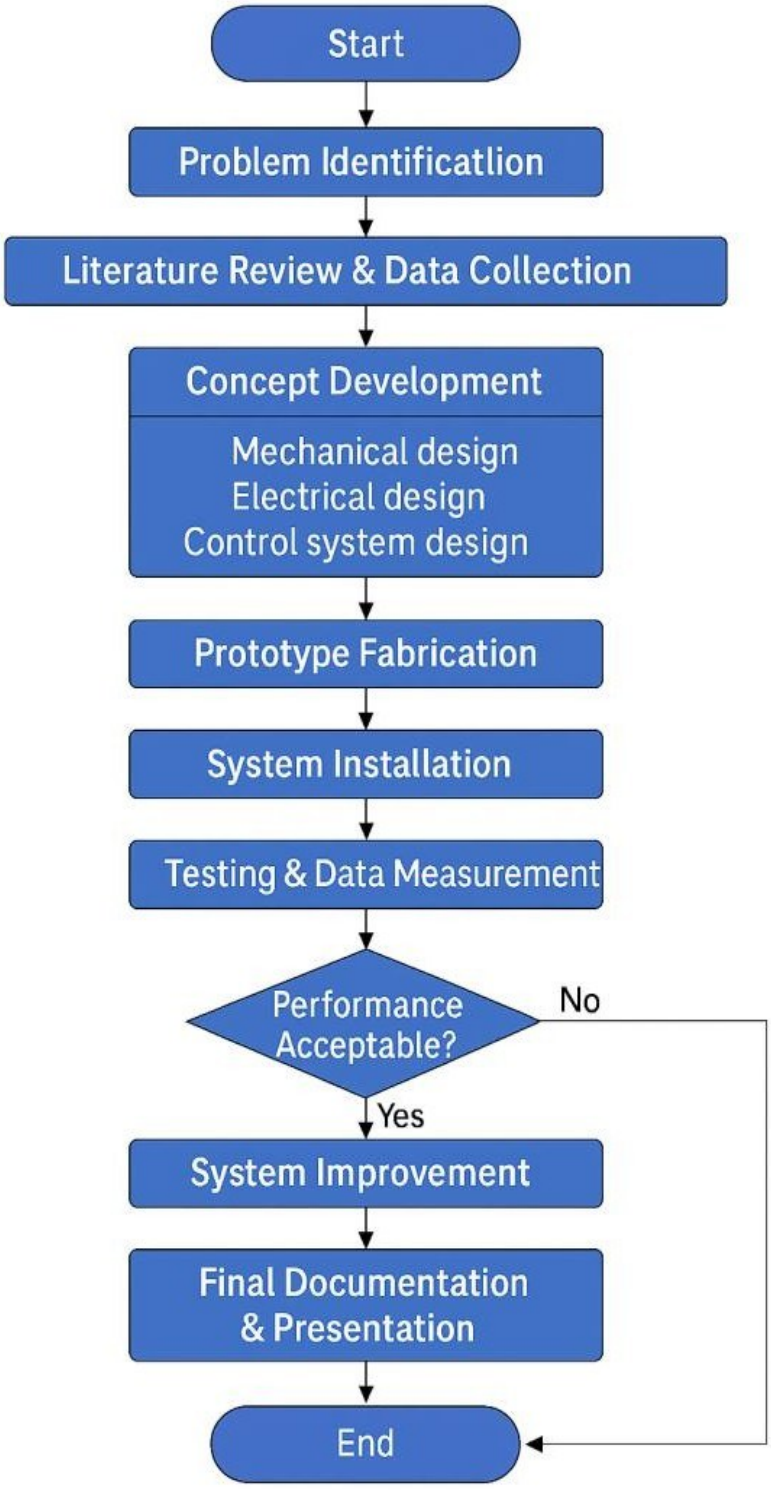


Figure 1. Project Development Flowchart of GENac4R System .

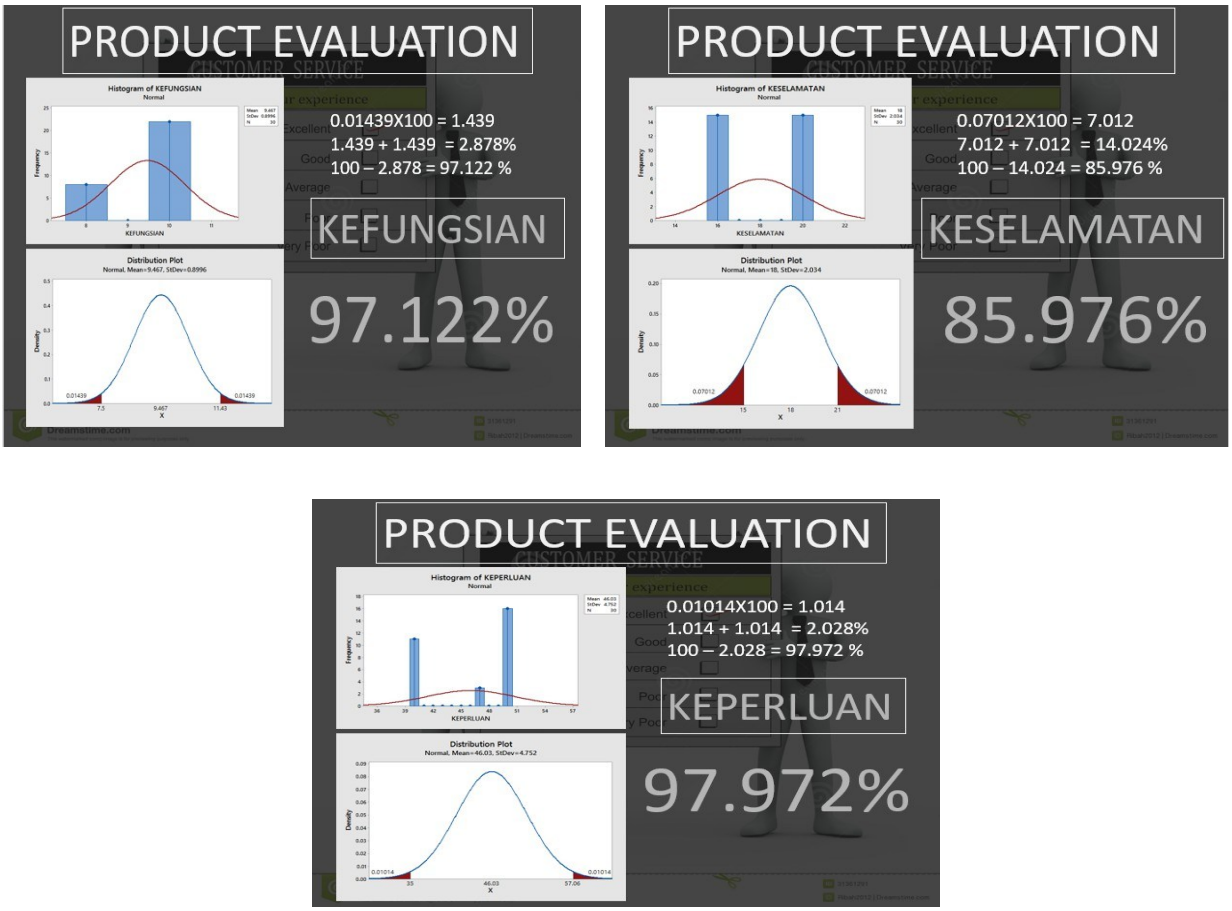
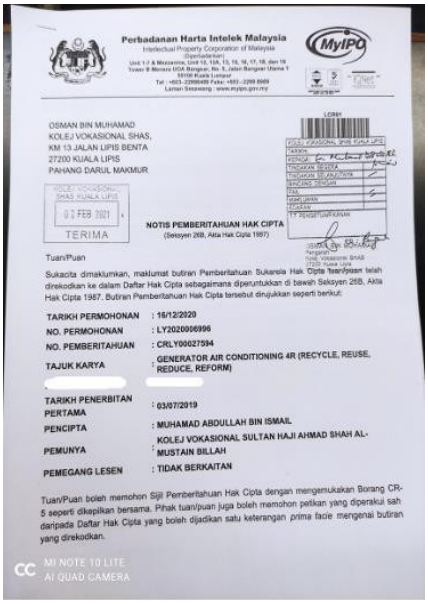


Figure 2. GENac4R System Performance.

3. Novelty and uniqueness

The project has been officially recognized by the Intellectual Property Corporation of Malaysia (MYIPO) under the copyright category, affirming its originality and innovative value.



Perbadanan Harta Intelek Malaysia
Intellectual Property Corporation of Malaysia

OSMAN BIN MUHAMAD
KOLEJ VOKASIONAL SHAS,
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27200 KUALA LIPIS
PAHANG DARUL MAKMUR

07 FEB 2021
TERIMA

NOTIS PEMBERITAHUAN HAK CIPTA
(Seksyen 26B, Akta Hak Cipta 1987)

Tuan/Puan

Sukacita dimaklumkan, maklumat butiran Pemberitahuan Sukarela Hak Cipta Tuan/puan telah direkodkan ke dalam Daftar Hak Cipta sebagaimana diperuntukkan di bawah Seksyen 26B, Akta Hak Cipta 1987. Butiran Pemberitahuan Hak Cipta tersebut dinyatakan seperti berikut:

TARIKH PERMOHONAN	: 16/12/2020
NO. PERMOHONAN	: LY2020006996
NO. PEMBERITAHUAN	: CRLY00027594
TAJUK KARYA	: GENERATOR AIR CONDITIONING 4R (RECYCLE, REUSE, REDUCE, REFORM)
TARIKH PENERBITAN PERTAMA	: 03/07/2019
PENCIPTA	: MUHAMAD ABDULLAH BIN ISMAIL
PEMUNYA	: KOLEJ VOKASIONAL SULTAN HAJI AHMAD SHAH AL-MUSTAIN BILLAH
PEMEGANG LESEN	: TIDAK BERKAITAN

Tuan/Puan boleh memohon Sijil Pemberitahuan Hak Cipta dengan mengemukakan Borang CR-5 seperti dikepilkan bersama. Pihak tuan/puan juga boleh memohon petikan yang diperakui sah daripada Daftar Hak Cipta yang boleh dijadikan satu keterangan *prima facie* mengenai butiran yang direkodkan.

MI NOTE 10 LITE
AI QUAD CAMERA

Figure 3. MYIPO Certificate

4. Benefit to mankind

Accordingly, the GENac4R system is capable of providing a free and environmentally friendly source of electricity based on ecological concepts. By utilizing this system, users can reduce household electricity bills by up to 20%. The diagram below illustrates the comparison of electricity bills before and after the implementation of the GENac4R system.

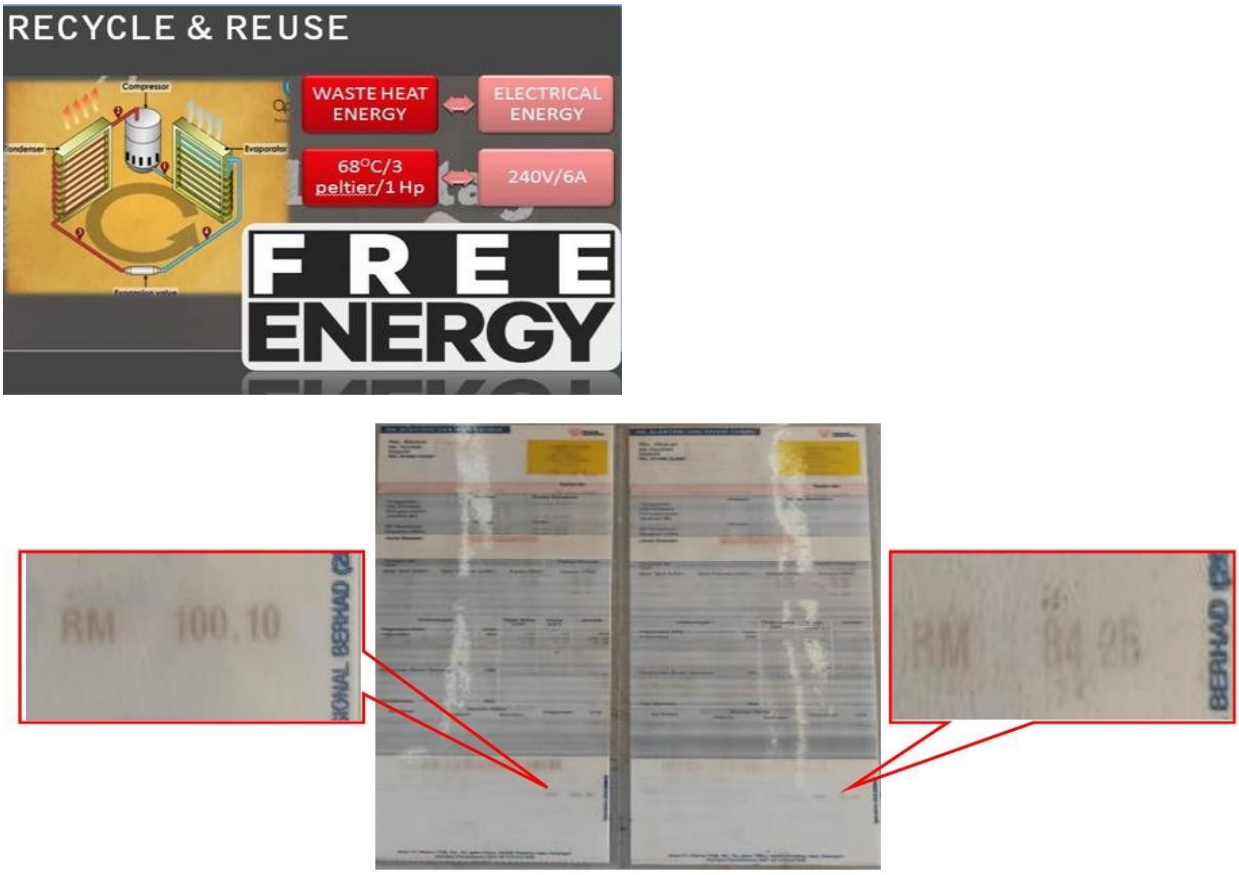

Figure 4. Electricity bills comparison.

5. Innovation and Entrepreneurial Impact

"Reduce"

The GENac4R product is a system designed to reduce contributions to global warming. This is achieved by utilizing a portion of the unused heat generated by air conditioners. Based on the analysis conducted, the GENac4R system is capable of reducing emissions released into the environment by a significant margin, as illustrated in the analysis below. Based on the analysis conducted, the GENac4R system reduced the temperature released into the environment from 68 °C to 45 °C. This represents a decrease in heat emission of approximately 33.8%, demonstrating the system's effectiveness in lowering thermal discharge and mitigating environmental impact.

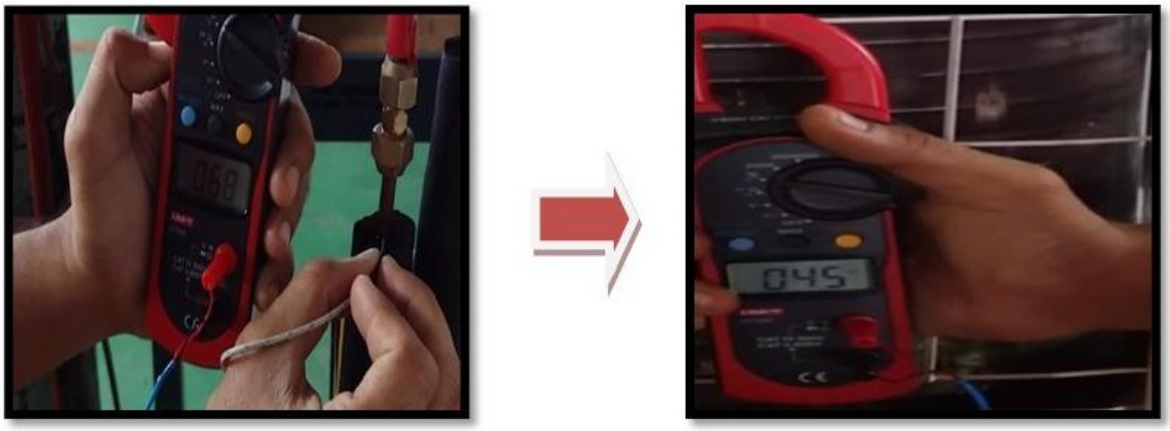

Figure 5. Measurement of reduce emissions.

6. Potential commercialization

The diagram below illustrates that the installation of the GENac4R system is carried out for domestic users, namely in households, as well as for industrial users in factories.

Figure 5. Installation of the GENac4R .

7. Acknowledgment

All praise be to Allah Almighty for granting me the opportunity and strength to complete this report, prepared to join the competition to represent Kolej Vokasional Shas Kuala Lipis. My deepest gratitude goes to all who were involved, especially the Director of Kolej Vokasional Shas Kuala Lipis, for the continuous support in advancing innovation at the college. I also extend my appreciation to all staff and lecturers, particularly the college innovation group, for their guidance and encouragement. Special thanks are also due to my family members who have provided unwavering motivation in fulfilling the responsibility entrusted by the college. Once again, I express

my heartfelt gratitude, and may Allah SWT reward all your kindness and bless our efforts both in this world and the hereafter.

8. Researchers' Biography

Muhamad Abdullah bin Ismail, a teacher of Kolej Vokasional Sultan Haji Ahmad Shah Al-Mustain Billah, specializes in the field of Refrigeration and Air Conditioning. Representing Kolej Vokasional Shas Kuala Lipis, he has actively contributed to the development of the GENac4R project, an innovative system designed to harness waste heat from air conditioners to generate renewable electricity while reducing global warming. His dedication to sustainable technology has earned recognition from the Intellectual Property Corporation of Malaysia (MYIPO) under the copyright category, affirming the originality and innovative value of his work. Residing in Lipis, Pahang, Muhamad Abdullah can be reached at 016-9584067 or via email at abdullah103151@gmail.com, reflecting his commitment to advancing eco-friendly solutions and promoting innovation in vocational education.

Eggster: A 3D-Printed Multifunctional Hygienic Egg Preparation Tool

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Muhammad Mirza Aiman bin Faizul Hisham and Roha Mohamed Noah
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ABSTRACT

Eggster is an innovative, 3D-printed kitchen appliance designed to improve efficiency, hygiene, and user comfort during egg preparation. It was developed to address common issues such as messy egg cracking, eggshell residue, hygiene concerns, and skin irritation caused by direct contact with raw eggs, particularly for users with sensitive skin conditions like eczema. By minimizing hand contact, Eggster offers a cleaner, safer, and more user-friendly cooking experience. Eggster is uniquely designed as a compact, multifunctional device that combines an egg cracker, mini whisk, and shredder into a single space-saving tool. This multifunctionality, combined with its hygienic design and ease of use, makes Eggster suitable for students, families, and working professionals who require practical kitchen solutions. From a socio-environmental perspective, Eggster promotes better kitchen hygiene and supports sustainable production through 3D printing, which reduces material waste and allows cost-efficient manufacturing. With low production costs, high scalability, and strong market demand for hygienic and multifunctional kitchen tools, Eggster has strong commercialization potential and offers a sustainable pathway for long-term business growth.

Keywords:
Egg cracker, 3D printing, Kitchen hygiene, Multifunctional kitchen tool, User-friendly design.

1. Product Description

Eggster is a breakthrough 3D-printed kitchen appliance designed to revolutionize egg preparation by making it cleaner, safer, and more efficient. This compact, multifunctional tool integrates an egg cracker, mini whisk, and shredder into one ergonomic device, allowing users to complete multiple cooking steps without switching utensils. Eggster ensures precise cracking of eggs without shell fragments, reducing food contamination and kitchen mess. Its design minimizes direct hand contact with raw eggs, which improves hygiene and prevents skin irritation for users with sensitive conditions such as eczema. The mini whisk provides quick and consistent egg beating, while the shredder simplifies ingredient preparation, saving time and effort. Eggster's lightweight and space-saving structure makes it ideal for students, families, and professionals living in compact homes or busy environments. Produced using 3D printing technology, Eggster offers cost-effective manufacturing, fast production, and easy customization to meet diverse consumer needs. With its unique combination of hygiene, convenience, and multifunctionality, Eggster is poised to become a must-have kitchen essential for modern households.

2. Schematic Diagram of Eggster Design and Production Flow

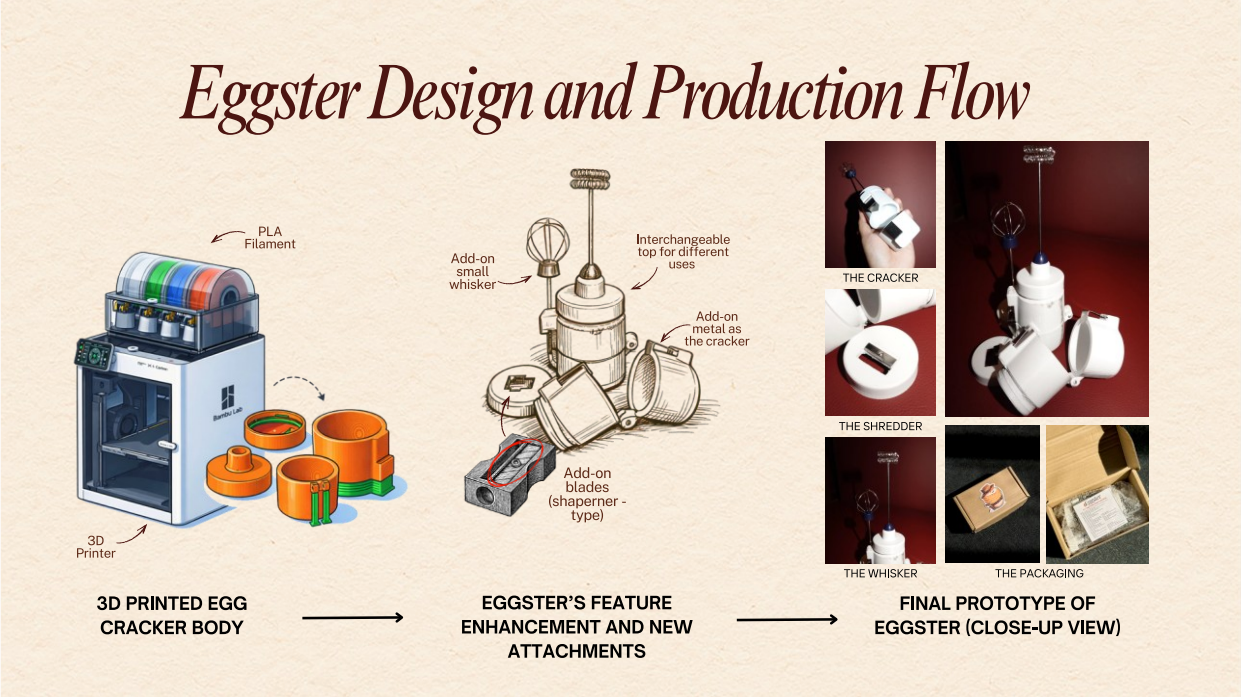


Figure 1. Eggster Design and Production Flow.

3. Novelty and uniqueness

Eggster is a groundbreaking kitchen tool that merges egg cracking and whisking into a single, compact device. Unlike conventional egg crackers or manual whisks, which serve only one purpose, Eggster features interchangeable attachments that allow users to crack eggs cleanly and whisk efficiently with the same tool. Its unique mechanical design minimizes mess, reduces hand strain, and enhances hygiene during food preparation. The 3D-printed construction makes it lightweight, customizable, and cost-effective to produce. Users can easily switch attachments for egg cracking, whisking, or shredding, depending on their needs. Compared to traditional methods, which rely on multiple tools and hand force, Eggster offers a smarter, more practical solution. Its portable size, modern aesthetic, and ease of use make it ideal for home cooks, students, and small food businesses. By combining multifunctionality, simplicity, and affordability, Eggster transforms a routine kitchen task into a cleaner, faster, and more enjoyable experience. Its innovative design sets it apart as a product that is both practical and forward-thinking, redefining how eggs are prepared in modern kitchens.

4. Benefit to mankind

Eggster improves cooking by making it safer, cleaner, and more efficient. It reduces the risk of hand injuries and strain, making it especially helpful for the elderly or those with weak grip strength. By preventing eggshells from contaminating food, it also ensures better hygiene and higher-quality dishes. Time-saving is another key benefit, particularly for home cooks and small food vendors who handle eggs frequently. The reusable, durable design encourages sustainable kitchen practices, cutting down on disposable or low-quality tools. Eggster also enhances the cooking experience by simplifying routine tasks, allowing users to focus on creativity and taste. Its multifunctionality supports healthier, more efficient, and stress-free food preparation. By

making everyday cooking safer, faster, and more enjoyable, Eggster contributes positively to households, communities, and small food businesses alike.

5. Innovation and Entrepreneurial Impact

Eggster exemplifies innovation by applying creative design thinking to solve a common kitchen problem. It encourages students and young entrepreneurs to observe everyday challenges and turn them into practical business solutions. From an entrepreneurial standpoint, Eggster demonstrates how low-cost technology, like 3D printing, can produce functional, market-ready products. The project highlights the value of combining design, innovation, and business strategy into a viable commercial idea. Within institutions and communities, Eggster inspires small-scale manufacturing, product customization, and student-led startups. It promotes a culture of creativity and problem-solving, showing how simple ideas can have real-world impact. By blending innovation with entrepreneurship, Eggster not only solves a practical need but also motivates future innovators to develop products that are functional, scalable, and commercially promising.

6. Potential commercialization

Eggster has strong commercial potential due to its simple design, low production cost, and wide appeal. It can be sold through online platforms such as Shopee and TikTok Shop, as well as through campus agents, kitchenware stores, and food stalls. The 3D-printed manufacturing process enables small-batch production and easy scaling as demand grows. Customization options, including colors or branded designs for cafes and food businesses, increase market appeal. With effective marketing, attractive packaging, and competitive pricing, Eggster can expand beyond local markets into regional markets. Its multifunctionality and affordability make it an attractive choice for home cooks, students, and small food enterprises. Eggster demonstrates how a simple, innovative idea can translate into a commercially viable product with strong growth potential, appealing to both individual consumers and businesses seeking practical, cost-effective kitchen solutions.

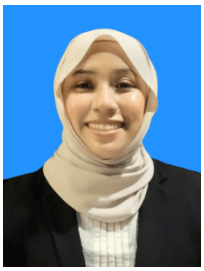
7. Acknowledgment

We would like to sincerely thank our teammates for their dedication, creativity, and teamwork, which has brought us this far. We are deeply grateful to our lecturer for guiding us from start to finish, providing valuable advice, feedback, and encouragement at every stage. This project would not have been possible without the support, patience, and insights
shared by everyone involved. We truly appreciate the collective effort that made this journey both successful and memorable.

8. Researchers' Biography

Firman Danish Putra bin Zainal Abidin is the creative mind who sparked the idea of Eggster. His ability to think outside the box and see opportunities in everyday challenges drives innovation. Always curious and imaginative, he inspires the team with bold ideas and a clear vision, turning a simple concept into a project with real potential. His originality and forward-thinking approach make him the team's idea engine.

Muhammad Mirza Aiman bin Faizul Hisham brings ideas to life through innovation and detail. He has a natural talent for improving designs, adding features, and making products more functional and engaging. His love for problem-solving and perfection ensures every aspect of Eggster is practical and exciting. Mirza's creativity, precision, and drive to enhance the project make him the team's engine of innovation.



Sofea Jasmeen binti Ismail is the heart of the team, transforming ideas into real and functional innovations. She coordinated the project, managed supplier communication, and ensured that Eggster was built and tested successfully. Beyond execution, she contributed strategic thinking by planning workflows, anticipating challenges, and making decisions to keep the project on track. Her dedication and commitment and drive turn ideas into reality, making her the backbone of the team.

Roha Mohamed Noah obtained her Bachelor's degree in Development Management from University Utara Malaysia (UUM). Then she obtained her Master's degree in Business and Entrepreneurship (Edu) from University Kebangsaan Malaysia (UKM). Currently, she is a lecturer at the Faculty of Business and Management, University Technology MARA Johor Branch (UiTMCJ). Her specializations include Management in Business and Entrepreneurship.

Serve U-iTM: An Integrated Digital Campus Service Platform

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ABSTRACT

Serve U-iTM is an innovative digital campus service application developed to enhance the daily lifestyle, efficiency, and convenience of Universiti Teknologi MARA (UiTM) students. The application functions as an all-in-one mobile platform that integrates essential campus services, including food ordering from campus food courts, parcel management, laundry booking, and the purchase of basic pharmacy and convenience items. Serve U-iTM was designed to address common challenges faced by students, such as long waiting times, inefficient manual systems, and difficulty managing daily tasks within a busy academic schedule. By centralizing multiple services into a single user-friendly application, Serve U- iTM reduces unnecessary movement around campus, saves time, and improves service accessibility. The platform also creates part-time employment opportunities for UiTM students as service assistants and delivery personnel, allowing them to earn income while gaining practical work experience and essential soft skills. In addition, on-campus vendors benefit from a more organized and efficient order management system that improves service quality and operational efficiency. Overall, Serve U-iTM supports digital transformation, student welfare, and sustainable campus-based entrepreneurship, with strong potential for commercialization and scalability across higher education institutions.

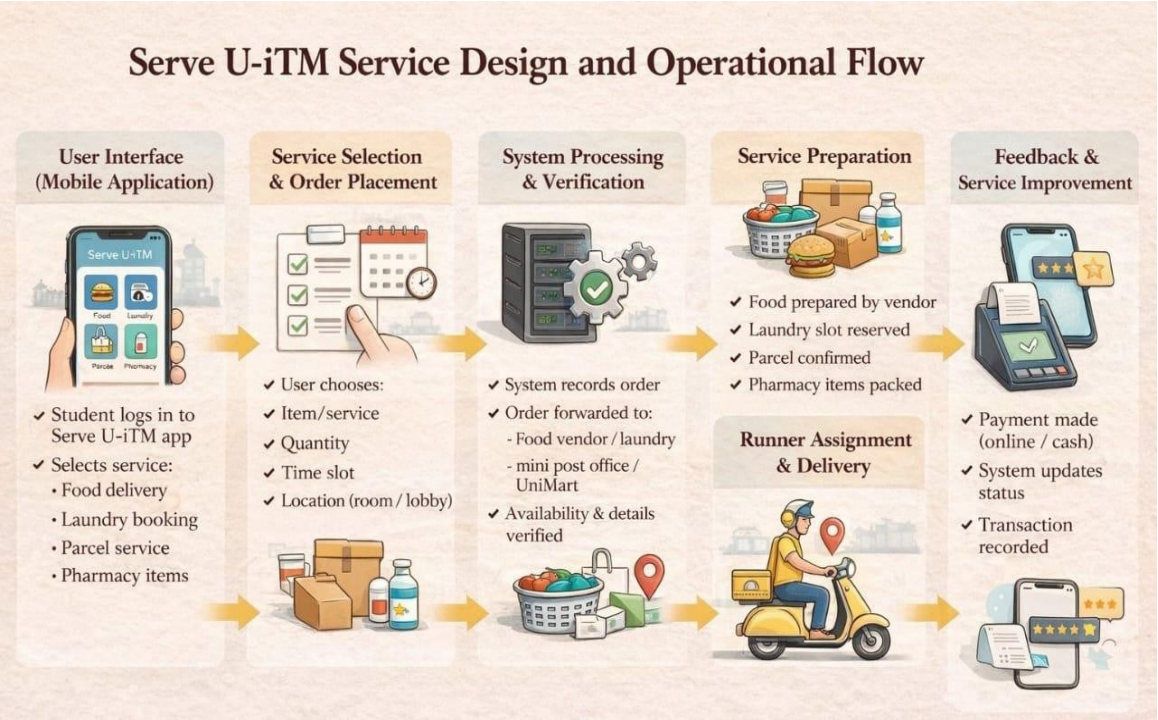
Keywords: Digital campus service, Mobile application, Student lifestyle, Campus entrepreneurship, Service efficiency.

1. Product Description

Serve U-iTM is a mobile-based digital platform designed specifically for the UiTM campus environment. The application integrates multiple essential student services into a single centralized system, enabling users to order food from campus food courts, manage parcel collection, book laundry services, and purchase basic pharmacy or convenience items through one application. This integration eliminates the need for students to move between multiple service points or rely on manual processes, significantly improving time management and daily efficiency. The application features a simple, intuitive, and user- friendly interface to ensure accessibility for all students. Orders and service requests are processed digitally, allowing vendors and service providers to manage operations more systematically. Serve U-iTM also incorporates student participation by offering part-time roles such as service assistants and delivery personnel, creating a student-driven service ecosystem. By combining convenience, employment opportunities, and efficient service management, Serve U-iTM enhances the overall campus experience.

2. Schematic diagram of Serve U-iTM Design and Service Flow

Figure 1. Serve U-iTM Design and Service Flow.



3. Novelty and uniqueness

Serve U-iTM is unique due to its comprehensive integration of multiple campus services into a single digital platform tailored specifically for UiTM students. Unlike existing solutions that focus on individual services such as food delivery or parcel management, Serve U-iTM combines various daily necessities into one centralized application. This approach reduces service fragmentation, improves efficiency, and enhances user convenience. Another key novelty is the platform's student-employment model, where UiTM students actively participate as service assistants and delivery personnel. This model not only supports operational sustainability but also empowers students by providing real- world work experience. Serve U-iTM's collaborative approach between students and campus vendors further distinguishes it as a holistic digital campus solution rather than a conventional service application.

4. Benefit to mankind

Serve U-iTM contributes positively to student well-being by reducing daily stress associated with long queues, inefficient manual systems, and time constraints. By simplifying access to essential services, students can better balance academic and personal responsibilities. The platform also promotes financial independence by offering flexible part-time employment opportunities within the campus. From a broader perspective, Serve U-iTM encourages digital adoption, operational efficiency, and sustainable practices within educational institutions. Vendors benefit from improved order accuracy and workflow management, while the campus community experiences enhanced service quality. Overall, Serve U-iTM supports a more efficient, inclusive, and student-friendly campus ecosystem.

5. Innovation and Entrepreneurial Impact

Serve U-iTM demonstrates innovation by applying digital technology to address everyday campus challenges through a practical and scalable solution. The project encourages an entrepreneurial mindset among students by transforming common problems into a viable business model. By integrating application development, service management, and student participation, Serve U-iTM highlights how innovation can be both functional and socially impactful. The platform also supports entrepreneurship education by providing students with hands-on experience in operations, customer service, and digital business management. Serve U-iTM serves as an example of how student-led initiatives can contribute meaningfully to institutional development while fostering creativity, responsibility, and innovation.

6. Potential Commercialization

Serve U-iTM has strong commercialization potential due to its low operational cost, digital nature, and scalability. The platform can be expanded across multiple UiTM campuses and adapted for use in other universities with similar service requirements. Revenue can be generated through service fees, delivery charges, and vendor partnerships. With effective marketing strategies and continuous system enhancement, Serve U-iTM can evolve into a standardized digital campus service solution. Its flexible design allows for the future integration of additional services, ensuring long-term sustainability and commercial viability within the higher education sector.

7. Acknowledgment

The team would like to express sincere appreciation to our lecturers, peers, and all individuals who provided valuable guidance, constructive feedback, and continuous support throughout the development of Serve U-iTM. Their knowledge, encouragement, and willingness to share insights were instrumental in guiding the project from its initial concept to a complete and meaningful outcome. We are also grateful for the motivation and cooperation received, which greatly contributed to the successful completion and overall quality of this project.

8. Researchers' Biography

Fatwa Nur Jasmien is the initiator of the Serve U-iTM concept and the main developer of the application. She identified common challenges faced by UiTM students in accessing daily campus services and transformed these issues into a functional digital solution. Fatwa led the application design, service integration, and system workflow development. Her initiative, problem-solving ability, and entrepreneurial mindset were central to the success of the project.

Auni Afreena contributed to service planning, user experience enhancement, and the operational design of Serve U-iTM. She played an important role in refining service workflows to ensure the application remains practical, efficient, and user-friendly. Her user- oriented perspective strengthened the platform's usability and relevance in meeting students' daily needs.

Nur Fitriyatul Najihah supported the project through research, documentation, and business feasibility analysis. She contributed to assessing service sustainability, operational efficiency, and potential implementation challenges, as well as proposing practical solutions. Her analytical approach and structured planning enhanced the project's overall viability and long-term potential.

Roha Mohamed Noah obtained her Bachelor's degree in Development Management from University Utara Malaysia (UUM). Then she obtained her Master's degree in Business and Entrepreneurship (Edu) from University Kebangsaan Malaysia (UKM). Currently, she is a lecturer at the Faculty of Business and Management, University Technology MARA Johor Branch (UiTMCJ). Her specializations include Management in Business and Entrepreneurship

Smart Vehicle Alert System (SVAS)

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ABSTRACT

This project introduces a comprehensive and innovative vehicle safety and security system equipped with various sensors and advanced features aimed at enhancing driver safety andpreventing theft. The system is designed to provide real-time monitoring and emergency response capabilities. Alcohol Detection and Automatic Engine Shutdown: The system incorporates an Alcohol Sensor (MQ-3) to detect alcohol levels exceeding a predefined threshold (Alcohol Reading > 50%). In such cases, the vehicle engine is automatically shut down, and an alert system is activated. Notifications are sent via SMS, and emergency calls are made to registered phone numbers. Rapid Emergency Child Alert System: Utilizing a Microphone Sensor (KY-037) and PIR Sensor (HS-SR501), the system responds to excessive noise levels (Sound Reading > 62%) or PIR sensor activation. When triggered, it sends alerts through SMS and initiates emergency calls to registered contacts. Anti-Theft Engine Locking System: Similar to the Rapid Emergency Child Alert System, this system employs the Microphone Sensor (KY-037) and PIR Sensor (HS-SR501). It activates if abnormal sound levels or PIR sensor activation are detected. In addition, users can activate the "LOCK SYSTEM" to disable the vehicle engine, ensuring enhanced security. The engine can only be reactivated after "LOCK SYSTEM" deactivation. Real-Time Accident Alert System: Equipped with a 3-Axis Accelerometer Sensor (ADXL 345), this system identifies drastic changes in vehicle speed along the X, Y , and Z axes, indicating a potential accident. In such situations, the engine is automatically disabled, and the alert system is engaged. It promptly notifies registered contacts through SMS and initiates emergency calls. Furthermore, it provides real-time accident location information. Real-Time GPS Tracking System: Users can access real-time vehicle location through a GPS tracking feature, allowing them to monitor the vehicle's whereabouts at any given moment. From a socio-economic perspective, SVAS aims to reduce medical costs and productivity loss associated with road accidents, while providing peace of mind to parents and vehicle owners. The commercialization prospects are significant due to the low-cost implementation using accessible components (Arduino, MQ-3, ADXL345) compared to the high safety value provided, making it an affordable solution for the mid-range automotive market and logistics companies through a subscription-based mobile application model.

Keywords: Smart Vehicle Alert System (SVAS), ADXL345 Accelerometer, IoT Safety, Anti-Theft System, Real-time GPS Tracking, Child Safety Sensor, Alcohol Detection, GSM Notification, Automotive Innovation.

1. Product Description

The Smart Vehicle Alert System (SVAS) is a comprehensive safety innovation designed by Kolej Vokasional Sultan Haji Ahmad Shah Al-Mustain Billah to proactively reduce road fatalities and enhance vehicle security. This intelligent system integrates five critical life-saving functions using advanced sensors and control logic to respond to emergencies in real-time. The Alcohol Detection feature utilizes an MQ-3 sensor to monitor the cabin; if levels exceed 50%, it automatically disables the engine and triggers an alarm to prevent drunk driving. To protect vulnerable passengers, the Rapid Emergency Child Alert uses PIR motion and microphone sensors to detect children left behind in parked vehicles, initiating immediate SMS and voice call alerts. Security is further bolstered by an Anti-Theft Engine Locking system and a Real-Time Accident Alert that employs a 3-axis accelerometer to detect drastic impacts, ensuring immediate notification of emergency contacts. Finally, the integrated Real-Time GPS Tracking provides precise coordinates for all triggered alerts, allowing for rapid response from emergency services or vehicle recovery. By combining automated engine control with instant communication, SVAS offers a high-impact technological solution to modern transportation risks.

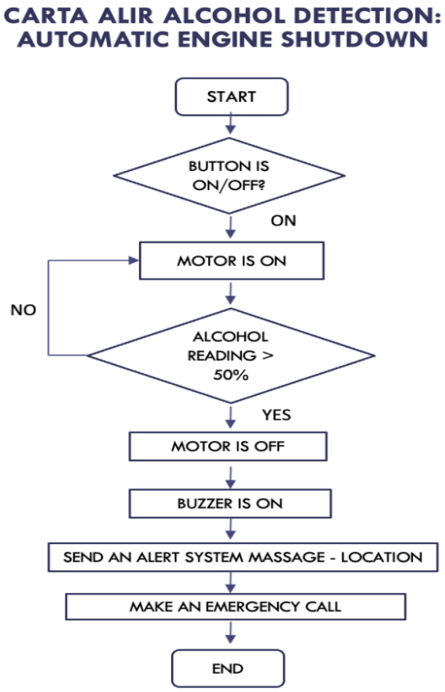
2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

Technical Design and System Features

The SVAS system is divided into several technical modules that function autonomously to ensure maximum safety.

1. Alcohol Detection and Automatic Engine Shutdown

As shown in **Figure 1**, the system is equipped with an Alcohol Sensor (MQ-3). When the alcohol reading exceeds the threshold (Alcohol Reading > 50%), the vehicle engine is automatically deactivated and the warning system is activated. The system then sends notifications via SMS and makes emergency calls to the registered phone numbers.

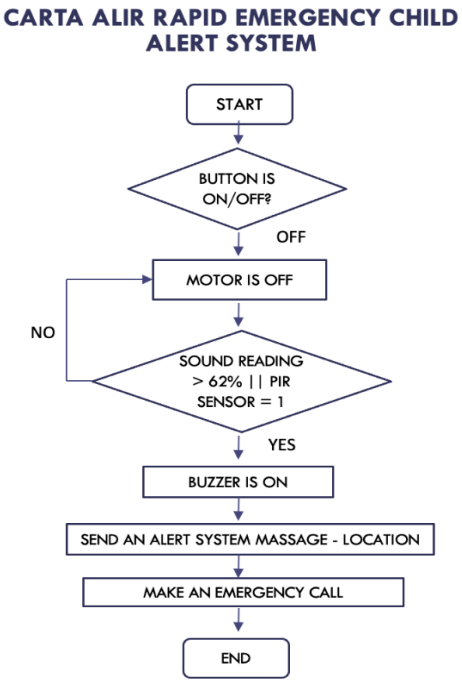


"This project is equipped with an Alcohol Sensor (MQ-3). When the alcohol reading exceeds the set value (Alcohol Reading > 50%), the vehicle engine will be deactivated and the alarm system will be activated.The system will send a notification via message and make an emergency call to the registered phone number."

Figure 1. Alcohol Detection: Automatic Engine Shutdown.

2. Rapid Emergency Child Alert System

Referring to **Figure 2**, when the sound reading exceeds 62% or the PIR sensor detects movement, the alert system is activated to prevent heatstroke incidents in the vehicle. Immediate alerts are sent to the owner via SMS and voice calls.

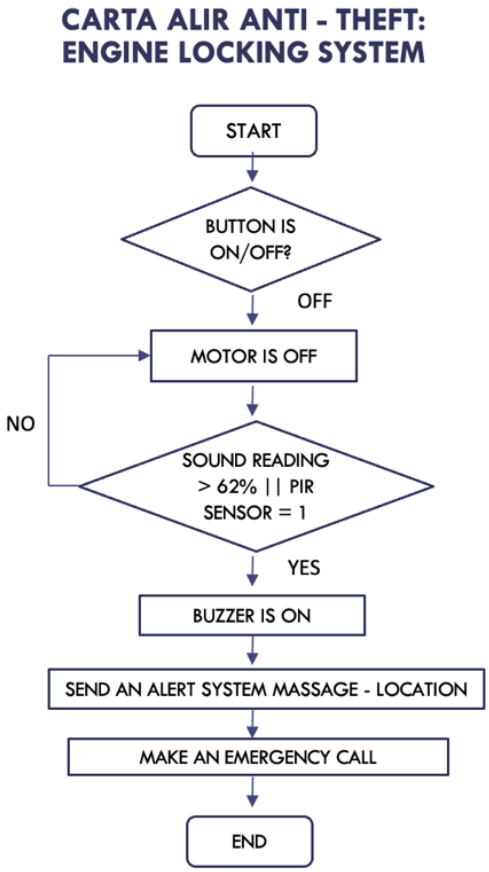


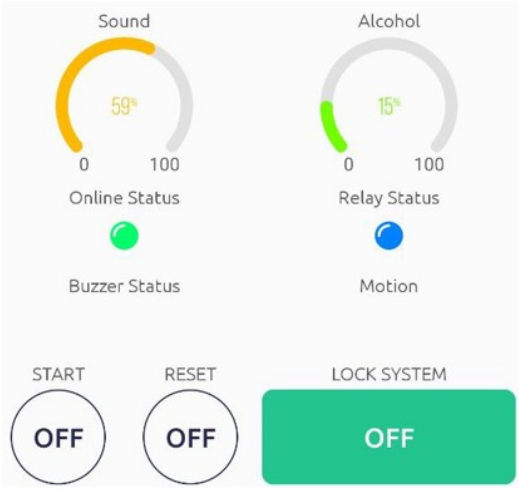
"This project is equipped with a Microphone Sensor (KY-037) and a PIR Sensor (HC-SR501). When the sound reading exceeds the set value (Sound Reading > 62%) or the PIR sensor reading equals 1, the alarm system will be activated. The system will send a notification via message and make an emergency call to the registered phone number."

Figure 2. Rapid Emergency Child Alert System.

3. Anti-Theft: Engine Locking System

For property security purposes, the anti-theft function is activated when there is a suspicious sound or movement interference as displayed in **Figure 3**. In addition to the automatic detector, users also have full power to activate the 'LOCK SYSTEM' remotely. Once activated, the vehicle engine will be shut down and can only be restarted after the system is unlocked by the authorized owner.





This project is equipped with a Microphone Sensor (KY-037) and a PIR Sensor (HC-SR501). When the sound reading exceeds the predefined threshold (Sound Reading > 62%) or the PIR sensor detects movement (PIR sensor = 1), the alarm system will be activated. The system will send a notification via message and make an emergency call to the registered phone number. In the event of an attempted car theft, the user can activate the 'LOCK SYSTEM'. Once the 'LOCK SYSTEM' is activated, the vehicle's engine will be deactivated.The engine can only be started again after the 'LOCK SYSTEM' has been deactivated.

Figure 3. Anti – Theft: Engine Locking System.

4. Real-Time Accident Alert and Location System

As illustrated in **Figure 4**, the system not only shuts down the engine to prevent fire but also sends precise GPS coordinates to rescue teams or family members to enable immediate assistance during the "golden hour".

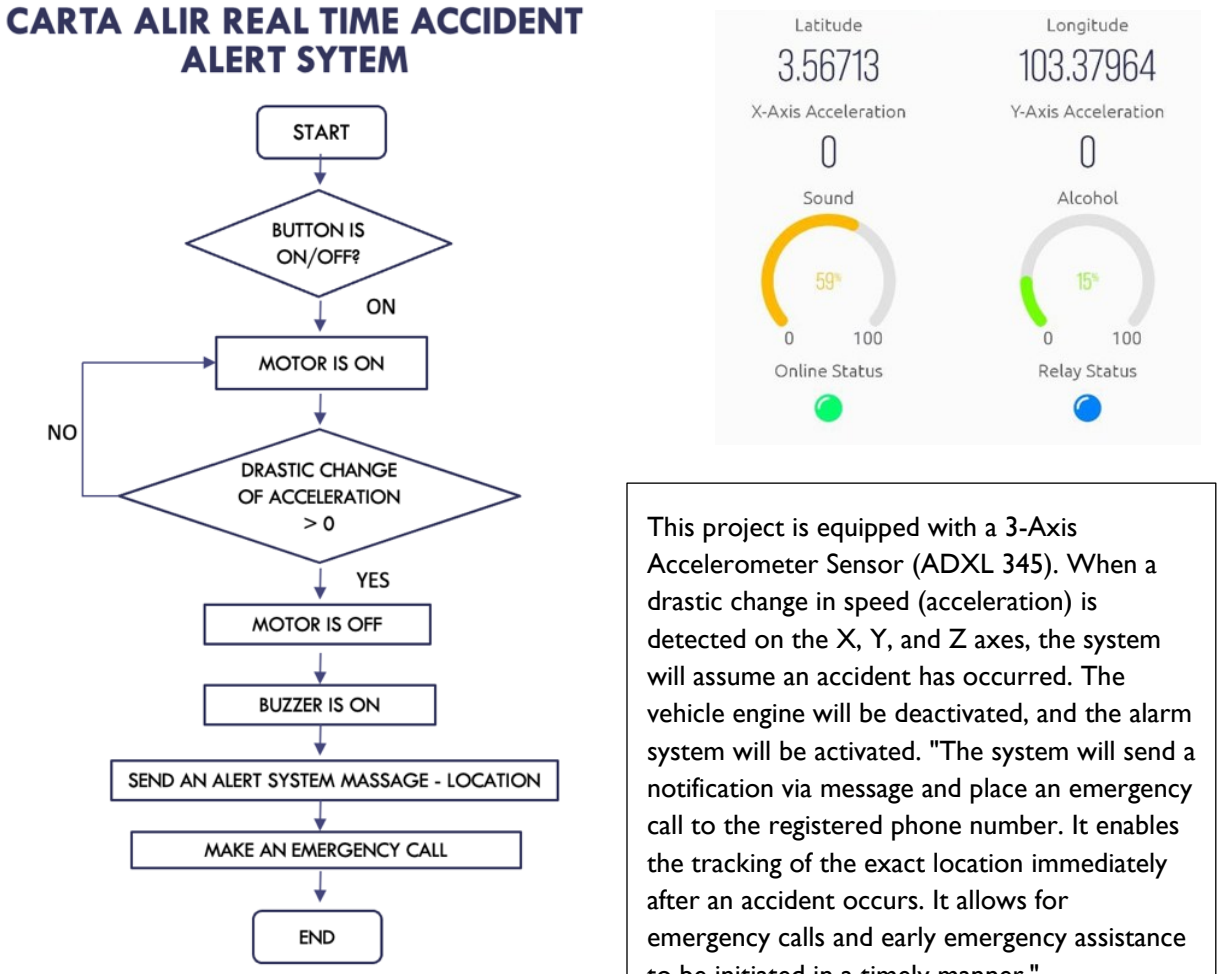
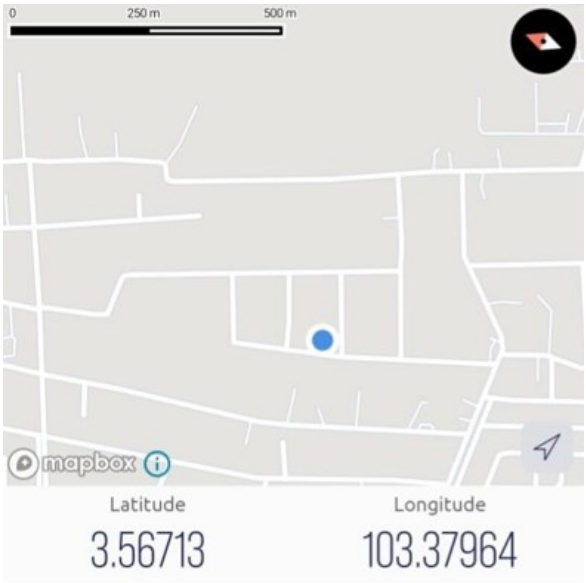


Figure 3. Real Time Accident Alert System.

5. Real-Time Location Tracking

Figure 5 shows the location monitoring interface where users can view the exact position of their vehicle at all times through GPS module integration. This is particularly useful for recovering stolen vehicles or monitoring the journeys of family members.



"Users can view the exact location of the vehicle in real-time."

Figure 5. Real Time Accident Alert System.

3. Novelty and uniqueness

The novelty and uniqueness of the Smart Vehicle Alert System (SVAS) lie in its seamless integration of five critical safety dimensions into a single, autonomous intelligent ecosystem. Unlike conventional security systems that operate in isolation, SVAS offers a holistic protection framework encompassing drunk driving prevention, child safety, anti-theft measures, and immediate accident response. A key innovation is its active intervention capability; the system does not merely alert the user but can autonomously deactivate the vehicle's engine when life-threatening risks—such as high alcohol levels or theft attempts—are detected. Furthermore, the system employs a unique hybrid sensing approach, combining PIR and microphone sensors to provide a more reliable detection layer for children trapped in vehicles, effectively reducing false negatives. The strategic integration of GPS and GSM modules ensures that every critical event is backed by real-time spatial data and automated emergency calls, bridging the gap between incident detection and professional medical or police response. This multi-dimensional approach transforms the vehicle from a passive machine into an active guardian, making SVAS a distinctive innovation in the field of automotive safety and intelligent transportation systems.

4. Benefit to mankind

The Smart Vehicle Alert System (SVAS) offers profound benefits to mankind by integrating life-saving technologies that address the most critical risks in modern transportation. By preventing individuals from operating vehicles under the influence of alcohol and providing immediate alerts for children left in hot cars, the system directly reduces preventable fatalities and protects the most vulnerable members of society. Furthermore, its real-time accident detection and GPS tracking capabilities ensure that emergency services receive precise location data during the "golden hour," significantly increasing the chances of survival for crash victims. Beyond physical safety, the anti-theft and remote locking features provide vehicle owners with enhanced security and peace of mind, reducing the socio-economic burden of vehicle loss. Ultimately, SVAS serves as a proactive guardian, transforming automotive technology into a powerful tool for preserving human life, enhancing public safety, and fostering a more secure driving environment for everyone.

5. Innovation and Entrepreneurial Impact

The SVAS project drives technological innovation by shifting vehicle security from passive monitoring to active, AI-driven intervention. By centralizing diverse sensors into a single protective hub, it challenges the automotive industry to move beyond standard safety features. This project fosters a culture of entrepreneurship by demonstrating how affordable components like the Arduino, MQ-3, and ADXL345 can be transformed into a high-value commercial product.

For institutions and local communities, it serves as a blueprint for problem-centric design, encouraging aspiring inventors to build scalable solutions for real-world crises like child heatstroke and drunk driving. The scalability of the "LOCK SYSTEM" and real-time tracking offers significant market potential for logistics companies and insurance providers. Ultimately, SVAS proves that innovation is not just about complex code, but about creating integrated, market-ready solutions that enhance human safety while opening new avenues for tech-based startups.

6. Potential commercialization

Unlike competitors that sell separate GPS trackers or alcohol interlocks, SVAS combines alcohol detection, child safety, anti-theft, and accident alerts into a single, cost-effective device. The system goes beyond passive alerts by actively deactivating the engine, a feature highly sought after by security-conscious consumers in high-theft regions. The GSM/GPS notification feature allows for a recurring revenue model through a dedicated mobile app for real-time monitoring and "system-as-a-service" updates. The design can be licensed to car manufacturers as a standard safety package for entry-level and mid-range vehicles, especially in markets with strict safety regulations.

7. Acknowledgment

First and foremost, I would like to express my deepest gratitude to Almighty God for His blessings and guidance, which provided me with the strength and perseverance to successfully complete this project. I would like to extend my sincere appreciation to my faculty and technical staff of our institution for providing the facilities, resources, and laboratory equipment necessary to conduct the testing and assembly of the various sensors and modules used in this project. Finally, I would like to thank all the individuals and contributors who provided indirect assistance,

whether through technical documentation, open-source resources, or constructive feedback, all of which helped in making this innovation a reality.

8. Researchers' Biography

Ts Mohamad Basir bin Baharudin graduated from Universiti Sains Malaysia (USM) with a degree in Electronic Engineering in 2013. He began his professional career as an engineer, serving in the industry from 2013 to 2016. In 2016, he transitioned into academia and has since been serving as a lecturer at Kolej Vokasional Sultan Haji Ahmad Shah Al-Mustain Billah. With his extensive background in both industrial engineering and technical education, he specializes in electronic systems and innovative safety solutions.

Danial Ariff Bin Nurul Fahmi is a final year student in the Electronic Technology Program at Kolej Vokasional Sultan Haji Ahmad Shah. He has a deep interest in the development of IoT-based systems and has been actively involved in the sensor integration phase of the SVAS project.

Muhammad Danish Ikram Bin Mohd Zulkifly is a student in the Electronic Technology Program at Kolej Vokasional Sultan Haji Ahmad Shah. He is responsible for the programming of the GSM and GPS modules and ensuring smooth data communication between the sensors and the user.

From Dye Pollution to Clean Water: Photodegradation of Methylene Blue via Alumina–Silica Catalyst

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ABSTRACT
Dye pollution from industrial effluents poses a serious threat to water quality due to the high stability of synthetic dyes. Methylene blue (MB) is commonly used as a model dye pollutant to evaluate advanced water treatment technologies. In this study, alumina–silica photocatalysts with Al:Si molar ratios of 1:1 and 3:2, along with a Ru-loaded Al_2O_3–SiO_2 photocatalyst (Ru/Al–Si), were successfully synthesized and applied for the photodegradation of MB in aqueous media. Alumina–silica was fabricated via the sol–gel method, while Ru/Al–Si was prepared using wet impregnation method. FTIR characterization confirmed the formation of the alumina–silica framework and the successful incorporation of Ru. The catalysts were evaluated for MB photodegradation, where efficiencies of 13.04% and 12.15% were achieved for 1:1 and 3:2 Al–Si, respectively. The highest efficiency of 15.25% was obtained using Ru/Al–Si after 180 minutes of visible light irradiation, demonstrating that Ru incorporation enhances performance. From the result, the photocatalyst could help with the removal of dye in wastewater for the benefit of the community, environment, and economy due to inexpensiveness, efficient dye removal, and less dye to pollute the environment. These findings highlight the potential of alumina–silica and Ru/Al–Si for degrading dye and organic pollutants in wastewater.

Keywords: Alumina-silica; Photodegradation; Ru/Al_2O_3-SiO_2; methylene blue; wastewater

1. Product Description
Alumina-silica, Al_2O_3-SiO_2, is a photocatalyst that can be used for degradation of organic pollutants such as dyes. The textile industry produces about 7×10^4 tons of organic dyes and some of them were discharged into water bodies, which would affect the aquatic life, and environment, as well as human health. To tackle this problem, this project introduces an initiative to produce a Al_2O_3-SiO_2 photocatalyst to study its efficiency on photodegrading the pollutants in wastewater. The alumina-silica was produced via sol-gel method, and the alumina-silica was integrated with Ruthenium metal, Ru via wet impregnation method to further improve the photocatalytic activity of alumina-silica. The surface of the alumina-silica can chemically act like a photocatalyst under exposure of light. It physically has a large surface area, is mesoporous, and high temperature stability. The Al_2O_3-SiO_2 shows great potential as a photocatalyst for removal of organic dye in wastewater. Experimental findings indicate that alumina-silica exhibits good photodegradation efficiency of methylene blue, and even greater when Ru is impregnated into Al_2O_3-SiO_2, demonstrating its suitability in wastewater treatment industry. Overall, the study confirms the ability of alumina-silica as a sustainable and efficient photocatalyst due to its low cost and material availability.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

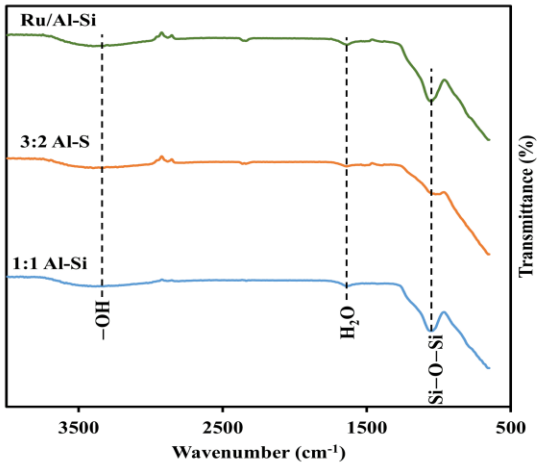

Figure 1. FTIR spectra for 1:1 Al-Si, 3:2 Al-Si, and Ru/Al-Si photocatalysts.

In the FTIR spectra, the broad peaks indicated at the wavenumber 3400 cm-1 and 1630 cm-1 were assigned as the stretching and bending water absorbed on the surface and hydroxyl groups, -OH (see **Figure 1**). The spectra show the peak at 1060 cm-1 is attributed to Si-O-Si asymmetric vibrations. It can be observed that the peaks attributed to Si-O-Si at 1060 cm-1 for 1:1 Al-Si and Ru/Al-Si catalyst have larger and sharper peaks than the peak for 3:2 Al-Si. This is due to the amount of silica content present in the 1:1 Al-Si, and Ru/Al-Si catalyst since both catalysts have larger silica to alumina ratio, which is 1:1. The very small decrease of the intensity of water molecules at 1630 cm^{-1} for Ru/Al-Si when compared to 1:1 Al-Si could indicates the confirmation of Ru integration. Overall, it demonstrates the successful synthesis of 1:1 Al-Si and 3:2 Al-Si, as well as the ruthenium supported by alumina-silica catalyst.

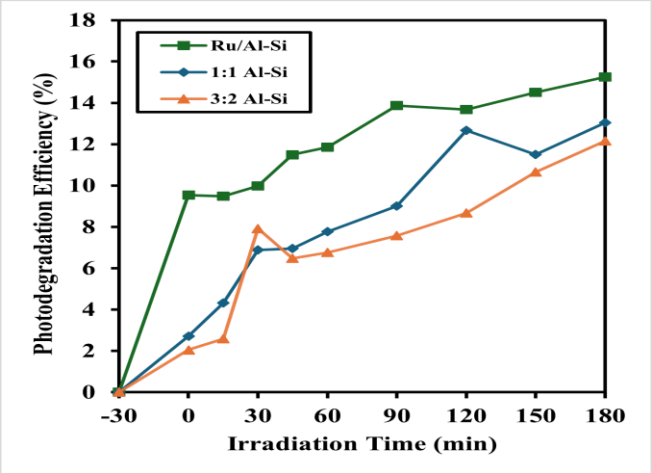

Figure 2. The effect of different alumina-to-silica ratios and alumina-silica-integrated Ru on photodegradation efficiency.

Figure 2 shows 1:1 Al-Si has a higher MB precent degradation, which is 13.04%, than 3:2 Al-Si, which is 12.15% under 180 minutes of irradiation. This is due to the higher silica content in 1:1 ratio than 3:2, in which higher silica content would lead to higher specific surface area due to

more porosity on the catalyst surface. Higher specific surface area would attribute to higher active catalytic site, thus improving the photocatalytic activity. The implementation of Ru/Al-Si increases the photodegradation efficiency of MB at 180 minutes, in which it degrades 15.25% of MB in the solution. The percent degradation gained is higher than any percent degradation from all the alumina-silica tested during this experiment. The increment could be explained by the bimetallic nature of Ru/Al-Si. The addition of Ru can reduce the large band gap of alumina-silica, which is in the range of 6.5-7.5 eV, and the photoexcited electron-hole pairs recombination rate can be lowered, which would improve the photocatalytic activities. The addition of Ru metal also extends photoabsorption towards visible light due to the formation of the intermediate energy level. Therefore, the incorporation of Ru metal into 1:1 Al-Si could help with the increase of photodegradation of organic dyes.

3. Novelty and uniqueness

This project introduces a systematic and novel approach to designing efficient photocatalysts by engineering the Al:Si ratio in alumina-silica composites as tunable structure for photocatalytic degradation application. Previous study treat alumina-silica as support material for photocatalyst, and this project uniquely demonstrate the application of alumina-silica as a photocatalyst, and how different composition of alumina-silica can control the physical aspect of the catalyst, which are surface area and pore distribution that can affect the number of available active sites of the catalyst and simultaneously affecting the photodegradation efficiency towards methylene blue. The research further advances innovation by impregnating Ru into alumina-silica, forming a bimetallic photocatalyst. Ru can improve the photoabsorption of visible light and reduce the rate of combination of electron-hole pairs that can induce photodegradation. This integration of Ru creates a highly efficient photocatalyst that has the potential for the application of wastewater treatment. This project is incomparable with others due to its catalyst design strategy by tuning Al:Si ratios, enabling versatility in organic pollutant degradation. The outcome of the project is a further development of photocatalyst, which creates a connection between material science with environmental remediation.

4. Benefit to mankind

The developed alumina–silica and ruthenium-integrated photocatalysts provide a sustainable and energy-efficient solution for removing toxic dyes and organic pollutants from wastewater. By harnessing light-driven degradation, the technology minimizes reliance on chemical additives and reduces secondary pollution, supporting cleaner industrial effluent treatment. This innovation contributes directly to environmental protection, helping prevent contamination of rivers and groundwater while safeguarding ecosystems and public health. Enhanced catalytic efficiency reduces treatment time and operational cost, making it suitable for scalable deployment in textile, pharmaceutical, and chemical industries. Additionally, the modular design allows adaptation for degrading various emerging contaminants, positioning the technology as a versatile platform for future water-purification systems. Ultimately, this project promotes sustainable water management, circular environmental practices, and green chemistry adoption, advancing global efforts toward cleaner, safer, and more accessible water resources.

5. Innovation and Entrepreneurial Impact

The innovation of the alumina-silica and ruthenium-integrated alumina-silica demonstrated entrepreneurial potential due to the sustainable, cheap, and easy to get material for alumina-silica

photocatalyst. This idea provides alternative photocatalyst to costly conventional photocatalysts especially for industries facing the issues of dye effluent discharged by textile industries. The utilization of ruthenium as a cheaper alternative for precious metal such as platinum, Pt and palladium, Pd to form bimetallic photocatalyst offers the promising sustainable product and decreasing the dependency of expensive materials.

6. Potential commercialization

The alumina-silica and ruthenium-integrated alumina-silica offers a strong commercialization potential to certain industries. They have potential as a scalable, sustainable, and low energy photocatalyst for industrial wastewater treatment, where the usage of the photocatalyst would not generate any sludge, reducing the cost due to no need for sludge removal. The profitability of the photocatalyst itself makes attractive to dye industries that require affordable wastewater treatment methods.

7. Acknowledgment

The authors are extremely grateful for the support lent by Faculty of Chemical Engineering, UiTM Cawangan Johor Campus Pasir Gudang for the provision of facilities, and laboratory equipment.

9. Researchers' Biography

Aziz Daniel Abdul Aziz is currently an undergraduate student at the Faculty of Chemical Engineering, Universiti Teknologi MARA (UiTM) Cawangan Johor Kampus Pasir Gudang. He recently conducted research with interest in wastewater remediation of dye removal via photocatalysis.

Siti Hajar Anaziah Muhamad is currently a Senior Lecturer under Faculty of Chemical Engineering, UiTM Cawangan Johor Kampus Pasir Gudang. The author received and graduated with a Master of Engineering in Chemical from Universiti Kebangsaan Malaysia. Her academic and research interests focus on environmental engineering and science, particularly on areas related to sustainable environmental management and pollution control.

Dr. Nur Hazirah Rozali Annuar is a Senior Lecturer at the Faculty of Applied Sciences, Universiti Teknologi MARA Johor, Pasir Gudang campus. She obtained her PhD from Universiti Teknologi Malaysia, where she conducted research on the cracking and isomerization of hydrocarbons over heterogeneous solid acid catalysts. Her current research interests include heterogeneous catalysts, petrochemicals and biofuels, materials chemistry, and photocatalysts. She has published in high-impact international journals, with one paper recognized as an Editor's Choice in the Journal of Molecular Catalysis A: Chemical. She also serves as a peer reviewer for high-ranking journals locally and internationally.

An Indoor LI-FI Communication System

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ABSTRACT

The rapid growth of wireless communication has led to congestion in the radio frequency (RF) spectrum and increased electromagnetic interference, particularly in sensitive indoor environments. This project presents the design and implementation of an indoor Light Fidelity (Li-Fi) communication system that utilizes infrared light as an alternative medium for short-range data transmission. Environmental data are collected using a temperature sensor and processed by a microcontroller before being transmitted through an infrared light source and detected by a receiver circuit. Experimental results demonstrate reliable indoor signal transmission and stable data detection. The proposed system offers a low-cost, secure, and interference-free communication solution suitable for RF-sensitive environments such as hospitals, laboratories, and electronic facilities. In addition, the system promotes socio-economic benefits by providing an affordable indoor monitoring platform that can support smart building applications and technology learning among students. With its simple architecture and low implementation cost, the system also shows strong potential for commercialization as a compact indoor monitoring device for homes, classrooms, and healthcare environments.

Keywords: Li-Fi communication, Infrared transmission, Indoor monitoring, Arduino, Optical wireless communication

1. Background of Study

The rapid growth of smart devices and Internet of Things (IoT) applications has significantly increased the demand for efficient and reliable wireless communication. Conventional wireless technologies such as Wi-Fi and Bluetooth rely heavily on the radio frequency (RF) spectrum, which is becoming increasingly congested and prone to interference. In addition, RF-based communication is unsuitable for sensitive environments such as hospitals, aircraft cabins, and industrial facilities due to electromagnetic interference and security concerns. These limitations have driven the need for alternative wireless communication technologies.

Light Fidelity (Li-Fi) has emerged as a promising solution by utilizing visible or infrared light for data transmission. Li-Fi offers advantages such as wider available bandwidth, improved data security, reduced electromagnetic interference, and suitability for short-range indoor communication. This project focuses on the design and implementation of a basic indoor Li-Fi communication system using infrared light to transmit environmental data. By employing low-cost components and simple system architecture, the project demonstrates the feasibility of optical wireless communication as a reliable and energy-efficient alternative for indoor applications.

2. Methodology

Figure 1 illustrates the block diagram of the proposed system, showing the flow of information from environmental sensing at the transmitter side, through light-based communication, to signal reception and visualization at the receiver side. This modular structure allows each stage to be designed and analyzed independently while ensuring reliable end-to-end data transmission using light as the communication medium. The transmitter driving circuit functions as the data acquisition and control unit of the system. A DHT22 sensor is used to monitor temperature conditions and generate trigger signals when predefined thresholds are exceeded. These sensor readings are processed by an Arduino microcontroller, which acts as the main control unit. The measured values are displayed on an LCD for real-time monitoring, while the microcontroller simultaneously outputs a digital trigger signal to activate the infrared (IR) emitter. This trigger drives the IR emitter to transmit event-based optical signals for notification and data transmission. The Li-Fi communication section functions as the optical channel for data transmission using infrared light. In this system, an SFH4550 infrared emitter transmits modulated light signals through free space, while an SFH309 phototransistor at the receiver detects the transmitted binary data. This line-of-sight communication demonstrates the basic Li-Fi principle and offers immunity to electromagnetic interference, making it suitable for short-range indoor applications.

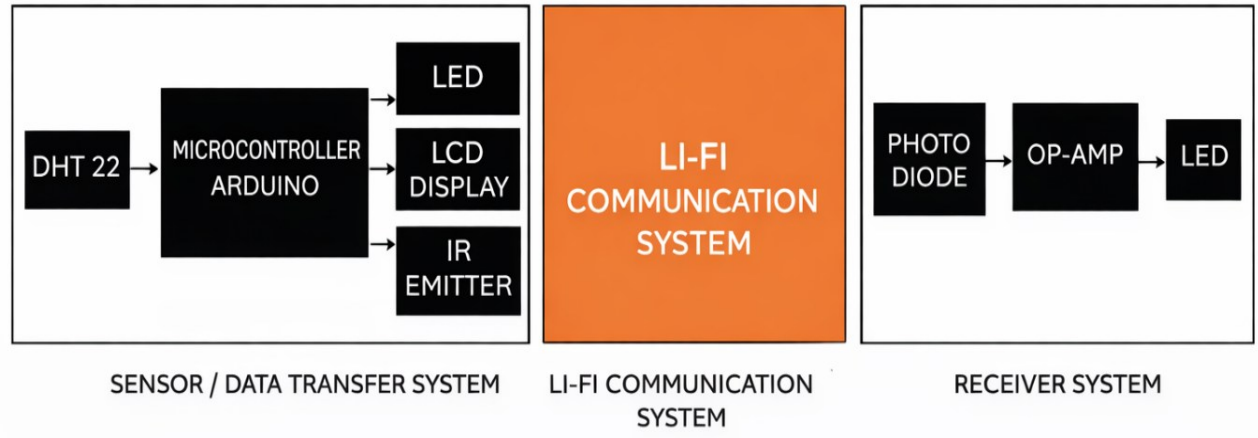


Figure 1. Block diagram of An Indoor LI-Fi Communication System.

Figure 2 illustrates the schematic circuit used in the proposed indoor Li-Fi communication system. When the DHT22 sensor at the transmitter detects a predefined temperature condition, the Arduino activates the SFH4550 infrared emitter to transmit an optical signal. The emitted infrared light is received by the SFH309 phototransistor, which converts the light signal into a corresponding electrical signal. This signal is then amplified using a TLV2372A operational amplifier to produce a stable output voltage. During transmission, when the infrared emitter is ON, the phototransistor conducts and the output voltage is pulled low, resulting in $V_{out} \approx V_{BE} \approx 0$ V. Conversely, when the infrared emitter is OFF, the phototransistor is inactive and the output voltage rises to approximately 5 V. The output is observed using an oscilloscope and indicated by an LED, providing visual confirmation of successful data reception.

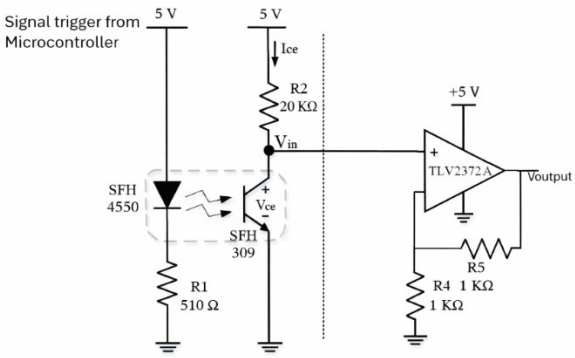
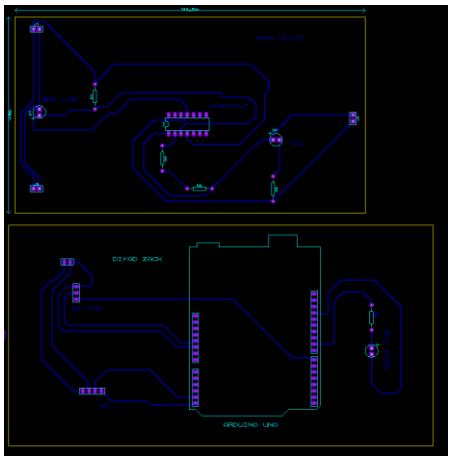
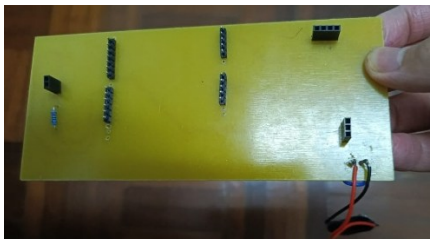


Figure 2. Schematic circuit for the indoor Li-Fi communication system.

Figure 3 presents the printed circuit board (PCB) design and physical implementation of the proposed indoor Li-Fi communication system. **Figure 3(a)** shows the finalized PCB layout developed using PCB design software, illustrating component placement and signal routing for both the transmitter and receiver circuits. **Figure 3(b)** and **Figure 3(c)** display the fabricated PCBs for the transmitter and receiver sections, respectively. The transmitter PCB integrates the microcontroller, sensor interface, and infrared emitter circuitry, while the receiver PCB contains the phototransistor and signal amplification stages. The separation of transmitter and receiver boards improves system modularity, simplifies testing, and enhances overall hardware reliability during experimental evaluation. **Figure 4(a)** shows the simulation of the proposed Li-Fi receiver circuit carried out using Proteus software. A signal generator is used to produce a square wave input ranging from 0 V to 5 V, representing the digital ON–OFF modulation used to drive the infrared emitter during data transmission. This simulation verifies the functional behavior of the circuit before hardware implementation. **Figure 4(b)** presents the corresponding output signal observed on an oscilloscope. The displayed waveform confirms successful detection and amplification of the transmitted signal at the receiver stage. The oscilloscope output demonstrates that the receiver circuit is able to correctly respond to the transmitted digital signal, validating the effectiveness of the optical detection and amplification process.



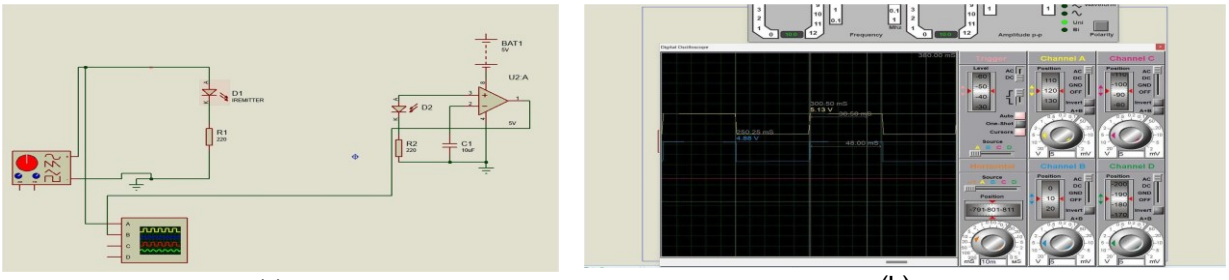
(a) PCB design of the system



(b) PCB Transmitter

(c) The PCB Receiver

Figure 3. (a) PCB layout design of the indoor Li-Fi communication system. **(b)** Fabricated PCB for the transmitter section. **(c)** Fabricated PCB for the receiver section.



(a) (b)

Figure 4. (a) Circuit simulation of the indoor Li-Fi communication system using a signal generator. **(b)** Output signal observed using an oscilloscope.

Figure 5 shows the completed prototype of the indoor Li-Fi communication system, integrating both the transmitter and receiver printed circuit boards within a single enclosure. The prototype arrangement allows proper alignment between the infrared emitter and phototransistor to ensure reliable line-of-sight optical communication. All electronic components are securely mounted to maintain circuit stability during operation. This final implementation demonstrates the practical feasibility of the proposed Li-Fi system and validates its functionality under real operating conditions.

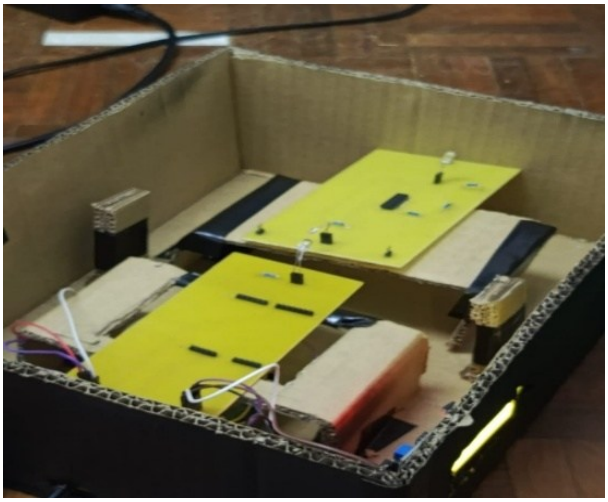


Figure 5. Final prototype of the indoor Li-Fi communication system.

3. Novelty and uniqueness

This project presents a low-cost indoor monitoring system based on Li-Fi using infrared (IR) communication instead of conventional radio frequency technologies. The use of IR enables invisible and interference-free data transmission, making the system suitable for continuous indoor operation. Unlike basic communication projects that transmit fixed data, this system transmits real-time temperature data obtained from a DHT22 sensor between two Arduino units. The inclusion of a push-button–controlled transmission improves user control and reduces unnecessary power consumption. Operating fully offline without Wi-Fi, Bluetooth, or internet connectivity, the system provides an alternative communication solution for RF-restricted environments while serving as an effective educational prototype.

4. Benefit to mankind

The project offers a practical and affordable solution for indoor temperature monitoring using infrared-based communication. It is particularly beneficial in environments where RF signals are restricted or undesirable, such as hospitals, laboratories, and sensitive electronic areas. The system improves user awareness of indoor environmental conditions, contributing to comfort and safety. From an educational perspective, it provides a hands-on learning platform for students to understand sensors, embedded systems, and alternative wireless communication technologies, promoting wider technological literacy**.**

5. Innovation and Entrepreneurial Impact

This project introduces an innovative application of infrared-based Li-Fi communication for indoor monitoring, offering an alternative to conventional RF-based systems that are prone to interference and security limitations. By utilizing light-based data transmission, the system provides a secure, interference-free, and energy-efficient communication method suitable for indoor environments. The design emphasizes simplicity, affordability, and modular architecture, enabling easy integration of additional sensors, data logging features, or smart monitoring platforms in future developments. From an entrepreneurial perspective, the project demonstrates how low-cost electronic components and open-source microcontroller platforms can be transformed into practical monitoring solutions. Its modular structure allows students, researchers, and technology enthusiasts to further develop customized applications such as smart classroom monitoring, environmental sensing, or laboratory safety systems. This encourages student innovation, technology entrepreneurship, and the development of locally designed smart monitoring products, contributing to the growth of home-grown technological solutions and supporting innovation-driven economic activities.

6. Potential commercialization

The system has strong commercialization potential as a compact indoor monitoring device for homes, offices, classrooms, and healthcare facilities. Its infrared communication approach offers a unique advantage in RF-sensitive environments. With further development, including enclosure design, multi-sensor integration, and user-friendly interfaces, the product can be scaled for mass production at low cost, making it attractive for startups and small businesses.

7. Acknowledgment

The author would like to acknowledge the support and facilities provided by the Faculty of Electrical Engineering, Universiti Teknologi MARA Cawangan Johor, Kampus Pasir Gudang, which contributed to the successful completion of this project.

8. Researchers' Biography

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Dr. Noor Hafizah Khairul Anuar is a Senior Lecturer at the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM), Johor Branch. She received her Ph.D. in Electrical Engineering from Universiti Teknologi Malaysia (UTM) in 2025, with a research focus on sensor development, instrumentation, and deep learning. She obtained her M.Sc. in Electrical Telecommunication Engineering and Information Technology from Universiti Teknologi MARA (UiTM) in 2012 and her B.Eng. in Electrical Telecommunication Engineering from Universiti Teknologi Malaysia (UTM) in 2008.

Dr. Nurul Nadia Mohamad is a Senior Lecturer at the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM) Terengganu Branch, Malaysia. She obtained her Ph.D. in Control Engineering, focusing on the hydro-distillation process using a self-tuning Fuzzy PID controller system. Her research interests include process control, intelligent control systems, and fuzzy logic-based controller design.

Tengku Irfan Haiqal Bin Tengku Mohd Fuad completed his Sijil Pelajaran Malaysia (SPM) in 2018. He received his Diploma in Electronic Engineering (Communication) from Politeknik Kuala Terengganu in 2023. He is currently pursuing a Bachelor of Engineering Technology in Digitalization and Automation with Honours at Universiti Teknologi MARA (UiTM), Johor Branch, Pasir Gudang Campus. His interests focus on designing smart systems using 3D modeling and embedded electronics.

Advanced Seismic Alert and Power Management System

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ABSTRACT
Infrastructure and human safety are seriously threatened by earthquakes, particularly when electrical systems are still running. A low-cost ESP32-based Advanced Seismic Alert and Power Management System with real-time seismic detection, device protection, and occupant warning capabilities is shown in this research. By calculating overall acceleration and examining vibration patterns, the system detects tremors using an ADXL335 accelerometer and a SW-420 vibration sensor. If dangerous earthquake condition is detected, evacuation notifications are delivered via the Blynk IoT platform using an infrared sensor to detect human presence. A white LED on the wall serves as a backup visual alert in the event of a communication breakdown, in addition to mobile notifications. Additionally, the earthquake alert device circuit of the system has an overcurrent prevention feature. To detect overcurrent conditions during testing, a potentiometer is utilized to replicate and portray current variation during abnormal current conditions. A relay is disconnected if overcurrent condition detected, and the device unit's blue LED and buzzer signal the occurrence. Real-time system status is displayed by an I2C LCD and wall-mounted red and green LEDs, guaranteeing dependable and understandable notifications. Homes, schools, and low-rise structures in seismically active locations can all benefit from this approach.

Keywords: Seismic Alert, Automatic Power Cut-Off, IoT-Based Safety Device, Low-Cost Monitoring System and Earthquake Detection System.

1. Product Description
The Advanced Seismic Alert and Power Management System is a low-cost safety device designed to detect earthquakes and protect both people and electrical systems in small buildings such as houses, schools, and offices. Unlike traditional earthquake monitoring systems that rely on expensive and complex seismometers, this system uses affordable sensors, including a vibration sensor and a three-axis accelerometer, to identify ground movement and measure tremor intensity. The system is controlled by an ESP32 microcontroller and provides real-time monitoring and response. When dangerous vibration levels are detected, it activates visual and audible alerts such as LEDs and a buzzer to warn occupants. In addition, the system can automatically manage electrical power by disconnecting supply during unsafe conditions, helping to reduce the risk of electrical fires, shocks, and equipment damage. To enhance safety further, the system includes human presence detection and sends warning notifications through an IoT platform, ensuring occupants receive evacuation alerts when necessary. By combining earthquake detection, power control, and user notification into a single integrated unit, this product offers a practical and economical solution for early warning and electrical protection in earthquake-prone areas.

2. Block Diagram, schematic diagram, flowchart and hardware configuration.

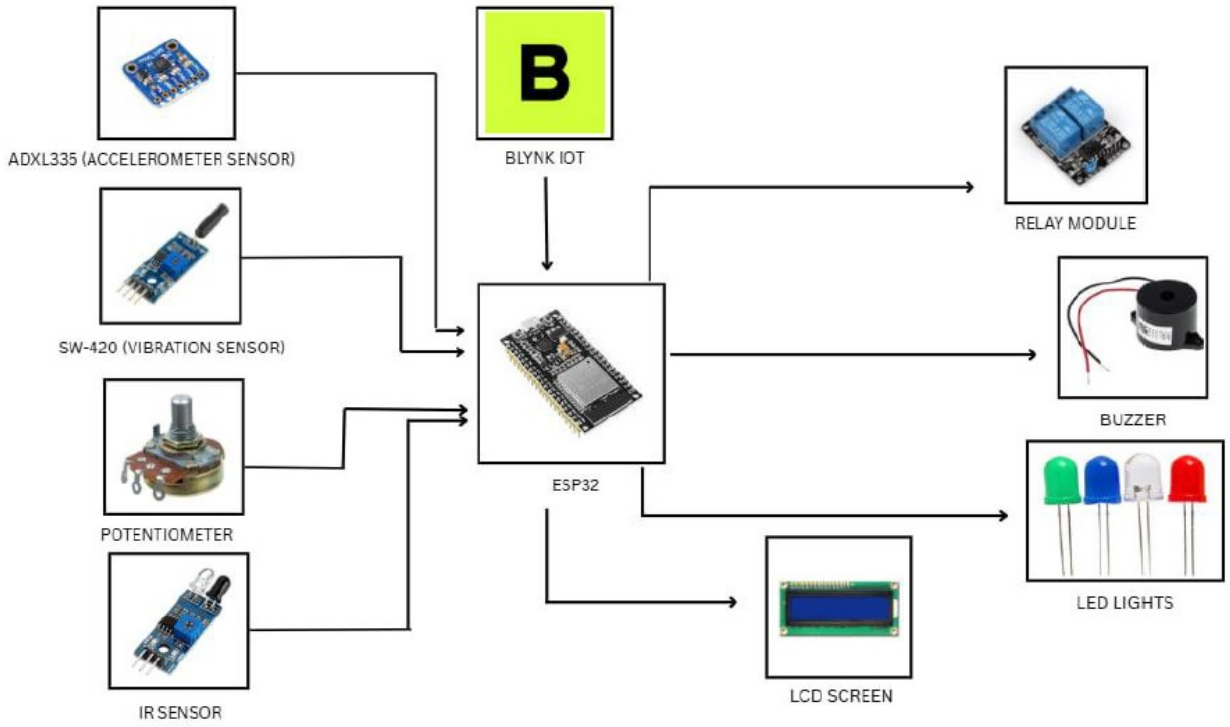

Figure 1. Block diagram of this project.

As shown in **Figure 1**, the entire procedure of the Advanced Seismic Alert and Power Management System is as follows. The system is based on an ESP32 microcontroller with a combination of sensors, the control of notifications and protection of the device on the power side. The SW-420 vibration sensor is an input sensor, which is used to detect the initial tremors, the accelerator is an ADXL335 device, which measures the intensity and nature of motion along X, Y, and Z planes, and the IR sensor, which is used to detect the presence of human beings within the building. As an example, a potentiometer is applied to simulate current input to enable testing of the overcurrent protection feature without using a high current load. The SW-420 sensor identifies the vibration first in operation. After detecting vibration, the ESP32 gets the accelerator data of ADXL335 and determines the total g-force and the tremor conditions as either SAFE or DANGER. Such a combination guarantees that the false alarms are not provoked by such minor inconveniences or noises. The sensor of presence of occupants will be monitored by the PIR sensor because evacuation notifications will be sent to the Blynk IoT 22 platform at the same time these Blynk notifications are sent and, as a back-up mechanism to signal occupant alerts, the sensor will also be flashing, an action also linked to the Blynk notifications being sent. The system also measures overcurrent in the circuit of the device and in case of an overcurrent, a relay will break off the power supply, and the device will have a blue flashing LED and a buzzer to indicate the fault. Wall-mounted green LED stands for SAFE while red LED activates along with a buzzer stands for DANGER are used to show tremor alerts, and I2C LCD constantly shows the real-time tremor status, relay condition, and current values to give simple and direct feedback. This combined system will maintain the early earthquake detection, real-time warning

of occupants, and individual electrical protection of their devices which make it appropriate to a home, school, or low-rise building.

The IR sensor is connected to GPIO 15 to detect human presence so that evacuation alerts are only triggered when occupants are present. The SW-420 vibration sensor is connected to GPIO 19 and functions as the initial tremor detection trigger, allowing the system to respond quickly to seismic activity. The ADXL335 accelerometer sensor is connected to analog input pins GPIO 35 for the X-axis, GPIO 32 for the Y-axis, and GPIO 33 for the Z-axis, enabling the ESP32 to read acceleration values in three directions and evaluate earthquake intensity. A potentiometer connected to GPIO 34 is used to simulate current input for testing the overcurrent protection function without using a real high-current load. Visual status indication is provided by multiple LEDs where the green LED on GPIO 26 indicates a safe condition, the red LED on GPIO 27 indicates a dangerous tremor condition, the white LED on GPIO 2 provides an evacuation warning and continues blinking as a backup indicator if communication fails, and the blue LED on GPIO 14 indicates an overcurrent or power fault condition. A loud buzzer is attached at GPIO 13 and will alert whenever there is a dangerous seismic event or electrical fault. This has power control managed by a relay attached to the GPIO 17, which breaks the electrical connection once a threatening tremor or a condition of overcurrent is detected to avoid electric risks. To show system real-time data, which include tremor state, relay state and current, an I2C LCD is connected to the system with the following configuration, SDA at GPIO 21 and SCL at GPIO 22 to display system information in real time and hence users can easily monitor the system and ensure the entire system is a complete safety and power protection system.

The SW-420 vibration sensor, the ADXL 335 accelerometer, and a potentiometer which determines the system's sensitivity threshold provide input data to the system before it starts up. The microcontroller determines the condition of the surroundings by calculating the current tremor level after gathering these inputs. The program then determines a tremor is happening by determining the G-force is greater than 3.5g and the vibration count is greater than or equal to 15. When tremor is detected, the system will be checking for current value first. If the value above or equal to 10A, the system will assume as “DANGER” but has an overcurrent occurrence so the output will make the LCD display “DANGER” for status tremor, and blinks for second time which is shows “WARNING !!” “OVERCURRENT !!”. At the same time, the relay will turn off to cut current flow, the buzzer will turn on, the blue led will flashing and also red led will turn on. For another case, which is “DANGER” but not overcurrent condition, the LCD will display “DANGER” only. At the same time, the relay will turn on, red led and buzzer also will turn on. For these two cases, it will go on for checking is that has a human in the house or not. If has someone in the house during tremor happened, the IR sensor will detect a motion, and the human will get alert message notification from Blynk and at the same time the white led will blinking simultaneously every when IR sensor detect human. For safe condition also has two categories, first, the “SAFE’ condition but has an overcurrent occurs, so the output will be LCD display “SAFE” for tremor status. After that, it blinks for second time and show “WARNING” “OVERCURRENT” happened. At the same time, the relay will turn off, the buzzer and the green led will turn on and the blue led will flashing. For “SAFE” condition only, the output will be the LCD display “SAFE”, the relay will always on and the green led also will turn on. To offer continuous monitoring, the entire logic sequence cycles back to the first sensor-reading phase once the motion check is over.

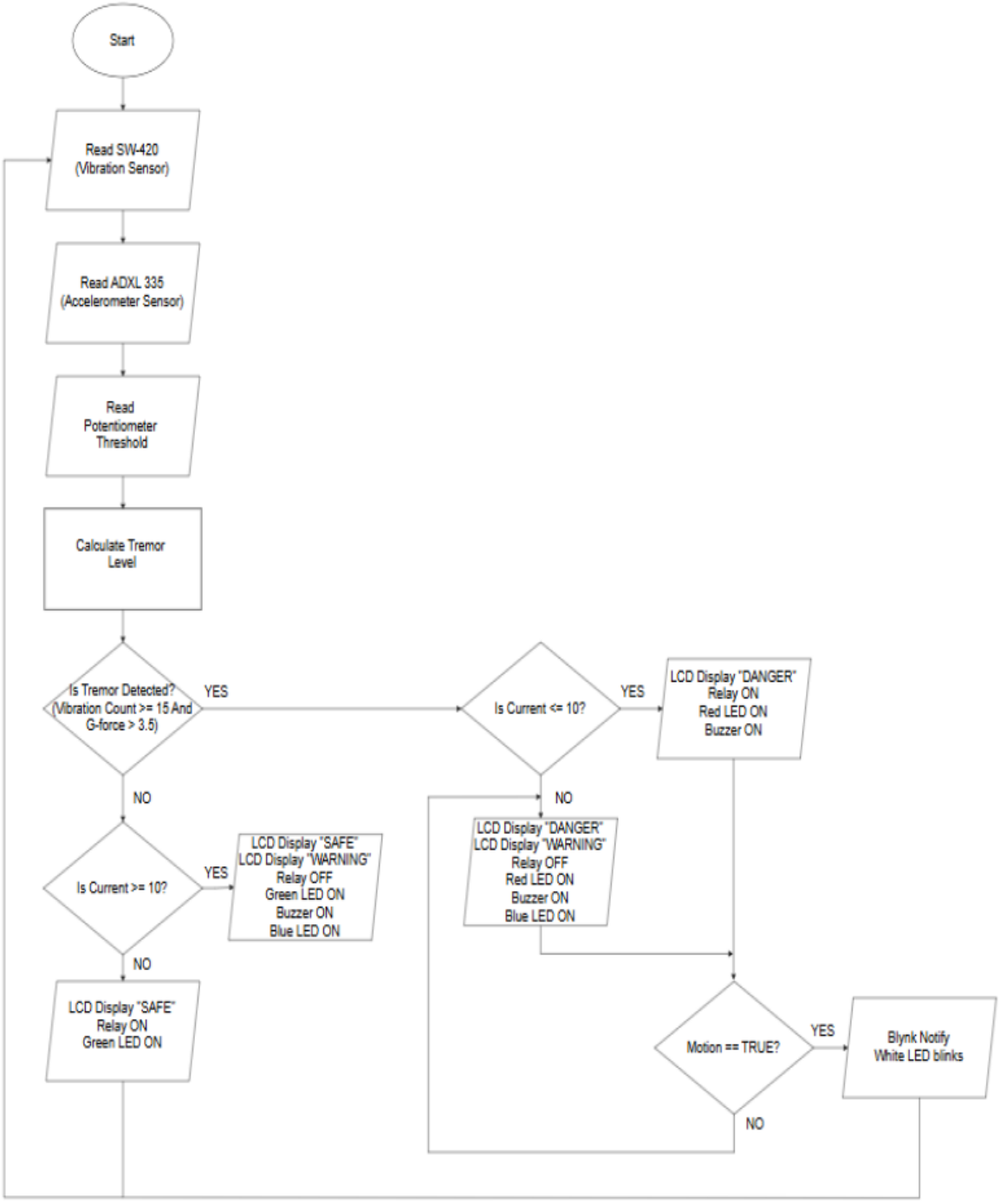

Figure 3. Flowchart of advanced seismic alert and power management.

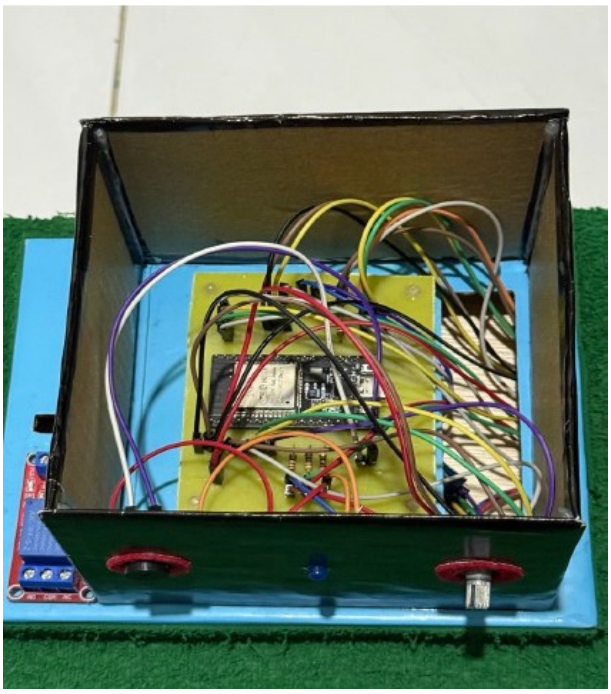

Figure 4. Overall circuit design.

The hardware design of the proposed system is depicted in figure 3.4 as a printed circuit board that has been assembled around to demonstrate the proposed hardware design and fitted into a mock-up house. An ESP32 microcontroller is the heart of the system, and it performs the data acquisition, data processing, and data out control. The input sensors used are the SW-420 vibration sensor which can be fitted on the ground at the back of the house to help in detecting tremors and another IR sensor fitted inside the house to help in detecting the presence of people during an earthquake. The ADXL335 accelerator (measuring strength and motion of the tremor) is available in the earthquake indicator device. A potentiometer is mounted on the wall of the earthquake indicator to simulate current sensing, a buzzer is provided to alert audibly in case of overcurrent or dangerous tremor conditions and blue LEDs are provided to indicate overcurrent conditions. The relay module will be placed on the side of the earthquake indicator to give automatic power cut-off in case overcurrent is detected. The left wall of the house is lit with Green, Red and White LEDs which give instant visual notifications and an I2C LCD is mounted on the wall to show real time conditions of the system which includes tremor condition, relay operation and a current value. The PCB connects all the components allowing stable electrical connections, a compact layout, and reliable operation in small scale safety applications.

3. Novelty and uniqueness

The novelty of this project lies in its integration of earthquake detection and electrical power management into a single low-cost system designed specifically for small-scale buildings. Unlike most existing earthquake warning systems that focus only on seismic detection or rely on expensive seismometers and complex infrastructures, this project combines with vibration sensing, acceleration analysis, and automatic power control using affordable components. This dual-function approach not only provides early warning of seismic activity but also actively reduces electrical hazards by disconnecting power during dangerous conditions. Another unique feature is the incorporation of human presence detection together with IoT-based notification.

Alerts are issued only when occupants are detected, improving relevance and reducing unnecessary warnings. In addition, the system includes local visual and audible alerts as backup mechanisms, ensuring warnings remain effective even if internet communication fails. Furthermore, the use of a simulated current monitoring method allows safe testing of overcurrent protection without requiring high-current loads, making the system practical for educational and prototype applications. Overall, this project presents a compact, low-cost, and multifunctional safety solution that uniquely combines seismic monitoring, power protection, and smart notification in one integrated platform.

4. Benefit to mankind

This project contributes to human safety by providing an affordable and practical earthquake alert and power management system for small buildings such as homes, schools, and offices. By detecting seismic activity in real time and issuing immediate warnings, the system helps occupants react faster and evacuate safely, reducing the risk of injury or loss of life. The automatic power cut-off feature further protects users by minimizing electrical hazards such as short circuits, fires, and equipment damage during earthquakes or abnormal current conditions.

In addition, the integration of IoT notifications allows alerts to be delivered remotely, improving awareness even when occupants are not near the device. The use of low-cost components makes the system accessible to communities in resource-limited and earthquake-prone areas. Overall, this project supports disaster preparedness, enhances public safety, and promotes the development of smart and resilient infrastructure for everyday living.

5. Innovation and Entrepreneurial Impact

This project promotes an innovation by demonstrating how low-cost sensors, microcontrollers, and IoT technology can be integrated into a practical safety product for everyday use. It transforms conventional earthquake detection concepts into a compact, multifunctional system that combines seismic monitoring, power protection, and smart notification in one device. This encourages creative problem-solving and the development of affordable smart safety solutions.

Based on entrepreneurial perspective, the project has strong potential for commercialization as a home and building safety product, especially in earthquake-prone regions. It is a simple design, low production cost, and scalable features make it suitable for further development into a market-ready device. The project also inspires students and young engineers to explore technology-based business opportunities by converting academic prototypes into real-world products. Overall, it supports a culture of innovation and entrepreneurship by linking engineering knowledge with practical applications that address real societal needs.

6. Potential commercialization

The proposed system has strong potential for commercialization as an affordable earthquake alert and electrical safety device for residential and small commercial buildings. Its low-cost hardware components and simple system architecture allow for mass production at minimal manufacturing cost. With further refinement, the system can be packaged as a compact plug-and-play unit that is easy to install and maintain. The product can be marketed to homeowners, schools, small offices, and building management companies in earthquake-prone regions as a preventive safety solution. Additional features such as mobile application support, cloud data logging, and integration with smart home systems can further increase its market value. Partnerships with construction companies, electrical service providers, and disaster management agencies could

support large-scale deployment. Overall, this project demonstrates clear commercial potential as a practical, scalable, and low-cost smart safety product.

7. Acknowledgment

The author would like to thank the project supervisor for continuous guidance, motivation, and technical advice that greatly contributed to the success of this project. Appreciation is also extended to all lecturers and faculty members who provided useful knowledge and support. Lastly, heartfelt thanks are given to family and friends for their constant encouragement and understanding throughout this project.

8. Researchers' Biography

Muhammad Amirul Hakimi Bin Roslim is a Diploma student in Electrical Engineering at Universiti Teknologi MARA (UiTM) Pasir Gudang. His final year project, Advanced Seismic Alert and Power Management System, focuses on safety systems for small-scale buildings. He possesses skills in problem-solving, teamwork, technical documentation, basic programming, circuit analysis, hands-on laboratory work, and project management. He is capable of working independently and collaboratively in engineering projects. He was awarded the Gold Award for Final Year Project 2, recognizing his commitment, creativity, and technical competence.

Mashitah Mohd Hussain is a lecturer at the college of Electrical Engineering, Universiti Teknologi MARA, Johor, Malaysia. She holds a Msc. degree in Electrical Engineering with specialization in electric power systems. Her research areas are electrical simulation network, algorithm implementation analysis and pattern recognition. She received a national grant in 2019. She has supervised many diploma students and has been awarded best innovation, golds, bronzes and many silvers on her innovative ideas. Her research interests include electrical transmission and distribution network analysis, transformers, artificial intelligent implementation and analysis, pattern recognition and solar PV performance. She can be contacted at email: mashitah1116@gmail.com.

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Solar-Powered Smart Room with Automatic Power Control

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ABSTRACT

This project focuses on the design and development of a room monitoring system using sensors and Internet of Things (IoT) technology, powered by a solar panel. The main objective of the system is to efficiently monitor room conditions and detect human activity while reducing energy consumption. The system utilizes three main sensors: a temperature sensor to monitor the room temperature, a light-dependent resistor (LDR) to detect the presence or absence of light, and a passive infrared (PIR) sensor to detect motion within the room. The sensor data are processed by a microcontroller to control three outputs. A buzzer is activated when motion is detected to provide an alert, while a display unit shows real-time room conditions and system status. In addition, an IoT interface is implemented to allow users to monitor and manually control the system using a smartphone remotely. The use of a solar panel as the power source ensures that the system operates using renewable energy, making it more energy-efficient and environmentally friendly. Overall, this project showcases a straightforward, practical, and intelligent room monitoring solution that seamlessly integrates automation, remote accessibility, and sustainable energy, enhancing security, comfort, and energy management.

Keywords: Room monitoring, IoT, sensors, solar panel, motion detection, temperature monitoring

Product Description

This project is developed as a unified smart room solution that integrates environmental monitoring, automated operation, user interaction, and real-time feedback. The ESP32 microcontroller which functions as the central control unit handles all data processing and control decisions. **Figure 1** present the overall system structure that organized into three functional blocks which are input, output units and the processing unit. The input unit includes a DHT22 sensor for temperature measurement, a passive infrared (PIR) sensor for motion detection, and a Light Dependent Resistor (LDR) for sensing ambient light conditions. The output unit comprises various actuators and display elements, including LEDs, a buzzer, a DC motor, and an LCD module. LEDs are used to indicate system states visually, while the buzzer generates audible alerts in response to specific events such as motion detection or abnormal conditions. The DC motor is employed to drive airflow or ventilation mechanisms when required. The LCD presents real-time information such as sensor readings, selected operating mode, and device status, enabling users to monitor system performance easily. The system is designed to operate in two distinct modes which is automatic and manual. During automatic operation, output devices are controlled autonomously in response to sensor inputs. In manual operation, users can override automated

behaviour through a smartphone interface using bluetooth communication, providing additional flexibility and user control. Overall, the system design demonstrates a compact and effective implementation of an IoT-based smart room solution that successfully combines sensing, control and user interaction for improving comfort, safety, and energy efficiency in indoor environments. **Figure 2** and **Figure 3** depict the flowchart of the overall system and the output of the project when detecting the sensor elements respectively.

2. Methodology

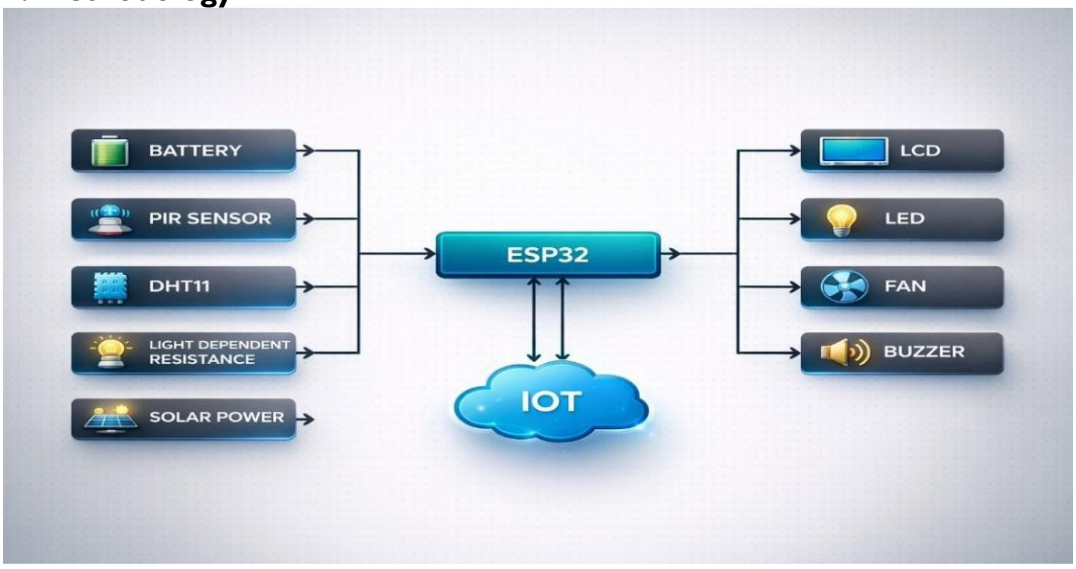

Figure 1. Block diagram of the system.

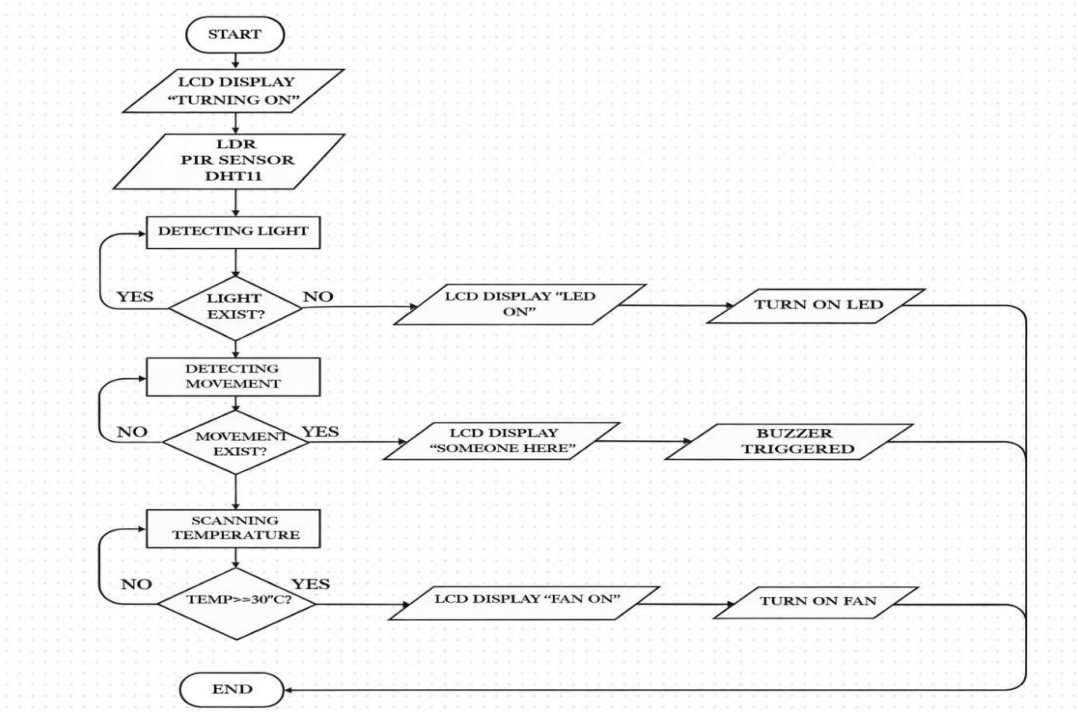

Figure 2. Flow chart of the system.

Figure 3(a). Prototype

Figure 3(b). Solar is charging the battery

Figure 3(c). Motion Display

Figure 3(d). LDR Sensor detected, the LED is activated

Figure 3(e). DHT22 sensor detected, the fan is activated and automatically off when temperature below 28.5 °C.

3. Novelty and uniqueness

This project lies in the integration of solar-powered operation with a multi-sensor IoT-based room monitoring system that supports both automatic and manual control modes. Unlike conventional smart room systems that rely on grid electricity and fixed automation, this system combines renewable energy usage, real-time sensing, and user override capability via smartphone

control. The other uniqueness key element is the unified architecture where environmental sensing, human activity detection, alert mechanisms, and remote accessibility are managed by a single ESP32 controller that offers a compact, low-cost, and energy-efficient solution suitable for small indoor environments. The dual-mode operation enhances adaptability, making the system unique in balancing automation with user flexibility.

4. Benefit to mankind

This project contributes positively to society by promoting energy conservation, enhanced indoor safety, and improved living comfort. The use of solar energy reduces dependence on non-renewable power sources, supporting environmental sustainability and lowering electricity consumption. The motion detection and alert system enhance personal and property security, especially for homes, offices, and small facilities. Real-time monitoring of temperature and lighting conditions improves thermal comfort and energy management, which is particularly beneficial in regions with high energy demand. Overall, the system supports smarter and greener living while making technology more accessible to everyday users.

5. Innovation and Entrepreneurial Impact

The solar-powered smart room with automatic power control promotes the seamless fusion of IoT technology, sensor-based automation, and renewable energy within a single smart room platform. The intelligent decision-making process where sensor data directly triggers outputs such as alerts, displays, and ventilation demonstrated practical automation. Furthermore, the inclusion of manual control via smartphone alongside autonomous operation introduces a human-centered design approach, allowing users to adapt the system according to personal needs. The real-time display and feedback mechanism further enhance system transparency and usability, making the solution both technically innovative and user-friendly. From an entrepreneurial perspective, this project has strong potential as a low-cost smart home and smart office solution, especially in developing regions and energy-conscious markets. The use of affordable components such as ESP32, common sensors, and solar panels enables scalable production at a competitive price point. This flexibility opens opportunities for startups, educational kits, and small-scale manufacturing businesses focused on smart and sustainable technologies.

6. Potential commercialization

The project demonstrates high commercialization potential in sectors such as residential smart homes, small offices, classrooms, hostels, and rural housing. With further refinement such as mobile application enhancement and enclosure design, this project can be transformed into a market-ready product. Furthermore, commercial versions could be offered as plug-and-play smart room kits, subscription-based monitoring services, or customized solutions for green buildings. The emphasis on renewable energy and IoT aligns well with global trends toward sustainable development and smart infrastructure, increasing its attractiveness to investors and consumers.

7. Acknowledgment

The authors would like to acknowledge faculty of Electrical engineering, Universiti Teknologi MARA (UiTM), Johor Branch, Pasir Gudang Campus for technical support, consultation and facilities provided throughout the development of this project.

8. Researchers' Biography

Mohamad Haziq Mohamad Wasli is currently pursuing a Diploma in Electrical Engineering (Power) at the UiTM Pasir Gudang Campus. He has demonstrated outstanding performance in both academic and extracurricular activities. He shows dedicated and has a good character

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Solar-Powered Smart Water Dispensing System with IoT-Based Remote Monitoring

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ABSTRACT

The increasing demand for hygienic, energy-efficient, and automated water dispensing systems has highlighted the limitations of conventional manually operated dispensers. These traditional systems often rely on continuous grid power, lack real-time monitoring, and pose hygiene risks due to frequent physical contact. This project presents a Solar-Powered Smart Water Dispensing System with IoT-Based Remote Monitoring designed to address these challenges. The system integrates an ESP32 microcontroller with ultrasonic sensors for contactless hand detection and water level monitoring, a DS18B20 temperature sensor for real-time temperature measurement, and a solenoid valve for automated water dispensing. Renewable energy is supplied through a solar panel supported by a battery and voltage regulation system, enabling off-grid and energy-efficient operation. Sensor data are transmitted to Google Sheets for cloud-based logging, while real-time monitoring and alert notifications are delivered via the Blynk platform and Telegram bot. The system enhances hygiene through touchless operation, improves water management efficiency through real-time monitoring, and promotes sustainable energy usage. This innovation is suitable for public facilities, educational institutions, and remote locations, with strong potential for commercialization as a smart and sustainable water management solution.

Keywords: Internet of Things (IoT), Smart Water Dispenser, Solar Energy, ESP32, Remote Monitoring

1. Product Description

The Solar-Powered Smart Water Dispensing System is an automated, touchless water dispenser designed to improve hygiene, sustainability, and monitoring efficiency. The system uses ultrasonic sensors to detect hand or cup presence and automatically activate a solenoid valve for water dispensing without physical contact. A separate ultrasonic sensor continuously monitors the water level, while a temperature sensor measures real-time water temperature. All sensor data are processed by an ESP32 microcontroller and displayed locally on a 16×2 LCD. To enable remote monitoring, the system uploads data to Google Sheets and sends instant notifications through the Blynk application and Telegram bot when critical conditions, such as low water level, are detected. Powered primarily by solar energy, the system reduces dependence on grid electricity and supports deployment in remote or off-grid areas. This product offers a practical, hygienic, and energy-efficient solution for smart water management in public and institutional environments.

2. System Architecture and Operation

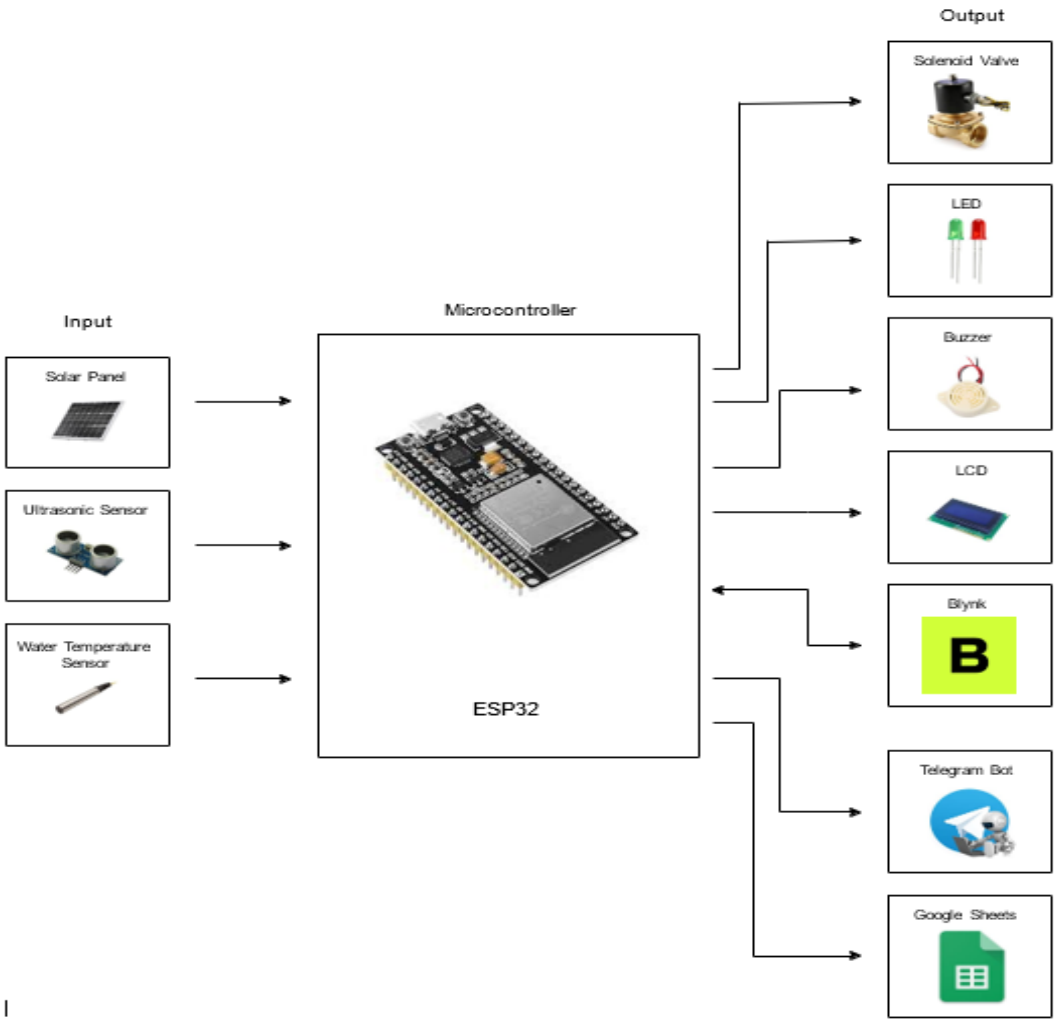

Figure 1. Block diagram of the Solar-Powered Smart Water Dispensing System.

Figure 1 illustrates the block diagram of the Solar-Powered Smart Water Dispensing System, highlighting the integration of sensors, control unit, power supply, and IoT platforms. The ESP32 microcontroller acts as the main processing unit, receiving input data from ultrasonic and temperature sensors. Based on the processed data, the system controls the solenoid valve, LCD display, buzzer, and LED indicators. Cloud platforms such as Google Sheets, Blynk, and Telegram enable real-time monitoring, data logging, and alert notifications. **Figure 2** shows the operational flowchart of the system. After system initialization and Wi-Fi connection, the ESP32 continuously monitors the water level and temperature. If the water level falls below a predefined threshold, alert notifications are triggered and dispensing is disabled. When a hand or cup is detected within a safe range, the solenoid valve is activated to dispense water automatically.

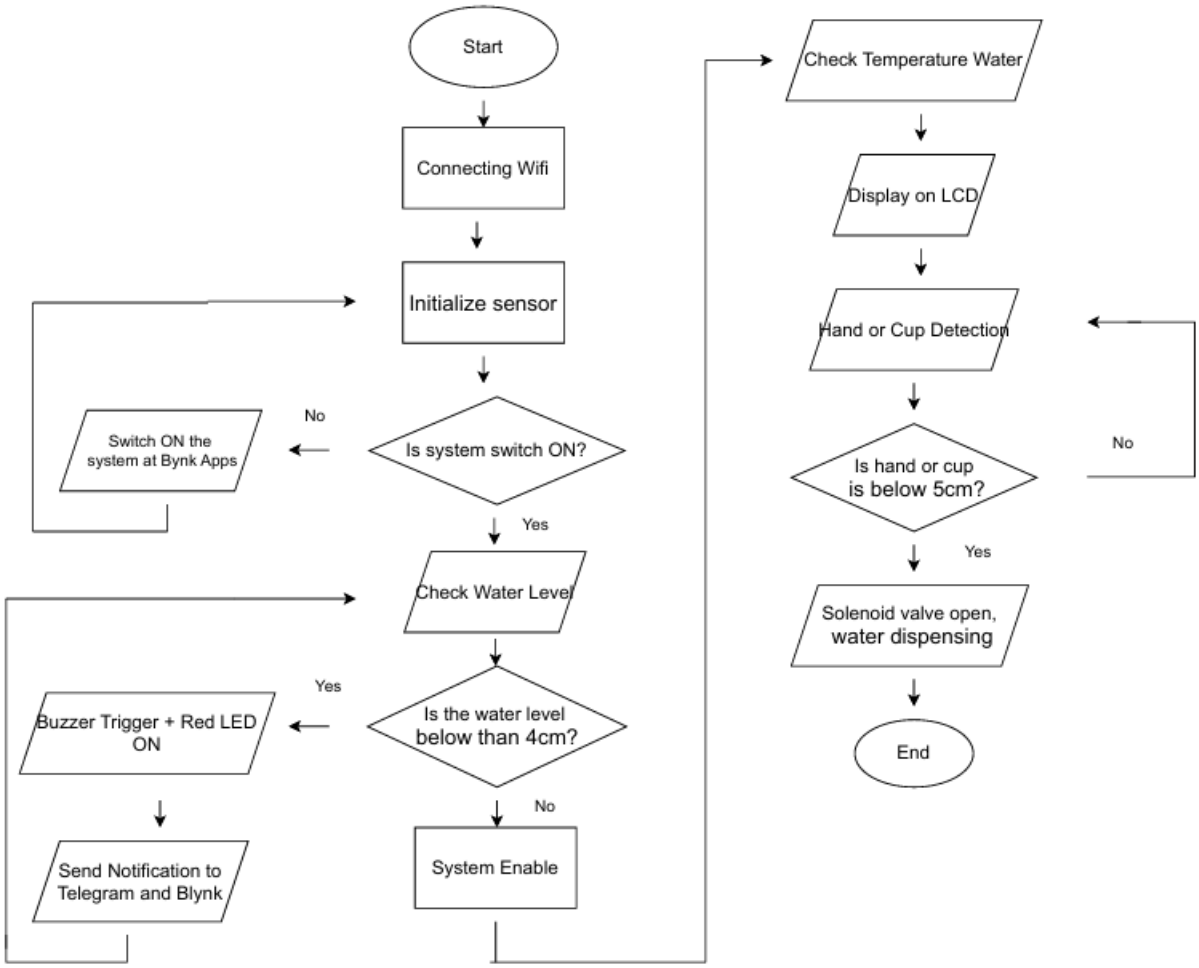

Figure 2. Flowchart of system operation.

3. Novelty and uniqueness

The proposed system offers several novel features compared to conventional water dispensers. Firstly, it integrates solar energy as the primary power source, enabling energy-efficient and off-grid operation. Secondly, the system provides a fully touchless dispensing mechanism using ultrasonic sensors, significantly enhancing hygiene in public environments. Thirdly, the integration of multiple IoT platforms—Google Sheets for data logging, Blynk for real-time monitoring, and Telegram for instant alerts—creates a comprehensive remote management solution. Unlike existing systems that focus only on automation or monitoring, this project combines renewable energy, contactless operation, and cloud-based intelligence into a single compact system. These features make the system scalable, sustainable, and suitable for smart facility applications.

4. Benefit to mankind

This project contributes to society by promoting hygienic and sustainable access to drinking water. The touchless dispensing mechanism reduces the risk of contamination and supports better public health practices. The use of solar energy minimizes electricity consumption and

carbon emissions, aligning with global sustainability goals. Real-time monitoring and alert notifications improve maintenance efficiency and reduce water wastage by preventing system misuse during low water conditions. Overall, the system enhances water management reliability in public facilities, educational institutions, and remote communities.

5. Innovation and Entrepreneurial Impact

The Solar-Powered Smart Water Dispensing System encourages innovation by integrating IoT technology with renewable energy in a practical, real-world application. The project fosters an entrepreneurial mindset by demonstrating how low-cost embedded systems can be transformed into market-ready smart products. Its modular design allows easy customization and scalability, making it suitable for smart campuses, smart cities, and commercial deployment. The system also supports the development of technical skills in embedded systems, IoT, and sustainable engineering, contributing to a culture of innovation within academic and industrial communities.

6. Potential commercialization

The proposed system has strong commercialization potential as a smart, energy-efficient water dispensing product. It can be deployed in schools, universities, public facilities, offices, and remote areas with limited access to grid electricity. The use of readily available components reduces production costs, while the IoT features add value through remote monitoring and maintenance capabilities. With further refinement in enclosure design and mass production, the system can be marketed as a sustainable smart water dispenser aligned with green technology initiatives.

7. Acknowledgment

The authors would like to express their sincere appreciation to Universiti Teknologi MARA (UiTM) and the Faculty of Electrical Engineering for providing the facilities and support required to complete this project. Special thanks are extended to the project supervisor for valuable guidance and technical advice throughout the development process.

8. Researchers' Biography

Muhammad Syazwan Farhan bin Shamsuri is a Diploma student in Electrical Engineering (Power) at Universiti Teknologi MARA (UiTM), Johor Branch, Pasir Gudang Campus. His academic interests include Internet of Things (IoT), embedded systems, renewable energy applications, and smart automation systems. He has completed a final year project focusing on solar-powered smart water dispensing systems with remote monitoring capabilities.

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Intelligent Public Restroom with IOT Monitoring and Privacy Protection

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ABSTRACT

Public restrooms in crowded areas often suffer from poor maintenance, bad hygiene, and lack of privacy, which can lead to user discomfort and increased operational costs. This project presents the design of an Intelligent Public Restroom with IOT Monitoring and Privacy Protection, integrated with the Internet of Things (IoT). The system utilizes a renewable solar energy source to power a suite of sensors controlled by an ESP32 microcontroller. Key features include a PIR sensor for occupancy detection, an IR sensor for touchless door locking to ensure hygiene, and a load cell to detect seated users, which triggers a privacy music masking system. Additionally, YF-S201 water flow sensor monitors water usage and detects leaks automatically, notifying maintenance staff via the Blynk mobile application. The application also enables remote closure of the water valve to prevent wastage. Simulation and testing results confirm the system effectively automates hygiene processes, enhances user privacy, and provides real-time maintenance alerts. This solution modernizes public infrastructure by combining automation, connectivity, and sustainability to promote environmental responsibility.

Keywords: Internet of Things (IoT), PIR sensor, IR sensor, Load Cell, Water Leak detection

1. Product Description

The Intelligent Public Restroom System is an innovative smart facility designed to address the critical issues of hygiene, water wastage, and user privacy in public amenities. Powered independently by solar panels with battery backup, the system ensures continuous operation even in off-grid or remote locations. At its core, an ESP32 microcontroller processes data from multiple sensors to automate the restroom environment. The system features a touchless entry and locking mechanism using IR and Servo motors to minimize physical contact and reduce the spread of bacteria. A unique privacy feature utilizes a load cell to detect user presence and automatically play background music, masking unpleasant sounds. Integrated with the Blynk IoT platform, the system provides facility managers with a real-time dashboard to monitor occupancy, receive instant water leak notifications, and remotely control the water valve to prevent damage and water wastage. The system is ideally suited for sustainable urban development and smart public infrastructure.

2. Block Diagram, Flow Charts, and Schematic diagrams

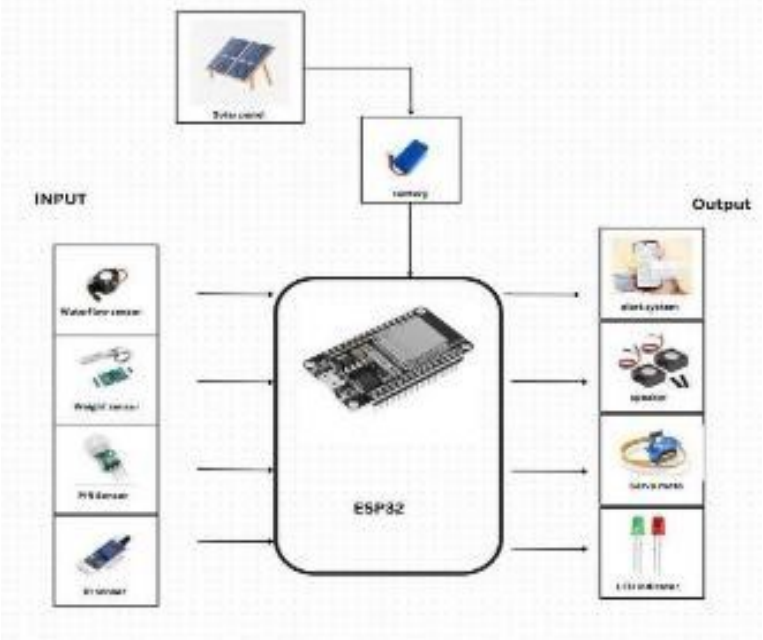
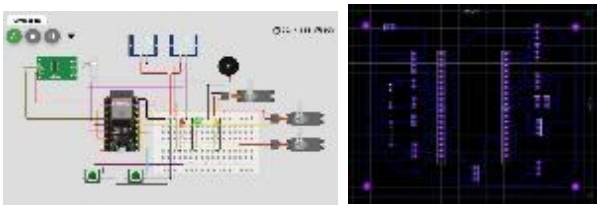
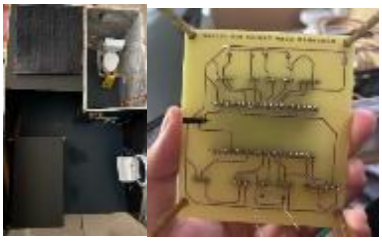


Figure 1. Block Diagram of the system.

Figure 2. Flow chart of the system.

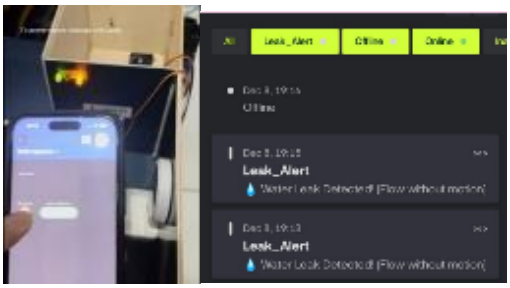


(a)Schematic diagram and PCB design



(b) The actual developed hardware and printed PCB

(c)The testing of developed hardware



(d) The result in the Blynk Mobile App

Figure 3. The system hardware testing and output display.

3. Novelty and uniqueness

The novelty of this project lies in its multi-sensor integration that combines hygiene, privacy, and maintenance into a single solar-powered ecosystem. Unlike conventional smart restroom systems that only track occupancy, this system introduces a Privacy Music Feature triggered by a weight sensor (load cell), addressing user psychological comfort which is often overlooked. Furthermore, the system features a Touchless Locking Mechanism using IR sensors to eliminate the need for physical contact with door handles, significantly improving hygiene standards. A distinctive feature of this system is the integration of water leak detection with remote valve actuation, allowing maintenance personnel not only to receive leak alerts via the Blynk application but also to immediately shut off the water supply remotely before arriving on-site.

4. Benefit to mankind

Hygiene & Health: The touchless entry and locking features reduce the transmission of germs and bacteria in public restrooms, protecting public health. Environmental Sustainability: By utilizing solar energy and implementing an active water leak detection system, the project significantly reduces electricity dependence and water wastage, conserving natural resources. User Comfort: The automated privacy music creates a more comfortable and dignified restroom experience for users, encouraging the use of public facilities. Operational Efficiency: Real-time IoT alerts enable rapid maintenance response, preventing facility deterioration and reducing long-term maintenance costs for building owners and municipal authorities.

5. Innovation and Entrepreneurial Impact

The innovation of this project is defined by its self-sustaining IoT architecture, where solar power is coupled with ESP32-based control systems to enable independent operation from the main power grid. This makes the solution highly suitable for rural areas, highways, and remote tourist locations. The system advances public hygiene standards through a fully touchless interface, utilizing IR sensors and servo motors for door operations. The integration of multiple sensors—PIR, IR, water flow, and load cell—into a single, unified dashboard provides precise monitoring capabilities that surpass existing market solutions.

Entrepreneurially, this product addresses the growing "Green Building" market. It can be commercialized as a "Green Sanitation Kit" that helps building owners achieve sustainability ratings by demonstrating water conservation and energy efficiency. Additionally, usage and consumption data can be leveraged for data-driven facility management and resource optimization

6. Potential commercialization

The Intelligent Public Restroom System has strong commercial potential for facility management sectors, particularly in Rest and Service Areas (RnR), public parks, and remote tourist destinations where grid power availability is limited. Its self-sustaining design makes it an ideal solution for highway operators, such as PLUS, seeking to improve green building ratings and reduce operational costs. The system is also highly suitable for shopping malls and Airports that prioritize premium user experiences and smart building management. Its modular design enables easy retrofitting into existing infrastructures, increasing its appeal to municipal councils aiming to modernize smart city sanitation facilities

7. Acknowledgment

Gratitude is extended to the faculty for the support and provision of resources and facilities necessary for the completion of this project. The assistance provided has been instrumental in ensuring the success of this work

8. Researchers' Biography

Muhammad Adam Danish Bin Hisham is a student of Electrical Engineering (Electrical) at UiTM Pasir Gudang who has consistently excelled academically, receiving the Dean's List Award every semester. He has demonstrated remarkable talent in innovation and invention, winning two gold award 2024 and 2024, and most recently, the Final Year Project achieve gold medal. This achievement reflects both technical proficiency and creativity, highlighting potential as a future leader in engineering and technology.

Siti Aliyah binti Mohd Saleh obtained her Bachelor of Electrical (Hons) Engineering from UTM in 2009 and a Master in Engineering (Applied Science) from Tokai University, Japan in 2012. She is currently serving as a lecturer at Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, in Electrical Engineering Studies in the Power Department. Her main research interests are high voltage and power systems.

Norlina binti Mohd Zain is a lecturer at Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus. She holds a M.Sc in Electrical Engineering from Universiti Teknologi MARA, Malaysia. With over 10 years of experience as both a lecturer and researcher, she has developed extensive expertise in the field of flexible materials for microwave applications, particularly in the design and optimization of flexible antennas. Her primary areas of focus include antenna design, microwave engineering, and the application of flexible materials in microwave technologies.

Web-Controlled Switch Timer with Sensor

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ABSTRACT

This project presents the development of a low-cost web-controlled switch timer system with sensor integration aimed at improving energy efficiency, accessibility, and user convenience. Conventional timer switches are often expensive, inflexible, and difficult to operate for elderly users and individuals with limited mobility. To address these issues, the proposed system combines manual timer control, scheduled automation, and ultrasonic sensor feedback using an ESP32 microcontroller. The system allows users to remotely control electrical appliances through a web-based interface hosted on the ESP32, accessible via internet connection. Time synchronization is achieved using internet-based Network Time Protocol (NTP), enabling accurate scheduling of appliance operation. An ultrasonic sensor provides interactive feedback by detecting nearby presence and activating visual indicators. In addition, system activities such as ON/OFF events are logged for monitoring purposes. The main advantages of this system include low cost, simple design, real-time remote access, and improved usability for elderly and disabled users. By ensuring appliances operate only when required, the system contributes to energy conservation and reduced electricity waste, offering significant socio-environmental impact through lower utility costs and sustainable energy management. This project demonstrates strong potential for smart home applications and future commercialization as an affordable, scalable automation solution for residential and caregiving environments.

Keywords: Web-controlled switch, timer system, ESP32, energy efficiency, smart home

1. Product Description

The Web-Controlled Switch Timer with Sensor is a smart automation system designed to control household electrical appliances efficiently and safely. The system uses an ESP32 microcontroller as the main controller, integrated with a relay module, ultrasonic sensor, and LED indicator. Appliances can be switched ON or OFF manually or automatically using scheduled timer settings through a web interface. Users can access the system remotely using any internet-enabled device without the need for a mobile application. Time synchronization ensures accurate scheduling, while the ultrasonic sensor provides presence-based feedback for enhanced interaction. The relay module allows safe control of high-voltage appliances, making the system suitable for real household use. This product is designed to be affordable, user-friendly, and scalable, making it ideal for smart homes, hostels, offices, and elderly care environments. Its modular design allows future upgrades such as energy monitoring and mobile notification features.

2. System Design and Implementation

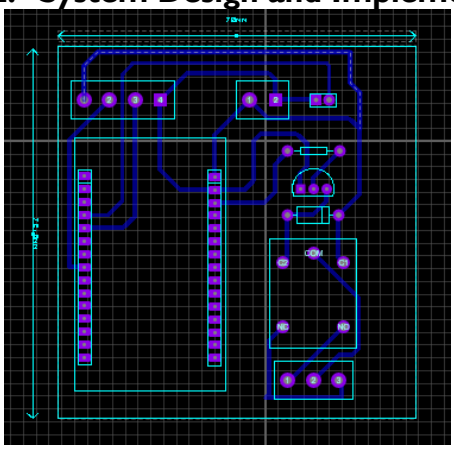


Figure 1. PCB simulation.

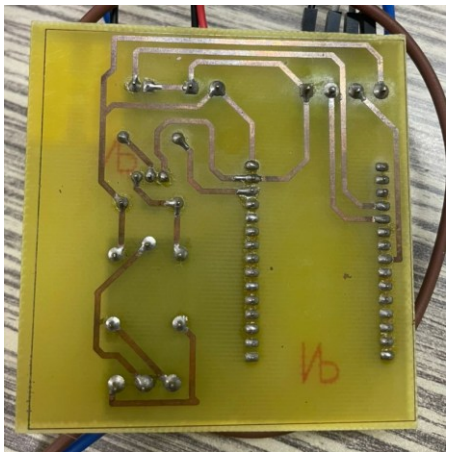


Figure 2. PCB hardware prototype.

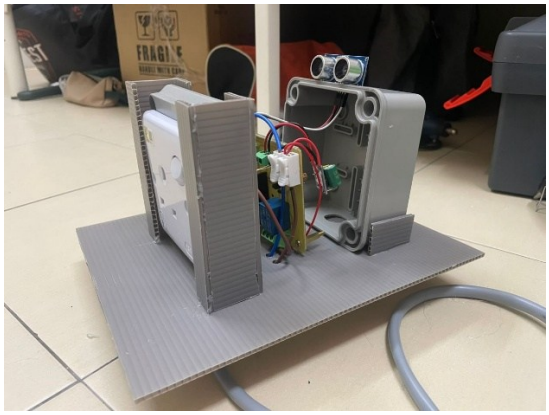


Figure 3. Completed hardware prototype.

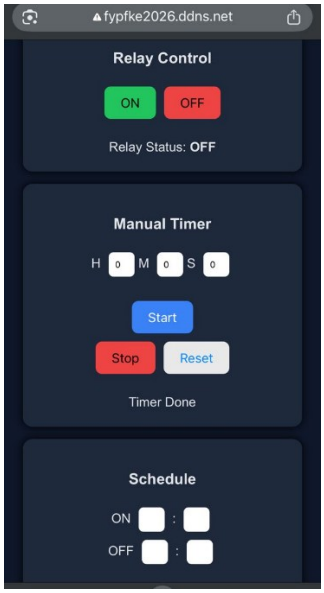


Figure 4. illustrates the web server interface.

Figure 1 illustrates the PCB simulation of the Web-Controlled Switch Timer with Sensor, developed using Proteus software. This simulation was used to verify the circuit design and electrical connections between the ESP32 microcontroller, ultrasonic sensor, relay module, LED indicator, and power supply before hardware implementation. **Figure 2** shows the PCB hardware prototype of the Web-Controlled Switch Timer with Sensor. The prototype demonstrates the physical integration of the ESP32, ultrasonic sensor, relay module, and output components, confirming that the system operates correctly in real-world conditions. **Figure 3** presents the complete hardware prototype, highlighting the ESP32 microcontroller, ultrasonic sensor, relay module, and output components, validating the physical implementation of the system. **Figure 4** illustrates the web server interface, which allows users to remotely control

the switch timer through an internet-enabled device, providing manual ON/OFF control, timer configuration, and scheduled operation.

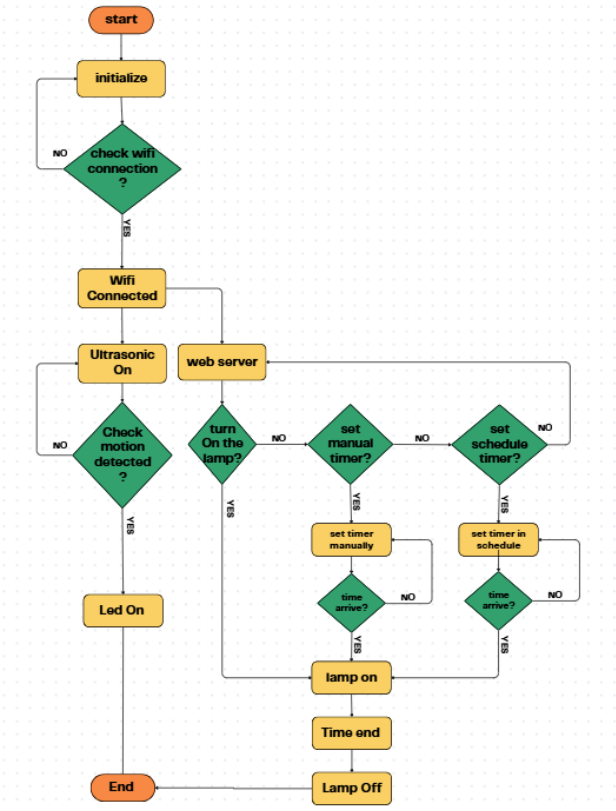


Figure 5 illustrates the flowchart of the web-controlled switch timer system, showing the interaction between the ESP32, ultrasonic sensor, relay module, and web interface.

Table 1 shows the system's response to manual ON/OFF actions, confirming that the relay operates correctly when controlled directly by the user.

	Log time	Mode	Manual ON	Manual OFF	Manual Duration
2	27/12/2025 23:40:37	MANUAL	23:40:27	23:40:32	5 sec
3	27/12/2025 23:42:03	SCHEDULE			
4	27/12/2025 23:42:30	MANUAL	23:42:17	23:42:27	10 sec
5	27/12/2025 23:46:09	MANUAL	23:46:00	23:46:05	5 sec
6	27/12/2025 23:48:04	SCHEDULE			
7	01/01/2026 00:54:58	MANUAL	00:54:49	00:54:54	5 sec
8	01/01/2026 00:55:20	MANUAL	00:55:06	00:55:16	10 sec
9	01/01/2026 16:32:05	MANUAL	16:31:56	16:32:01	5 sec
10	01/01/2026 16:32:33	MANUAL	16:32:21	16:32:31	10 sec
11	01/01/2026 16:36:02	SCHEDULE			
12	13/01/2026 14:52:48	MANUAL	14:52:37	14:52:42	5 sec
13	13/01/2026 14:54:44	MANUAL	14:54:11	14:54:41	30 sec
14	13/01/2026 14:57:03	SCHEDULE			
15	13/01/2026 15:01:20	MANUAL	15:01:10	15:01:15	5 sec

Table 2 shows the system's response to scheduled timer operations, verifying that the relay switches automatically according to preset times.

Schedule ON	Schedule OFF	Schedule Duration
23:41:00	23:42:00	60 sec
23:47:00	23:48:00	60 sec
16:35:00	16:36:00	60 sec
14:56:09	14:57:00	60 sec

3. Novelty and uniqueness

The novelty of this project lies in its integration of web-based timer control, real-time scheduling, and sensor-based interaction in a single low-cost system. Unlike conventional timer switches that rely solely on fixed schedules or manual operation, this system offers remote access, flexible control modes, and interactive feedback using an ultrasonic sensor. Most existing smart switch systems are costly and require complex mobile applications or third-party platforms. In contrast, this system uses a built-in web server on the ESP32, eliminating the need for additional software installation. The inclusion of internet time synchronization ensures accurate scheduling, while activity logging improves transparency and monitoring. The project uniquely focuses on accessibility, making it suitable for elderly users and individuals with limited mobility through simplified control and automation. Its modular architecture also allows easy expansion for future smart home features.

4. Benefit to mankind

This project benefits society by enhancing energy efficiency, safety, and accessibility in everyday appliance usage. By automating appliance control through timers, schedules, and sensor inputs, unnecessary energy consumption is reduced, lowering electricity bills and supporting environmental sustainability. The web-based interface allows remote monitoring and control, minimizing the need for physical interaction, which is particularly useful for elderly users and people with disabilities. Remote access also improves convenience and safety, enabling users to manage appliances from anywhere. In addition, logging and monitoring features encourage responsible energy usage and help track appliance performance over time. Overall, the system promotes smarter, more efficient living while remaining affordable, practical, and adaptable for a variety of household needs, demonstrating a meaningful contribution to modern, accessible, and sustainable home automation.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by transforming a traditional electrical switch into a smart, internet-enabled automation product. It encourages an entrepreneurial mindset by demonstrating how low-cost hardware and open-source platforms can be used to create market-ready smart home solutions. The system has strong potential for student startups, small-scale manufacturers, and local entrepreneurs focusing on affordable smart technologies. It also supports innovation culture within educational institutions by bridging engineering knowledge with real-world applications and commercialization opportunities.

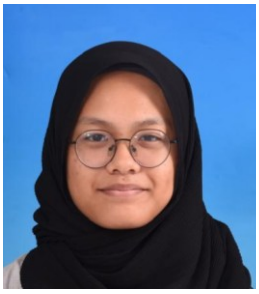
6. Potential commercialization

The Web-Controlled Switch Timer with Sensor has strong commercialization potential due to its low production cost, simple installation, and high demand for smart home solutions. It can be marketed as an affordable smart switch for residential homes, rental properties, hostels, and elderly care facilities. Future commercial versions may include energy monitoring, mobile app integration, and compact casing for mass production. The product can be sold as a standalone smart switch or bundled within smart home starter kits, making it competitive in the growing IoT market.

7. Acknowledgment

The author would like to express sincere appreciation to Universiti Teknologi MARA (UiTM) for providing the necessary facilities, resources, and academic environment that greatly contributed to the successful completion of this project. Special thanks are extended to the project supervisor for their invaluable guidance, continuous support, and expert advice throughout all stages of the research and implementation process. Their encouragement, constructive feedback, and mentorship have been instrumental in enhancing the quality of this work. The author is also grateful to all faculty members and staff who offered assistance, knowledge, and support, ensuring that the project was conducted efficiently and effectively.

8. Researchers' Biography



Ezatul Erina Natasya binti Farid Hafizah is a student in the Diploma of Electrical Engineering (Electronic) at UiTM Pasir Gudang, Johor. She focuses on embedded systems, IoT applications, and automation technologies. In the current project, she contributed to the design and implementation of the Web-Controlled Switch Timer with Sensor, developing both hardware prototypes and software interfaces. Through hands-on work with microcontrollers, sensors, and relay modules, she gained practical experience in system integration and smart device development. Her work demonstrates a strong interest in applying electronic engineering principles to real-world automation and IoT solutions.

Predicting Cloud Infrastructure Failure Using Machine Learning

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ABSTRACT

The challenge of maintaining dependable and stable cloud infrastructures has increased due to the growing use of cloud computing platforms. Because traditional maintenance techniques are mostly reactive, they are unable to predict service interruptions and frequently lead to expensive downtime and inefficient use of resources. To overcome these constraints, this work suggests a machine learning-based proactive cloud failure prediction solution. The study focuses on predicting infrastructure breakdowns linked to resource underutilisation using historic cloud performance metrics. Grid Search hyperparameter tuning was used to build and optimise three machine learning algorithms: Random Forest, Logistic Regression, and XGBoost across various data split ratios (60:40, 70:30, and 80:20). According to experimental results, the best performance was obtained by using Logistic Regression with a 70:30 data split, which recorded an F1-score of 99.18% and a testing accuracy of 99.28%. With a precision of 99.90%, the model also showed good generalisation ability, successfully reducing false alarms, a crucial aspect of automated maintenance systems. A web-based predictive prototype was created using the optimised model to offer maintenance suggestions and real-time system condition alerts. By transitioning from reactive to proactive techniques, this method increases system dependability while promoting socio-environmental sustainability through reduced energy consumption and carbon emissions in data centers. Furthermore, the project supports Sustainable Development Goal (SDG) 9 by fostering resilient infrastructure through intelligent automation and aligns with Malaysia's New Industrial Master Plan 2030 (NIMP 2030) Mission 2, which aims to "Tech Up for a Digitally Vibrant Nation". With its high precision in reducing false alarms, the system presents significant commercialization prospects for Cloud Service Providers (CSPs) as a diagnostic plug-in to reduce operational overhead. Future research will explore deep learning integration for dynamic cloud environments.

Keywords: Cloud Computing, Predictive Maintenance, Machine Learning, Infrastructure Reliability, Cloud Virtual Machines

1. Product Description

The prototype of the cloud failure prediction is an automated prognostic device that transforms the paradigms of the cloud maintenance from reactive to active ones. It takes multi-dimensional logs, such as CPU usage and memory usage, bandwidth and latency, and computes a complex score, the resource utilization score. This score is used as the key health indicator regarding the infrastructure. The system is implemented through a web-based Streamlit application, where administrators have the option to post CSV datasets or real-time sliders to simulate the status of the system. The system ensures continuous service

availability and optimal resources distribution in highly complex clouds by detecting underlying failure patterns that would often be ignored by human operators.

2. Research Framework & Methodology

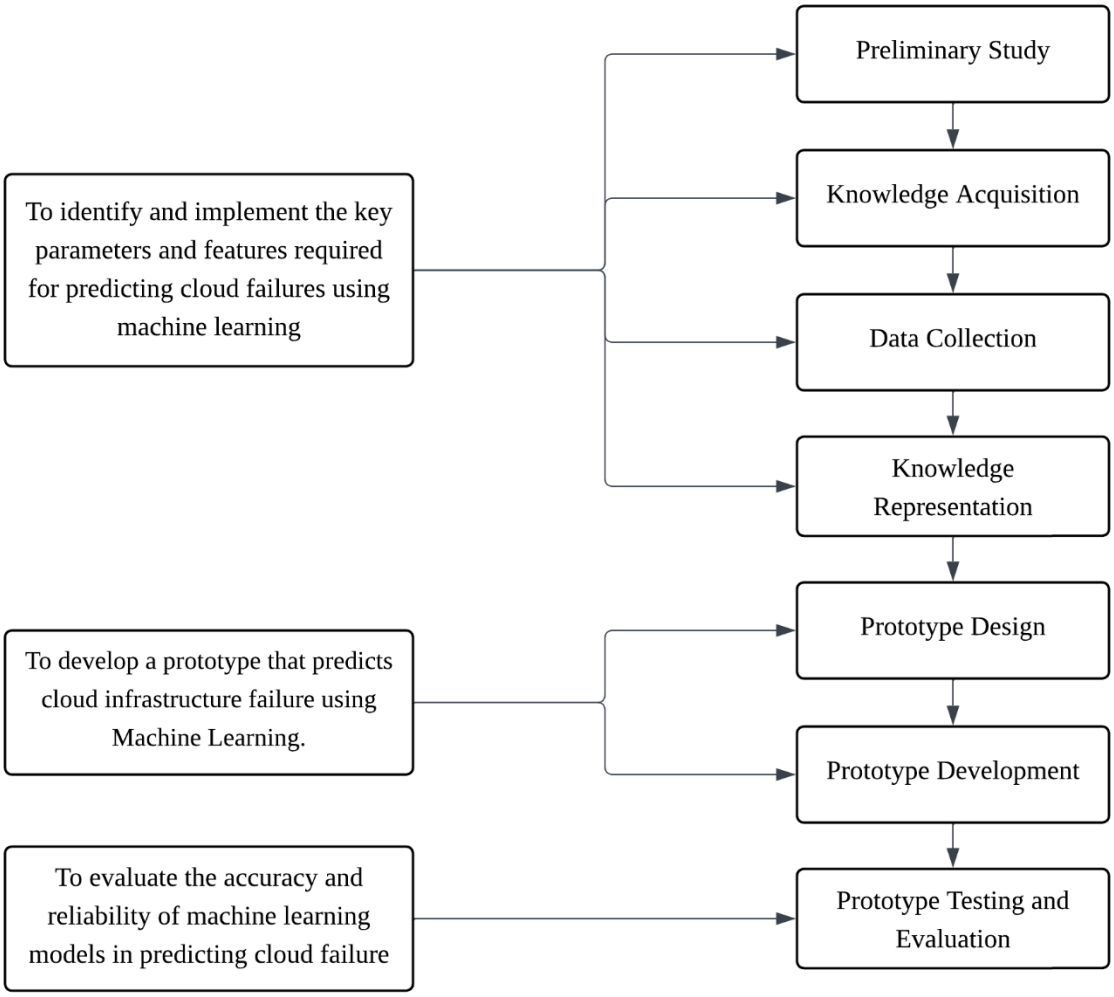

Figure 1. Research Framework.

The research framework depicted in **Figure 1** followed a structured seven-phase methodology namely the Preliminary Study, Knowledge Acquisition, Data Collection, Knowledge Representation, Prototype Design, System Development and System Testing and Evaluation across three objectives:

- Knowledge & Feature Identification: Identified key performance indicators from the Cloud Data Orchestration Dataset retrieved from Kaggle, including CPU, memory, bandwidth, and a derived "Resource Utilization Score" metric.
- System Prototyping: Built a Streamlit-based application to process resource metrics and output status recommendations.

- Evaluation & Reliability: Evaluated the reliability of machine learning models in predicting cloud failure.

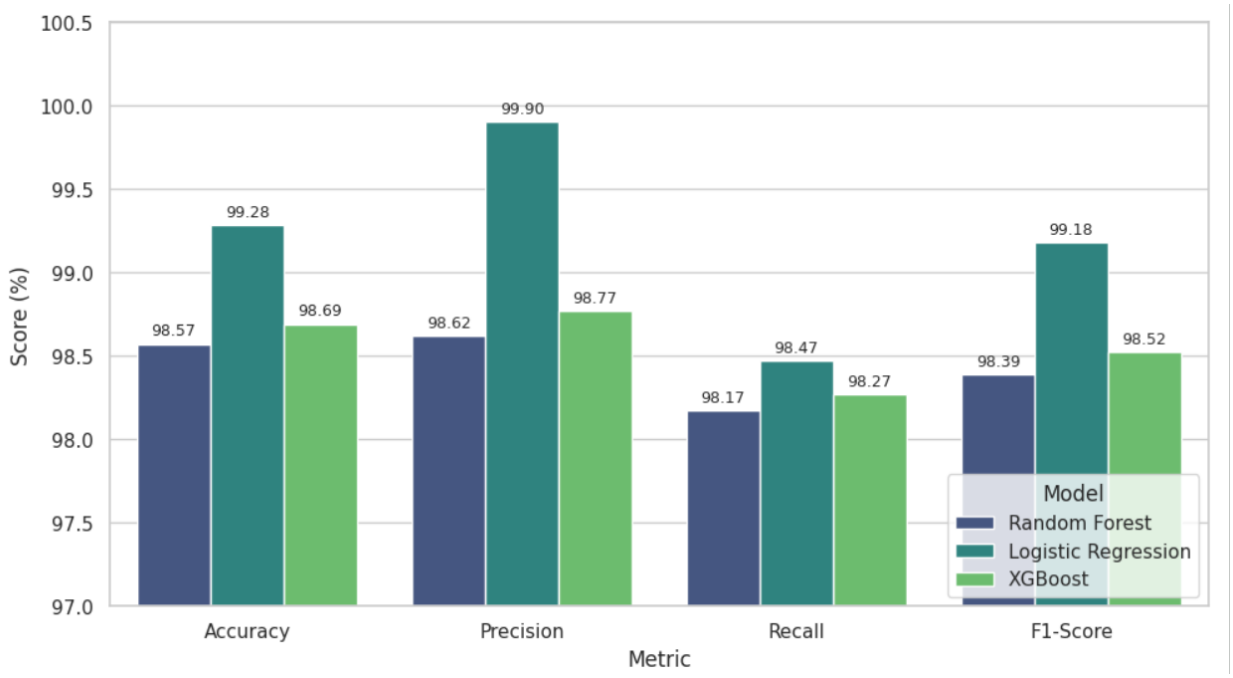

Figure 2. Performance Comparison of Optimized Models.

The optimized models in **Figure 2** shows that the better model to use in this application would be Logistic Regression that was trained on the split of 70:30. It had the best Accuracy of 99.28% and Precision of 99.90% and Recall of 98.47% and F1 of 99.18%. The key aspect of such a choice is precision of the model. The precision of the Logistic Regression was nearly perfect with 99.90 against both the XGBoost and the Random Forest that had an overall accuracy of 98.77% and 98.62% respectively. The high level of accuracy is substantial, in this case of cloud infrastructure since it paves the way to automated remedial actions that are activated at the moment when a failure is eminent and not due to resources wasting. In addition, Logistic Regression demonstrated the least gap between training and testing results, which means that it is the best generalization performance and will never be overfitted in the production setting. Although XGBoost and the Random Forest models are more robust models, the linear separability of the cloud metric features must have biased the less complex, but more robust, use of Logistic Regression (Tengku Asmawi et al., 2022).

3. Novelty and uniqueness

The novelty of this project is in the fact that an empirical discovery and validation was made that a carefully designed linear model can perform better than a complicated ensemble architecture in cloud failure detection. Whereas modern literature may prefer complex models, such as the Random Forest or the XGBoost, this paper will show that a tuned Logistic Regression model is more linearly separable and more stable when applied to cloud resource
metrics. One technical prerequisite that is unlike other components is the accomplishment of 99.90% Precision, which is almost perfect and is very valuable to cloud operators. This will ensure

that automated remedial measures are not activated until there is an actual threat of failure and this will result in the false alarm of threats and the waste of resources being virtually eradicated. In addition, it has the smallest generalization gap between the model and other algorithms which makes the model robust and reliable in this regard as it faces various real-world operational logs.

4. Benefit to mankind

This innovation enhances sustainability of digital services because it ensures that unexpected failures of infrastructure systems do not befall the international users of millions. It causes the data centers to consume less energy and emit less carbon since unwarranted migrations of resources are minimized by high-precision modeling. Moreover, it is also in line with Sustainable Development Goal (SDG) 9 that aims to create a resilient infrastructure and make industrialization more inclusive and sustainable by promoting intelligent automation.

5. Innovation and Entrepreneurial Impact

The encouragement of an entrepreneurial culture in this project is the ability to create a cost-effective and scalable failure-prediction engine that an organization can make use of to run its cloud clusters without having to spend money on proprietary software. It is in tandem with the New Industrial Master Plan 2030 (NIMP 2030) of Malaysia, Mission 2, which is Tech Up for a Digitally Vibrant Nation. Through the continued development of AI on a localized level in predictive maintenance, the project will promote cities and local industries to implement their own intelligent systems and stop overreliance on imported technology and the development of high-tech innovation in the institution and industry.

6. Potential commercialization

The commercialization prospect is high for cloud service providers (CSPs) and enterprise data centers looking for lightweight, high-precision monitoring tools. The Streamlit integration can be used to enter the prototype as a possible solution to real-time system health dashboarding. The market size can be observed in the expanding market of predictive maintenance whereby the system may be licensed to the organizations in the form a diagnostic plug in to augment their existing IT management structures to a large extent reducing the overhead of maintenance and the cost of emergency management.

7. Acknowledgment

I would like to thank the Faculty of Computer & Mathematical Sciences at Universiti Teknologi MARA (UiTM) for providing the resources and supervision necessary to complete this project. Special appreciation is extended to Dr. Mansir Abubakar for his expert guidance throughout the project. Also, my gratitude is noted towards Ts. Nurzeatul Hamimah Abdul Hamid, Dr. Farah Aqilah Bohani and Mrs. Siti Nur Kamaliah Kamarudin for their guidance on conducting this research project.

8. Researchers' Biography

Syahdanish Zamshuri Sani Zamshuri is a final year student at Universiti Teknologi MARA (UiTM) Shah Alam, pursuing Bachelor of Information Systems (Hons.) Intelligent Systems Engineering. His research interests include machine learning, cloud computing, and predictive maintenance. For his Final Year Project, he developed an intelligent system to predict cloud failures with high precision, demonstrating his capability in data science and prototype development.

Dr. Mansir Abubakar is a Senior Lecturer at Universiti Teknologi MARA (UiTM) Shah Alam, with 14 years of university-level teaching experience. He earned his Ph.D. in Intelligent Computing from Universiti Putra Malaysia (UPM). A certified Learning Management System (LMS) facilitator, he has contributed to national AI policy initiatives and facilitated smart agriculture programs. His research in intelligent computing and emerging technologies is widely published in Scopus and WoS-indexed journals. He has held significant leadership roles, including Head of Department and Acting Dean at Al-Qalam University Katsina.

Solar Tracking System with a Booster Circuit

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ABSTRACT
This project focuses on developing a single axis solar tracking system to overcome the limitations of fixed solar panels, which are unable to capture maximum solar energy due to their static position. The proposed system uses an Arduino microcontroller and light dependent resistors (LDRs) to detect sunlight intensity and automatically adjust the position of the solar panel so that it follows the movement of the sun throughout the day. This tracking mechanism helps improve energy capture and increases power output. In addition, a voltage booster circuit is integrated into the system to reduce energy losses and provide a more stable and higher output voltage, especially under low or fluctuating sunlight conditions. The novelty of this project lies in the combination of real-time solar tracking and voltage boosting in a single, low cost system, unlike conventional trackers that focus only on panel movement. The system is designed to be simple, affordable, and effective, making it suitable for off grid and remote applications. Overall, this project supports the use of renewable energy, reduces dependence on fossil fuels, and encourages the development of practical and sustainable energy solutions.

Keywords: Solar Tracker, LDR, Booster Circuit

1. Product Description
This project is designed to improve the performance of solar panels in a simple and practical way. Unlike fixed solar panels that remain in one position, this system automatically adjusts the panel angle to follow the sun throughout the day. This allows the panel to receive more sunlight and produce higher energy output. The system uses an Arduino microcontroller as the main controller and LDR sensors to detect the direction and intensity of sunlight. Based on this information, a motor rotates the solar panel to the most suitable position. A built in voltage booster circuit is also included to increase and stabilize the output voltage, especially during cloudy weather or low-light conditions. This helps reduce power loss and ensures a more reliable energy supply. The system is low cost, easy to install, and user friendly, making it suitable for students, small projects, rural areas, and educational purposes. It offers a practical solution to improve solar energy usage and supports clean and sustainable energy applications. In general, this system increases energy harvesting efficiency while maintaining stable power delivery under varying environmental conditions. Its simplicity and adaptability make it a scalable approach for promoting wider adoption of renewable energy solutions in real world applications.

2. Block Diagram and Flow Chart
Block Diagram
The solar tracking system, as shown in **Figure 1**, is designed to optimize energy generation by aligning the solar panel with the sun's direction throughout the day. The system relies on sunlight, and in its absence such as at night or during extremely low light conditions, it switches to standby

mode. Light intensity sensors, such as LDRs, detect the sunlight's strength and send this data to a microcontroller, which processes the information and activates a servo motor to adjust the solar panel's angle for maximum light absorption. The output voltage from the panel is then passed through a booster circuit, which increases and stabilizes the voltage to a usable level, ensuring consistent energy delivery. While the system cannot operate at night, its dynamic tracking mechanism significantly enhances energy output during daylight hours.

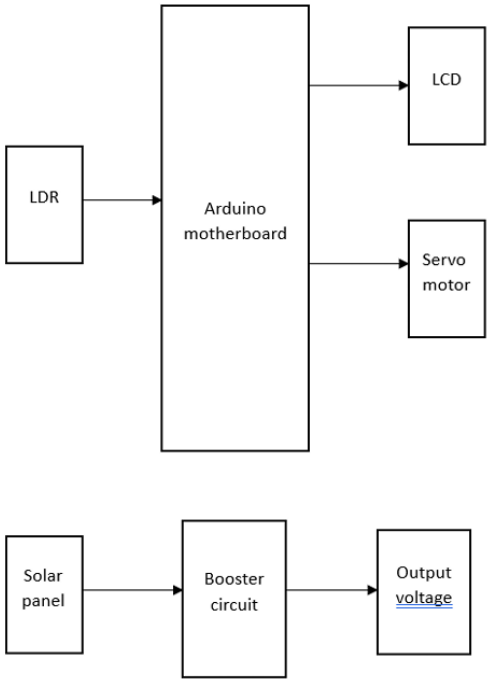


Figure 1. Block Diagram.

Flow chart

Figure 2 illustrates the flowchart of an effective method for maximizing solar panel output using an Arduino-based solar tracking system. The process begins with the Arduino software, which establishes communication with light intensity sensors to detect the strength and direction of sunlight. The data collected from these sensors is analysed by the Arduino to determine the optimal orientation for the solar panel. If the analysis is successful, a signal is sent to the servo motor, prompting it to rotate the solar panel to the position where it can gather the maximum amount of sunlight. This continuous adjustment ensures that the panel is always aligned with the sun's trajectory throughout the day. The power generated by the solar panel is then directed to a booster circuit, which increases and stabilizes the voltage to a suitable level for practical use, such as charging batteries or powering connected devices. If the analysis is unsuccessful, the system reevaluates the Arduino code to ensure proper operation, repeating this process until the desired outcome is achieved. This iterative and dynamic tracking mechanism guarantees that the solar panel consistently remains at an optimal angle, significantly enhancing energy production and overall system efficiency. By dynamically altering the panel's orientation in response to sunlight conditions, the Arduino-based tracking system effectively increases solar energy output, making the technology a highly efficient and practical solution for renewable energy generation.

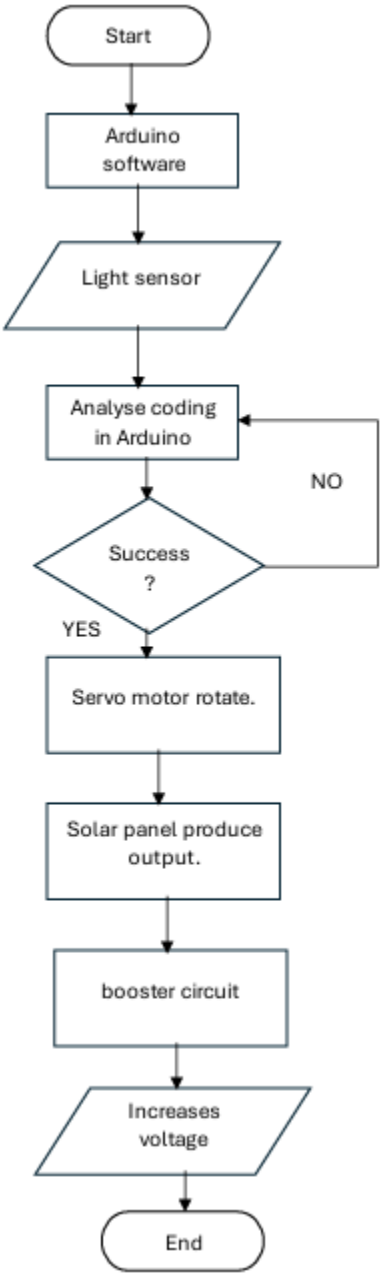
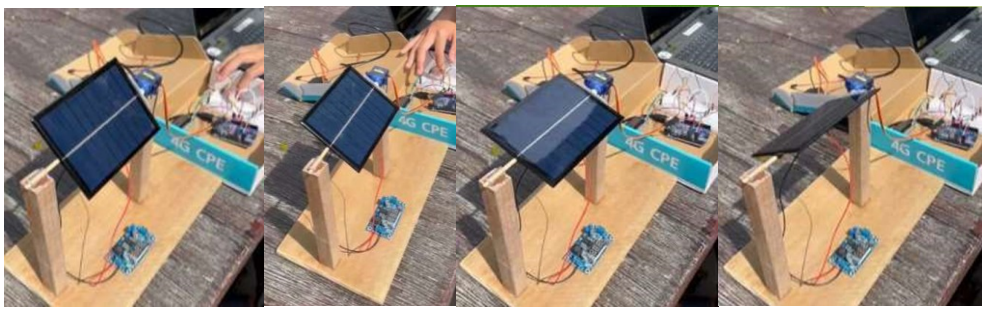


Figure 2. Flow Chart.

Hardware Results

Figure 3 shows the hardware results for the solar tracker system with four difference positions (initial position during sunrise, morning, afternoon and evening reach). The position of solar panel during afternoon reaches the highest output voltage.



(a) (b) (c) (d)

Figure 3. Hardware results of solar tracking system (a) Solar initial position during sun rise, (b) Solar position during morning, (c) Solar position during afternoon, (d) Solar position during evening reach.

Table 1. Output voltage without and with booster circuit.

Time (hour)	Output Voltage Without Booster Circuit (V)	Peak Output Voltage With Booster Circuit (V)
Morning (8.00 a.m. – 11 a.m)	2.4	25.1
Afternoon (12 p.m – 2.00 p.m)	5.6	41.0
Evening (3.00 p.m – 5.00 p.m.)	3.5	20.0
Sunset (6.00 p.m. – 7.00 p.m.)	1.7	5.6

Table 1 shows the difference in output voltage, before and after entering the booster circuit. The booster circuit can further increase the output voltage. Therefore, the efficiency with the booster circuit is higher compared to without booster circuit.

3. Novelty and uniqueness

This project offers a simple yet effective improvement to conventional solar tracking systems. Most existing solar trackers focus only on adjusting the position of the solar panel to follow the sun. In contrast, this system combines solar tracking with a built-in voltage booster circuit in a single design. This allows the system to improve performance in two ways at the same time. First, the solar panel continuously follows the sun to capture maximum sunlight throughout the day. Second, when sunlight is weak or unstable, the voltage booster helps increase and stabilize the output voltage. By integrating both functions into one system, the need for additional external components is reduced. This makes the overall design simpler, more compact, and easier to use. As a result, the system is more efficient and practical compared to traditional solar tracking systems.

4. Benefit to mankind

A solar tracking system provides clear benefits to humans by improving the efficiency of solar energy generation. Unlike fixed solar panels, a solar tracker allows the panel to follow the movement of the sun throughout the day, ensuring better exposure to sunlight. This results in higher electrical energy production and makes the system more efficient and reliable. With increased energy output, dependence on fossil fuel–based energy sources can be reduced, which helps lower electricity costs over time. In addition, solar tracking systems are environmentally

friendly because solar energy is a renewable resource and does not produce harmful air pollution or greenhouse gas emissions. Solar trackers are also especially useful in remote or rural areas where access to the main power grid is limited. By providing a stable and independent source of electricity, the system supports daily human needs and improves quality of life. Overall, the use of solar tracking technology encourages the adoption of green energy and contributes to a more sustainable and environmentally friendly future.

5. Innovation and Entrepreneurial Impact

This project demonstrates innovation by using simple and easily available components to solve a real-world energy problem. By combining an Arduino-based solar tracker with a voltage booster circuit, the system improves solar energy efficiency without using complex or expensive technology. This approach encourages creative thinking and hands-on learning, especially among students and young innovators. From an entrepreneurial perspective, the low-cost and simple design makes the system suitable for small-scale production. Local technicians, students, or startups can further develop or customize the system for specific applications such as rural electrification or small solar projects. The project helps promote an entrepreneurial mindset by showing how technical knowledge can be turned into practical and marketable solutions.

6. Potential commercialization

The system has strong potential for commercialization due to its simple design and affordable cost. It can be used as a plug-and-play add-on for existing solar panels, allowing users to improve performance without replacing their current systems. This reduces installation costs and makes the product more attractive to users. The system is suitable for off-grid applications such as rural areas, small farms, and IoT-based devices. Its ease of installation and maintenance allows small businesses or startups to produce and market the system, supporting wider adoption of renewable energy solutions.

7. Acknowledgment

Appreciation is extended to the supervisor and colleagues for their assistance, and to Universiti Teknologi MARA (UiTM), Permatang Pauh Campus, for providing the necessary facilities and resources.

8. Researchers' Biography

Ameer Razin Mohd Azhar is a Diploma student in Electrical Engineering at Universiti Teknologi MARA (UiTM), Penang Branch, Permatang Pauh Campus. His academic interests include renewable energy systems, power electronics, and control applications. His final year project involves the design and implementation of a solar tracking system with a booster circuit, aimed at improving energy harvesting efficiency.

Siti Sarah Mat Isa received the M.Eng. degree in Power Systems and Electrical Energy from Universiti Malaya (UM) in 2011. Her current research interests include power system transients and renewable energy, with particular focus on battery energy storage systems.

Shahilah Nordin currently serves as a senior lecturer at Faculty of Electrical Engineering, Universiti Teknologi MARA, Cawangan Pulau Pinang. She is interested in exploring knowledge, especially in the field of electronic communication engineering. She has teaching experience in this field of electronics since 2003.

Quakewatch: Real-Time Vibration Alert System

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ABSTRACT
The QuakeWatch: Real-Time Vibration Alarm System is designed to enhance safety and the environment in the workplace. This system integrates vibration sensors and information to workers. The sensor (SW-420) will detect vibrations and give a signal to buzzer, LED and will display the information. Such as, if the vibration is above the threshold that has been set, it will trigger the other component and will display a DANGER ZONE to the workers through a notification or it will display on the LCD. Additionally, LCD display monitors will display all the information to the workers, and a notification will be sent through Telegram. The project aims to create a cost-effective and safety solution that improves workplace safety and reduces accidents in the workplace.

Keywords: Vibration Sensor, Threshold Detection, Embedded System, IoT-Based Alert, Workplace Safety

1. Product Description
QuakeWatch is a product that focuses on safety and alerting the pedestrian and workers about vibration that can occur without unnoticed. It uses vibration sensors to detect abnormal vibrations and automatically alerts workers through an LED, buzzer, LCD display, and mobile notifications via Telegram when thresholds are exceeded. The LED and buzzer will turn ON while the LCD displays vibration detected and 'DANGER ZONE'. By providing immediate, real-time warnings, QuakeWatch helps prevent accidents, protect equipment, and support a safer working environment.

2. Product prototype.
Figure 1 and **Figure 2** shows the block diagram and schematic of the system. **Figure 3** is the system flowchart while **Figure 4** shows the developed prototype. **Figure 5** indicates the notification for the user.

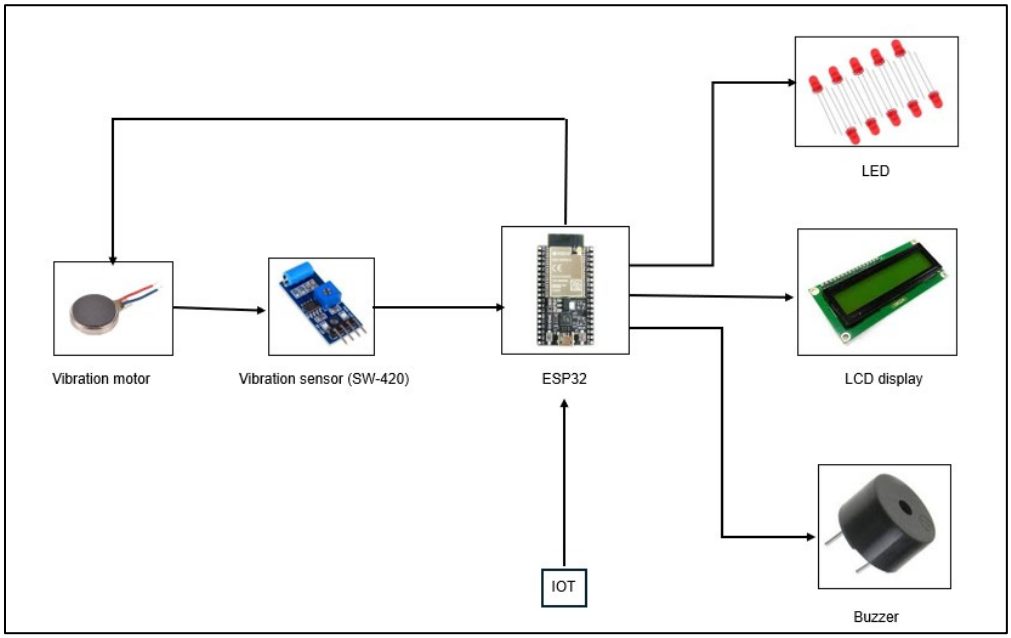

Figure 1. Block Diagram of the QuakeWatch: Real-Time Vibration Alert System.

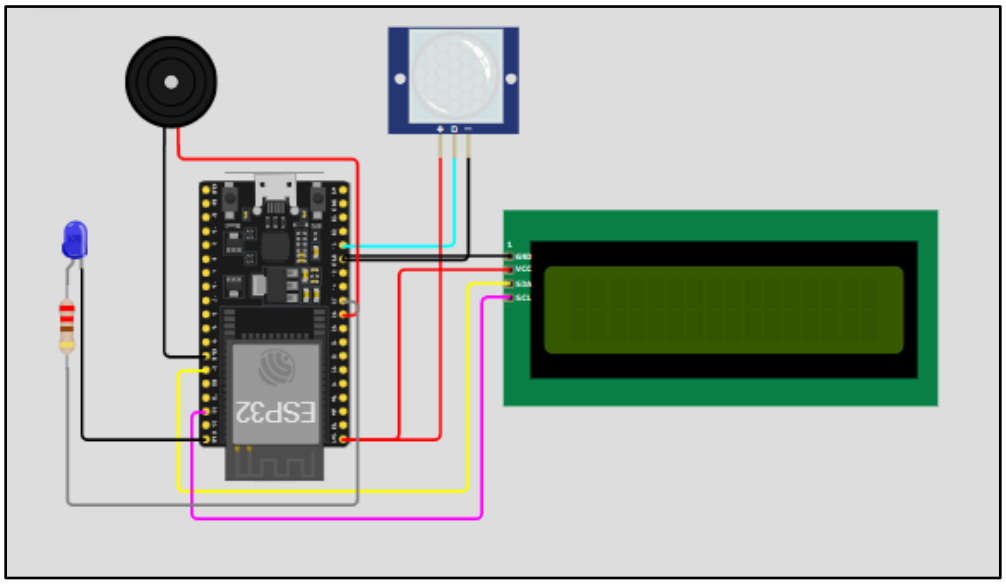

Figure 2. Simulation Diagram of the QuakeWatch: Real-Time Vibration Alert System.

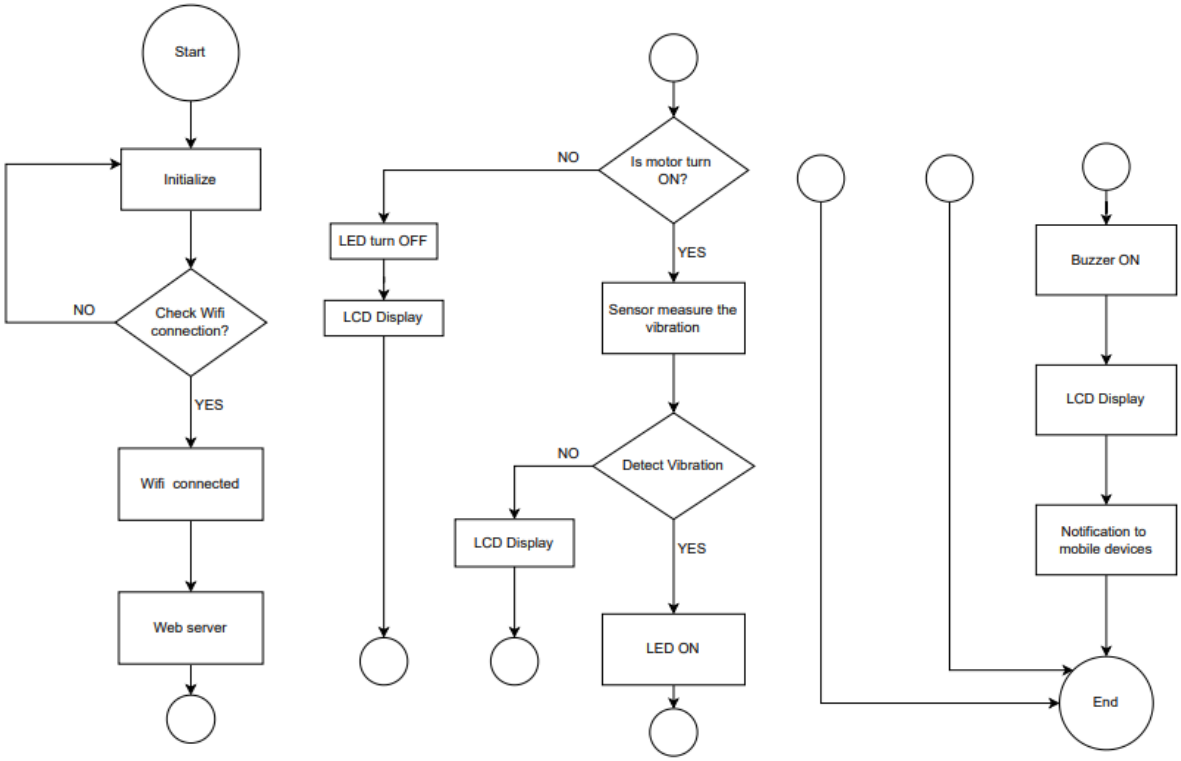

Figure 3. Flowchart of the QuakeWatch: Real-Time Vibration Alert System.

Figure 4. Prototype of the QuakeWatch: Real-Time Vibration Alert System.

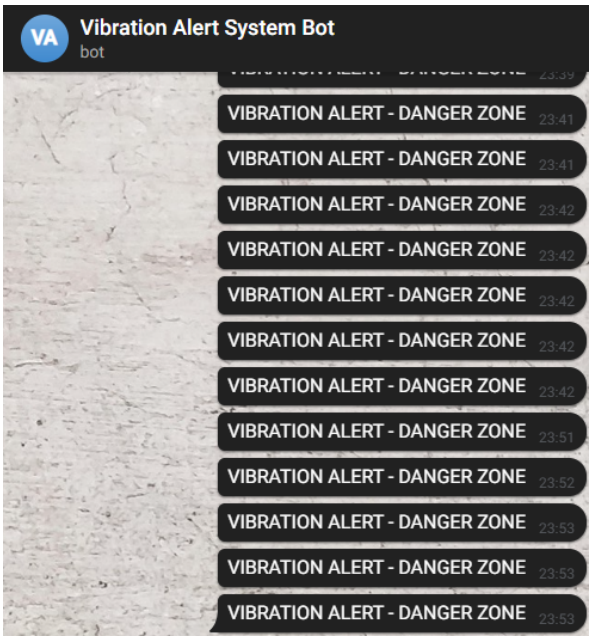

Figure 5. Notification through the mobile user from Telegram of the QuakeWatch: Real-Time Vibration Alert System.

3. Novelty and uniqueness

QuakeWatch is unique because it combines real-time vibration monitoring, automated alerts, and IoT connectivity in a single system. Unlike traditional methods, it continuously detects abnormal vibrations and triggers a multi-channel alert system—including LED, buzzer, LCD display, and mobile notifications via Telegram—ensuring workers are immediately informed. Its threshold-based design reduces false alarms, activating only when vibration levels exceed safe limits. The IoT-enabled feature allows remote monitoring, making it practical for large or unsupervised workplaces. Cost-effective and easy to deploy, QuakeWatch provides an innovative solution to enhance workplace safety, prevent equipment damage, and support proactive hazard management.

4. Benefit to mankind

One of the main benefits of machine vibration monitoring is that it can help you prevent costly downtime and keep the process running. By understanding the condition of your machines and catching problems before they turn into failures, you can keep your machines running and save yourself the money that would have been lost had the machines broken down. In addition, this will allow your employees to spend time on more productive tasks. Another benefit of vibration monitoring is that it can help you increase overall safety. Hazardous conditions can arise when a machine is running roughly. You can take preemptive action to keep your employees safe and out of harm's way with vibration monitoring. The sooner issues are detected, the more likely it is that they will be easily fixed.

5. Innovation and Entrepreneurial Impact

This project demonstrates innovation by integrating real-time vibration sensing, automated safety alerts, and IoT-based mobile notifications into a single, cost-effective system. This approach

introduces a practical solution for early fault detection and workplace safety enhancement without relying on expensive industrial monitoring equipment.

6. Potential commercialization

The commercialization potential of vibration alert systems is substantial, especially in industrial predictive maintenance and infrastructure safety. With strong growth forecasts and multiple application areas, companies can capitalize by offering integrated solutions and subscription-based services.

7. Acknowledgment

The author would like to acknowledge the Faculty of Electrical Engineering, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus for its support.

8. Researchers' Biography

Nurqistina Iwani Mohd Ridzuan is a student of Diploma in Elctrical Engineering (Electronic) program at the Faculty of Electrical Engineering, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus. She is a receiver of the Dean's award for 3 consecutive semesters and is currently on track to complete his studies in August 2026.

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Siti Hazurah Indera Putera is a Senior Lecturer at the Faculty of Electrical Engineering, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus. She has over 20 years of experience as an academician. She obtained her PhD in Automatic Control and System Engineering from The University of Sheffield, Master of Engineering in Mechatronics and Automatic Control from Universiti Teknologi Malaysia (UTM) in and Bachelor of Engineering in Elctrical (Electronics) Engineering from UTM. Her primary research interests are machine learning and embedded systems.

Fatimah Khairiah Abd Hamid received her B.Eng. Degree in Electrical-Electronic from Universiti Teknologi Malaysia (UTM), in 2011. Meanwhile, she pursued her Master and PhD in Electrical Engineering in the same university in 2013 and 2016, respectively. She is currently a senior lecturer with the Faculty of Electrical Engineering, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus. Her research interests include modelling and simulation nanoscale transistor, radar and satellite system, sensor and IOT application

Smart Attendance System Using Rfid

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ABSTRACT
This mini project presents the development of a Smart Attendance System using an ESP microcontroller and Radio Frequency Identification (RFID) technology to automate attendance management in educational institutions. The system was designed to address the inefficiencies of traditional paper-based attendance methods, which are time-consuming, prone to human error, and vulnerable to proxy attendance. By integrating RFID with Wi-Fi connectivity, the system automatically records attendance when a valid card is scanned and transmits the data in real time to Google Sheets, functioning as a cloud-based database. The innovation lies in combining low-cost IoT hardware with real-time cloud storage, providing a simple yet effective digital solution without the need for complex servers. Key features include contactless operation, instant data logging, and user feedback through LCD and LED indicators. The system improves administrative efficiency, supports data accuracy, and reduces paper usage, contributing to sustainable practices and better resource management. From a socio-economic perspective, the system supports digital transformation in education and offers a scalable, affordable solution with strong potential for commercialization as a smart attendance product.

Keywords: Smart Attendance System, RFID Technology, Internet of Things (IoT), Cloud-Based Data Management

1. Product Description
The Smart Attendance System is a compact digital solution developed to modernize attendance management in educational institutions. Designed for installation at classroom entrances, the system allows students to record attendance quickly through a contactless card scanning process. Immediate visual feedback confirms attendance status, ensuring a smooth and efficient experience for both students and lecturers. Attendance records are stored digitally and can be accessed conveniently for monitoring and documentation purposes. This eliminates the need for manual paperwork and reduces the time spent on attendance taking, allowing more focus on teaching and learning activities. The system is designed with user convenience in mind, featuring a practical structure that supports easy interaction and organized student flow. By replacing traditional attendance methods with a digital approach, the product improves record accuracy, streamlines administrative tasks, and creates a more efficient classroom environment. Its simplicity, affordability, and ease of deployment make it suitable for schools, colleges, and training institutions seeking a reliable and modern attendance solution.

2. Visual Representation of the System

System Diagram

Figure 1 shows the system diagram of the Smart Attendance System .The Smart Attendance System is intended for use in educational environments such as classrooms and lecture halls. As shown in **Figure 1,** the system operates by allowing students to scan RFID cards, where the data is processed by an ESP32 microcontroller and transmitted wirelessly to a cloud platform for storage and monitoring. The main purpose of the system is to provide an efficient and automated solution to replace manual attendance recording. The system benefits society by improving administrative efficiency, reducing human error, and supporting better learning management through real-time attendance monitoring. From an environmental perspective, the system reduces paper usage and promotes digital record-keeping, contributing to sustainable and environmentally friendly practices.

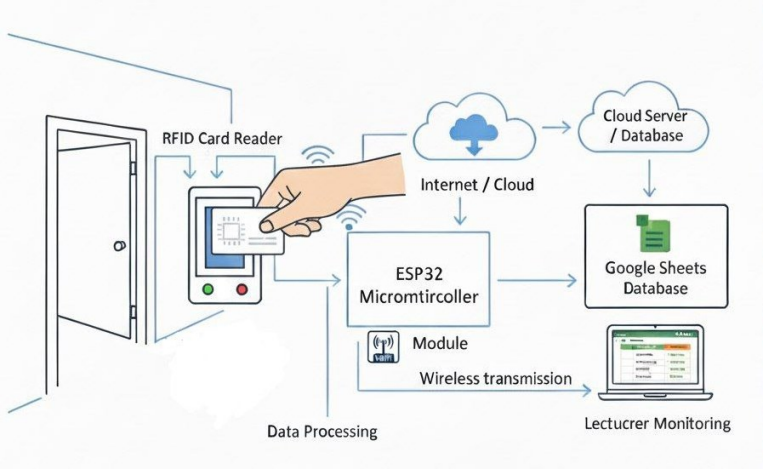

Figure 1. System Diagram.

Block Diagram

Figure 2 shows the block diagram of the Smart Attendance System .The RFID card is scanned by the RFID reader, which sends its unique identification data to the ESP32 microcontroller for processing. The ESP32 controls the LCD to display the attendance status and activates LED as the system indicator. The processed data is then transmitted through Wi-Fi to Google Sheets for data storage.

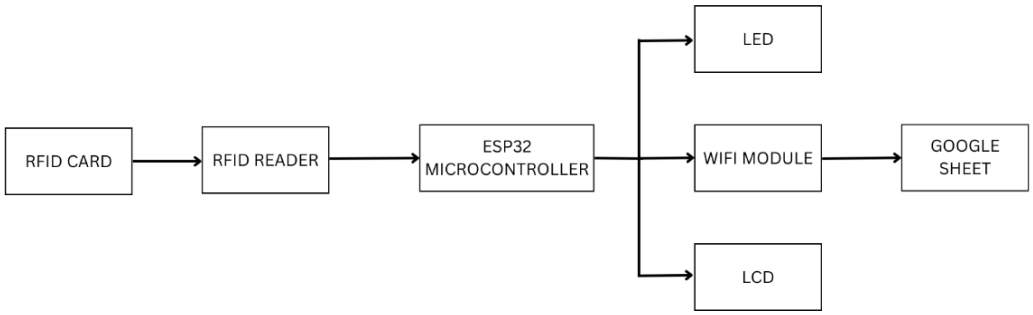

Figure 2 : Block Diagram

Operation System

Figure 3 shows the flowchart of the Smart Attendance System .The system starts by powering on and connecting to a Wi-Fi network. After the connection is established, the system waits for an RFID card to be scanned. When a card is detected, the system checks whether the card is valid. If the card is invalid, the red LED is activated, and the LCD displays a "Card is invalid" message. If the card is valid, the ESP reads the card's UID and records the attendance data. The data is then transmitted to Google Sheets through Wi-Fi. Upon successful transmission, the green LED turns on and the attendance information is displayed on the LCD. The system then returns to the waiting state for the next scan.

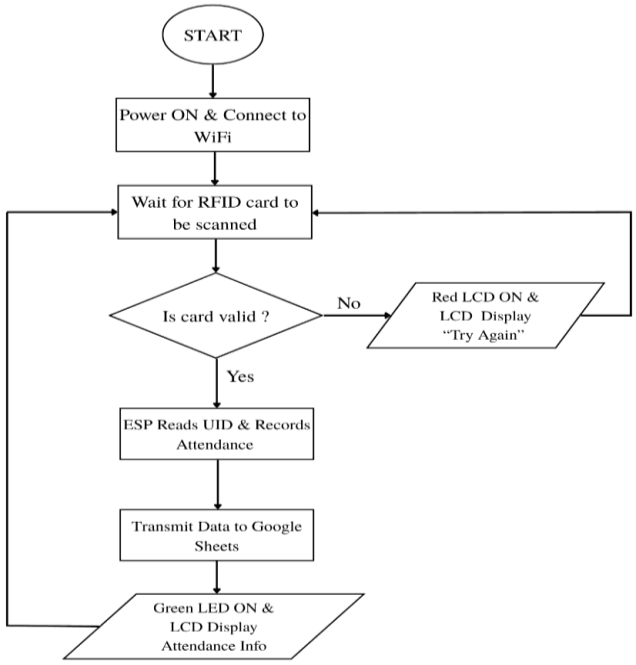

Figure 3 : Flowchart

Simulation of the system

Figure 4 shows the simulation of the Smart Attendance System developed using Wokwi . Push buttons were used to simulate valid and invalid RFID cards . The simulation verifies system logic before hardware implementation**.**

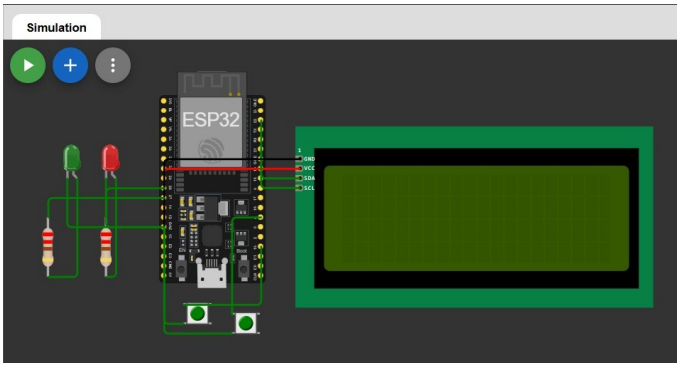

Figure 4 : Schematic Diagram

Hardware Implementation

Figure 5 presents the actual hardware implementation on a breadboard. It shows the ESP32 connected with the RFID module, LCD, and LEDs. This figure confirms that the system was successfully built and tested physically.

Prototype Design

Figure 6 illustrates the final prototype casing designed using AutoCAD. The ergonomic design ensures easy card scanning and clear LCD visibility. This figure demonstrates the physical product design and user-oriented considerations.

LCD Output Display

Figure 7 shows the LCD output when a valid RFID card is scanned. The display provides immediate feedback by showing the student's name and attendance status, while LED indicators signal successful or failed scans.

Cloud Attendance Record

Figure 8 presents the attendance data stored in Google Sheets. The spreadsheet includes student ID, name, date, and time of attendance. This figure confirms successful real-time data transmission and cloud storage capability.

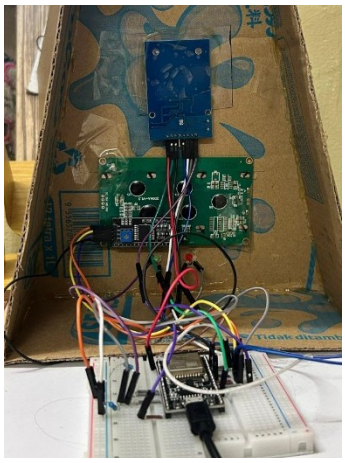

Figure 5 . Hardware

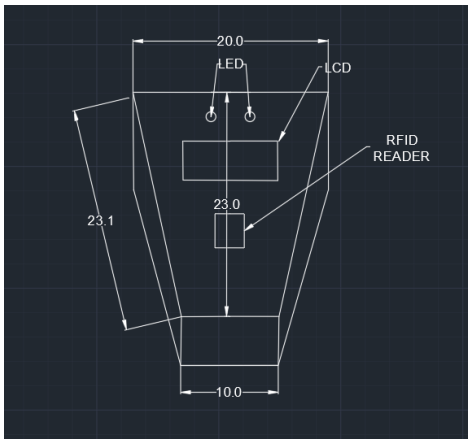

Figure 6. Prototype.

Figure 7. Hardware Output.

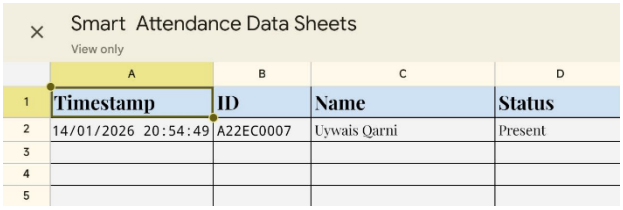

Figure 8. Google Sheets.

3. Novelty and uniqueness

The novelty of this project lies in its integration of RFID technology, ESP32 microcontroller processing, and real-time cloud data storage using Google Sheets. Unlike conventional attendance systems that rely on manual sign-in sheets, this system records attendance digitally and uploads the data instantly through Wi-Fi. This removes the need for manual data entry and reduces the risk of lost or damaged records. Another unique aspect is the complete development process, which includes circuit simulation, hardware implementation, and physical prototype design. This ensures that system functionality, reliability, and user interaction were carefully tested and validated. The inclusion of LCD feedback and LED indicators enhances usability by clearly informing users of successful or failed scans. The project emphasizes practical innovation by using affordable components while delivering a system that is easy to integrate into existing classroom environments. By combining real-time data logging, wireless communication, and user-friendly design, the system offers a modern improvement over traditional attendance methods.

4. Benefits to Mankind

This project benefits society by improving efficiency and accuracy in attendance management within educational institutions. Automated recording using RFID technology reduces time spent on manual attendance taking and minimizes human errors such as incorrect or missing entries. Lecturers can monitor attendance records directly from Google Sheets, enabling better tracking of student participation and academic engagement. The system supports SDG 4: Quality Education by improving administrative efficiency in learning environments. Environmentally, replacing paper attendance sheets with digital records stored online reduces paper consumption, supporting SDG 12: Responsible Consumption and Production. The contactless RFID scanning method also improves convenience and hygiene in shared learning spaces. Overall, the system promotes a more organized, efficient, and environmentally responsible educational environment.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by applying IoT technology, specifically ESP32 microcontroller systems and cloud-based data management, to solve a common administrative challenge in education. It demonstrates how embedded systems, RFID technology, and Wi-Fi communication can be combined into a practical and scalable attendance solution, supporting SDG 9: Industry, Innovation and Infrastructure through the adoption of digital systems in institutional environments . From an entrepreneurial perspective, the system has strong potential as a commercial product for schools, colleges, and training institutions. It creates opportunities for startups to provide system installation, customization of Google Sheets databases, and ongoing technical maintenance. By transforming a traditional manual attendance process into a smart digital system, the project encourages technology-driven entrepreneurship and supports the development of practical engineering solutions within the education sector.

6. Potential Commercialization

The Smart Attendance System has strong commercialization potential in the education sector. Educational institutions such as schools, colleges, tuition centers, and training facilities can adopt the system as a cost-effective RFID-based attendance solution. The product can be marketed as a hardware package that includes the ESP32 microcontroller unit, RFID reader module, display components, and system setup services. Additional services such as cloud database setup using Google Sheets, system customization, and technical support can be offered to increase value. The

use of affordable electronic components allows for low production costs, making large-scale deployment feasible. With further improvements in data security and system scalability, the product can evolve into a comprehensive smart attendance solution for modern educational institutions.

7. Researchers' Biography

Nurmirzani Insyirah binti Muhazam is a Semester 3 Diploma student in Electrical Power Engineering at Universiti Teknologi MARA (UiTM) who is developing her skills in embedded systems and Internet of Things (IoT) applications. She has been learning circuit analysis, power engineering fundamentals, and engineering tools such as AutoCAD, Microsoft Excel, and Python via Google Colab. By learning data management in Excel, she was able to apply similar knowledge using Google Sheets in her project for cloud-based attendance recording.

Nurr Iman Syanaaz Haizal Mohd Rohaiza is a Semester 3 Diploma student in Electrical Power Engineering at Universiti Teknologi MARA (UiTM) who is developing her skills in embedded systems and Internet of Things (IoT) applications. She has gained knowledge in circuit analysis, power engineering fundamentals, and engineering tools such as AutoCAD, Microsoft Excel, and Python using Google Colab. Through learning data management in Excel, she was able to apply the same skills using Google Sheets for cloud-based attendance recording in her project.

Omar Haris bin Adzamee is a Semester 3 Diploma student in Electrical Power Engineering at UiTM. He is learning embedded systems and IoT, and has basic skills in circuit analysis, AutoCAD, Excel, and Python. He applied his Excel knowledge using Google Sheets for cloud-based attendance in his project.

Nor Diyana Md Sin is an Associate Professor in Electrical Engineering at Universiti Teknologi MARA (UiTM), Malaysia. Her research interests include sensor technology, metal oxide semiconductors, and nanotechnology, with a focus on research that contributes to academic advancement and broader societal impact.

Sims-Codrog: Solar-IOT-Based System for Controlled Drying, Roasting, and Grinding of Coffee Beans

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ABSTRACT

This study introduces SIMS-CoDRoG, a Solar-IoT-Based System for the Controlled Drying, Roasting, and Grinding of Coffee Beans, aimed at enhancing coffee quality and production efficiency. Old-fashioned ways of drying beans in the sun are slow, unreliable, and easy to contaminate, which makes the beans less tasty. SIMS-CoDRoG solves these problems by combining solar power with IoT technology to keep an eye on and control important factors like temperature, humidity, and moisture in real time. Within 10 hours, the system reached the perfect moisture level of 10–12%. This is much faster than traditional sun drying, which leaves 27.52% moisture. Tests of grinding performance showed that it could handle 1/2 to 1/4 kg loads in less than 5 minutes. The system also recorded an average response time of 2.19 seconds and 99.63% accuracy for humidity. The user evaluation showed that people liked it a lot, with an average rating of 3.625 (Agree). The fact that SIMS-CoDRoG combines renewable energy with smart monitoring for precise and clean coffee processing is what makes it special. It helps small-scale farmers by providing a cheap, energy-efficient way to grow coffee that is good for the environment and the economy. It also cuts down on losses after harvest. The system has a lot of potential for commercialisation because it is a scalable, environmentally friendly technology that supports smart and sustainable farming in the Philippines.

Keywords: quality of coffee, drying with solar power, IoT-based system, moisture, and sustainable technology

1. Product Description

This study centres on the development of a solar-powered, automated system for coffee drying and quality assurance. The system will use microcontrollers and sensors to control the temperature and humidity for the best drying. This will speed up the process, lower the risk of contamination, and keep the coffee's natural flavour and nutrients. SIMS-CoDRoG: a Solar-IoT-Based System for Controlled Drying, Roasting, and Grinding of Coffee Beans. Powered by solar energy and equipped with sensors and an application, the system monitors and controls temperature, humidity, and moisture in real time to improve efficiency and preserve coffee quality.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

System Architectural Design

Figure 1. Simulated Prototype.

Figure 2. Actual Prototype.

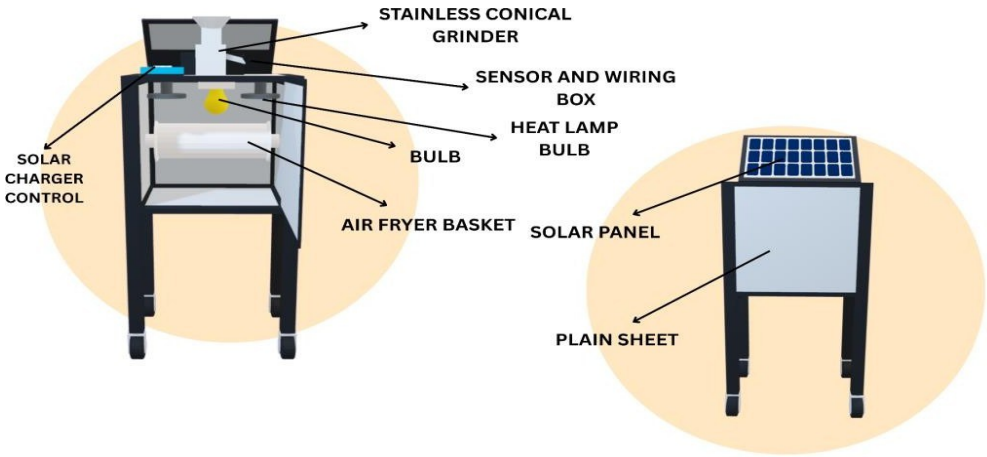

Figure 3. Project Anatomy.

Figures show how the SIMS-CoDRoG prototype works. The system has a stainless steel conical grinder, a heat lamp bulb, an air fryer basket, and an internal bulb to make sure that the heat is evenly spread out and the grinding is always the same. A microcontroller connects to temperature and humidity sensors so that they can be monitored and controlled in real time. The system runs on a solar panel, a charge controller, and a battery, which makes it energy-efficient and good for making coffee in a way that is good for the environment.

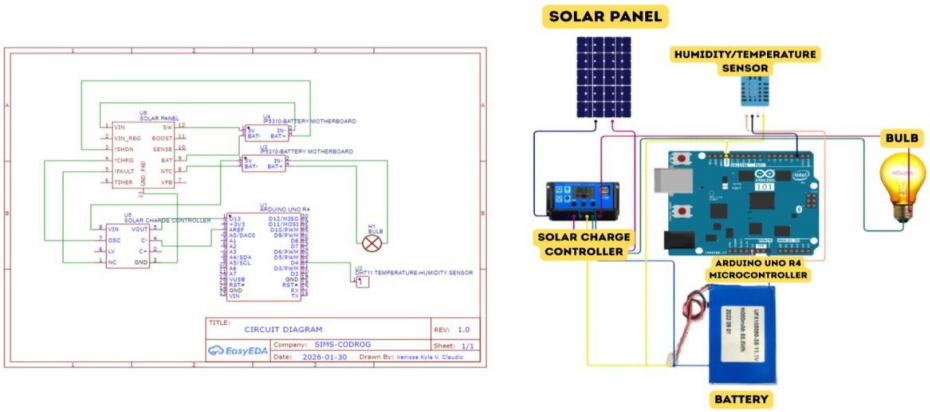

Figure 4. Circuit Diagram.

Figure 4 shows the circuit diagram for the SIMS-CoDRoG system. A solar panel, a battery, and a charge controller work together to power the Arduino Uno R4 microcontroller. The microcontroller gets real-time data from temperature and humidity sensors. It then controls the heat bulb and other parts to make coffee processing automatic and efficient.

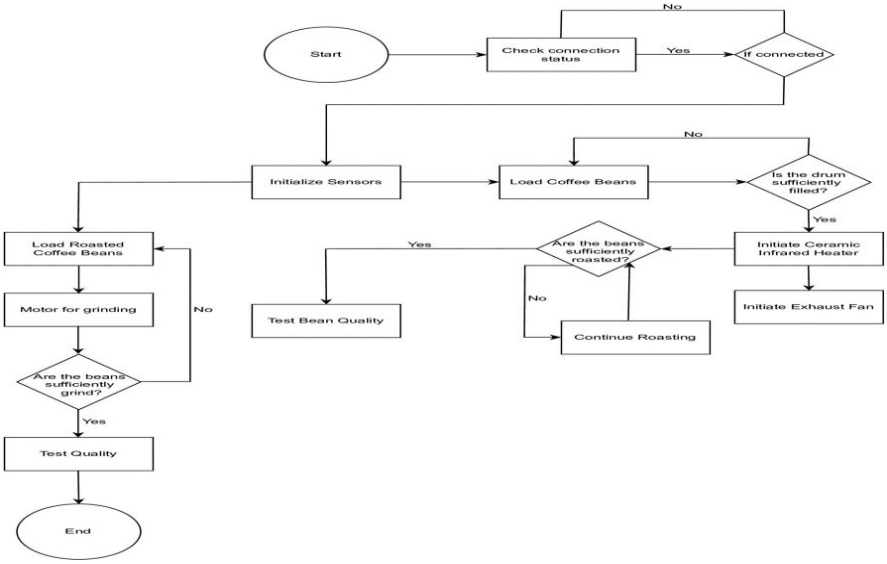

Figure 5. Schematic Diagram.

Figure 5 shows a diagram of how the system works. First, the system checks the sensors and IoT connections. Then, while the coffee is drying and roasting, it keeps an eye on the temperature and humidity. The heater keeps the right temperature while the exhaust fan controls the flow of

air. The beans are moved to the grinder after roasting until the right grind consistency is reached.

3. Results and Discussion

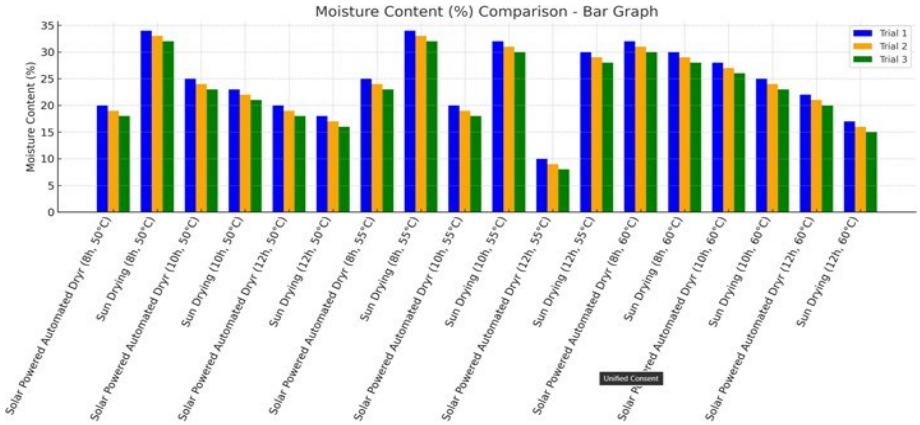

Figure 6. Comparison of Moisture Content Across Different Drying Methods, Drying Duration, and, Temperature Measured in Three Trials.

Figure 6 shows the moisture reduction in coffee beans using the SIMS-CoDRoG system compared with traditional sun drying at different temperatures and drying times. The Solar-IoT-based system consistently achieved lower moisture levels in all trials. For example, at 50°C for 8 hours, moisture decreased to about 18–20%, while sun drying remained higher at 34–37%. At 60°C for 12 hours, the system reached the lowest moisture level of about 5–6%, while sun drying only reduced moisture to about 17–18%. These results show that the SIMS-CoDRoG system is more efficient than traditional sun drying in reducing moisture content. Similar findings by Soeswanto et al. (2021) reported that controlled drying can reduce drying time and energy use while improving efficiency.

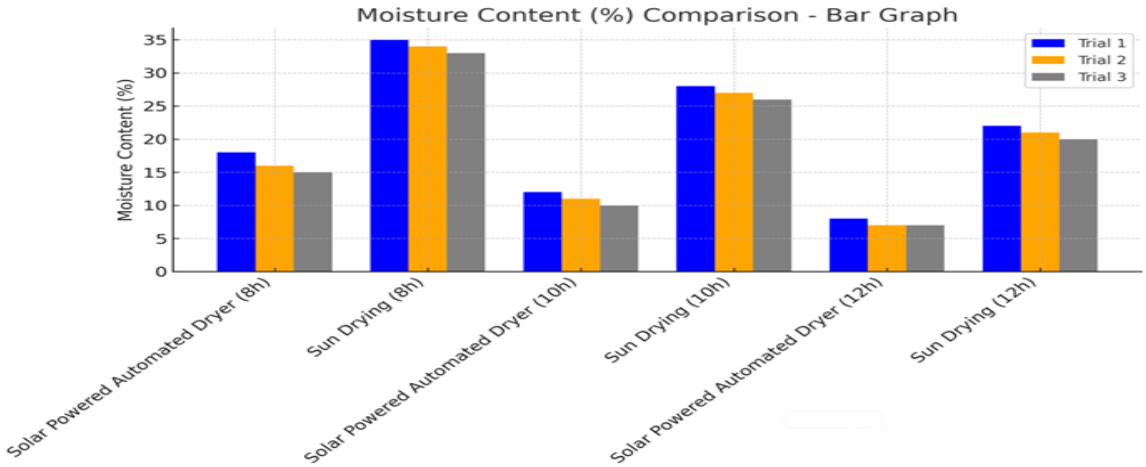

Figure 7. Moisture Content of Coffee Beans between The Solar Powered Automated Dryer and Sun Drying across Three Different Drying Durations in Three Trials.

Figure 7 presents the average moisture content of coffee beans using the Solar-IoT-based system and traditional sun drying over 8, 10, and 12 hours. At 8 hours, both methods produced moisture levels of about 20–22%, with the SIMS-CoDRoG system showing slightly lower values. At 10 hours, moisture temporarily increased due to possible environmental factors. By 12 hours, moisture levels decreased to about 18–20%, with the Solar-IoT-based system still performing better than sun drying. These results indicate that controlled drying systems can improve drying efficiency and reduce processing time compared to traditional methods.

Table 1. Efficiency Result of Temperature Sensor in Coffee Processing.

Task Type	Temperature Sensor (°C)										
	TOTAL TRIALS										
	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Mean
Sorting & Cleaning (0–50 beans)	28.5	28.7	28.6	28.4	28.8	28.9	28.7	28.5	28.6	28.8	28.65
Drying Stage (51–100 beans)	49.2	50.1	49.8	50.3	50.0	49.9	50.2	49.7	50.1	50.0	49.93
Roasting Stage (101–250 beans)	180.5	181.2	180.8	181.5	181.0	180.9	181.3	180.7	181.1	181.4	181.04
Grinding & Brewing (251–400 beans)	92.5	93.1	92.8	93.0	92.7	93.2	92.9	93.1	92.6	93.0	92.89
GRAND MEAN	88.63										

Table 1 presents the raw data on the temperature readings of the Temperature Sensor during various stages of coffee processing. The data is organized according to different task types—Sorting & Cleaning, Drying, Roasting, and Grinding & Brewing—measured over ten (10) trials. Analysis shows that each processing stage significantly affects the sensor's recorded temperature. Specifically, **Table 1**8 indicates that the roasting stage (101–250 beans) reached the highest mean temperature, demonstrating the sensor's responsiveness in monitoring heat during the roasting process. According to Those Coffee People (November 2023) Roasting coffee beans is a precise process with three main stages: drying, caramelization, and development. In the drying stage, green beans with about 10–12% moisture are heated at around 160°C for 4–8 minutes to remove water. **Table 2** presents the raw data on the humidity levels detected by the Humidity Sensor during various stages of coffee processing. The data is organized according to different task types: Freshly Harvested Beans, Drying Stage, Roasting Stage, and Grinding & Brewing Stage measured over ten (10) trials. Analysis shows that the processing stage significantly affects the sensor's

recorded humidity. Specifically, **Table 1**8 indicates that freshly harvested beans exhibited the highest humidity levels, while the roasting stage recorded the lowest, highlighting the sensor's effectiveness in monitoring changes in moisture content throughout the coffee processing cycle. According to Firmansyah, N.M.A., etc. (January 2025) system achieved high accuracy: 97.1% for temperature, 94% for humidity and responded quickly, enabling precise environmental control to improve coffee yields.

Table 2. Efficiency Result of Humidity Sensor in Coffee Processing.

Task Type	Humidity Sensor (%RH)										
	TOTAL TEMPERATURE										
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**Mean**
Freshly Harvested Beans (High Moisture)	68.2	67.9	68.5	67.8	68.1	68.6	67.7	68.3	67.9	6.4	**68.14**
Drying Stage (Moisture Reduction)	38.5	39.1	38.7	39.2	38.8	39.0	38.6	39.9	38.9	39.0	**38.89**
Roasting Stage (Low Moisture Retention)	7.8	8.1	7.9	8.0	8.2	7.7	7.9	8.1	7.9	8.0	**7.95**
Grinding & Brewing Stage (Final Moisture)	13.5	13.8	13.6	13.7	13.9	13.4	13.6	13.8	13.5	13.7	**13.65**
GRAND MEAN	**32.16**										

Table 3. The Grinding Performance of Solar IoT-based Controlled Drying In Terms of Grinding.

Trials within 5 minutes	Weight of Roasted Coffee Beans (kg)	Grind Result
Trial 1	1/4 kg	Medium-Fine Grind
Trial 2	1/2 kg	Medium-Fine Grind
Trial 3	1 kg	Medium Grind
Trial 4	1 1/4 kg	Medium-Coarse Grind
Trial 5	1 1/2 kg	Coarse Grind

Table 3 illustrates the grinding performance of the Solar-IoT-Based System for Controlled Drying, Roasting, and Grinding of Coffee Beans across three trials within a 5-minute duration.

The results show that the system was able to grind different amounts of roasted coffee beans while maintaining varying levels of grind quality. In Trial 1, the system processed 1/4 kg of beans, producing a medium-fine grind. In Trial 2, it handled 1/2 kg, still yielding a medium-fine grind. In Trial 3, the system ground 1 kg, resulting in a medium grind. In Trial 4, the system ground 1 1/4 kg, resulting in a medium-coarse grind. By Trial 5, the system ground 1 1/2 kg, resulting in a coarse grind. These findings demonstrate that the system is capable of handling increasing bean weights within the same time frame, although grind fineness tends to decrease slightly as the load increases. This highlights the system's efficiency and flexibility for small-scale coffee production.

Table 4. Accuracy Application Results.

ACCURACY		
Trials	Results (%)	Display (App)
1	99.60	50.2
2	99.80	50.6
3	99.61	51.2
4	99.61	51.3
5	99.62	51.2
6	99.62	52.7
7	99.81	53.1
8	99.81	53.6
9	99.44	54.3
10	99.63	54.7

Table 4 presents the statistical analysis of the accuracy of SIMS-CoDRoG's application in displaying humidity data compared with actual sensor readings during the drying process of coffee beans. The analysis is organized based on the differences between the sensor's measured values and the application's displayed values across ten (10) trials. The accuracy for each trial was computed using the accuracy formula. If the calculated accuracy values are consistently above 95%, this indicates that the application reliably mirrors the sensor readings with only minimal error. Furthermore, the analysis evaluates possible variations in the accuracy levels across trials to ensure the consistency and dependability of the SIMS-CoDRoG: Solar-IoT-Based System for Controlled Drying, Roasting, and Grinding of Coffee Beans. **Table 5** presents the statistical analysis of the efficiency of SIMS-CoDRoG's application in recording and displaying humidity data during the drying process of coffee beans. The analysis will organize the data based on the time taken by the application to process and display information across ten (10) trials. A one-way Analysis of Variance (ANOVA) will be conducted at a significance level (α) of 0.05 to compare the mean efficiency values across the trials. If the p-value exceeds 0.05 and the critical F-value is greater than the calculated F-value, it will indicate no significant differences among the efficiency results. Furthermore, the analysis will also examine possible variations in the consistency of the application's performance, ensuring the reliability and efficiency of the SIMS-CoDRoG: Solar-IoT-Based System for Controlled Drying, Roasting, and Grinding of Coffee Beans.

Table 5. Efficiency Result Application.

EFFICIENCY	
Trials	Display (Second)
1	2.1
2	2.3
3	2.0
4	2.2
5	2.1
6	2.4
7	2.2
8	2.3
9	2.1
10	2.2
Mean	2.19

Table 6. Evaluation Result of the System's Functionality.

I	Functionality	WM	Interpretation
1.1	The system operates smoothly without frequent errors or interruptions.	3.4	Neutral
1.2	The IoT interface clearly shows drying, roasting, and grinding status.	4	Agree
1.3	The solar power supply is stable and supports continuous operation.	3.6	Agree
1.4	The system performs reliably under different conditions (e.g., varying weather).	3.5	Agree
	WM TOTAL	**3.625**	**Agree**

Legend: 4.21 – 5.00 (Strongly Agree), 3.41 – 4.20 (Agree), 2.61 – 3.40 (Neutral), 1.81 – 2.60 (Disagree),1.00 – 1.80 (Strongly Disagree)

Table 6 presents the results of the system's functionality, showing a weighted mean of 3.625, which indicates that the respondents "Agree" that the system is capable of providing functions that meet the stated and implied needs of the users under the specified conditions of use. The system was able to perform the required tasks, such as receiving input data and processing information.

4. Novelty and uniqueness

SIMS-CoDRoG stands out as an innovative coffee processing system due to its advanced and sustainable features. It uses solar energy, which helps lower operational costs while promoting environmental sustainability and reducing dependence on traditional electricity sources. This

makes the system suitable for rural and farming communities. SIMS-CoDRoG also integrates drying, roasting, and grinding into one automated machine, eliminating the need for multiple equipment and improving efficiency, space utilization, and time management. The system is equipped with IoT sensors that enable real-time monitoring of important processing data such as temperature, moisture level, and duration, ensuringconsistent and high-quality output. In addition, accurate processing information is delivered through a digital or mobile application, allowing users to easily track operations and make informed decisions. Compared to traditional coffee processing systems that rely on separate machines and manual labor, SIMS-CoDRoG provides a unified, smart, and efficient solution that enhances productivity, supports sustainability, and modernizes the coffee processing industry.

5. Benefit to mankind

The goal of this project is to give small-scale farmers an affordable, efficient, and easy-to-use system that boosts productivity and cuts down on losses after harvest.

a. **Coffee Farmers and Producers**. The system automates drying and grinding while monitoring moisture and temperature. This results in more consistent coffee quality, reduced labor, and improved productivity and profit.
b. **Consumers.** Improved processing ensures better-tasting and safer coffee products. Consistent bean quality leads to a more satisfying cof fee experience.
c. **Government.** The study supports the advancement of smart farming practices. It helps improve local coffee production, reduce waste, and contribute to economic development.
d. **Researchers.** The researchers gain practical experience in developing IoT- based and sensor-driven systems. This strengthens their skills in creating real-world technological solutions.
e. **Future Researchers.** This study can serve as a useful reference for future research in agriculture and technology.

6. Innovation and Entrepreneurial Impact

This innovation contributes to a culture of entrepreneurship by providing small-scale farmers with affordable, high-tech solutions that increase productivity, reduce post-harvest losses, and enhance the value of their coffee beans. This project contributes to the following communities, institutions, and industries:

a. **Agricultural Sector.** Small-scale coffee farmers, agricultural cooperatives, and local producers in coffee-growing regions.
b. **Technology and Engineering.** Innovators and engineers working in the field of IoT, renewable energy, automation, and system integration.
c. **Environmental Sustainability.** Communities and organizations focused on sustainable farming practices and renewable energy solutions.
d. **Research and Development.** Institutions involved in agricultural research, especially in the areas of smart farming and sustainable technologies.
e. **Local Government and NGOs:** Institutions working on rural development, agricultural modernization, and community empowerment.
f. **Educational Institutions:** Universities and vocational training centers offering courses in agriculture, engineering, and environmental studies.

7. Potential commercialization

The SIMS-CoDRoG project offers coffee farmers and community members a sustainable, cost-effective alternative to traditional drying methods. By providing a low-cost, durable solution, it empowers small-scale farmers to enhance their coffee production efficiency while maintaining the quality of their beans. The system is designed to be affordable, reducing the reliance on expensive commercial drying equipment. Its long-lasting nature ensures that farmers can continue to benefit from the technology over time, improving productivity and reducing post-harvest losses. As a scalable solution, SIMS-CoDRoG has the potential for widespread adoption in local farming communities, helping to elevate the overall quality and competitiveness of locally produced coffee. This makes it a viable product for commercialization, with opportunities for partnerships with agricultural cooperatives, government programs, and coffee industry stakeholders who aim to promote sustainable farming practices and improve the livelihoods of farmers.

8. Acknowledgment

First and foremost, we would like to thank God for His guidance, strength, and wisdom throughout the completion of this research. Without His blessings, this study would not have been possible. All glory to Him, for guiding us in every step of this journey. We would like to thank our research advisor, Nelson B. Malificiado, from the bottom of our hearts for his help, patience, and helpful advice. His constant support and encouragement helped us finish this research and do it well. We are also very grateful to our consultant, Zeavier Benz Cabanban, for sharing his knowledge and giving us helpful tips that helped us make our study better. We also want to thank Engr. Eugene N. Pancho, who helped us stay on track with our research and guided us through the whole process. We would like to thank Ava Marie Odal, the Manager of Coffee Grower Association Inc., from the bottom of our hearts for helping us check our study and sharing her knowledge, which was a huge help in making sure our research was correct. We are also thankful to Mr. and Mrs. Casabal for their help in checking the data for our study and for their valuable support. We are very grateful to Venisse Kyle V. Claudio for helping us with the paper, giving us advice, and helping us meet all the requirements. Your help made the process smoother and more organized. Finally, we'd like to thank Althea S. Sariego for believing in us and always cheering us on and pushing us to do our best along the way. Your words of support gave us the strength to keep going and do our best. We are very grateful to everyone who helped with this research in any way. This study would not have been possible without your help and cooperation.

9. Researchers' Biography

Lemuel D. Calamba is a senior high school student enrolled in the Science, Technology, Engineering, and Mathematics (STEM) strand. He has demonstrated excellence in robotics and is a certified first aider. He actively participates in extracurricular activities that further develop his academic knowledge and technical skills. In 2025, he attained national recognition by winning multiple awards at the National Robotics Competition (NRC) in the Philippines, highlighting his proficiency in innovation, collaboration, and practical application of STEM concept

Sophia R. Duyo is a senior high school student from Tupi National High School, currently enrolled in the Science, Technology, Engineering, and Mathematics (STEM) strand. She has been a consistent honor student since ninth grade, showing strong dedication to her academic responsibilities. Sophia is known for her discipline and commitment to learning. Beyond the classroom, she actively participates in extracurricular activities that enhance her skills. In 2025, she proudly represented her school by participating in the National Robotics Competition in the Philippines, gaining valuable experience in teamwork and innovation.

Rheyanne D. Fedrequilan is a dedicated STEM student from Tupi National High School, recognized for her consistent academic excellence and strong leadership skills. She has been an honor student from seventh grade up to the present, demonstrating commitment, discipline, and a passion for science and innovation. As a STEM learner, she actively engages in research and technology activities. In 2025, she achieved national recognition after winning the National Robotics Competition in the Philippines. Her research studies have earned multiple awards at both national and international levels, reflecting her perseverance, creativity, and a promising future in science and technology.

Kristina Cassandra P. Caresma is a STEM student from Tupi National High School, known for her outstanding leadership abilities and steady academic success. Since junior high school, she has consistently received honors, demonstrating dedication, self-control, and a deep love of science and innovation. As a STEM learner, she actively participates in research and technology-related activities. She has joined several research competitions and placed second in the Philippines' National Robotics Competition. She is also the leader of their research project, showing strong leadership skills in guiding her team and organizing their work. In addition, she was the one who first discovered and developed the idea for their research project, which highlights her creativity and initiative. Her accomplishments demonstrate her perseverance, inventiveness, and determination to build a bright future in science and technology.

From Waste Cooking Oil to High-Performance Coating: A UV LED Curable Epoxy Acrylate Innovation

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ABSTRACT
This study presents a sustainable UV-curable epoxy acrylate coating synthesized from waste palm cooking oil (WPCO), offering a high-value "waste-to-wealth" solution to a pervasive environmental pollutant. To functionalize the waste oil, WPCO first underwent epoxidation using hydrogen peroxide and formic acid, introducing reactive oxirane rings. These epoxidized intermediates were then acrylated to form epoxy acrylate oligomers (EAWPCO), creating a bio-based resin suitable for UV crosslinking. This EAWPCO resin was formulated with reactive diluents and cured efficiently under UV LED light, an energy-saving technology that also lead to zero volatile organic compound (VOC) emissions. The optimized coating formulation demonstrated superior performance, including high crosslinking density (gel content >90%), enhanced surface hydrophobicity (water contact angle >90°), and excellent chemical resistance. By integrating a two-step chemoenzymatic modification with green UV LED curing, this work establishes a scalable pathway to transform waste oil into high-performance, industrially viable epoxy acrylate coatings. The innovation aligns with circular economy principles, reducing environmental pollution while providing a competitive, sustainable alternative to petroleum-based coatings for various industrial applications.

Keywords: UV LED, Curable Coating, Waste Palm Cooking Oil, Epoxidation, Green Technology

1. Product Description
This research pioneers the development of a high-performance, UV LED-curable epoxy acrylate resin coating synthesized from waste palm cooking oil (WPCO), an abundant and low-cost renewable resource in Malaysia. The process involves a precise two-step chemical transformation: first, WPCO undergoes epoxidation using hydrogen peroxide and formic acid to create reactive oxirane rings; these intermediates are then acrylated to yield a novel bio-based epoxy acrylate oligomer (EAWPCO). This synthesized EAWPCO acts as a green, multifunctional oligomer that is formulated with reactive diluents and photoinitiators to create a sustainable photopolymer resin. The formulation cures rapidly and efficiently under UV LED light, a technology renowned for its low energy consumption, reduced heat output, and minimal emission of volatile organic compounds (VOCs), ensuring an environmentally benign manufacturing process. The left side of **Figure 1** below represents the uncured system, consisting of EAWPCO

oligomer/prepolymers (orange circles), reactive monomers (green crosses), and photoinitiators (yellow diamonds). Upon UV LED exposure for 5 minutes, the photoinitiators generate reactive species either free radicals or cationic (strong acid) that initiate polymerization, forming a crosslinked cured EAWPCO network. The study investigates the influence of various reactive monomers (with di-, tri-, and tetra-functional acrylates) and photoinitiator systems on the final coating's performance. The resulting EAWPCO-based coatings are engineered to exhibit superior properties, including enhanced crosslink density, exceptional chemical and solvent resistance, improved adhesion, and high surface hydrophobicity. Compared to conventional petroleum-based epoxy acrylates, this innovation offers a unique combination of sustainability, cost-effectiveness, and competitive performance, making it an ideal eco-friendly alternative for demanding industrial applications such as protective metal coatings, electronic encapsulants, and high-durability wood finishes.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

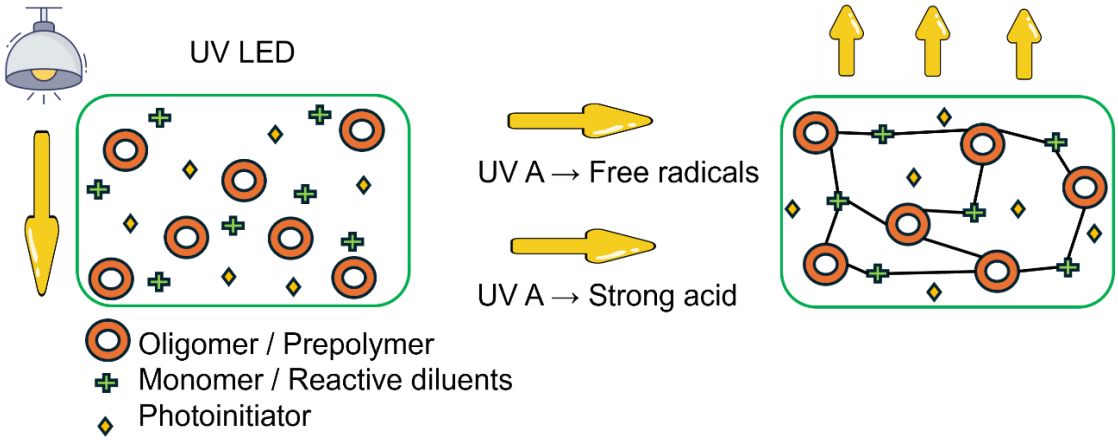

Figure 1. UV LED Curing Reaction Sequence to produce Solid AEWPCO Coating.

3. Novelty and uniqueness

This research uniquely develops Epoxy Acrylate from Acrylated Epoxidized Waste Palm Cooking Oil (AEWPCO), creating a high-performance, sustainable resin. The novel two-step synthesis transforms WPCO through epoxidation and acrylation, creating a highly reactive bio-based resin optimized for rapid, energy-efficient UV LED curing. This process displaces fossil-fuel-derived acrylic and epoxy resins with a renewable, locally sourced alternative, directly reducing the carbon footprint of the coatings industry. UV LEDs operate at room temperature and convert electricity to light with high efficiency, reducing energy use by up to 70% compared to thermal curing. The 100% solid-content formulation eliminates solvents, and the rapid, low-temperature cure prevents VOC release. This innovation directly addresses a critical national issue, as Malaysia the world's second-largest palm oil producer can transform its abundant WPCO from a persistent disposal problem into a valuable resource for advanced, sustainable coatings. The resulting coatings offer superior properties, including excellent chemical resistance and adhesion. This innovation's core uniqueness lies in its dual valorization: solving an environmental waste problem while creating a high-value, industrial product that supports a circular and green economy.

4. Benefit to mankind

This innovation delivers profound societal and environmental benefits. It tackles pollution by diverting toxic waste oil from waterways and landfills, leading to cleaner ecosystems and improved public health. By creating a high-performance, bio-based coating, it reduces reliance on fossil fuels, lowering the carbon footprint of the manufacturing sector and combating climate change. This effort directly supports key UN Sustainable Development Goals (SDGs), including Climate Action (SDG 13), Responsible Consumption and Production (SDG 12), and Industry, Innovation, and Infrastructure (SDG 9). The technology fosters a circular economy, transforming a waste burden into economic opportunity through green job creation and sustainable industry growth. Furthermore, the resulting non-toxic, solvent-free coatings contribute to safer indoor air quality and safer workplaces.

5. Innovation and Entrepreneurial Impact

This project fosters a powerful culture of innovation and entrepreneurship by demonstrating a viable, green chemical pathway that turns a low-value waste stream into a high value industrial product. It promotes technological innovation through its novel, patentable synthesis process, establishing a new benchmark for sustainable coating resins. This creates a direct commercialization pathway for startups and spin-offs to develop eco-friendly coating products, stimulating green job creation and attracting investment into the circular economy. Within the institution, it serves as a premier case study for interdisciplinary collaboration and can be integrated into entrepreneurial curricula to inspire the next generation of sustainability-driven entrepreneurs. By validating a market for AEWPCO, it incentivizes local collection and recycling initiatives, empowering communities and transforming environmental liability into an engine for economic and innovative growth.

6. Potential commercialization

This innovation has strong commercial potential, specifically for cost-competitive wood coatings and protective conformal coatings for electronics. The core value proposition is a significantly lower price point, achieved by using waste feedstock and the ultra fast, energy efficient UV LED curing process that reduces factory footprint and production time. For price-sensitive buyers, this offers a direct economic advantage. Furthermore, it directly supports corporate Environmental, Social, and Governance (ESG) goals by providing a sustainable product that reduces carbon emissions and waste, enhancing brand value and meeting stricter environmental regulations without a cost premium. This combination of low cost, high performance, and strong ESG alignment creates a compelling market entry strategy for green building materials and electronics protection.

7. Acknowledgment

The authors greatly thank to Kementerian Pengajian Tinggi (KPT) Malaysia for the funding.

8. Researchers' Biography

Munirah Onn is a full time PhD student at Faculty of Chemical and Energy Engineering Universiti Teknologi Malaysia (UTM). She is also working as Senior Lecturer at Universiti Teknologi MARA (UiTM), Kampus Pasir Gudang which receives a Science Degree from Universiti Teknologi MARA (UiTM) and Science Master's Degree from UTM. During the study she received a Best Degree Student, Best Thesis Writing and Vice Chancellor Award from UiTM and Best Student for Master Programme from UTM. She has industrial work experience as a Production Engineer, Research Officers and Executive Chemist for 4 years. Her current research interest is in renewable and advanced materials.

Prof. Dr. Mat Uzir Wahit is a distinguished scholar specializing in polymer and composite materials, particularly in the areas of natural fiber composites, polymer nanocomposites, and biodegradable materials. Prof. Wahit is currently a Dean and Professor in the Faculty of Chemical and Energy Engineering at UTM, where he also serves as Deputy Dean (Research, Innovation and Development). Prof. Wahit's research emphasizes sustainable materials and innovative composite technologies, including natural and silk fiber-reinforced epoxy composites, and cellulose nanocomposites. He is also affiliated with Advanced Composite Materials (CACM), where he contributes extensively to the centre. His extensive publication record includes over 100 peer-reviewed papers and conference proceedings, reflecting his contributions to advancing material science.

Aznilinda Zainuddin obtained both her bachelor's degree and master's degree in electrical engineering from Universiti Teknologi MARA (UiTM), Shah Alam, Malaysia. Her research activities are centered on engineering education, inventive problem-solving, and space weather. Currently, she is completing her PhD studies in UiTM. Her research expertise is on Fabrication, Nanofabrication, Sensor Development, Thin films and Nano Technology, Titaniums, and Nano Electronics. She has a working experience in Western Digital (M) Sdn Bhd for 3 years and in Agilent Technologies (M) Sdn Bhd for 4 years. Her current research interest is on inventive problem solving and machine learning on space weather.

Mazleenda Mazni has completed her Ph.D. at Universiti Teknologi Malaysia (UTM), focusing on deep learning models for structural health monitoring, particularly in surface crack classification and measurement. Prior to her academic career, she gained industry experience as an engineer in manufacturing companies. Currently, she serves as a Senior Lecturer at Universiti Teknologi MARA (UiTM), Pasir Gudang Campus. Her research expertise encompasses control applications in dynamic systems, network control systems, mechatronics, and artificial intelligence.

MagTrack IoT

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ABSTRACT

MagTrack IoT is an innovative solar-powered monitoring system designed to track magnetic field variations in remote and off-grid environments. The device integrates a Hall effect magnetometer, temperature and humidity sensors, and an ESP32 microcontroller with built-in Wi-Fi, enabling real-time data transmission via a cloud-based platform. This solution addresses the growing need for cost-effective and reliable magnetic field monitoring, especially in areas where traditional systems fall short due to their reliance on conventional power sources and complex infrastructure. The system operates autonomously, utilizing renewable solar energy to minimize maintenance and reduce dependence on external power. The prototype demonstrates the capability to detect subtle magnetic fluctuations, offering valuable data for applications such as infrastructure safety, space weather monitoring, and geophysical studies. With its affordable, scalable design, and energy- efficient operation, MagTrack IoT presents a viable solution for industries such as geophysical research, environmental monitoring, and industrial applications, aligning with sustainable energy goals and promoting improved operational efficiency.

Keywords : Solar monitoring, Magnetic sensing, IoT system, Sustainability, Remote monitoring

1. Product Description

MagTrack IoT is a compact, solar-powered device designed to monitor magnetic field variations continuously and autonomously, making it ideal for remote and off-grid environments. This product integrates an affordable hall effect magnetometer, temperature and humidity sensors, and an ESP32 microcontroller with built-in Wi-Fi connectivity. These features enable real-time data acquisition and remote monitoring via a cloud-based IoT platform. As the need for reliable and cost-effective magnetic field monitoring grows, particularly in remote locations, traditional systems often fall short due to their reliance on conventional power sources and complex infrastructure. Moreover, industries such as geophysical research, space weather monitoring, and industrial applications demand continuous, real-time monitoring of magnetic fluctuations for safety, operational efficiency, and accurate data analysis. The absence of an affordable and scalable solution limits the ability to monitor environmental conditions, detect geomagnetic anomalies, and ensure the safety of critical infrastructure. To address these challenges, MagTrack IoT offers a renewable, energy-efficient solution that operates entirely on solar power, removing the dependence on conventional energy sources. The system is designed to test the functionality of magnetic field detection using the HMC5883L hall effect sensor, integrated with temperature and humidity sensors, and linked to a mobile application for real-time data transmission. This preliminary study will evaluate the system's functionality, focusing on its ability to autonomously monitor and transmit data through IoT connectivity.

2. The MagTrack IoT Prototype

The MagTrack IoT system prototype is illustrated in **Figure 1**, which shows the physical implementation of the monitoring device. The prototype integrates several key components including a hall effect magnetometer sensor, temperature and humidity sensors, an ESP32 microcontroller, a solar power unit, and an LCD display within a compact structure. The prototype demonstrates the practical implementation of the proposed monitoring device, highlighting its portable and modular design. The solar-powered configuration enables autonomous operation in remote or off-grid environments, while the ESP32 microcontroller facilitates wireless communication with the cloud platform for real-time data transmission. This configuration ensures continuous environmental monitoring with minimal maintenance requirements.

Figure 1. The MagTrack IoT prototype.

As depicted in **Figure 2**, the magnetic field variation data recorded by the MagTrack IoT prototype is presented. The data is recorded on Google Sheet reflects real-time measurements captured by the magnetometer sensor and transmitted through the IoT communication system. These recorded values demonstrate the ability of the prototype to detect subtle changes in magnetic field intensity that may occur due to environmental factors or nearby electrical activities. The magnetic variation trend is further illustrated in **Figure 3**, where the collected data is presented in graphical form. This visual representation enables users to easily observe patterns, fluctuations, and potential anomalies in the magnetic field over time. Such graphical visualization enhances data interpretation and supports more effective monitoring of environmental conditions. In addition, the plotted trend may assist users or authorities in identifying abnormal magnetic disturbances at an early stage, thereby supporting proactive monitoring and infrastructure safety management.

1	Date	Time	# X-axis (G)	# Y-axis (G)	# Z-axis (G)
2	2026-01-19	1:45:05 PM	0.384	0.586	0.137
3	2026-01-19	1:44:52 PM	0.45	0.609	0.19
4	2026-01-19	1:44:38 PM	0.469	0.543	0.137
5	2026-01-19	1:44:23 PM	0.466	0.553	0.149
6	2026-01-19	1:44:10 PM	0.477	0.542	0.149
7	2026-01-19	1:43:55 PM	0.448	0.549	0.152
8	2026-01-19	12:47:47 PM	0.467	0.56	0.19
9	2026-01-19	12:47:34 PM	0.466	0.564	0.198
10	2026-01-19	12:47:21 PM	0.462	0.553	0.198
11	2026-01-19	12:47:07 PM	0.463	0.561	0.203
12	2026-01-19	12:46:54 PM	0.467	0.567	0.2
13	2026-01-19	12:46:41 PM	0.466	0.565	0.187
14	2026-01-19	12:46:27 PM	0.477	0.564	0.202
15	2026-01-19	12:46:14 PM	0.485	0.567	0.195
16	2026-01-19	12:46:00 PM	0.485	0.553	0.209
17	2026-01-19	12:45:46 PM	0.494	0.549	0.225

Figure 2. Magnetic variation data recorded from the prototype.

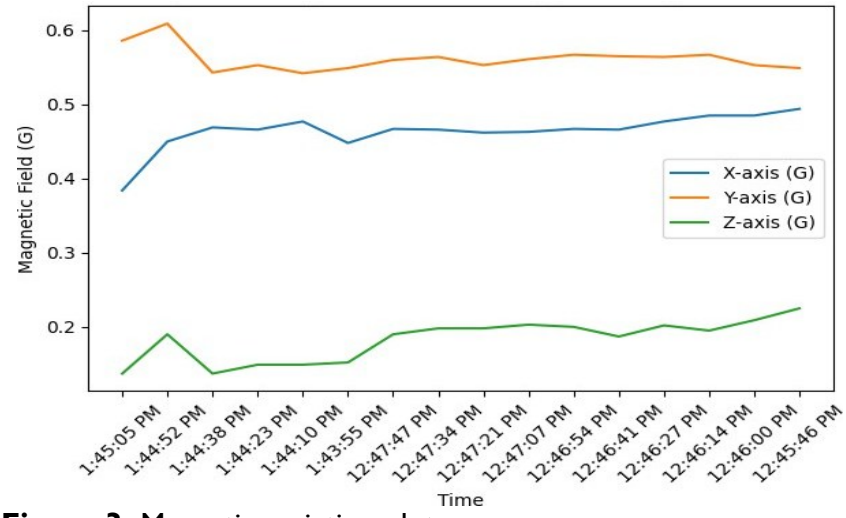

Figure 3. Magnetic variation plot.

3. Novelty and uniqueness

MagTrack IoT offers a unique solution for continuous, solar-powered magnetic field monitoring in remote environments. Unlike traditional systems, it operates autonomously without the need for external power sources, making it ideal for off-grid locations. The integration of the HMC5883L Hall effect sensor with temperature and humidity sensors in a single, compact device allows for comprehensive environmental monitoring. Its cost-effective design, combined with

energy efficiency, scalability, and real-time data transmission via a mobile app, ensures accessibility for both commercial and institutional users. This innovation provides a versatile, easy-to-deploy solution for industries such as geophysical research, space weather monitoring, and industrial applications, enabling enhanced safety, operational efficiency, and data-driven decision-making.

4. Benefit to mankind

MagTrack IoT offers a valuable solution that directly contributes to SDG 9 (Industry, Innovation, and Infrastructure) and SDG 7 (Affordable and Clean Energy) through its innovative, renewable energy-powered magnetic field monitoring system. The device detects fluctuations in magnetic field strength, supporting a variety of applications such as infrastructure monitoring, environmental assessment, and detection of anomalies like geomagnetic storms or underground structures. In geophysical studies, it aids in understanding geological features, detecting mineral deposits, monitoring tectonic activity, and even supporting archaeological research. In space weather monitoring, MagTrack IoT tracks magnetic field variations caused by solar wind and geomagnetic storms, which can disrupt satellite operations, communication systems, and power grids on Earth. Additionally, it supports industrial applications by monitoring key systems like power transmission lines and MRI machines. Its reliable performance in remote areas, powered entirely by solar energy, reduces the need for conventional energy sources, thus aligning with SDG 7, promoting affordable and clean energy while supporting the safety and efficiency of critical infrastructure across sectors.

5. Innovation and Entrepreneurial Impact

MagTrack IoT represents a significant innovation in the field of magnetic field monitoring, combining sensors technology, renewable energy, and IoT connectivity into a single, cost-effective solution. Its ability to autonomously detect magnetic field variations in remote, off-grid environments opens new opportunities for industries such as geophysical research, space weather monitoring, and infrastructure safety. By addressing the gap in affordable, scalable monitoring systems, it empowers entrepreneurs and organizations to deploy reliable monitoring solutions in areas where traditional systems are impractical. From an entrepreneurial perspective, MagTrack IoT's low production cost, ease of deployment, and energy-efficient design make it an attractive product for commercial markets. Its scalable architecture enables applications across various sectors, providing immense potential for growth and expansion. As a sustainable solution, it encourages innovation in environmental monitoring while promoting clean energy use, contributing to both economic growth and long-term sustainability.

6. Potential commercialization

MagTrack IoT has strong potential for commercialization, offering a unique, cost-effective solution for continuous magnetic field monitoring in remote and off-grid locations. Its integration sensors connectivity makes it an attractive option for industries such as geophysical research, space weather monitoring, infrastructure safety, and industrial applications. The device's flexible design and scalable structure open opportunities for deployment in various sectors, including environmental monitoring, smart facility management, and security. The product's low production cost and energy-efficient operation may provide a competitive advantage in markets where traditional monitoring systems are expensive and maintenance-heavy. Additionally, MagTrack IoT's real-time data transmission through mobile apps and cloud platforms ensures ease of access and long-term usability. These features make it an ideal candidate for widespread adoption across

institutional, governmental, and commercial markets. As demand for reliable, renewable energy-powered solutions grows, MagTrack IoT has the potential to become a key player in global monitoring systems.

7. Acknowledgment

The authors would like to express sincere appreciation to Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM) for providing the facilities, guidance, and support throughout the development of this project.

8. Researchers' Biography

Muhammad Ateef Saroni is a diploma student in Electrical Engineering at Universiti Teknologi MARA (UiTM), Pasir Gudang. Passionate about innovation and technology, he is actively developing his skills in integrating smart systems. His dedication to learning reflects his commitment to excelling in the field of engineering.

Aznilinda Zainuddin obtained both her bachelor's degree and master's degree in electrical engineering from Universiti Teknologi MARA (UiTM), Shah Alam, Malaysia. Her research activities are centred on engineering education, inventive problem-solving, and space weather. Currently, she is a PhD student, and research focuses on the development of prediction models for geomagnetically induced current.

Dr. Zatul Iffah Abd Latiff completed her PhD at Universiti Teknologi MARA (UiTM) with a research focus on Space and Earth Electromagnetism. She obtained her Bachelor of Engineering in Electrical Engineering from Korea University, South Korea, in 2010, and her Master of Science in Telecommunication and Information Engineering from UiTM in 2013. She is a co-researcher in the MAGDAS (Magnetic Data Acquisition System) network, responsible for monitoring and maintaining a MAGDAS observatory in Johor, Malaysia. Her research interests include geomagnetically induced currents, space weather, ionospheric currents, Earth's electromagnetism, and ground magnetic and satellite data analysis

Automated Traffic Light Priority System for Ambulance Using Siren Detection

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ABSTRACT

Delays in emergency response due to traffic congestion pose critical safety risks. This project presents a real-time Sound Siren Detection System designed to prioritize emergency vehicles, particularly ambulances, at intersections. Developed using an ESP32 microcontroller and a microphone module, the system employs acoustic analysis to detect siren ambulance and give priority to emergency vehicle. Upon validating a siren signature, the system automatically overrides the traffic signal to Green, activates an LCD warning, and triggers an alert indicator to clear the path. A built-in timing mechanism ensures the traffic lights revert to standard operation once the vehicle passes. Aligned with Intelligent Transportation Systems (ITS), this affordable and scalable solution aims to significantly reduce response times and prevent intersection accidents caused by human error. This innovation serves as a vital proof of concept for integrating acoustic recognition into smart city infrastructure, enhancing both road safety and urban efficiency.

Keywords: Traffic Light, Ambulance, Priority, Siren Detection, Alert Indicator

1. Product Description

The Hospitality Traffic Control system is a specialized smart infrastructure solution designed to prioritize emergency access at critical zones, particularly hospital entrances. The prototype integrates hardware and software components, comprising an ESP32 microcontroller, a high-sensitivity microphone sensor module, and a relay-controlled traffic light interface. The core functionality relies on continuous real-time acoustic monitoring. The system analyzes environmental sound frequencies to detect specific ambulance siren signatures. To ensure reliability and minimize false positives, the algorithm includes a validation window of 5–7 seconds before confirming an emergency event. Upon verification, the system automatically triggers the relay module to switch the traffic signal to Green for the approaching vehicle while halting other lanes. Simultaneously, the system leverages the Blynk IoT platform for remote connectivity. This allows hospital administrators or facility managers to monitor traffic status and siren detection logs in real-time via a mobile dashboard. By combining sound recognition automation with IoT feedback, this product offers a scalable, intelligent solution for "Smart Hospitality Zones," significantly reducing ambulance response delays and enhancing safety in high-traffic medical environments.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

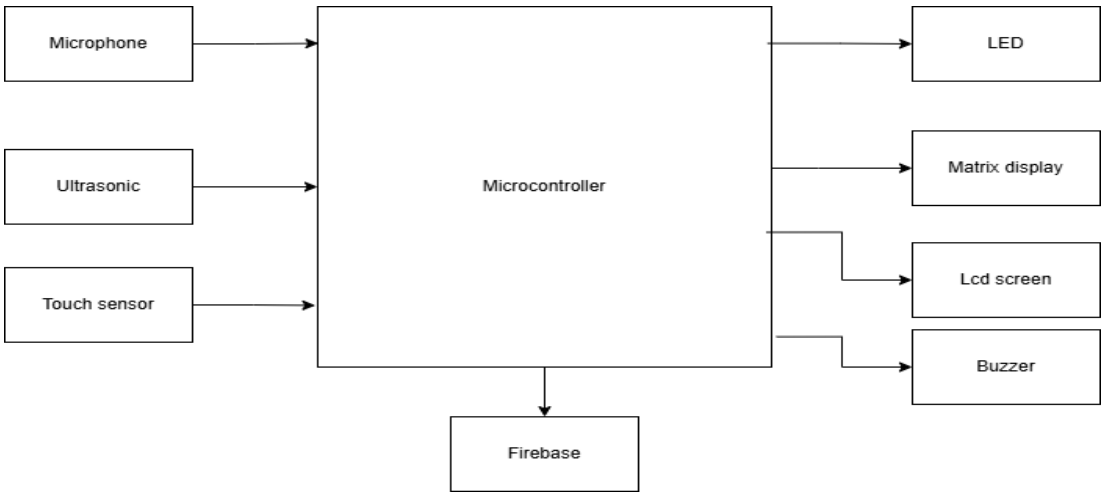

Figure 1. Block diagram Automated Traffic Light Priority System For Ambulance Using Siren Detection.

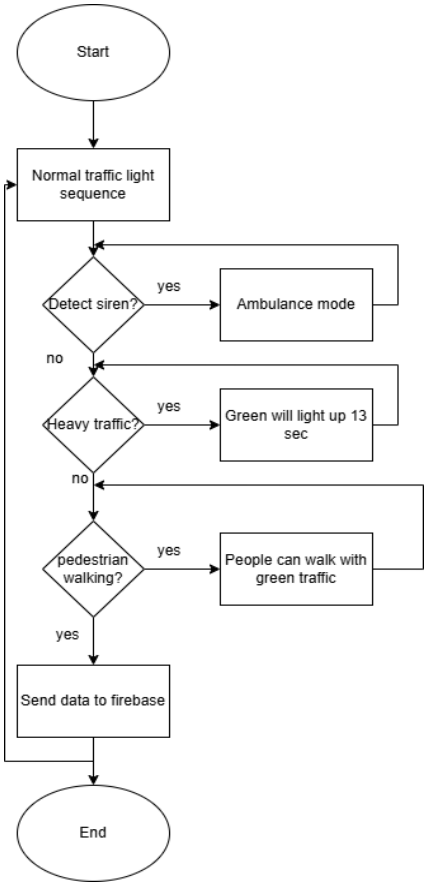

Figure 2. Flow Chart Automated Traffic Light Priority System For Ambulance Using Siren Detection.

Figure 1 shows the system operation of a sound-based project using a microcontroller. The microphone detects sound which is sound from siren ambulance from the traffic and sends the signal to the microcontroller. The touch sensor is used to activate the system that will consider to pedestrian . It decide by user according to particular situational. Once the microcontroller receives the input signals, it processes the traffic light whether it is siren of ambulanced triggers specific outputs like LED of traffic light and buzzer. If the sound level meets with ambulance sound, the buzzer produces an alert sound, the LED lights up ,with green light and the LCD displays a message or value that said "Ambulance Mode" if there are any ambulance . The system also connects to firebase for live monitoring through a mobile device or laptop far from that project. **Figure 2** illustrates the step-by-step process of how the sound detection system works using an Arduino microcontroller. The process begins when the switch button is pressed, which activates the system and powers on the microphone. The microphone then starts detecting sound from the traffic and sends the signal to the Arduino for processing. If the sound is low than 600 the light of the traffic light will remain same as normal. LCD will display colour of the traffic light with input of the sound simultaneously. When the input of the sound is more than 600 and lower than 900 with continuously for 5 seconds the buzzer will be triggered. Not only that, green light from the traffic light also will light up at the same time. After this happen, ambulance and the others car can pass through traffic light without accident and more safe

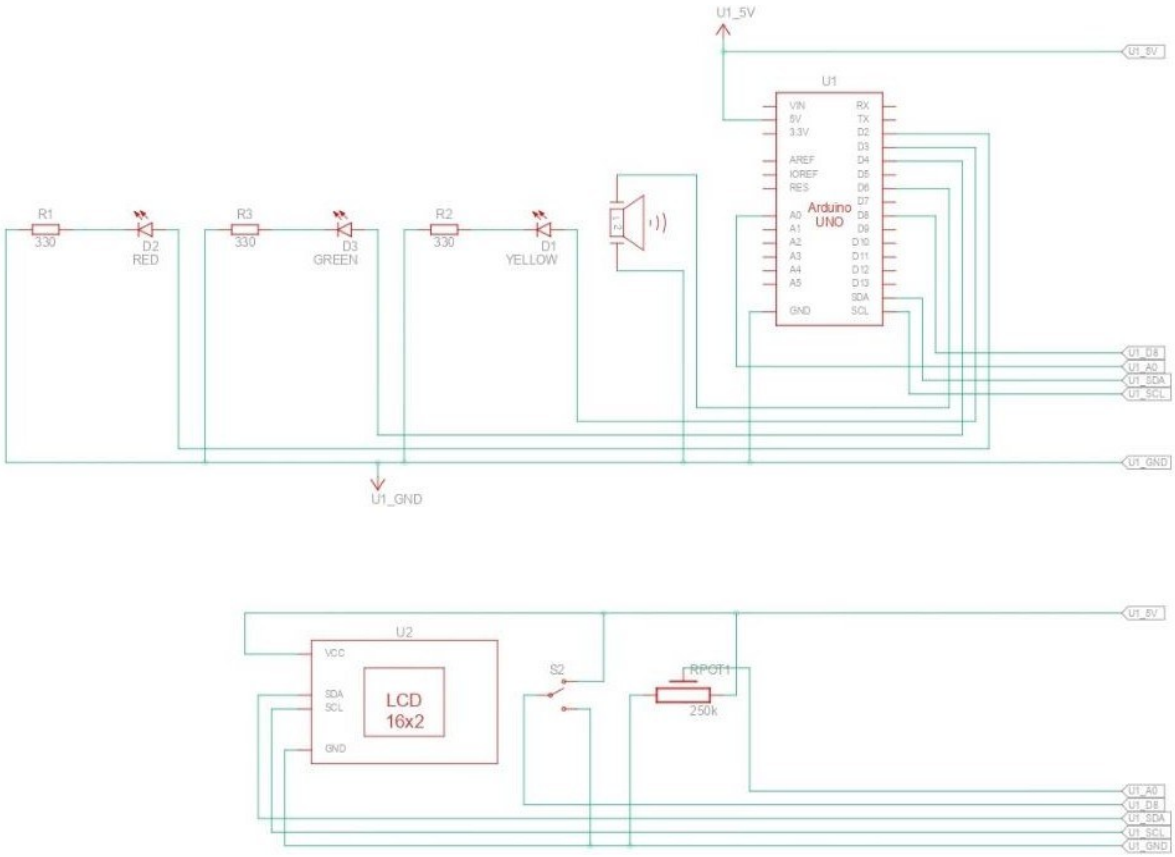

Figure 3. Schematic Diagram of Automated Traffic Light Priority System For Ambulance Using Siren Detection.

Figure 3 shows that from simulation that had before. So, for more details this schematics will explain everything. Start with, three LED red, yellow and green are connected to digital pins which is 2,3 and 4 respectively. Each of them had current limiting resistor to stimulate traffic signals. buzzer is connected to pin 6 to provide sound alerts during ambulance mode. A potentiometer is connected to analog pin A0, simulating a microphone by generating analog values that represent sound levels. An I2C LCD (16x2) is connected to the SDA and SCL lines (A4 and A5) to display system status and sound readings. A push button connected to pin 7 allows manual activation of the green LED, while a toggle switch connected to pin 8 serves as a system ON/OFF controller. When the switch is OFF, all outputs are turned off, and the LCD shows "System OFF." When ON, the system either runs the normal traffic light cycle or detects siren patterns to activate emergency mode, allowing emergency vehicles to pass.

3. Novelty And Uniqueness

The uniqueness of this project is its focus on sound detection specifically for hospital entrances. Most current smart traffic systems use expensive sensors buried in the road or cameras that need a clear line of sight. In contrast, our system simply "listens" for the specific frequency of ambulance sirens to clear the way.A key feature of our design is the 5-to-7 second verification rule. Instead of reacting instantly to any loud noise, the system analyzes the sound for a few seconds to confirm it is a real siren. This simple but effective method prevents false alarms caused by normal car horns or construction noise, making it more reliable than basic sound sensor. Additionally, this project combines automatic control with IoT monitoring. While the traffic light changes automatically for safety, the system also sends live updates to the Blynk app. This allows hospital staff to monitor traffic status remotely on their phones. By solving the traffic jam problem right at the hospital gate, this innovation helps ambulances complete their journey faster.

4. Benefit To Mankind

This project directly contributes to saving lives by significantly reducing ambulance delays at hospital entrances. In medical emergencies, every second counts; faster access to the emergency room can be the difference between life and death for critical patients. By automating the right-of-way, we ensure that medical help is not delayed by local traffic congestion. Furthermore, the system improves overall road safety for the public. Drivers often panic or make dangerous maneuvers when they hear sirens but cannot see the ambulance. This system manages the intersection automatically, reducing the risk of accidents caused by human error or confusion. Ultimately, it creates a safer environment for commuters and ensures that healthcare services operate more efficiently for the community.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by demonstrating a cost-effective, acoustic-based solution to traffic management, challenging the traditional reliance on expensive radar or camera systems. It bridges the gap between embedded systems and cloud computing (IoT), proving that accessible technology like the ESP32 can solve critical infrastructure problems. From high-impact, low-cost innovations that align with current Industry 4.0 trends and solve actual community needs.

6. Potential Commercialization

The primary market for this innovation encompasses both public and private healthcare sectors. Specifically, it targets the Ministry of Health (MOH) and private hospital groups seeking to upgrade their emergency infrastructure without extensive civil works. The system can be commercialized through a Business-to-Business (B2B) model, where the hardware is sold as a specialized retrofit package for existing hospital entrances. Additionally, we propose a subscription-based model for the IoT dashboard, generating recurring revenue through data analytics and maintenance services. There is also significant potential to collaborate with Local Authorities (PBT) and Smart City developers to scale this technology for general critical intersections, or to license the sound recognition algorithm to established traffic signal manufacturers.

7. Acknowledgment

We would like to express our sincere gratitude to the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM) for providing the laboratory facilities and technical support necessary to complete this research. We also extend our deepest appreciation to our supervisor for their invaluable guidance, patience, and constructive feedback throughout the development of the Sound Siren Detection System. Finally, we thank our fellow peers and laboratory technicians for their assistance during the hardware testing and validation phases.

8. Researchers' Biography

Muhammad Khalil Bin Muzam Shah is currently an Electrical Engineering student at Universiti Teknologi MARA (UiTM). His passion for engineering and innovation was sparked during his time at MRSM Muadzam Shah, where he achieved 2nd place in a STEM competition during Form 2. Specializing in embedded systems, he led the hardware prototyping and sensor integration for this siren detection project. Khalil is dedicated to applying his technical skills to solve real-world problems, with a specific interest in IoT and smart city technologies.

Ts. Sufian bin Mohamad is a Senior Lecturer in the Department of Communication, Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM) Johor Branch, Pasir Gudang Campus. He has over 15 years of teaching experience in various electrical engineering subjects.His academic portfolio includes active involvement in research and publications, student supervision, student development activities, and industrial linkages. He has received innovation awards and has served as an invited jury and panel member for academic and innovation programs. In addition, he serves as an internal auditor and is actively involved in community service initiatives.

Scholarsync E-ScholarBank: Discover Your Path, Fund Your Future

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ABSTRACT
SCHOLARSYNC E-ScholarBank is a student-centric application developed to assist post-Sijil Pelajaran Malaysia (SPM) students in exploring suitable career pathways while gaining access to relevant scholarship opportunities through a unified platform. The system addresses the common challenges faced by students in identifying career interests and locating reliable financial aid information, which often leads to uninformed decisions and unequal access to higher education. Designed using programming language of Python and the Tkinter graphical user interface (GUI) framework, E-ScholarBank adopts a modular and event-driven architecture to ensure usability, scalability, and cross-platform compatibility. The application integrates trusted external career assessment tools and organizes scholarship information into major fields of study, enabling users to seamlessly link career interests with appropriate funding options. The key strength of E-ScholarBank lies in its integrated approach that combines career guidance and scholarship discovery, reducing information fragmentation and improving accessibility. From a socio-economic perspective, the system promotes inclusive and equitable education by minimizing information barriers and supporting early career planning, in line with Sustainable Development Goal 4 (Quality Education). The platform also shows strong commercialization potential as a scalable educational support system for schools and educational institutions.

Keywords: Career guidance, Scholarship information system, SPM students, SDG 4, Inclusive education

1. Product Description
E-ScholarBank is a Python-based desktop application developed using the Tkinter graphical user interface framework to provide integrated career guidance and scholarship information for post-SPM students. The system architecture as shown in **Figure 1** follows a modular, event-driven architecture, where the main application window illustrated in **Figure 2** functions as the central controller responsible for navigation and coordination between system modules. The application consists of two primary functional modules: the Career Test Module shown in **Figure 3** and the Scholarship Bank Module as in **Figure 4**. The Career Test Module connects users to trusted external career assessment platforms, tracks user progress, and controls access using validation

mechanisms and progress indicators. The Scholarship Bank Module presents scholarship information through an interactive interface featuring selectable scholarship cards, dynamic information panels, and direct access to official application websites via embedded links. Input validation is implemented at the main interface to ensure accurate user data entry, while event handlers manage window transitions without reloading the entire application. The system utilizes the Pillow library for image handling and the web browser module for external resource integration. This design ensures cross-platform compatibility, maintainability, and ease of future enhancement, such as database integration or automated scholarship updates.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

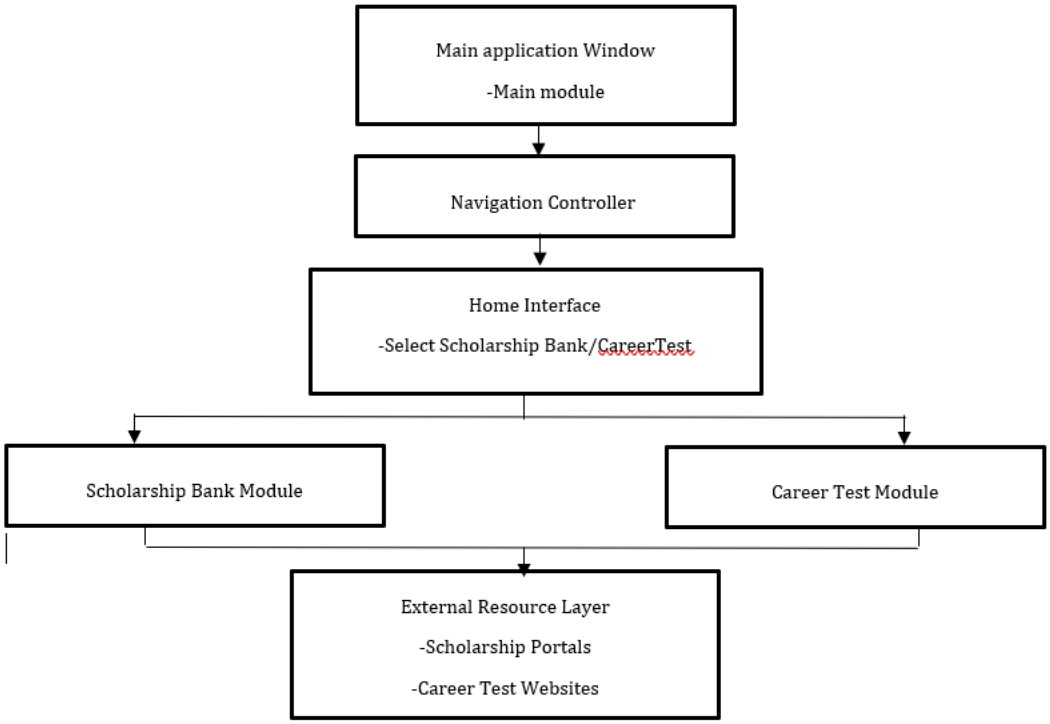

Figure 1. System Architecture Mapping.

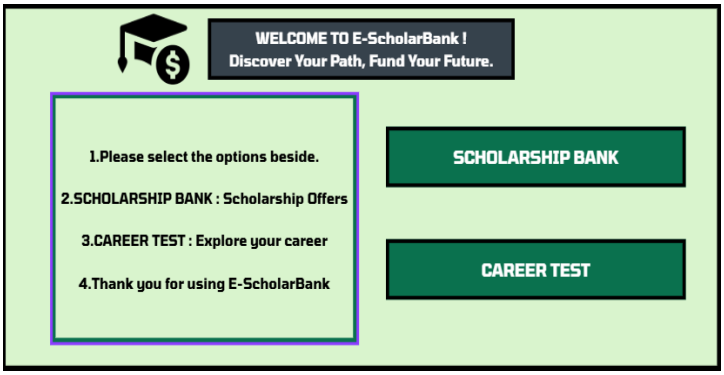

Figure 2. Main Application System Window.

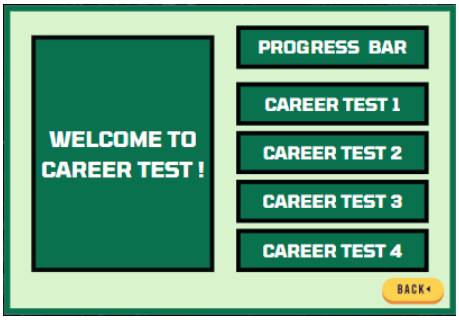

Figure 3. Career Test Window.

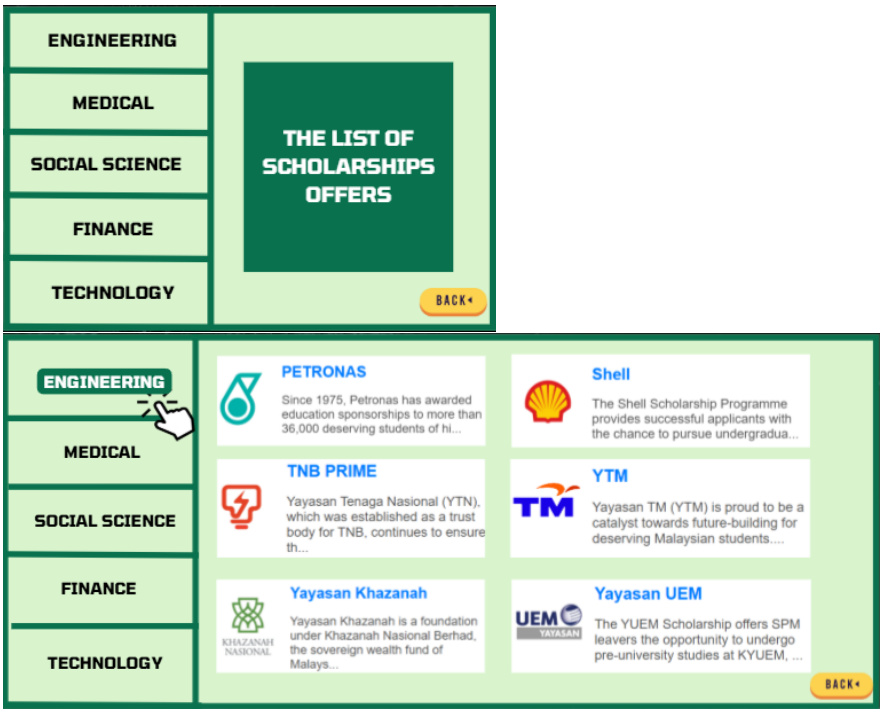

Figure 4. Scholarships Bank.

3. Novelty and uniqueness

E-ScholarBank is an innovative, all-in-one platform that bridges the gap between career exploration and scholarship access for post-SPM students. Unlike conventional websites, which treat career guidance and scholarship information separately, this system integrates both functions, enabling students to identify their strengths and interests while directly connecting to relevant funding opportunities. Its modular, event-driven design ensures smooth navigation between modules without reopening the application, while dynamic scholarship cards and interactive information panels enhance usability. Built with Python and Tkinter, the system is cross-platform, lightweight, and easy to maintain, making it suitable for schools, educational institutions, and student organizations. E-ScholarBank also includes validated input controls, progress tracking for career tests, and secure external link access, features that improve reliability and user experience. By providing equitable access to career resources and financial aid, it addresses socio-educational challenges and promotes early career planning, supporting

Sustainable Development Goal 4 (Quality Education). The platform's combination of technology, accessibility, and social impact creates strong potential for commercialization. With further enhancements, such as database integration and automated scholarship updates, E-ScholarBank could be adopted widely as a scalable educational support tool, empowering students to make informed decisions about their future.

4. Benefit to mankind

E-ScholarBank provides significant benefits by empowering students to make informed educational and career decisions, particularly for post-SPM learners facing uncertainty about their future. By integrating career guidance with scholarship access, the system reduces information gaps and minimizes financial barriers, enabling students from diverse backgrounds to pursue higher education opportunities. The application promotes inclusive and equitable access to quality education, aligning with Sustainable Development Goal 4 (Quality Education). It helps students identify their strengths, explore suitable career paths, and connect with financial resources, fostering self-confidence, proactive planning, and lifelong learning. Beyond individual advantages, E-ScholarBank contributes to societal development by supporting a more skilled and educated workforce, reducing inequality in educational opportunities, and enhancing social mobility. Its scalable, user-friendly design ensures that the benefits can reach a wide audience, making a positive impact on both students and the broader socio-economic landscape.

5. Innovation and Entrepreneurial Impact

E-ScholarBank introduces a novel approach by combining career exploration and scholarship information in a single, easy-to-use digital platform, addressing gaps in existing educational resources. Its modular design, event-driven operation, and dynamic interface showcase practical application of modern software to solve real student challenges. The system encourages a spirit of entrepreneurship by helping students discover their interests, plan their educational journey, and pursue opportunities aligned with their skills and goals. Educational institutions can use E-ScholarBank as a learning and mentoring tool to promote problem-solving, digital skills, and proactive decision-making among learners. Furthermore, its scalability and commercialization potential open doors for student-led initiatives or institutional partnerships, showing how technology-driven solutions can create social and economic value, nurture innovative thinking, and foster a culture of entrepreneurship and lifelong learning within the community.

6. Potential commercialization

E-ScholarBank has strong potential for commercialization as a scalable educational support platform for schools, educational institutions, and student organizations. Its modular design and cross-platform compatibility make it easy to deploy and maintain, while its integrated approach to career guidance and scholarship access addresses a real and persistent need among post-SPM students. The system can be enhanced with database integration, automated scholarship updates, and search functionalities, increasing its value and usability for a wider audience. Educational institutions could adopt E-ScholarBank as part of their student support services, while private organizations or edtech startups could license or customize the platform for targeted markets. By providing a practical solution that reduces barriers to education and promotes informed career planning, E-ScholarBank has commercial appeal both as a digital tool and as a social impact product. Its potential extends beyond Malaysia, offering opportunities for regional or global deployment in student career guidance and scholarship facilitation.

7. Acknowledgment

Our sincerest gratitude to Ms Farhah Abd Wahab for her continuous guidance, encouragement, and constructive feedback throughout this project. Special thanks to the Dean of Faculty of Centre for Foundation Studies, Universiti Teknologi PETRONAS (CFS UTP), Ts. Dr Aliza Sarlan and whole centre for providing the necessary facilities, funding and support to complete the system development. The assistance of each teammates, classmates and external scholarship and career resources that contributed to the successful design of SCHOLARSYNC E-ScholarBank are much appreciated. All support was invaluable in making this project both feasible and meaningful.

8. Researchers' Biography

Muhammad Ammar Amsyar Bin Muhammad Syukran is an 18-year-old foundation studies student at Universiti Teknologi PETRONAS (UTP). He achieved an excellent academic record with 9As in the Sijil Pelajaran Malaysia (SPM) examination. He aspires to pursue a degree in Computer Engineering, driven by a strong interest in technology and innovation. During his primary school years, he was awarded as a Robotics Icon, reflecting his early passion in robotics. He is currently interested in learning artificial intelligence and website development to build practical technological skills.

Aiming to pursue a degree in Chemical Engineering, Hannah Toh is a second-semester Foundation in Engineering and Science student at Universiti Teknologi PETRONAS (UTP) with a strong passion for innovation and technology-driven problem solving. She is currently part of the development team for eScholarBank, a programming-based project designed to improve the management of student scholarship information. With a keen interest in chemical engineering and digital solutions, Hannah enjoys exploring how technology can enhance efficiency, transparency, and sustainability in real-world systems. Through collaborative teamwork, continuous learning, and hands-on projects, she aims to contribute meaningfully to innovative solutions that create positive social impact.

Harith Danial is a second-semester foundation student with a strong academic interest in chemistry and scientific research. He is currently pursuing foundation studies and plans to continue his degree in Applied Chemistry at Universiti Teknologi PETRONAS (UTP). His academic interests include analytical chemistry, chemical applications in industry, and sustainable scientific solutions. Harith is motivated to develop a solid theoretical and practical foundation to support future research and professional work in the chemical sciences. Through continuous learning and collaborative academic projects, he aims to contribute meaningfully to innovation and problem-solving within the field of applied chemistry.

Farhah Abd Wahab is a lecturer at the Department of Business and Computing, Centre for Foundation Studies Universiti Teknologi PETRONAS (UTP), specializing in algorithm and programming in educational technology application system. With over 10 years of experiences in academics, her research focused mainly on pattern recognition and intelligent systems, and has been an advisor with experience of mentoring hundreds of students' projects in designing user-centric software solutions. She is passionate about developing technology that supports education and equitable access to resources.

Farmetrix – Adaptive Animal Care with Smart Power Conversion

Ahmad Hariz Khusairy Ahmad Tarmizi[1], Mohamad Zhafran Hussin[1], Nor Diyana Md. Sin[1], Syahrul Aqmal bin Husni[1]
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ABSTRACT

Farmetrix is an IoT-based poultry management system designed to modernize livestock care by feeding, hydration, and environmental regulation using an ESP32 architecture integrated with low-cost sensors, including DHT22, load cells, and LDRs. The system employs a dual-mode control strategy, combining autonomous operation with a pulsing water-dispensing algorithm and brownout mitigation for power stability, alongside manual remote control via the Blynk platform. To address cloud bandwidth constraints, Farmetrix utilizes a bandwidth-optimized pull-request data architecture that enables reliable local automation with minimal cloud dependency. Leveraging its low-cost, modular design, Farmetrix bridges traditional poultry farming with digital automation, reducing labor requirements, improving livestock consistency, and supporting scalable, technology-driven agriculture for small- and medium-scale farmers.

Keywords: Internet of Things (IoT), Smart Poultry Management, Automated Environmental Control, Brownout Mitigation, Precision Agriculture

1. Product Description

Farmetrix is an integrated IoT solution designed to enhance poultry farming efficiency by autonomously regulating feeding, hydration, and environmental conditions. Built upon the ESP32 microcontroller, the system employs a multi-sensor network including temperature and humidity sensor (DHT22), load cells, and LDRs to continuously monitor the coop's internal climate and resource availability. A proprietary Pulsing Pump Algorithm (0.3s actuation followed by a 3s settlement period) suppresses water ripples induced by sensor noise, enabling precise hydration without overflow. Power instability in rural environments is addressed through brownout protection during Wi-Fi operations. Additionally, Farmetrix employs a bandwidth optimized architecture in which control logic runs locally, while cloud data logging follows a pull-request model to minimize bandwidth usage. User interaction is facilitated through the Blynk mobile application, which offers dual-mode functionality: an "Autopilot" mode for remote management and a "Manual Override" mode for maintenance. This combination of robust edge computing and efficient cloud connectivity makes Farmetrix a highly scalable, retrofittable, and cost effective solution for maximizing livestock yield and modern poultry management.

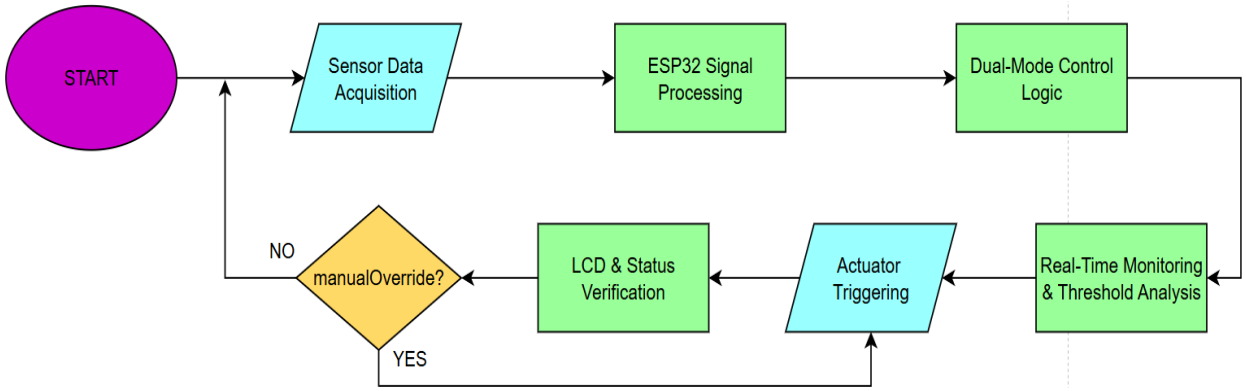

Figure 2. The Farmetrix Dual-Mode Control Strategy and Data Architecture.

This flowchart illustrates the system's operational logic, beginning with Sensor Data Acquisition and ESP32 Signal Processing. The core Dual-Mode Control Logic performs real time threshold analysis to manage the coop autonomously. A decision node continuously monitors for a Manual Override signal. If detected (YES), the system bypasses autonomous analysis to execute remote commands directly for Actuator Triggering. If no override is present (NO), the system completes its autonomous cycle, displaying status on the LCD before returning to data acquisition and thus ensuring a fail-safe, resilient monitoring loop.

Figure 3 and Figure 3 Farmetrix – Adaptive Animal Care with Smart Power Conversion Prototype Layout

The system features a zoned architecture. Inside the coop, a roof mounted DHT22 and LED module manage climate and lighting, assisted by a raised, wall mounted 5V DC fan. Externally, resource management is centralized, where an LDR sensor above the feed storage regulates the internal LED, while a load cell beneath the feed tray triggers the feed door opening/closing. A water level sensor inside the trough controls the external pump to ensure precise pumping.

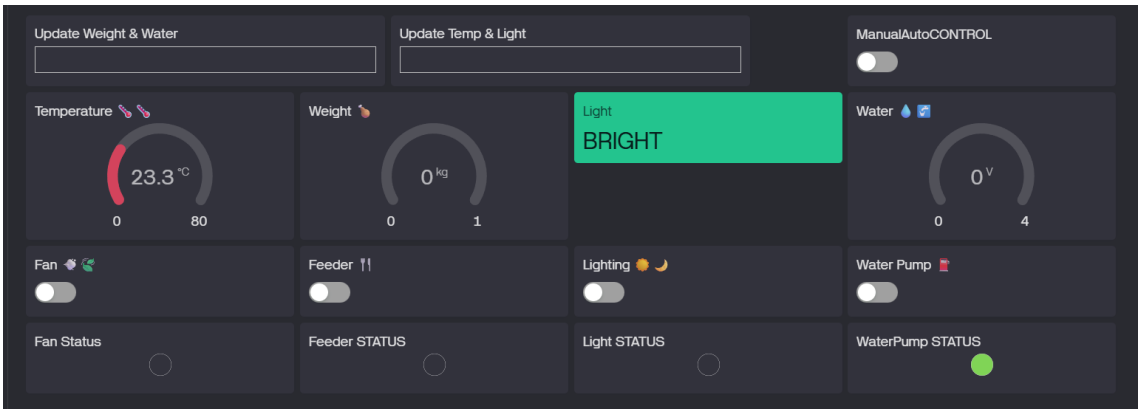

Figure 4. Blynk IoT Web Dashboard.

The interface displays real time values for environmental conditions (Temperature, Light) and resource levels (Feed Weight, Water Level). It features a "Manual/Auto" toggle and a dedicated "UPDATE" button which executes the "Pull-Request" protocol, where it fetches the latest sensor data only on demand to strictly adhere to bandwidth conservation limits. Specific control switches for the Fan, Feeder, Lighting, and Pump were also integrated, with green LED indicators confirming the active status of the hardware.

2. Novelty and uniqueness

Farmetrix distinguishes itself from conventional automated feeders through its resilient, environment first engineering designed specifically for resource constrained infrastructure. Unlike standard timer based systems, Farmetrix employs a Proprietary Pulsing Hydro-Regulation Algorithm. By cycling the water pump (0.3s active / 3s rest), the system eliminates sensor noise caused by water turbulence, ensuring precise water refilling sequence without the overflow risks common in gravity used systems. Furthermore, the system introduces a novel Brownout Mitigation Protocol. Recognizing that rural power grids and power-intensive components such as pumps and Wi-Fi operation can cause voltage sags, the software implements a soft-start logic sequence that prevents microcontroller resets a critical failure point in many existing IoT solutions. Additionally, Farmetrix adopts a bandwidth-optimized data architecture in which all automation logic runs locally on the ESP32, with cloud synchronization performed via a Pull-Request model for the Blynk IoT platform. This hybrid approach enables reliable, real-time operation even during internet disruptions, outperforming purely cloud-dependent smart farming systems.

3. Benefit to mankind

Farmetrix directly supports the livelihoods of small-scale poultry farmers, a demographic often marginalized by the high costs of industrial automation. By democratizing access to smart technology, the system reduces the physical burden of manual labor, allowing elderly or physically limited farmers to manage livestock independently. Crucially, the system enhances food security. Poultry is a primary protein source globally, yet mortality rates in manual farms due to heat stress and dehydration are high. Farmetrix's precise environmental regulation drastically lowers these mortality rates, ensuring a stable food supply for the community. Furthermore, the "resource-aware" design minimizes water waste through the pulsing algorithm and operates on unstable power grids, thus creates a sustainable, high-yield farming accessible in developing regions where

resources are scarce. This transition from "survival farming" to "precision agriculture" uplifts the economic status of rural communities.

4. Innovation and Entrepreneurial Impact

Farmetrix acts as a spark for Smart Agripreneurship by bridging the gap between traditional agriculture with the digital economy. By demonstrating that effective automation can be achieved using accessible, low-cost platforms such as the ESP32, the project promotes frugal innovation and challenges the perception that IoT solutions require expensive proprietary infrastructure. This approach empowers engineers and local innovators to develop practical, solution-driven technologies for underserved agricultural communities. Furthermore, the system's modular design creates new entrepreneurial opportunities for technical service providers, specifically in 'retro-fitting' legacy farms with smart technology. This opens a market for installation, customization, and maintenance services, shifting the industry perspective from labor intensive farming to technology-driven business management. Ultimately, Farmetrix lowers the technical barrier to entry, attracting a younger generation of tech-savvy entrepreneurs to revitalize the aging agricultural landscape.

5. Potential commercialization

Farmetrix targets the massive, underserved market of small-to-medium poultry enterprises (SMEs), a sector currently priced out of industrial automation solutions. The product's primary competitive advantage is its "Retrofit-Ready" modularity; unlike industrial competitors that require complete infrastructure overhauls, Farmetrix is designed as a "plug-and-play" add-on for existing coops. This drastically lowers the Capital Expenditure (CAPEX) for farmers, removing the primary barrier to adoption. The business model utilizes a dual-revenue stream: direct hardware sales of the base controller and a scalable service model for the IoT platform. While basic monitoring is free, future iterations can offer a "Premium Tier" for historical data analytics and veterinary AI insights. With the global smart agriculture market projected to experience exponential growth, Farmetrix captures the "long tail" of this economy by empowering the millions of backyards and semi commercial farmers to digitize their operations cost-effectively.

6. Acknowledgment

The author would like to express their gratitude to Universiti Teknologi MARA (UiTM), Pasir Gudang Campus and supervisor PM. Dr. Ts. Mohamad Zhafran bin Hussin for their guidance, technical support, financial support, and facilities provided throughout the development of this project.

7. Researcher's Biography

Ahmad Hariz Khusairy Bin Ahmad Tarmizi is a final-year Electrical Engineering (Power) student at Universiti Teknologi MARA (UiTM), Johor Branch Pasir Gudang Campus. His research interests focus on the Internet of Things (IoT), embedded systems, and sustainable agricultural automation. Throughout his academic career, he has developed expertise in microcontroller programming (ESP32/Arduino) and sensor integration for real-time monitoring systems.

Mohamad Zhafran Hussin is a senior lecturer in the Faculty of Electrical Engineering of the Universiti Teknologi MARA (UiTM), Malaysia. He received his PhD in Electrical Engineering from the Universiti Teknologi MARA (UiTM), Malaysia in 2014. His research interest is in the area of Renewable Energy, Energy Efficiency and Electrical Machines.

Nor Diyana Md. Sin is a senior lecturer in the Faculty of Electrical Engineering of the Universiti Teknologi MARA (UiTM), Malaysia. She received her PhD in Electrical Engineering (Nanoelectronics) from the Universiti Teknologi MARA (UiTM), Malaysia in 2014. Her research interest is in the area of Digital system, Internet of Things, Sensors, Metal Oxide Semiconductors, Nanotechnology and Nanodevices.

Syahrul Aqmal Bin Husni is a final year Electrical Engineering (Power) student at Universiti Teknologi MAR (UiTM). His research interest focuses on Wireless Power Transfer (WPT), power electronics and thermal management systems. Throughout his academic career, he has developed expertise in circuit simulation, PCB design and the implementation of intelligent safety control mechanisms for power converters.

AI-Based System for Early Identification of Machine-Induced Human Health Risks

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[2]Department of Electrical Power Engineering, Islamia University of Bahawalpur, Pakistan

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ABSTRACT

Traditionally, industrial safety systems have focused on monitoring the condition of machines and have not paid attention to the long-term health consequences of the exposure of employees to machines. This project proposes an Artificial Intelligence-based system that will be used to detect the machine-induced human health risks at an early stage by transforming the machine-centric safety intelligence into human-centric risk assessment. It is based on the joint assessment of exposure to workers and cumulative exposure time aimed at combining and assessing exposure intensity, which makes it possible to model the health risk in a realistic manner, with a sense of time. In contrast to the traditional methods where the regulatory thresholds are constant, the suggested solution provides the adaptive risk classification, in which health risk levels constantly change according to the changing operational and exposure patterns. This enables identification of dangerous developments in advance before the safety limits are violated. The system will act as a preventive decision-support health tool that helps industries in being proactive in terms of scheduling as well as reducing the long exposure and lowering the occupational health risks in the long term. Combining the analysis of mechanical exposure to that of AI-based health risks intelligence, the presented solution serves to connect engineering systems with occupational healthcare to increase workplace safety, facilitate a sustainable industrial experience, and carries a good potential of scalable implementation to diverse industrial fields.

Keywords: Occupational Health, AI Safety Systems, Human-Centric Risk Assessment, Industrial Exposure, Preventive Safety.

1. Product Description

The system that is proposed is an occupational health intelligence platform, which is AI-driven and aimed at assessing and predicting human health risks caused by machines during industrial activities. The system does not look at the parameters only in the machine but uses a combination of exposure intensity, time spent working and cumulative exposure history to assess workers exposure. The system has adaptive machine learning models that enable it to continually revise health risk classifications with the changing operational conditions and exposure patterns. This dynamic evaluation can also be used to identify the up-and-coming risks at the earliest before regulatory limits are violated. The platform transforms actionable insights to safety managers and enables proactive optimization of the schedule through tasks rotation, exposure time, and optimization of schedules. This system is a preventative decision support and will improve the

well-being of the workers, minimize long term health hazards and syndicate with the current industrial safety structures.

2. Tables

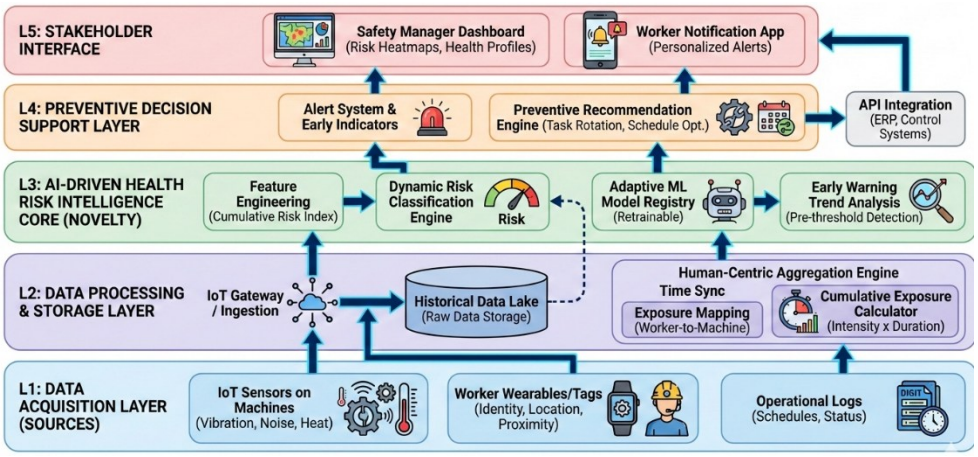

***Figure** 4 Overall Architecture Diagram*

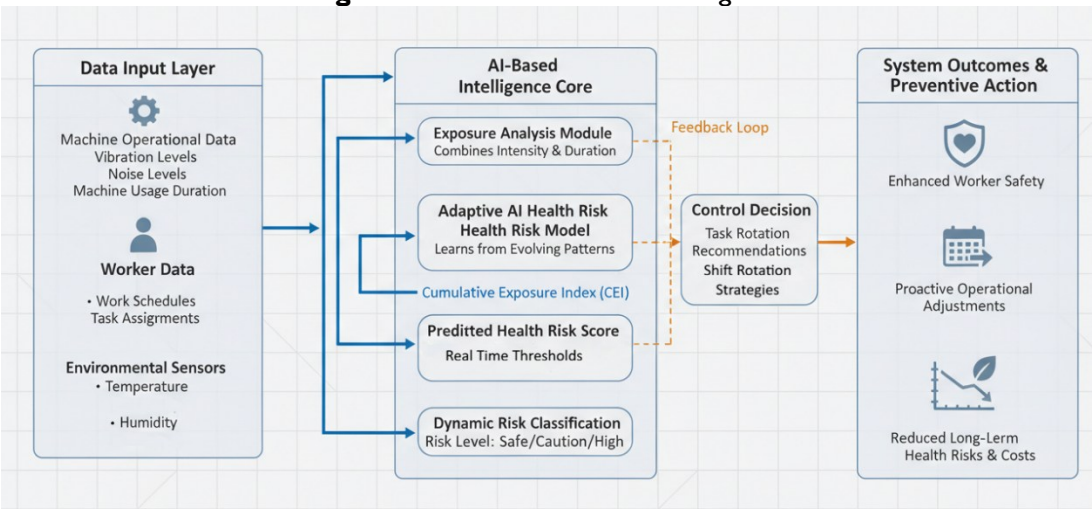

Figure 5 Dataflow Diagram

Table 3 Human-Centric Health Risk Assessment Framework

Component	Description
Exposure Intensity	Level of mechanical, vibrational, or environmental exposure
Exposure Duration	Time-based accumulation of worker exposure
Cumulative Risk Index	Aggregated long-term exposure assessment
Adaptive Risk Classification	Dynamic AI-based risk level adjustment
Early Warning Indicators	Detection of hazardous trends before limits
Preventive Recommendations	Suggested actions for exposure mitigation

3. Novelty and uniqueness

The innovation aspect of this project is that it will transform the machine-based safety monitoring to the human-based health risk intelligence. In contrast to the traditional systems that rely on fixed values of safety thresholds, the proposed solution makes use of adaptive AI models to take into consideration cumulative exposure and changing patterns of operations. It is possible to combine the time-conscious exposure analysis with the predictive risk classification to preempt the intervention, which makes the system tools particularly appropriate in occupational health safeguarding, on a long-term basis, but not fault detection.

4. Benefit to mankind

The system will help in enhancing the occupational health by mitigating the risk of work related chronic injuries and illnesses drought on prolonged exposure to machines. It places wealth on the power of industries to take preventive measures to safeguard workers and improve workplace safety culture and cheap healthcare costs related to the long-term occupational hazards. The solution facilitates sustainable and socially responsible industrial processes through promotion of human wellbeing.

5. Innovation and Entrepreneurial Impact

The given project is innovative as it combines artificial intelligence with industrial safety engineering and the field of occupational health. It opens infrastructure entrepreneurial opportunities in AI-driven place of work safety systems, digital health observation systems, and preventive risk analytics. The system promotes predictive and human-centered safety initiatives by companies, which promote the use of safety management practices that are driven by innovation.

6. Potential commercialization

The suggested system presents a high-level of commercialization due to the ability to be a digital occupational health analytics system of manufacturing plants, construction sites, and heavy industries. It can be provided either as a subscription-based software service or as part of the current systems of managing industrial safety. The level of its scalability and adaptation facilitates installation in various industries, which favors its commercial acceptability and sustainability.

7. Acknowledgment

Another aspect would be to give credit to the institution, their supervisors, and their partners in terms of support and help they gave throughout the entire process of developing this project.

8. Researchers' Biography

Muhammad Wasim is a researcher in Electronic Engineering, The Islamia University of Bahawalpur, Pakistan. He competed in many projects about power generation and energy saving. A full size ceiling fan 56" powered by a cell phone battery. Cell phone battery charging system through walking for shoes with piezoelectric. Hydrogen fuel cell and hydrogen production from water with cheap way and running a bike through hydrogen. Cell phone charging system through radio signals coming from cell towers. A

Smart watch where sound transfer from wrist to finger. The listener put finger on his ear to listen to the call. A water purifier and micro plastic remove the system from a muddy water. Charging free Magnesium based water battery system design from disaster and remote arias.

Muhammad Inam ul Haq an undergraduate researcher in Electronic Engineering, The Islamia University of Bahawalpur, Pakistan. He is a Double Gold Medalist and National Award Recipient of Pakistan, having received a Gold Medal from the Government of Pakistan (Medal No. GPK-GM-2025-017) and a Gold Medal from the Parliament of Pakistan (Medal No. PPK-GM-2025-042). I am also a National Award Recipient (National Award ID: NA-PK-EE-2025-311) in recognition of engineering innovation and research excellence. He is also an active member of the Center of Automation, Robotics, and Embedded Systems (CARE), where I engage in interdisciplinary research and applied engineering. My research interests include artificial intelligence, VLSI and IC design, FPGA-based acceleration, embedded and cyber-physical systems, and secure hardware–software co-design. In parallel, He is involved in research projects related to military and national security applications, with a focus on quantum intelligence and resilient cyber-physical infrastructures. My long-term goal is to develop secure, energy-efficient, and intelligent systems for next-generation computing, healthcare, and critical infrastructure.

Muhammad Rashid is working as Research Assistant in the Department of Electrical Engineering, The Islamia University of Bahawalpur, Punjab, Pakistan since March, 2021 and also served as Instructor (Electrical) in Electrical department, Govt. College of Technology Bahawalpur, Pakistan from Dec 2016 to Feb 2019. He completed M.Sc (Electrical Power Engineering) from "The Islamia University of Bahawalpur", Punjab, Pakistan in 2020. He hold a B.Sc Degree in Electrical (Power) Engineering (2016) from The Islamia University of Bahawalpur, Punjab, Pakistan. One research article has been accepted in a HEC recognized Journal and presented one article in a conference held at The Islamia University of Bahawalpur, Punjab, Pakistan in March 2021.

Zeeshan Ahmad Arfeen is an Assistant Professor in theDepartment of Electrical Engineering in “The Islamia University of Bahawalpur," Pakistan. He doctorate from University Technology Malaysia (UTM) Skudai Johor Bahru, Johor, Malaysia. He is a senior member of the IEEE organization NJ. USA, member of IEEE Power and Energy Society (PES), life member IEEE Pakistan, and member of “The Institution of Engineers Pakistan” (IEP). Further, he is also a life member of the Pakistan Engineering Council. Arfeen is an Author/Coauthor of 50+ high indexed Journals with several conferences and book chapters and a distinguished potential reviewer of hundred International Conferences Proceedings and hundred International Journals. He was awarded a Partial doctoral scholarship from the Higher Education Commission (HEC) Pakistan. Arfeen also got an International doctoral fellowship (IDF) and UTM Young Scholarship Grant from the University of Technology Malaysia (UTM). His paper was the most downloaded in 2019 and 2020 and two of papers Wiley's and MDPI publisher's top 10 cited papers in 2020 and top downloaded.

IoT Based Industrial Energy Audit and Fault Detection System

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ABSTRACT

The IoT Based Industrial Energy Audit and Fault Detection System operates as an all-inclusive solution throughout industrial settings which enables constant assessment of electrical power usage and power quality. The system uses IoT sensors together with a web-based dashboard to achieve real-time monitoring of voltage and current and active/reactive/apparent power and power factor and THD and energy and equipment temperature. The system identifies three types of anomalies which include overcurrent and low power factor and high harmonics and it generates alerts that display different levels of severity. The system provides three unique functions which are real-time waveform charts and trend analytics and users can create load profiles for motors and heaters and transformers and custom models. The system enables organizations to conduct fault diagnosis activities while implementing energy audits which improve their overall operational performance. The system enhances operational performance by protecting systems from faults while minimizing energy consumption. The system offers automated report generation for daily and weekly and monthly audits which combined with its user-friendly interface enables SMEs and utilities to operate the system effectively. The system demonstrates strong potential for commercial success because the IoT energy management market is expected to reach approximately US$222 billion by 2030.

Keywords: IoT; Energy Audit; Fault Detection; Power Quality; Dashboard

1. Product Description

The system consists of three components which are IoT sensors and data collection gear and a web dashboard. The Wi-Fi-enabled microcontroller receives data from voltage and current sensors together with optional temperature and vibration sensors which transmit measurements to a central server. The dashboard user interface (UI) combines real-time parameter cards with a control panel that allows users to select load types and generate reports which the design team built using TailwindCSS and Chart.js. The measurement cards display voltage and current and active power and reactive power and apparent power and power factor and total harmonic distortion and energy consumption and temperature and vibration levels. The trend charts display voltage-current and power and PF/THD and temperature/vibration patterns which show historical data for more detailed analysis. The embedded logic system uses its built-in thresholds to detect defects which include overcurrent and sag/swell and harmonic distortion and PF drop then it activates alarms in the "Active Alerts" panel. Users can access the UI to view audit reports which they can generate for daily and weekly and monthly periods while they can also identify alarms. The output generates two reports which include energy consumption data and power quality measurements to support proper load management activities.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

The implemented measurement and monitoring pipeline gets summarized through the block diagram which appears in **Figure 1.** The ESP32 hardware samples voltage and current waveforms after it completes analog scaling and filtering processes to send the data to a cloud dashboard. The dashboard calculates electrical parameters through RMS voltage and current measurements and active and reactive power and power factor and frequency and harmonic analysis while it detects faults through voltage sag and swell and overcurrent and harmonic distortion detection. The system generates alerts about abnormal conditions while it shows trends and waveforms through its fault detection system. **Figure 2** presents the cloud-based dashboard for the IoT energy audit and fault detection system, which continuously monitors electrical metrics and power quality indicators sourced from field sensors. The primary metrics which need measurement include RMS voltage and current, active and reactive power, and total energy use which is expressed in kilowatt-hours (kWh). The dashboard tracks total harmonic distortion (THD) which helps to evaluate the quality of the waveforms. The system uses temperature and vibration data to help engineers find equipment problems which affect motor operations. The user-friendly interface provides real-time updates together with fast deviation detection capabilities.

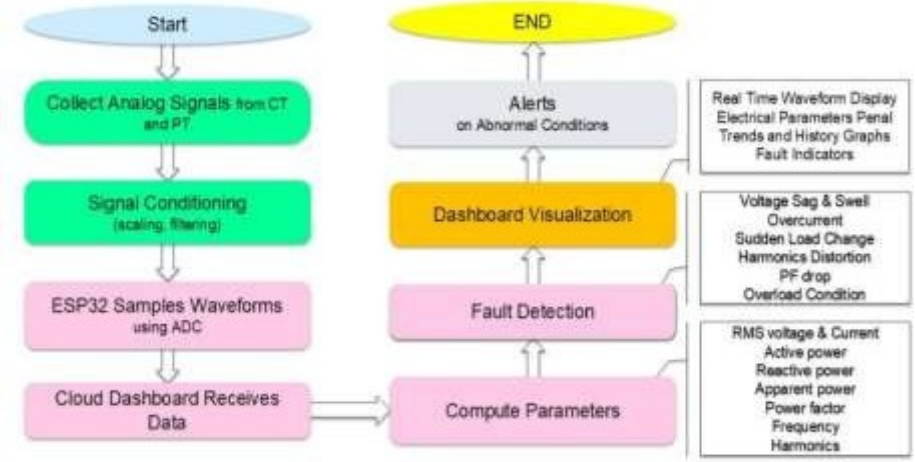

Figure 1. Operational flowchart of the proposed IoT based power quality monitoring and fault detection system.

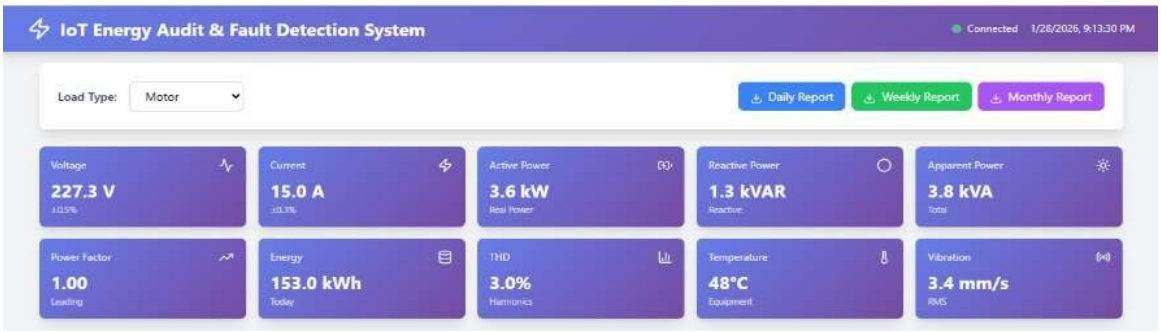

Figure 2. Real-time IoT Dashboard for Energy Audit and Fault Detection, displaying key electrical parameters and environmental metrics.

Table 1 lists sample real-time electrical parameters from the dashboard UI. For example, voltage, current, power factor, THD, and daily energy metrics are:

Table 1. Sample real-time electrical parameters from the dashboard UI.

Parameter	***Value***	***Unit***
Voltage	227.3	V
Current	15.0	A
Power Factor	1.00	-
THD	3.2	%
Energy(Today)	153.0	kWh
Active Power	3.6	kW
Reactive Power	1.3	kVAR
Apparent Power	3.8	kVA

The system also logs fault events; typical detected fault types include:

Table 2. Recorded fault events from the monitoring system.

Severity	***Fault Type***	***Description***	***Value***	***Timestamp***	***Action***
High	*Overcurrent*	*Current exceeds threshold*	*18.5A*	*10:05:11 PM*	*Acknowledged*
Medium	*Low Power Factor*	*Power Factor below 0.85*	*0.82*	*10:05:11 PM*	*Acknowledged*
Low	*High THD*	*THD exceeds 5%*	*5.8%*	*10:05:11 PM*	*Acknowledged*

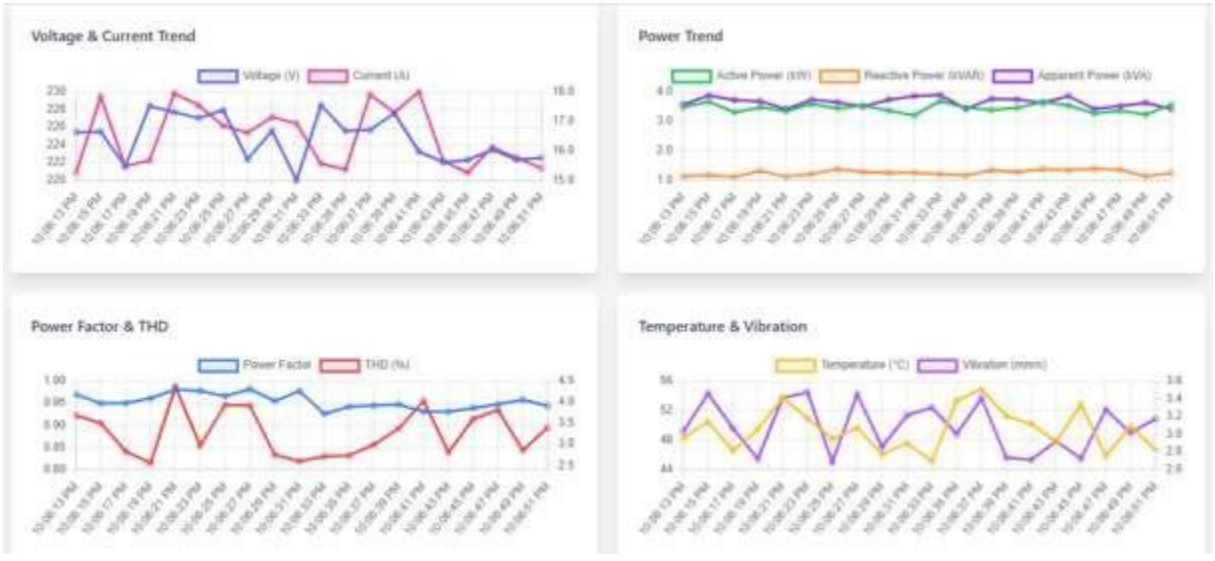

Figure 3. Time-series trends of voltage, current, power components, power factor, total harmonic distortion (THD), temperature and vibration.

3. Novelty and Uniqueness

Our system uniquely integrates continuous energy auditing with dynamic fault analytics. The system enables instantaneous diagnostics through its capacity to visualize real-time waveforms and parameter trends (voltage, current, power) of the system. The dashboard enables users to create load profiles that include motor and heater and transformer and user-defined options so that audit thresholds match their equipment requirements. The system deploys multiple methods for fault detection because it can identify different fault types which include overcurrent and voltage sag/swell and harmonics and PF drop and shows them in the user interface according to their severity levels. The system provides advanced functionality with its automated report generation and interactive alerts which exceed the capabilities of traditional energy meters. Our product for industrial energy auditing stands out because it combines real-time analytics with load-specific monitoring and automated fault diagnostics.

4. Benefit to Mankind

The system improves safety and energy efficiency through its capability to monitor operations continuously while detecting faults at their initial stages. The system detects conditions that waste energy through harmonic overloads which enables users to reduce their energy usage and carbon emissions. The system can detect critical faults which include overheating and overcurrent before equipment damage occurs thus preventing fires and operational interruptions. Predictive alerts enable maintenance planning which extends equipment lifespan while decreasing equipment waste. The system helps sustain energy consumption while establishing safer operational conditions in industrial environments.

5. Innovation and Entrepreneurial Impact

The IoT-based audit solution for the market combines energy management with fault diagnosis functions. The industrial users and energy consultants can use the system because of its modular design and easy-to-use interface. The global IoT energy management market is expected to reach approximately US$222B by 2030 according to its current growth rate. The product enables data-driven audits and analytics functions which support current digitalization developments. The technology enables manufacturers and service providers to enhance operational efficiency through its implementation while the unique feature set of real-time analytics and fault detection provides a competitive advantage in smart energy.

6. Potential Commercialization

The system works effectively for SMEs and utility companies that need to improve their energy consumption. Consultants can use customized load profiles to create specific audits for their individual clients. The system provides built-in reporting tools which produce PDF documents for daily, weekly, and monthly periods to help users with documentation and compliance tasks. The company provides two product options which include a sensor kit with cloud dashboard access for customers to perform remote monitoring and data analysis. The system's scalable design allows organizations to choose between cloud or on-site installation while its affordable IoT devices make it suitable for businesses and utility companies that want complete solutions to perform energy audits and fault detection.

7. Acknowledgment

The authors wish to express their deepest thanks to Dr. Zeeshan Ahmad Arfeen who provided essential help throughout the project development together with his technical guidance. The Department of Electrical Engineering gave us essential resources and laboratory space which we needed to finish our project work. The project success depended on their academic support and encouragement which they provided.

8. Researchers' Biography

Muhammad Afzal is a final-year BSc. Electrical Engineering student. His work centers on energy monitoring systems that use IoT technology to assess power quality. Afzal worked on the system design process by developing the sensor system and dashboard interface. He developed the data acquisition system together with his work on calibration procedures. He belongs to the university robotics club while holding expertise in embedded systems and smart grid simulation technologies. Afzal competed in national engineering contests which earned him an academic excellence scholarship. He studies sustainable energy solutions together with automation technologies.

Muhammad Waqar ul Hassan is a final year BSc. Electrical Engineering student. He develops algorithms which detect system faults and gather information from different sources. Waqar developed the microcontroller system which operates parameters in real time and he created procedures for fault-based classification. He built sensor calibration systems and signal-processing components for the web UI control panel and alert system development. He participates in IEEE student chapter activities at the university while taking part in engineering competitions. His expertise covers instrumentation systems and he develops algorithms which enable power system analysis.

Muhammad Waleed is a final-year BSc. Electrical Engineering student. He works in energy systems through his software development and data analysis expertise. Waleed built the dashboard through his work on real-time data tracking and charting features and developed the reporting functionality. He created the server-side data processing system and handled all database connectivity tasks. He completed his industrial automation internship while working as a teaching assistant for embedded systems laboratory sessions. His interests include machine learning, IoT networking, and optimizing energy systems

Zeeshan Ahmad Arfeen is an Assistant Professor in the Department of Electrical Engineering in "The Islamia University of Bahawalpur," Pakistan. He doctorate from University Technology Malaysia (UTM) Skudai Johor Bahru, Johor, Malaysia. He is a senior member of the IEEE organization NJ. USA, member of IEEE Power and Energy Society (PES), life member IEEE Pakistan, and member of "The Institution of Engineers Pakistan" (IEP). Further, he is also a life member of the Pakistan Engineering Council. Arfeen is an Author/Coauthor of 50+ high indexed Journals with several conferences and book chapters and a distinguished potential reviewer of hundred International Conferences Proceedings and hundred International Journals. He was awarded a Partial doctoral scholarship from the Higher Education Commission (HEC) Pakistan. Arfeen also got an International doctoral fellowship (IDF) and UTM Young Scholarship Grant from the University of Technology Malaysia (UTM).

Repurposed Laptop Batteries as a Home Energy Storage Application

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ABSTRACT
This project investigates the feasibility of repurposing discarded laptop lithium-ion batteries into a sustainable home energy storage system for backup power applications. Although electricity access is widespread, power interruptions still occur and disrupt daily activities. Simultaneously, large quantities of lithium-ion batteries are disposed of as electronic waste despite retaining usable capacity. This project addresses both issues by extending the life cycle of discarded batteries and transforming them into a functional and environmentally friendly energy solution. The proposed system combines repurposed battery packs, a Battery Management System (BMS), a microcontroller, and an inverter to form a portable backup power supply for low-load household appliances. MATLAB simulations and manual battery evaluations are conducted to analyze charging behavior, voltage stability, and system reliability over repeated cycles. Beyond technical feasibility, the project delivers societal impact by reducing environmental pollution, promoting sustainable energy practices, and improving energy resilience for low-income and rural communities. It fosters innovation through student-led startups, encourages a "reuse before replace" mindset, and supports green technology initiatives.

Keywords: Battery repurposing, Battery Management System (BMS), lithium-ion batteries, sustainable power supply, electronic waste reduction.

1. Product Description
The Repurposed Laptop Battery Power Supply is a compact home energy storage unit developed from discarded laptop lithium-ion cells. The system is designed to provide reliable backup power for low-load household appliances during outages while reducing electronic waste. The recovered cells are carefully tested, matched, and assembled into a protected battery pack integrated with a Battery Management System (BMS), microcontroller-based monitoring, and a DC–AC inverter. The prototype delivers a total energy capacity of 315 Wh with a nominal capacity of 25,600 mAh, enabling it to power essential devices such as lamps, fans, phone chargers, and small electronics. Real-time voltage monitoring is displayed on an LCD, allowing users to observe battery status and ensure safe operation. The BMS safeguards the system against overcharging, over-discharging, overcurrent, and short circuits, ensuring reliability when using second-life cells.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .
Figure 1 shows the basic operation of the repurposed laptop battery power supply system. Power from the wall socket is regulated by a buck converter to safely charge the repurposed

lithium-ion battery pack. The battery voltage is monitored by a microcontroller and displayed on an LCD for user reference. When backup power is needed, the stored DC energy is sent to an inverter, which converts it into AC power for low-load household appliances such as lamps and fans. This block diagram illustrates how charging, storage, monitoring, and power conversion are integrated into a single system to provide a safe and sustainable home energy storage solution.

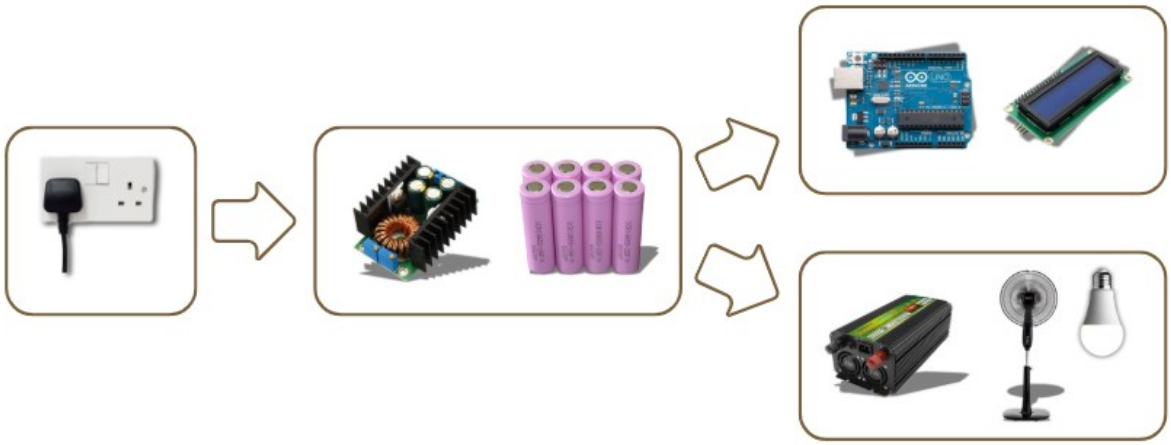

Figure 1. System Block Diagram.

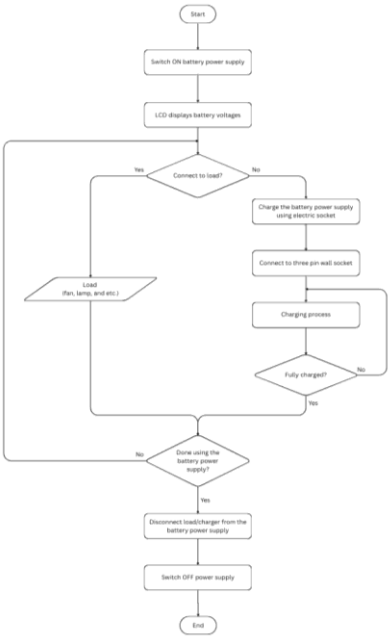

Figure 2. System Flowchart.

Figure 2 illustrates the operational flow of the repurposed battery power supply system. The process begins when the user switches ON the power supply, and the LCD immediately displays the battery voltage. The system then checks whether a load is connected. If a load is present, the battery supplies power to appliances such as a fan or lamp through the inverter. If no load is connected, the system enters charging mode, where the user connects the unit to a wall socket and the battery begins charging. The charging process continues until the battery is fully charged, after which the system returns to monitoring. During operation, the system repeatedly checks

whether the user has finished using the power supply. Once the user is done, the load or charger is disconnected and the power supply is switched OFF, ending the process. This flow ensures safe switching between charging and discharging modes while preventing overcharging and unnecessary power usage.

Figure 3. Image of Prototype.

Figure 4. Discarded Laptop Batteries.

Figure 3 shows the completed prototype of the repurposed laptop battery power supply system enclosed in a portable housing. The unit integrates the repurposed lithium-ion battery pack, Battery Management System (BMS), inverter, and control circuitry into a single compact structure. An LCD is mounted on the front panel to display real-time battery voltage, allowing users to monitor the system status. The prototype provides AC output sockets for connecting low-load household appliances such as lamps and fans, as demonstrated by the illuminated bulb in the figure. This prototype confirms the practical implementation of the proposed design, demonstrating that discarded laptop batteries can be transformed into a functional, safe, and portable home energy storage solution for backup power applications. **Figure 4** shows the examples of discarded laptop lithium-ion batteries recovered for this project. The image shows several laptop battery packs and their extracted cylindrical cells, which originate from different laptop models with typical ratings of 11.1 V and capacities ranging from approximately 44 Wh to 85 Wh. Although these battery packs are no longer suitable for use in laptops, many of their internal cells remain electrically functional. The recovered cells, commonly of the 18650 types, exhibit nominal voltages of about 3.6–3.7 V, making them suitable for reuse in low-voltage energy storage applications. This figure highlights the availability of reusable energy resources within electronic waste and demonstrates how discarded laptop batteries can serve as valuable raw materials for constructing a sustainable home energy storage system.

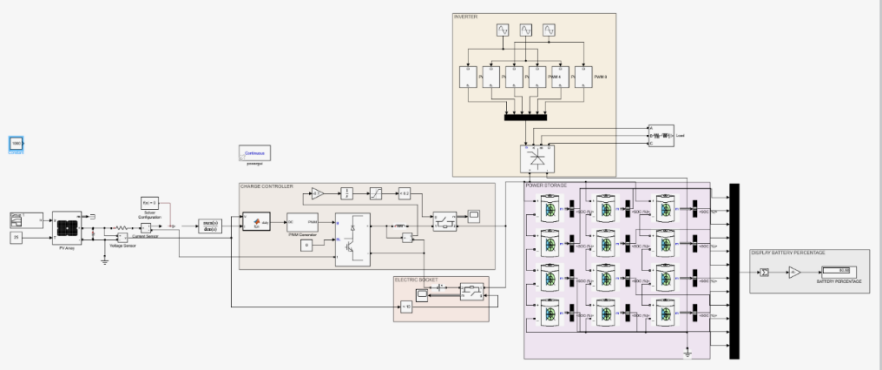

Figure 5. MATLAB Simulink Simulation.

Figure 5 presents the MATLAB Simulink model of the system and represents the initial simulation of the project before any modification was made. This simulation illustrates the conceptual design of the repurposed battery power supply, including the energy source, charge control stage, battery storage unit, inverter, and monitoring blocks. Each subsystem models the flow of power from the input source through regulation and storage, followed by DC–AC conversion for load operation. The battery block simulates the behavior of the repurposed lithium-ion cells, while the control and display sections represent voltage sensing and monitoring. This initial simulation served as a foundation for understanding system behavior, verifying power flow, and identifying design requirements before the hardware prototype was developed and refined.

```
#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27, 16, 2);

const int sensorPin = A0;
const int ledPin = 13;

void setup()
{
  lcd.init();
  lcd.backlight();

  pinMode(ledPin, OUTPUT);

  lcd.setCursor(0, 0);
  lcd.print("Battery Voltage:");
}

void loop()
{
   int sensorValue = analogRead(sensorPin);
   float vOut = (sensorValue / 825.0) * 4.032;
   float voltage = vOut * 3.125;

  lcd.setCursor(0, 1);
  lcd.print("V = ");
  lcd.print(voltage, 2);
  lcd.print(" V   ");
}
```

Figure 6. Arduino UNO Programming.

Figure 6 shows the Arduino Uno program developed to monitor and display the battery voltage of the repurposed power supply system. The code begins by including the LiquidCrystal_I2C library and initializing a 16x2 LCD with the I2C address 0x27. An analog input pin is assigned to read the battery voltage through a sensing circuit, while a digital pin is reserved for an indicator LED. During the setup stage, the LCD is initialized, its backlight is activated, and a fixed label, "Battery Voltage:", is displayed on the first row. In the main loop, the Arduino continuously reads the analog value from the voltage sensor, converts it into a real voltage using calibrated mathematical expressions, and displays the result on the second row of the LCD in real time. This program enables continuous monitoring of the battery condition, allowing users to observe the system status and ensuring safe operation of the repurposed energy storage system.

3. Novelty and uniqueness

This project is novel in its practical transformation of discarded laptop lithium-ion batteries into a fully functional home energy storage system. Unlike conventional backup power solutions that rely on newly manufactured batteries, this work demonstrates a structured method for recovering, testing, matching, and reassembling second-life cells into a safe and reliable battery pack. The system integrates a Battery Management System (BMS), microcontroller-based monitoring, LCD display, and inverter into a compact portable unit. Its uniqueness lies in combining low-cost hardware with systematic battery evaluation and protection techniques, ensuring safe reuse of electronic waste. By converting end-of-life laptop batteries into a usable backup power source, the project bridges sustainability with real-world engineering application, proving that waste materials can be transformed into valuable energy resources.

4. Benefit to mankind

This project benefits society by addressing two major issues: power interruptions and electronic waste. The developed system provides households with a reliable backup power source for essential low-load appliances such as lighting and fans during outages, improving comfort, safety, and continuity of daily activities. At the same time, it reduces environmental pollution by extending the life cycle of discarded lithium-ion batteries that would otherwise contribute to e-waste. The approach promotes responsible resource utilization and raises public awareness about sustainable energy practices. By offering a low-cost alternative to commercial backup systems, it makes energy resilience more accessible, especially for low-income communities and rural areas. Overall, the project enhances quality of life while encouraging environmentally conscious behavior.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by demonstrating how electronic waste can be converted into a marketable energy product through simple engineering techniques. It encourages a mindset of "reuse before replace," inspiring students and communities to view discarded components as opportunities for value creation. The system can be replicated using locally available materials, enabling small-scale production, repair services, and community workshops. This creates opportunities for student-led startups, recycling-based enterprises, and social innovation initiatives focused on green technology. By combining sustainability with affordability, the project supports a culture of entrepreneurship that emphasizes environmental responsibility. It aligns with emerging green industries and equips learners with practical skills in battery technology, power electronics, and system integration, fostering future innovators in sustainable engineering.

6. Potential commercialization

The developed prototype shows strong potential for commercialization as a low-cost portable backup power unit. With minor refinement in enclosure design, safety certification, and user interface, the system can be packaged as a consumer-ready product. It is suitable for households, small shops, dormitories, and rural communities experiencing frequent power disruptions. Production can leverage recycled battery cells sourced from repair centers and e-waste facilities, significantly reducing manufacturing costs. The product can be marketed as an eco-friendly alternative to conventional power banks and mini generators. Modular battery expansion, solar charging options, and mobile app monitoring can further enhance market appeal. This creates opportunities for sustainable startups focused on green energy solutions while reducing dependency on newly manufactured batteries.

7. Acknowledgment

First and foremost, I am expressing my gratitude to Allah SWT for giving me the will and strength to commence my diploma and for accomplishing it with triumph. Next, I am also expressing my deepest gratitude to my supervisor, Dr. Norlee Husnafeza Binti Ahmad, for her guidance and support throughout my crucial moment in finishing this project. Not to forget, my sincerest thanks also go to my family for their constant encouragement, motivation, and unwavering support during the duration of finishing my project. Especially my father, whose insights and expertise played an important role in helping me making this project come true. Furthermore, I am grateful to UiTM for providing the essential resources and facilities that facilitated the efficient execution of my research. Finally, my heartfelt gratitude towards my friends for always being there for me throughout the process of accomplishing this project. Their contributions, both technically and morally, have been one of the reasons for my success.

8. Researchers' Biography

Lily Nurhidayah Nor Hashim is a Diploma student in Electrical Engineering (Power) at Universiti Teknologi MARA (UiTM), Johor. Her research interest focuses on sustainable power solutions, particularly in repurposing discarded lithium-ion batteries to develop a new home energy storage system. She has consistently demonstrated academic excellence by being listed on the Dean's List for four consecutive semesters. Lily is also an award-winning innovator, having received *The Most Innovative Design Award* and the *Diamond Award* at the 11th Electrical, Electronic, and Systems Engineering Exhibition (EESEE) 2026. She aspires to contribute to environmentally responsible engineering and green technology development.

Norlee Husnafeza Ahmad is a Senior Lecturer at the Faculty of Electrical Engineering, Universiti Teknologi MARA, Pasir Gudang Campus. She obtained her Ph.D. in Electrical Engineering, specializing in the development of electricity market models for the Malaysia Electricity Supply Industry using a System Dynamics approach. Her research primarily focuses on power system economics and economic modelling of energy systems, with particular interest in electricity tariff design, renewable energy integration, and long-term energy policy assessment. She is actively involved in developing simulation-based frameworks that integrate technical, economic, and policy variables to support strategic decision-making in the energy sector.

Mrs. Norbaiti Sidik received her first formal education at government primary school, Sekolah Kebangsaan Batu Lima in Sik Kedah. The second foundation, her academic journey was laid at Arabic high school established as Maktab Mahmud Alor Setar, Kedah Darul Aman. Her studies continued at Universiti Kebangsaan Malaysia in Bandar Baru Bangi Selangor right after completed 1 year Science Matriculation Certificate at Science Matriculation Centre, Ipoh Perak Darul Ridzuan. She graduated her Bachelor Engineering Degree in Electrical, Electronics and System within 3 years from Universiti Kebangsaan Malaysia, Bandar Baru Bangi Selangor Darul Ehsan and she further developed her academic and professional skills by obtaining Master Engineering Degree in Communication and Computer also from the same university in 2002. She is very committed, passionate and dedicated in education line who is now a senior lecturer and having experienced more than 15 years in teaching & learning and lecturing at Electrical Engineering Studies, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, Johor Darul Takzim.

IoT-Based Trash Rake System for Residential Drainage Filtration

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ABSTRACT
In this century, the problem of Dumping solid waste into rivers and residential drainage systems is a major global issue causing flash floods, and the Department of Statistics Malaysia (DOSM) reported that Malaysia recorded flood losses of RM933.4 million in 2024. Therefore, an IoT-based trash rake system for residential drainage filtration was developed to filter the trash contained in the drainage before it is released into the river. This system was equipped with two ESP32 microcontrollers where ESP32 (A) functioned as a data input system while ESP32 (B) functioned as an actuator control system. This system used an ultrasonic sensor to detect the presence of garbage by measuring the time-of-flight (ToF) and a float switch to detect the water level. This system implemented a conveyor-based trash rake that used a DC gear motor. The water pump was used to lower the water level in the drainage. The project successfully filtered trash such as plastics, twigs, and dry leaves on the drainage prototype when the ToF was less than 485 µs, which was used as an indicator for detecting the presence of trash. This system contributes to reducing river pollution and minimizing the risk of flooding in residential areas.

Keywords: trash, drainage, ultrasonic, time-of-flight

1. Project Overview
Solid waste disposal into rivers and residential drainage systems has increasingly become a global environmental concern because it causes the flash floods that occur all over the world. Flash floods occur faster and more frequently when trash is dumped into rivers and residential drainage systems because the trash blocks the flow of water, which in turn causes rapid overflow of water during heavy rains. Therefore, an IoT-based trash rake system for residential drainage filtration has been developed to filter the trash in the drainage before the drainage water released into the river. This system is equipped with an ultrasonic sensor to detect the presence of trash and a float switch to detect the water level of the residential drainage. The data from these sensors is transmitted to Google Sheets as a cloud database and evaluated for the trash filtration process by the trash rake system, which uses a conveyor mechanism and water pump. Integration of Internet of Things (IoT) allows monitoring of system data and alert messages displayed on the Gemini dashboard and Telegram. Overall, IoT-based trash rake system integrates sensing, automation, and IoT for efficient drainage monitoring, reducing labor and flood risks.

2. Flow Charts of the Project
ESP32 (A) functions as the system data input node by collecting sensor data, processing it, and transmitting the data to Google Sheet via Google Apps Script using a Wi-Fi connection. Google Sheet acts as a cloud database that stores drainage condition status, trash detection using ToF values, and drainage water levels for real-time access. ESP32 (B) makes special requests to Google

Sheet to retrieve the latest data for the purpose of controlling the DC gear motor, water pump, and warning system. The flowchart of the ESP32 (A) operation as shown in **Figure 1** describes the data input system control process starting from system activation and Wi-Fi connection to sensor data monitoring and transmission.

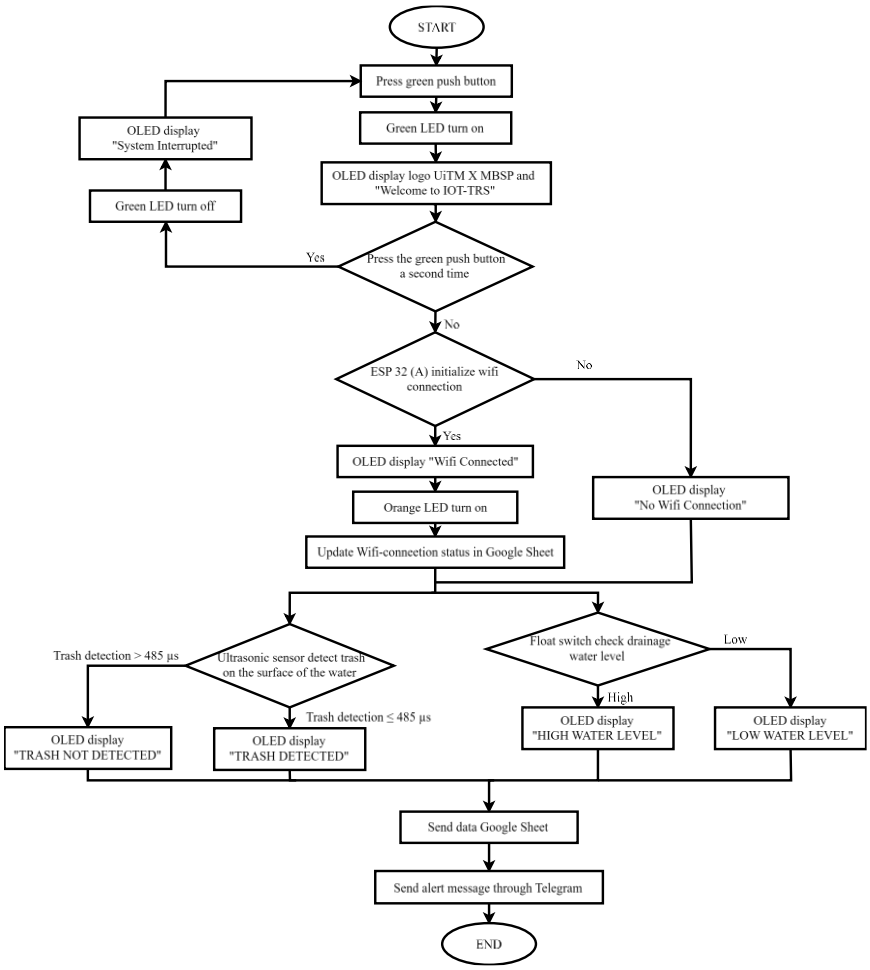

Figure 1. The flowchart of ESP32 (A) operation.

The system starts when the green push button is pressed and the ESP32 (A) receives a digital input signal as a command to turn on the system. The green LED is activated as a visual indicator that the system is in an active state. The OLED displays the UiTM X MBSPP logo and the message "Welcome to IOT-TRS" as a system initialization process. The system then checks whether the green push button is pressed a second time as a manual interruption mechanism. If the button is pressed a second time, the green LED is turned off, and the system is considered to be in an interrupted state. The OLED display will display the message "System Interrupted" and the system returns to a waiting state for the system to be reset. If no interruption is detected, the ESP32 (A) will start the Wi-Fi connection initialization process. If the Wi-Fi connection is successful, the OLED display will display the status "Wi-Fi Connected" and the orange LED will turn on as a physical indicator that the network connection is stable. Then, the Wi-Fi connection status will be updated to the Google Sheet using Google Apps Script. If the Wi-Fi connection fails, the OLED display will show the message "No Wi-Fi Connection". The system will continue

sensor operation even without Wi-Fi connection for local monitoring. Ultrasonic sensor is used to detect trash on the water surface based on the ToF value in µs. If the ToF value is less than or equal to 485 µs, the system confirms the presence of trash and displays "TRASH DETECTED" on the OLED. If the ToF value exceeds 485 µs, the system assumes there is no trash and displays "TRASH NOT DETECTED". Then, the float switch is used to check the drainage water level whether it is in a high or low state. The OLED display will display "HIGH WATER LEVEL" or "LOW WATER LEVEL" based on the status of the float switch. All sensor data will be transmitted to Google Sheet and Google Apps Script is applied to process the data and automatically generate alert messages to the Telegram platform. The flowchart of the ESP32 (B) operation as shown in **Figure 2** illustrates the trash rake system control process which includes data acquisition, drainage condition evaluation, and actuator activation. The ESP32 (B) system starts when the yellow push button is pressed to activate the trash rake system.

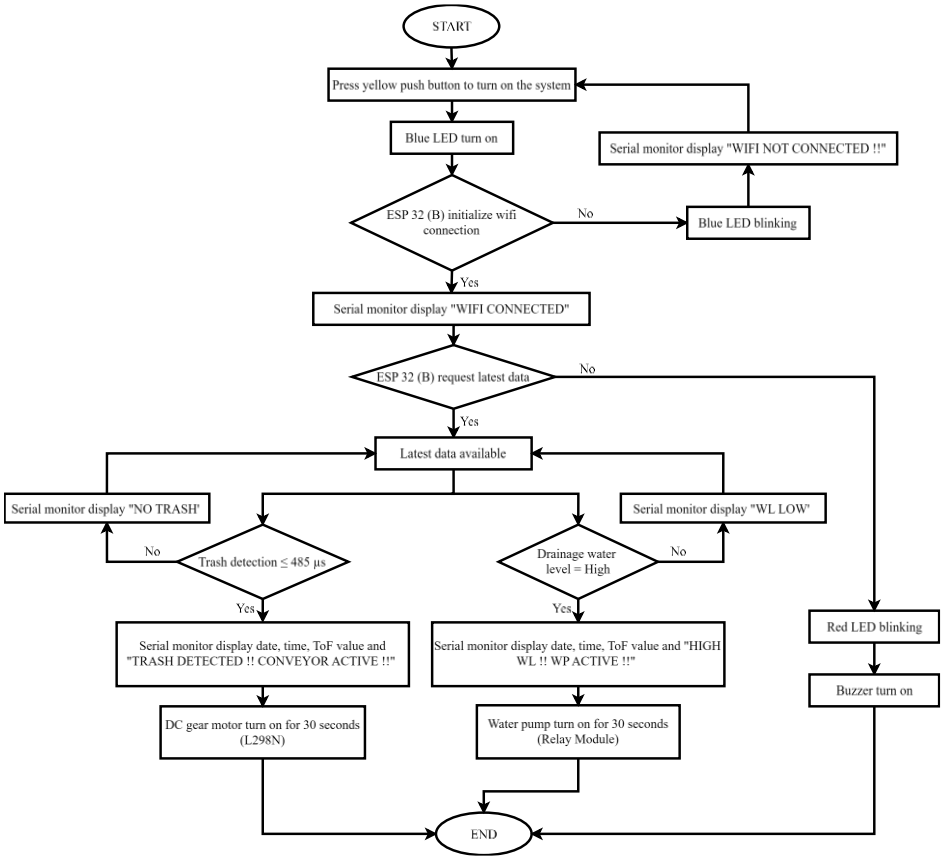

Figure 2. The flowchart of ESP32 (B) operation.

The blue LED is turned on as an indicator that the ESP32 (B) is in the active state. After that, the ESP32 (B) will start the Wi-Fi connection initialization process. If the Wi-Fi connection fails, the blue LED will blink as a visual warning and the display on the serial monitor in the Arduino IDE software will display the message "WI-FI NOT CONNECTED !!". The system will continue to wait until the Wi-Fi connection is successfully established. Once the Wi-Fi is successfully connected, the serial monitor in the Arduino IDE software will display the message "WI-FI CONNECTED". Then, the ESP32 (B) makes a special request to the Google Sheet via Google Apps Script to retrieve the latest system data from the Google Sheet. If the data is successfully

obtained, the system confirms that the latest data is available for processing. The system will evaluate the ToF value to determine the presence of trash. If the ToF value exceeds 485 µs, the serial monitor in the Arduino IDE software will display the message "NO TRASH". The system will also evaluate the status of the drain water level based on the data received. If trash is detected, the serial monitor in the Arduino IDE software will display the date, time, ToF value and the message "TRASH DETECTED !! CONVEYOR ACTIVE !!". The DC gear motor will be activated using the L298N driver for 30 seconds to drive the trash collection system. If the drain water level is high, the serial monitor will display the message "HIGH WL !! WP ACTIVE !!". The water pump will be activated via the relay module for 30 seconds to lower the water level. If the latest data is not available, the red LED will flash as a warning, and the buzzer will be activated to give an audio signal. The red push button on the ESP32 (B) is used as an emergency and maintenance switch which functions to immediately stop all actuator control processes when pressed. This IoT-based trash rake system for residential drainage filtration uses two ESP32s that operate separately, where ESP32 (A) functions as a data input system while ESP32 (B) functions as an actuator control system. The design of this system allows the system to continue operating even if one of the ESP32s is inactive. If ESP32 (A) can still detect and send data to Google Sheet even if ESP32 (B) is turned off. If ESP32 (A) is not operating, ESP32 (B) can still be turned on but the DC gear motor and water pump will not be turned on due to the lack of current data to process.

3. Novelty and uniqueness

The novelty of this project lies in the implementation of a dual-ESP32 architecture combined with cloud-based decision making for residential drainage trash filtration. Unlike conventional trash rake systems that rely on manual operation, this system separates sensing and actuation tasks using two independent ESP32 microcontrollers. ESP32 (A) focuses on real-time data acquisition, processing, and cloud transmission, while ESP32 (B) performs actuator control based on the latest cloud data. This separation improves system reliability and fault tolerance. Another unique aspect of this system is the use of Google Sheets as a cloud database integrated with Google Apps Script to perform data processing, decision logic, and alert triggering. Most existing systems rely on proprietary IoT platforms, whereas this project uses a low-cost and widely accessible cloud solution. The system implements ultrasonic time-of-flight (ToF) sensing combined with float switch detection to classify drainage conditions accurately. In addition, the conveyor-based trash rake mechanism driven by a DC gear motor is designed for continuous low-speed and high-torque operation that makes it suitable for residential drainage environments. The integration of Telegram alerts and Gemini Dashboard further enhances real-time monitoring without requiring physical presence. These combined features make the system unique, scalable, and suitable for real-world drainage automation.

4. Benefit to mankind

This project provides significant benefits to the public by reducing the risk of flash floods in residential areas. The automated trash rake system helps prevent drainage blockage by removing solid trash before it enters main drains and rivers. This reduces water overflow during heavy rainfall and minimizes damage to houses, roads, and vehicles. The system reduces dependence on manual labor, which is dangerous and inefficient during flood events. Real-time monitoring using IoT technology allows authorities to observe drainage conditions remotely and respond faster to critical situations. The automatic water pump control helps lower drainage water levels during high-risk conditions. In addition, the system supports environmental protection by reducing river

pollution caused by solid waste. The use of low-cost components makes the system affordable and suitable for deployment in many residential areas, especially flood-prone communities.

5. Innovation and Entrepreneurial Impact

This project promotes innovation through the integration of sensing, control systems, and IoT technologies into a practical drainage management solution. The use of dual ESP32 microcontrollers demonstrates an advanced distributed control architecture suitable for real-time automation applications. Cloud-based data processing using Google Apps Script introduces a flexible and scalable approach to IoT system design. From an entrepreneurial perspective, this project encourages the development of low-cost smart infrastructure solutions using readily available hardware and open-source software. It demonstrates how engineering knowledge can be translated into a functional product that addresses real societal problems. The system design can inspire students, engineers, and startups to develop similar smart monitoring solutions for urban infrastructure. This project supports a culture of problem-solving, innovation, and technology-driven entrepreneurship within the engineering community and local authorities.

6. Potential commercialization

This IoT-based trash rake system has strong potential for commercialization, particularly for use by local authorities, municipal councils, and drainage management agencies. The system is designed using low-cost hardware such as ESP32, ultrasonic sensor, and standard DC gear motor that make large-scale deployment economically feasible. The modular design allows customization based on drainage size, trash volume, and power requirements. Cloud-based monitoring and alert systems reduce operational costs by minimizing the need for on-site supervision. The system can be offered as a complete solution, including hardware installation, cloud configuration, and maintenance services. With increasing concerns over urban flooding and smart city development, this system can be commercialized as a smart drainage automation product. It can also be expanded into subscription-based monitoring services for long-term infrastructure management.

7. Acknowledgment

First of all, we would like to thank Allah for His blessings throughout the journey of developing my Final Year Project proposal. This experience has been challenging, and we were truly grateful for the strength and patience given to me throughout this process. Nothing is possible unless Allah SWT wills it. We would like to express my deepest gratitude to our supervisor, Puan Azwati Binti Azmin for her invaluable support, encouragement, and expert guidance throughout this project. Her dedication and commitment have contributed greatly to the quality of my work. I am very grateful to my parents and family for their support and prayers, which have been a source of strength and perseverance for me throughout this journey. Finally, I would like to express my deepest gratitude to all those who have helped me throughout this journey and whose support has kept me motivated in my efforts to increase my knowledge and contribute significantly to the development of this project.

8. Researchers' Biography

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Verbs to the Rescue!

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ABSTRACT

'Verbs to the Rescue!' is an online illustrated grammar e-book designed to enhance the English verb comprehension, especially among the primary school students aged 7-12. This project was developed to help young learners resolve their struggles with grammar due to the rule-heavy nature, which often affects their interests and confidence to learn. To address this issue, *'Verbs to the Rescue!'* reimagines grammar through storytelling, visual illustrations, and interactive elements that showcase verbs in a more enjoyable and meaningful way. The innovation lies within combining linguistic accuracy and digital creativity, it aims to produce an engaging learning experience both from home and classroom use. This project contributes to socio-educational development by creating an easily accessible and visually appealing grammar e-book. This offers young learners, an engaging alternative to plain traditional worksheet based practices. Besides its educational purposes, this project demonstrates a strong entrepreneurial potential. The e-book will be published on Amazon Kindle and Google Play Books, with a future potential expanding into a complete grammar learning series. These will continue to expand through the ongoing support of social media posts and possible collaborations with other talented online book creators.

Keywords: Verbs, storytelling, grammar e-book, digital learning, primary education

1. Product Description

'Verbs to the Rescue!' is a digitally illustrated grammar e-book designed to improve the understanding of English verbs, especially among young primary learners. The e-book displays strong approaches where verbs are introduced through the superheroes' actions, colourful illustrations, and other engaging elements. In addition, each page contains highlighted bold verbs used in meaningful situations, ensuring children understand the functions in daily communication. Other than that, there are voice explanations on every verb, where they briefly explain each verb. However, compared to the traditional materials which rely on rule-heavy worksheets and drills, this e-book allows children to experience verbs through a child-friendly approach and visually engaging content. This digital approach ensures that learning is easier and accessible across online

devices, allowing them to study independently either from home or with teacher guidance in classrooms. Created as an interactive and engaging material, 'Verbs to the Rescue!' provides parents and teachers with an alternative to boring worksheets, which aims to encourage and build confidence towards learning English grammar.

2. Pie Charts

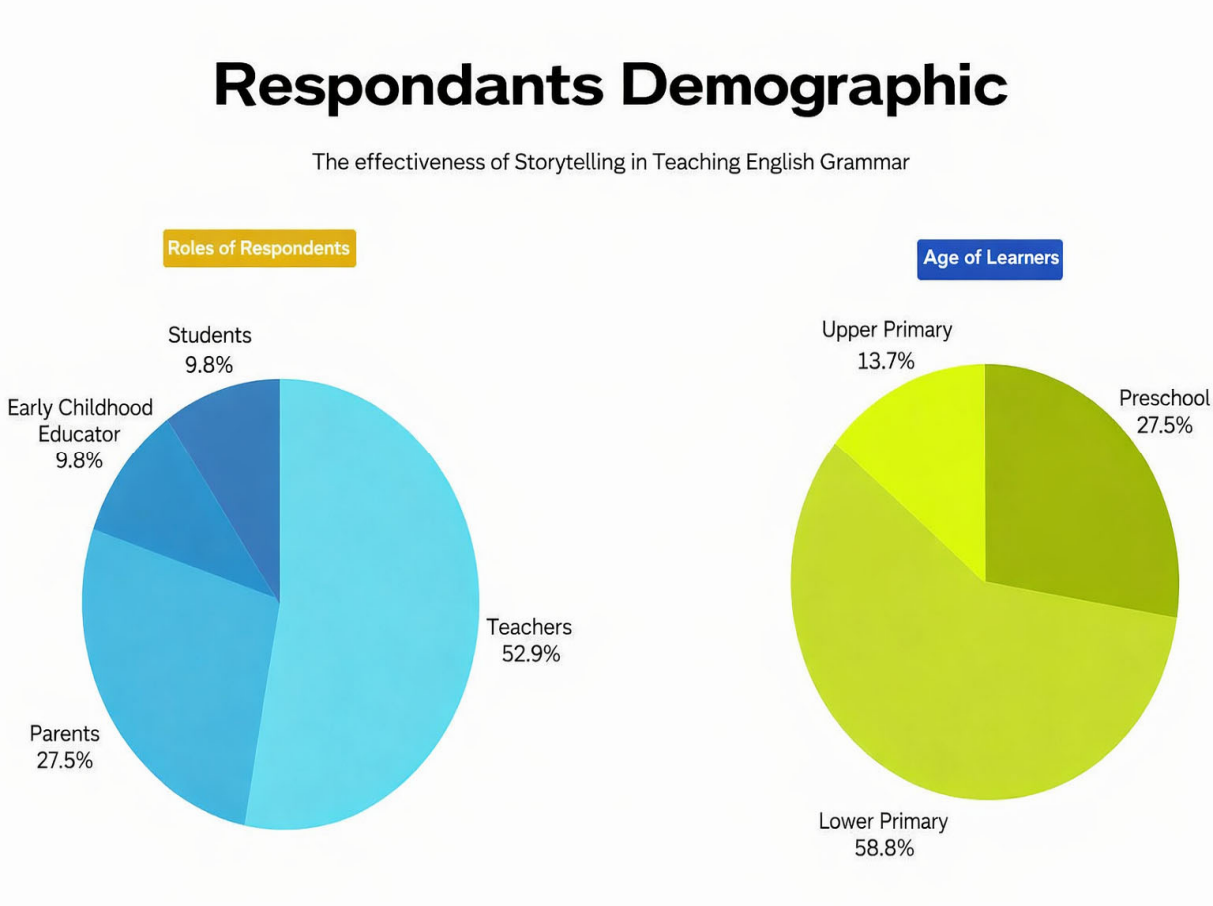

Figure 1. Respondents Demographic.

A total of 51 respondents participated in the survey conducted to examine perceptions regarding the effectiveness of storytelling in teaching English grammar verbs to primary learners. In terms of respondent roles, teachers formed the largest percentage of (52.9%), which is 27 people, followed by parents consisting of (27.5%), which is 14 people, while the remaining 19.6%, compromised individuals with the general interest and knowledge of children's education, including students and early childhood educators. However, regarding the age range of children associated with the respondents, the majority reported the involvement of lower primary students (58.8%), followed by preschool students (27.5%), while the remaining 13.7%, consists of students from the upper primary level.

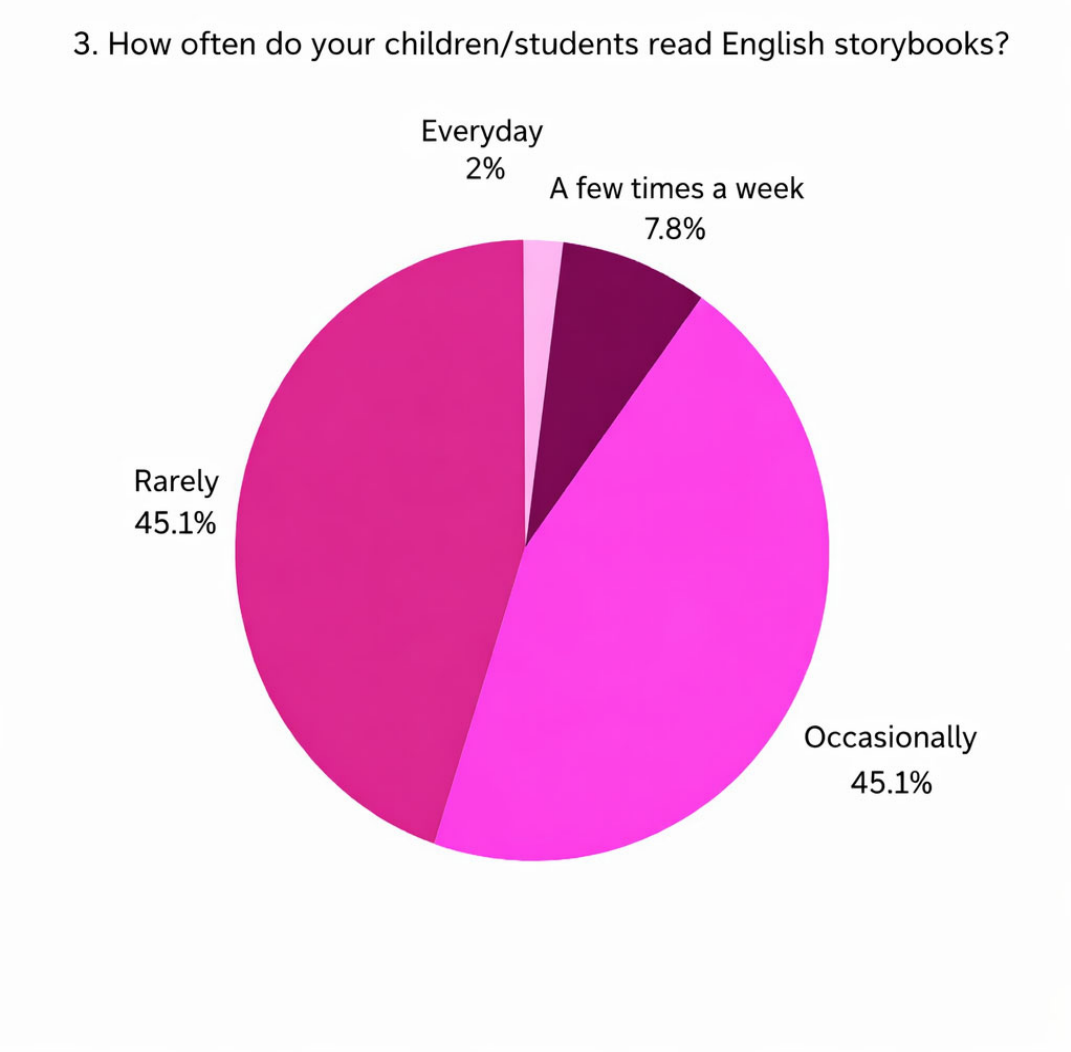

Figure 2. Reading Frequency.

Responses show that children have multiple reading frequencies, even with various exposure to English reading materials. Concerningly, nearly half of the respondents **(45.1%),** reported that children occasionally or even rarely read English storybooks, while the other **9.8%**, indicated frequent reading. These numbers highlight the poor exposure of young learners to English materials, which contributed to the inconsistencies found among the children and heightened the necessity for free engaging materials.

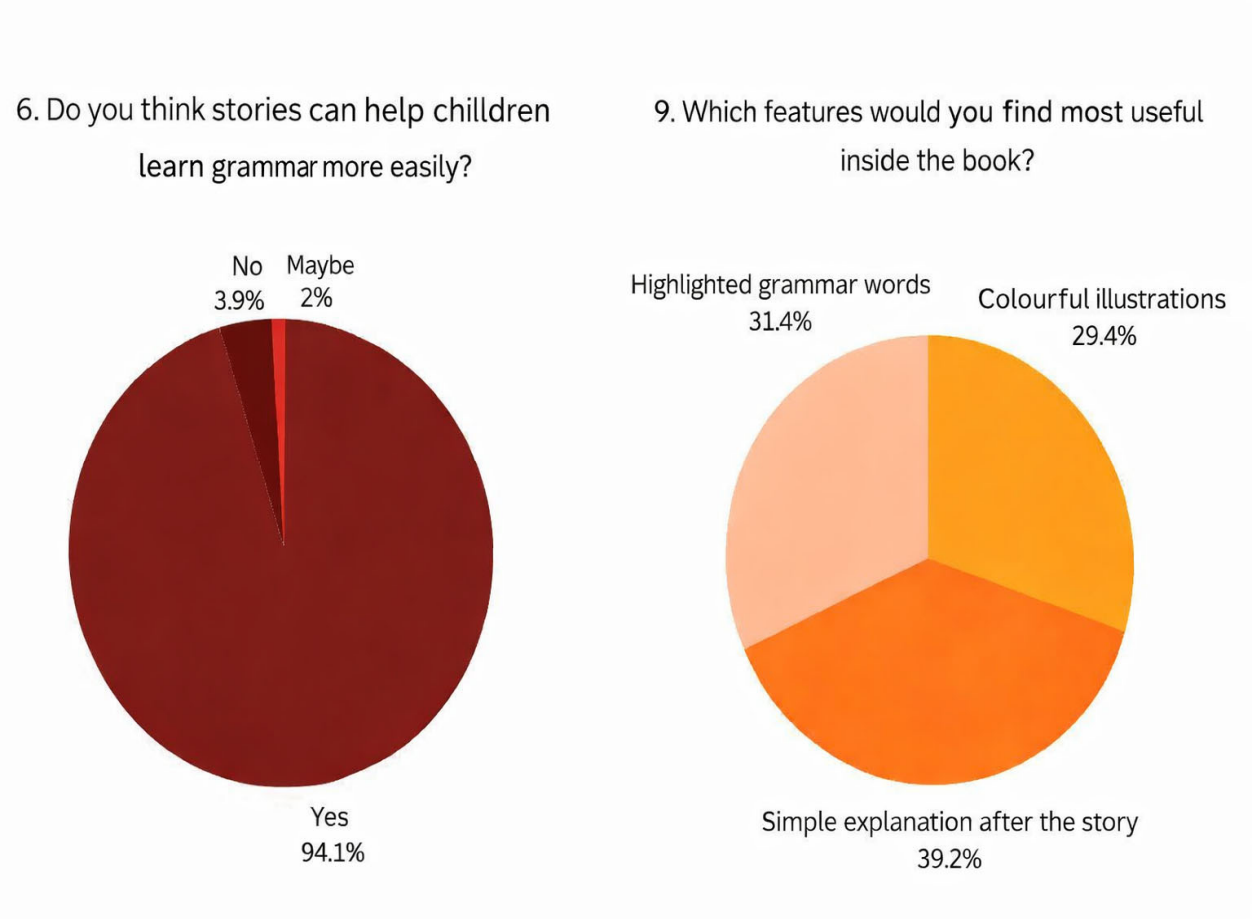

Figure 3 Grammar Effectiveness

The survey further demonstrates that respondents perceived *'Verbs to the Rescue!'* as an effective alternative to use as a teaching tool for English verbs to primary learners. A majority of respondents, **94.1%,** agreed that storytelling is the most effective approach to attract children, as e-books contain colourful narrative elements which indulge learners engagement to study grammar naturally.

3. Novelty and uniqueness

'Verbs to the Rescue!' introduces grammar learning through an interactive superhero theme storyline, instead of through traditional methods such as worksheets and drills. This project serves as an alternative that increases the children's interest in learning grammar. Unlike the rule-heavy materials, this project allows them to experience verbs through action words and colourful illustrations rather than memorising. The e-book contains verbs highlighted and bold within the sentences to ensure that the children are able to understand and apply it in their daily communication. Additionally, there are voice explanations after each verb making it easier for kids to understand the functions. This project is unique from others due to its integration of the visual design, storyline and the correct usage of linguistic content in one single product. By transforming verbs into a part of an action-packed adventure, grammar seems less intimidating

and understandable. The digital use in this project enhances its uniqueness by making learning flexible and suitable according to the modern teaching methods whether at home or in class.

4. Benefit to mankind

This project contributes to early language development especially among children aged 7-12 years old, by enforcing a better understanding of English grammar. When young learners are taught verbs from a young age, they would be able to develop excellent writing and speaking skills. As we know, verbs are the foundation to a complete sentence structure and without it the sentence would have no meaning. The e-book aims to invoke the sense of enjoyment and curiosity instead of boredom and anxiousness during grammar lessons. This e-book could be used as an alternative whether in the classroom or at home. Parents and Teachers would benefit from having this as a child-friendly and engaging tool. Most importantly, training the language comprehension at a primary level enhances academic growth and future communication skills, which are important in employment and academics. By implementing positive learning experiences, this project allows for a long term education improvement in the future.

5. Innovation and Entrepreneurial Impact

Through the innovation aspect, this project merges linguistic knowledge and digital storytelling to overcome common challenges in education. Instead of viewing grammar as complicated, *'Verbs to the Rescue!'* is designed as an interactive digital learning experience. By redesigning into something interactive this shows how that academic knowledge can be incorporated into a single creative product. This project also involves entrepreneurial thinking by analyzing the problems in child-friendly grammar materials, pre-existing research and developing a suitable solution. It promotes a foundation where students and educators can transform their ideas into meaningful products that could be used by the community. Some of the products would even be the answers to all the communities needs. Overall, this portrays innovation, entrepreneurship and creativity.

6. Potential commercialization

As a digital product, *'Verbs to the Rescue!'* would be published on online platforms such as Amazon Kindle and Google Play Books, which would reach a wide group of audience using minimal production cost. The target market includes parents, teachers and early childhood educators which seek engaging grammar materials. The project could be used during classroom or homeschool use. Furthermore, the entrepreneurial potential of expanding into a complete series covering other grammar components such as Nouns, Adjectives and Prepositions. Furthermore, future development may focus on another group of people such as secondary students. An additional thought is to incorporate other merchandise such as interactive digital activities and printable worksheets could further improve the product. With the increasing demand for online educational materials, this project has the potential to become a more convenient learning tool within the digital education world.

7. Acknowledgment

The author would like to express her heartfelt gratitude to both of her parents and family for their endless support throughout this journey. A sincere appreciation to the lecturers and supervisor 'Madam Sharifah Amani' for their guidance and assistance in completing my Final Year. Finally, thanks are given to the friends for their encouragement and support.

8. Researchers' Biography

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Sharifah Amani Bte Syed Abdul Rahman is a senior lecturer at the Academy of Language Studies, UiTM Pasir Gudang, Johor Bahru. She holds a Master in TESL and has been lecturing in UiTM for the past 15 years. Her areas of research interest are English language teaching, language learning and materials development.

The Rice Husk Biosilica Machine Set

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ABSTRACT

Rice, a major food source consumed by a majority of the population, produces a byproduct often thrown away and burned called rice husks. Rice husks are essentially the skin of the rice and an estimated 90% of rice husks in developing countries are burned without fully utilizing the full potential of them. Various research has been conducted to find out how to utilize an otherwise useless byproduct. A popular way of utilization that has been researched extensively is to process rice husks into biosilica. The process consists of calcining rice husks and treating them with chemicals to produce biosilica. Compared to developed countries where this method has been used extensively in their industrial production, developing countries are lacking behind due to the high cost of this method. With the low-cost machine this paper proposes to develop, the problem of unutilized rice husks will be solved in developing countries. Along with solving the environmental problems of waste rice husks, it will also generate income for those interested in the machine.

Keywords: Rice husk, machining rice, organic, green technology

1. Product Description

The product is a set of integrated machines that process rice husks into biosilica from start to end. The aim of this product is to provide a greener, simple, and budget-friendly system of processing an often thrown out agricultural waste into useful biosilica. The set of machines consists of an incinerator for calcining the rice husk, a grinder to grind the rice husk ash for a more efficient process, a chemical leaching machine for the grinded ash to turn it into biosilica, and an oven to dry the final product. The processes are as described in **Figure 1.** In an effort for environmental sustainability, a filtration system is installed to the main producer of pollution in the system, the incinerator. This unit will capture pollutants from the calcining process, which includes carbon dioxide, carbon monoxide, nitrogen oxide, suful dioxide, and volatile organic compounds. Further measures are also installed on all machines to promote a greener production process when compared to conventional silica gathering. The target users of this product include small and medium-scale industries seeking affordable and greener technologies.

2. Flow Charts/Flow Diagram/ Table

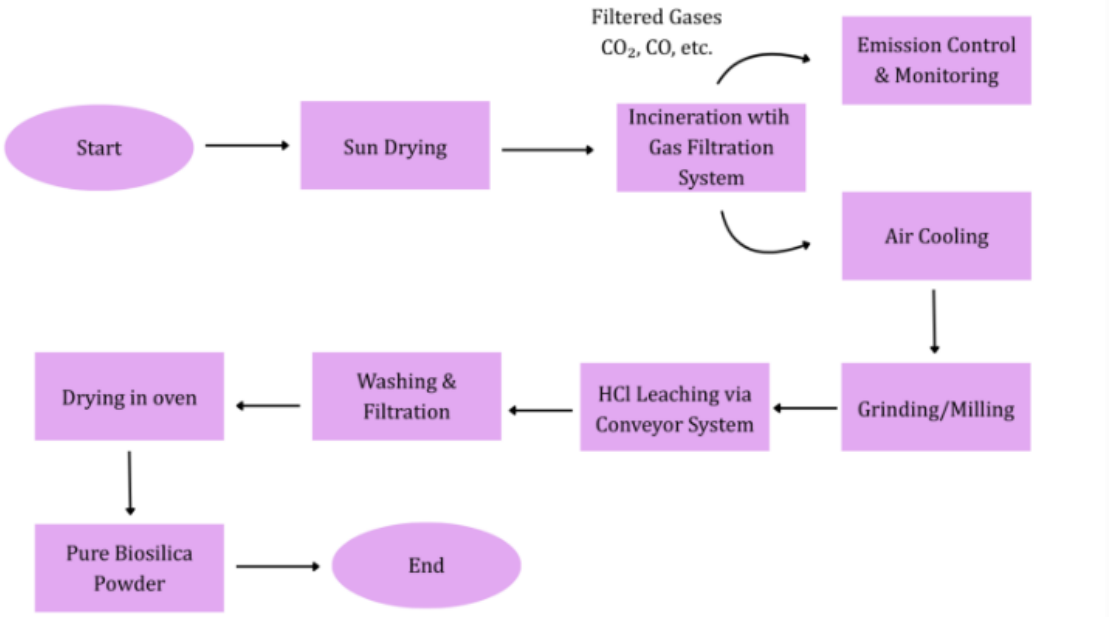

Figure 1. illustration of the details the step-by-step production process for converting rice husk into high-purity biosilica powder.

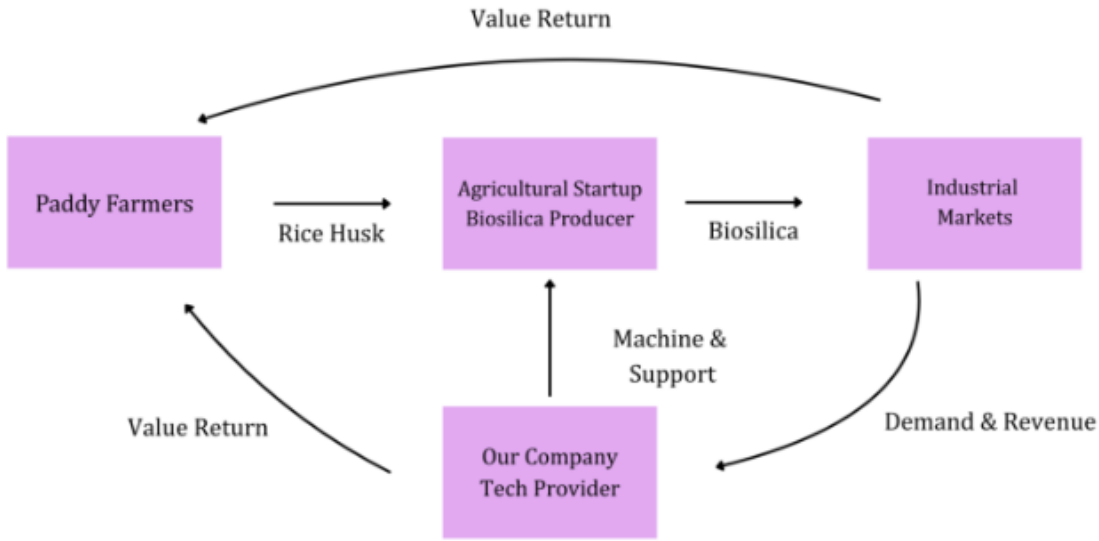

Figure 2. illustration of the circular value flow connecting technology provider, agricultural partner, farmers, and industrial markets.

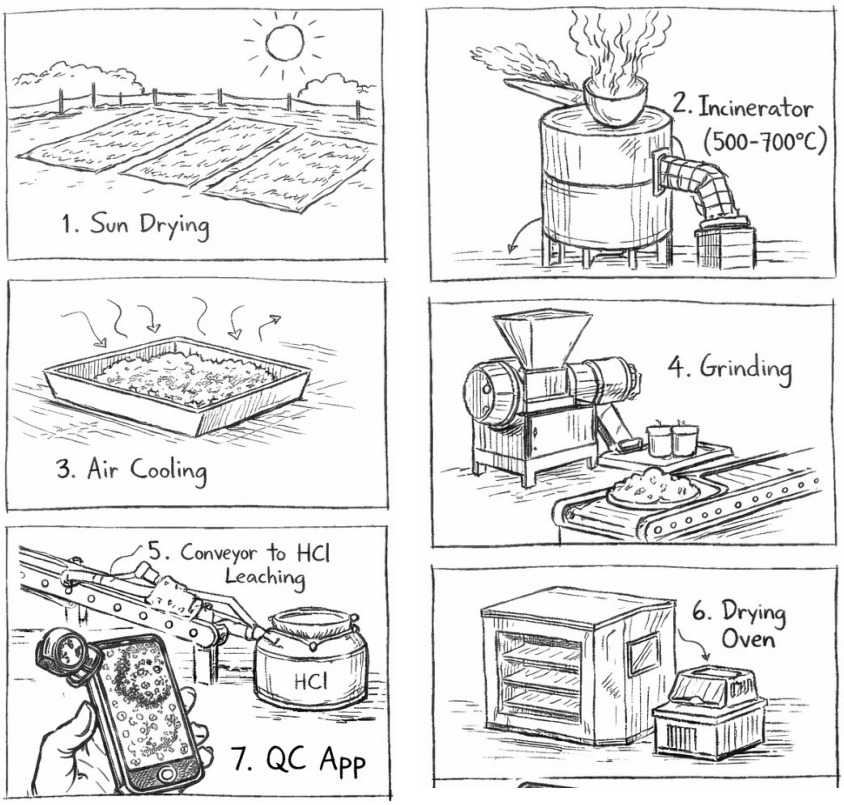

Figure 3. illustration of the flow of the machine.

Table 1. Chemical Composition and Physical Properties of Rice Husk Ash (RHA) .

Property	Constituent	RHA
Chemical (% by weight)	SiO_2	91.15
	Al_2O_3	0.41
	Fe_2O_3	0.21
	CaO	0.41
	MgO	0.45
	SO_3	0.62
	K_2O	6.25
	Na_2O	0.05
	L.O·I.	0.45

3. Novelty and uniqueness

The novelty of our product lies in its integrated system that replaces conventional, high-impact steps with a continuous green workflow. Unlike traditional processes that use electric ovens, contributing to CO_2 emissions from grid electricity (MTGC, 2017) that we employ a solar tunnel dryer or heat pump dryer, eliminating fossil fuel-based drying entirely (ResearchGate, 2023). Furthermore, while standard acid leaching relies on strong mineral acids like HCl, we uniquely

implement biodegradable organic acids such as gluconic acid, which reduce hazardous effluent while achieving ~89.9% silica recovery (PubMed, 2021). In quality control, instead of generating lead-contaminated waste from XRF testing, we introduce non-chemical acoustic or mobile imaging methods, avoiding toxic byproducts (Springer, 2023). No existing compact system combines these green drying, leaching, and testing methods into one sustainable process, making our approach uniquely eco-friendly from start to finish.

4. Benefit to mankind

This Rice Husk Biosilica Machine Set effectively transforms plentiful agricultural waste into valuable biosilica, turning an abundant by-product into a useful industrial material. Rice husk silica can be produced by controlled combustion and extraction, yielding high-purity amorphous silica that improves the mechanical properties and durability of concrete when used as a supplementary cementitious material in construction, leading to stronger and more resilient infrastructure while reducing reliance on traditional cement (RHA pozzolanic material research, 2025). Silica recovered from rice husk also shows promise in water filtration applications, where porous silica materials derived from rice husk waste can be used to create effective eco-friendly filters for contaminant removal (silica water filter fabrication study, 2024). By converting waste into an industrial resource, this technology helps reduce agricultural burning pollution and supports a circular economy approach, fostering sustainable industry, lowering carbon emissions, and contributing to a cleaner, more resource-efficient future.

5. Innovation and Entrepreneurial Impact

This project fosters innovation by consolidating the entire biosilica production process from calcination to drying into a single machine system. The integrated emission filters render green processing fundamental rather than discretionary. This turnkey system converts theoretical waste valorisation into practical implementation, facilitating effective circular economy solutions. Furthermore, the project cultivates a culture of entrepreneurship by transforming academic research into a market-driven venture. It serves as a live case study within our institution, demonstrating the commercialization pathway from laboratory innovation such as our greener rice husk processing method to a viable business model. For the community, it creates a replicable framework for converting local agricultural waste into economic opportunity, encouraging grassroots enterprise. Within the industry, it introduces a disruptive, sustainable technology, challenging established players to innovate and create niches for new startups.

6. Potential commercialization

Our machine creates a synergistic commercial ecosystem. Farmers and rice millers gain a new revenue stream by selling waste husks, turning disposal costs into income and solving a pollution problem. They have become our reliable feedstock partners. Sustainable biosilica start-ups are our primary customers. They leverage our machine as their core, scalable technology, allowing them to launch quickly and focus on marketing high value biosilica to premium markets without prohibitive R&D costs. The construction industry benefits as a major end-user. The cement industry is responsible for approximately 5% of global anthropogenic CO_2 emissions (Merali & Tagnit-Hamou, 2011). With our machine, they can access sustainable biosilica to produce low-carbon concrete, helping them meet critical green building standards and ESG targets, which wins them more projects. Finally, tire manufacturers secure a green supply chain, procuring biosilica for eco-friendly products. The adoption of bio-circular silica in tire manufacturing is a significant

step toward industry-wide sustainability (Solvay, 2025). This completes a powerful circular economy which shows that's agricultural waste is upcycled into a valuable industrial material, reducing landfill use and carbon-intensive mining while providing economic value at every step of the chain.

7. Acknowledgment

We are grateful to Universiti Teknologi Petronas (UTP) for providing the academic environment for this work. We extend our sincere thanks to Madam Nurul Izni for her invaluable supervision throughout the development of this abstract.

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9. Researchers' Biography

Nurliana binti Mohd Khairizal is a second-year Chemical Engineering student Universiti Teknologi Petronas (UTP). Her research interests include reusable and sustainable energy solutions. She has demonstrated her innovative skills through achievements in the IChemE Reverse Engineering Challenge and the International Creative & Innovative Idea Competition (ICIIC), where she received a Golden Award.

Mohamed Danish Zikry Bin Tony is a second-year Electrical and Electronics Engineering student at Universiti Teknologi Petronas (UTP). His research interest includes electrical machines and communication systems. Proof of skills through achievement was shown through the Invencmax 4.0 competition where his team got to the top 10 finalist groups.

Christa Lorna anak Rundeng is a second-year Chemical Engineering student at Universiti Teknologi Petronas (UTP). Her interest include valorization of waste and providing solution prioritizing sustainable energy.

Enoch Seli Anak Maurice Medan is a second-year Chemical Engineering student at Universiti Teknologi Petronas (UTP). His research interest include renewable energy and sustainability with a focus on biomass utilization.

Smart Solar-Powered Portable Energy System

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ABSTRACT
This project presents the design and development of a Smart Solar-Powered Portable Energy System intended to provide a reliable, sustainable, and portable power solution for outdoor, emergency, and off-grid applications. The system was developed to address limitations of conventional portable power sources that rely heavily on non-renewable energy and lack real-time monitoring capabilities. The proposed solution integrates a photovoltaic solar panel, rechargeable battery storage, solar charge controller, and an ESP32 microcontroller to enable efficient energy harvesting, storage, and controlled power distribution. Real-time monitoring of battery voltage, battery percentage, temperature, and load status is implemented using embedded sensors and displayed via an LCD interface to enhance user awareness and system safety. Protective features such as low-battery alerts, temperature-based cooling control, and load switching through relay modules are incorporated to ensure reliable operation. Experimental testing demonstrates stable voltage regulation and consistent performance under various operating conditions. The system offers advantages in portability, cost-effectiveness, and environmental sustainability while supporting essential electrical loads such as lighting, ventilation, and mobile device charging. With its modular design and low production cost, the system has strong potential for commercialization and wider adoption in renewable energy and portable power markets.

Keywords: Solar energy, portable energy system, renewable energy, ESP32, smart power monitoring

1. Product Description
The Smart Solar-Powered Portable Energy System is an innovative portable renewable energy solution designed to provide reliable electricity for outdoor, off-grid, and emergency applications. The system integrates solar energy harvesting, battery storage, and intelligent energy monitoring into a compact backpack-based platform, allowing users to easily carry and deploy the system wherever power is needed. A detachable flexible solar panel functions as the primary energy source, converting sunlight into electrical energy. The generated energy is regulated using a solar charge controller (SCC) and stored in rechargeable lithium-ion batteries to ensure continuous power supply even when sunlight is unavailable. This enables the system to operate as a portable and sustainable power source for mobile users.
An ESP32 microcontroller serves as the intelligent control unit, continuously monitoring important system parameters such as battery voltage, current flow, and temperature conditions using integrated sensors. The system status and battery information are displayed in real time on an LCD screen, enabling users to monitor system performance easily. The system also supports

USB charging for mobile devices, LED lighting for illumination, and a cooling fan for thermal protection, making it suitable for activities such as camping, emergency backup power, and off-grid operations. Overall, the system provides a portable, environmentally friendly, and intelligent energy solution that promotes sustainable energy usage.

2. Methodology

The development of the Smart Solar-Powered Portable Energy System was carried out through a structured process involving system design, hardware integration, and prototype implementation. The overall system architecture is illustrated in **Figure 1**, which presents the block diagram of the system. In this configuration, the solar panel functions as the primary energy source, converting sunlight into electrical energy. The generated energy is regulated using a solar charge controller (SCC) before being stored in rechargeable batteries to ensure stable charging and to prevent overcharging or deep discharge. An ESP32 microcontroller acts as the central controller of the system. It collects data from sensors such as voltage and temperature sensors to monitor the battery condition and system status. The measured data is displayed on an LCD screen for real-time user monitoring. The system also includes a buzzer alert, LED lighting, cooling fan, and USB output, which are controlled by the ESP32 to ensure safe and efficient operation.

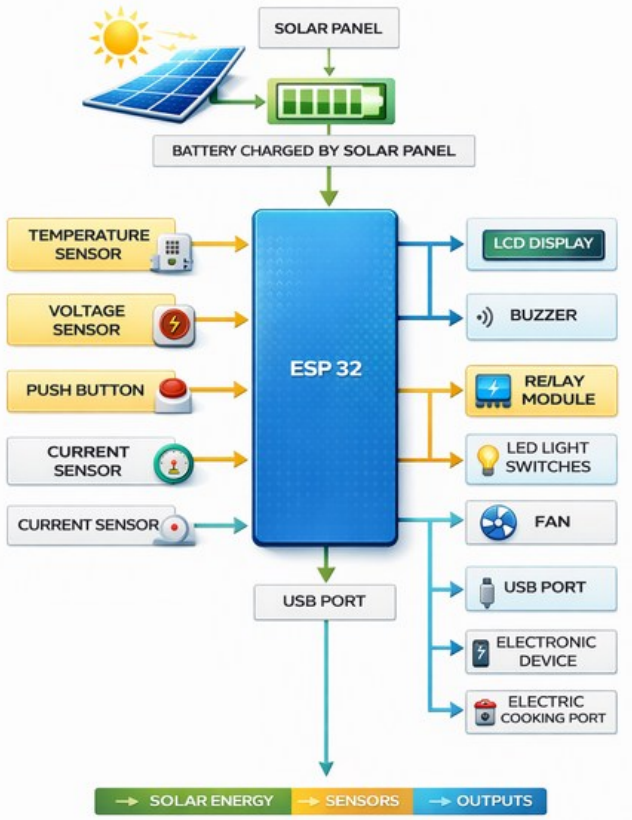

Figure 1. Block diagram for Smart Solar-Powered Portable Energy System.

The physical implementation of the system is shown in **Figure 2**, which presents the backpack-integrated prototype with a detachable flexible solar panel. All electronic components, including the battery pack and control circuit, are installed inside the backpack to maintain portability. The

solar panel can be deployed when sunlight is available and stored when not in use, allowing the system to provide a portable and renewable energy solution for outdoor and off-grid applications.

Figure 2. Backpack-integrated prototype with detachable flexible solar panel.

3. Novelty and uniqueness

The novelty of this product lies in its wearable energy architecture combined with on-demand solar deployment. Unlike conventional power banks that rely solely on pre-charged batteries or rigid solar installations, this system introduces a detachable flexible solar panel that is only deployed when needed, protecting the panel while maximizing usability. The integration of smart monitoring and safety control through an ESP32 microcontroller enables real-time awareness of system health, which is rarely available in low-cost portable energy solutions. The backpack-based design enhances portability without compromising functionality, allowing energy generation, storage, monitoring, and distribution to coexist within a single compact platform. The modular hardware layout supports scalability and customization for different power demands. This combination of flexibility, intelligence, and user-centric design distinguishes the system from existing portable power solutions.

4. Benefit to mankind

This project promotes sustainable energy usage by reducing dependence on fossil fuels and grid-based electricity. It provides a reliable power source for individuals affected by power outages, natural disasters, or limited infrastructure. The system supports outdoor activities, rural applications, and emergency response by enabling access to essential electrical power. Real-time monitoring and safety alerts enhance user awareness and prevent equipment damage. By encouraging renewable energy adoption at the individual level, the system contributes to environmental protection, energy independence, and responsible energy consumption.

5. Innovation and Entrepreneurial Impact

The project demonstrates how renewable energy, embedded systems, and smart monitoring can be transformed into a market-ready product. Its low-cost, modular design supports small-scale manufacturing and startup development. The system encourages innovation-driven entrepreneurship by addressing real-world problems with scalable and customizable solutions. It also serves as a platform for future enhancements, fostering a culture of green innovation within educational institutions and the renewable energy industry.

6. Potential commercialization

The product has strong commercialization potential due to its affordability, portability, and increasing demand for sustainable power solutions. Target markets include outdoor enthusiasts, emergency preparedness users, rural communities, and educational institutions. With improved casing, branding, and higher-capacity battery options, the system can be mass-produced as a consumer-ready product. Custom variants can also be developed for disaster relief kits and institutional use.

7. Acknowledgment

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8. Researchers' Biography

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Bio-Phalt Composite

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ABSTRACT

Bio-Phalt Composite is a revolutionary, carbon-neutral construction material designed to replace traditional Portland cement with a 100% waste-derived binder system. This innovation addresses the high CO2 emissions of the construction industry by utilizing a geopolymer matrix composed of silica-rich agricultural ash (wood ash extract) and calcium-dense eggshell powder. To overcome the brittleness typical of standard masonry, the composite is reinforced with high-tensile pineapple leaf which provide internal structural bridging and crack resistance. The chemical activation is achieved through a "green" alkaline solution of hydrated lime powder for the minimal usage of NaOH. This product offers a circular economy solution by diverting agricultural and food waste from landfills into high-value infrastructure materials. Bio-Phalt Composite is particularly suited for eco-paving, pedestrian walkways, and sustainable bricks, offering significant socio-economic benefits by lowering material costs and providing a scalable commercial prospect for the green building sector.

Keywords:
Pineapple Leaf, Agricultural waste, High-tensile, Sustainability, Circular economy.

1. Product Description

This product is a sustainable alternative to Ordinary Portland Cement (OPC). The binder is formulated from a precise blend of silica-rich agricultural ash (such as wood ash extract) and calcium-rich eggshell powder. Unlike traditional concrete which is brittle, this product is reinforced with pineapple leaf fibers, which provide internal "bridging" to prevent micro-cracks. The innovation utilizes a "hybrid activator" system—leveraging the natural alkalinity of hydrated lime powder to reduce reliance on industrial chemicals. This results in a material that is lighter than traditional concrete, has excellent thermal insulation properties, and a significantly lower carbon footprint. It is designed for non-structural and semi-structural applications such as pavers, wall panels, and eco-friendly bricks.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc.

Metric	*Bio-Phalt Composite*	*Ordinary Portland Cement (OPC)*
Carbon footprints	Low (Waste derived)	High (CO2 Intensive)
Tensile strength	Enhance (With presence of Pineapple leaf fiber)	Brittle
Primary binder	Wood ash extract, eggshell powder	Calcined Limestone / Clay
Activator type	Hydrated lime powder	Finite Raw materials

Figure 1. Comparative Analysis the use of materials between Bio-Phalt Composite and . Ordinary Portland Cement (OPC)

Parameter	*Specification*	*Purpose*
Sand Ratio: 1.0 (1000g)	-	-
Binder Ratio: 2.5 (400g)	Wood ash extract Eggshell Powder	To maximize structural integrity
Fiber usage	1% to 3% of Pineapple Leaf	Optimal "bridging" for crack resistance
Activator	Hydrated lime powder (The usage depends of the current molarity) pH of hydrated lime powder (Rough calculations): 8% = 12.42 6% = 12.29 4% = 12.09 2% = 11.83% 1% = 11.42%	Reduces chemical footprints and cement's molarity

Figure 2. Rough idea of target specifications for Bio-Phalt prototype (1st attempt).

3. Novelty and uniqueness

The novelty of this project lies in the integration of three sustainable components: reduced synthetic alkali activation, lime-supported hybrid binder chemistry, and pineapple leaf fiber reinforcement sourced from local agricultural waste. While alkali-activated materials have been extensively studied and most systems rely on high molarity NaOH solutions, increasing chemical dependency and safety concerns. This study proposes a reduced-alkali hybrid activation strategy that maintains mechanical performance while minimizing chemical input. Furthermore, the incorporation of pineapple leaf fiber introduces a localized circular economy approach specific to Pontian, Johor, a region known for pineapple cultivation. The fiber not only improves crack resistance but also addresses agricultural residue management challenges. The combined chemical optimization and bio-reinforcement strategy differentiate this project from conventional geopolymer research by emphasizing environmental balance, regional resource utilization, and scalable sustainability.

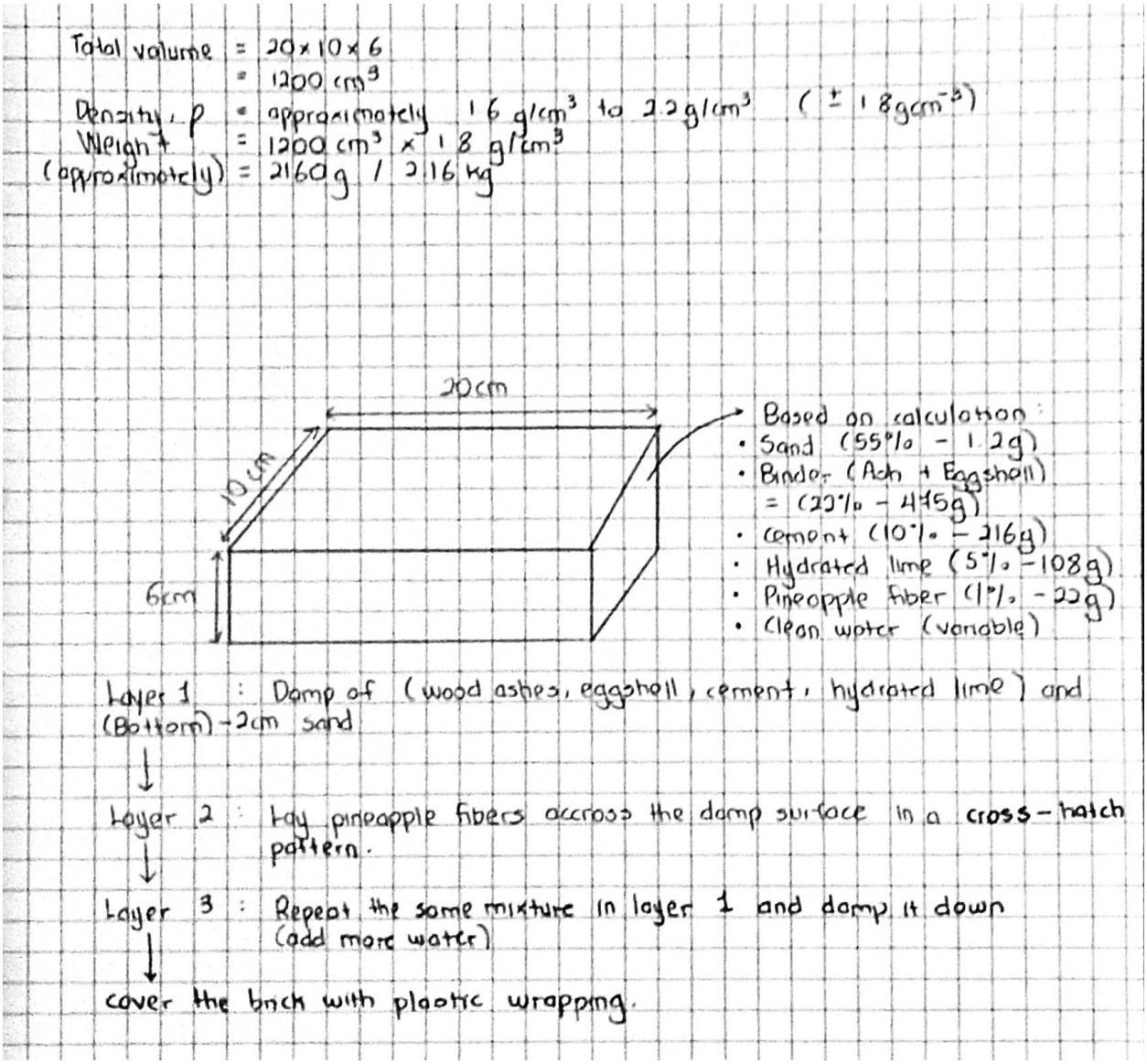

Figure 3. Rough sketch of brick production with matrix counts of each material.

4. Benefit to mankind

This innovation contributes to environmental sustainability by reducing reliance on high-carbon cement production and synthetic chemical consumption. The utilization of pineapple agricultural waste promotes responsible waste management and provides additional economic value to local farming communities. The material offers potential for low-cost eco-construction solutions in developing regions, supporting green building initiatives and sustainable infrastructure development. By lowering energy requirements and promoting circular resource use, the project aligns with global Sustainable Development Goals (SDGs), particularly climate action and responsible production.

5. Innovation and Entrepreneurial Impact

The project fosters innovation by combining applied chemistry, material science, and agricultural waste valorization into a scalable construction material solution. It encourages interdisciplinary research linking environmental science and sustainable engineering. Entrepreneurially, the product opens opportunities for eco-material startups targeting green construction markets. Local sourcing of pineapple fiber reduces raw material costs and supports community-based supply chains. The project promotes a culture of sustainability-driven entrepreneurship within academic and industrial sectors by transforming waste into high-value construction materials.

6. Potential commercialization

The proposed of Bio-Phalt can be commercialized as an eco-friendly construction material for non-structural applications such as paving blocks, garden tiles, pedestrian walkways, and decorative panels. These products do not require extremely high structural strength which making them suitable for early-stage market entry. The key commercial advantage lies in its use of pineapple leaf fiber sourced from Pontian, reducing agricultural waste while lowering raw material costs. This creates an opportunity for collaboration with local pineapple farmers and forming a sustainable supply chain. In addition, the material can be marketed to green building developers and environmentally conscious consumers seeking low-carbon alternatives. As sustainability regulations become stricter globally, demand for eco-friendly construction materials is expected to increase. The product may also be introduced as a laboratory-scale sustainable cement kit for universities, creating an additional education-based revenue stream.

7. Acknowledgment

The author would like to acknowledge the Faculty of Applied Sciences, Universiti Teknologi MARA Perak Branch Tapah Campus, for laboratory facilities and academic guidance supporting this research development.

8. Researchers' Biography

Nur Khairina Huda Khairul Anuar is a Diploma in Science Student at Universiti Teknologi MARA (UiTM) Perak Branch, Tapah Campus with a focused passion for sustainable material innovation and applied chemistry. She is a three-time Gold Award recipient, winning at the National I3C Competition (MIICA) in 2025, the International STEM Innovation Competition (ISIC'WOU) in 2024, and the National Smart Management, Innovative, Low Carbon and Eco Class Challenge (SMILE-C22) in 2022. Her work centers on transforming environmental challenges into scalable scientific solutions, particularly in low-carbon materials and circular economy applications. She is committed to advancing impactful innovations that bridge research excellence with real-world sustainability needs.

S.M.A.R.T. Tuba: Solar-Powered Monitoring and Automated Regulation Technology for Real-Time Fermentation

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Tupi National High School; El Cid Jireh A. Parreñas
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Tupi National High School; Angel Kaye G. Trasmonte

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ABSTRACT

S.M.A.R.T. TUBA (Solar-powered Monitoring and Automated Regulation Technology for Tuba) is an innovative system designed to improve the fermentation process of traditional coconut wine or *tuba*. The device was developed to address common challenges in manual fermentation, such as inconsistent product quality, lack of real-time monitoring, and unreliable electricity supply in rural areas where most tuba production occurs. The system integrates sensors that monitor important fermentation parameters, including temperature, pH level, and alcohol content in real time. It also features an automated cooling fan to regulate temperature, an LCD display for data monitoring, and a buzzer alert system to notify users when fermentation conditions change. Powered by a solar panel and rechargeable battery, the device can operate in off-grid communities, making it accessible to small-scale producers. The main advantage of S.M.A.R.T. TUBA lies in its combination of smart monitoring, automated regulation, and renewable energy in a simple and affordable system. This innovation helps improve fermentation accuracy, product safety, and overall quality while reducing manual guesswork. Socio-economically, it supports local producers by improving productivity and income opportunities, while environmentally, it promotes sustainable practices through solar energy use. With its low-cost design and practical features, S.M.A.R.T. TUBA has strong potential for commercialization as an accessible smart fermentation technology for traditional coconut wine producers.

Keywords: Tuba, fermentation, coconut wine, solar-powered bot, smart monitoring

1. Product Description

This study focuses on developing a solar-powered, automated system for tuba fermentation and quality control. It employs microcontrollers and sensors to regulate temperature, pH, and alcohol content for ideal conditions. This accelerates production, minimizes contamination risks, and maintains tuba's authentic taste and safety. S.M.A.R.T. TUBA: Solar-powered Monitoring and Automated Regulation Technology for Tuba Fermentation. Fueled by solar energy with integrated sensors, LCD display, and alerts, it tracks and adjusts parameters live to boost efficiency and uphold superior quality.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc

System Architectural Design

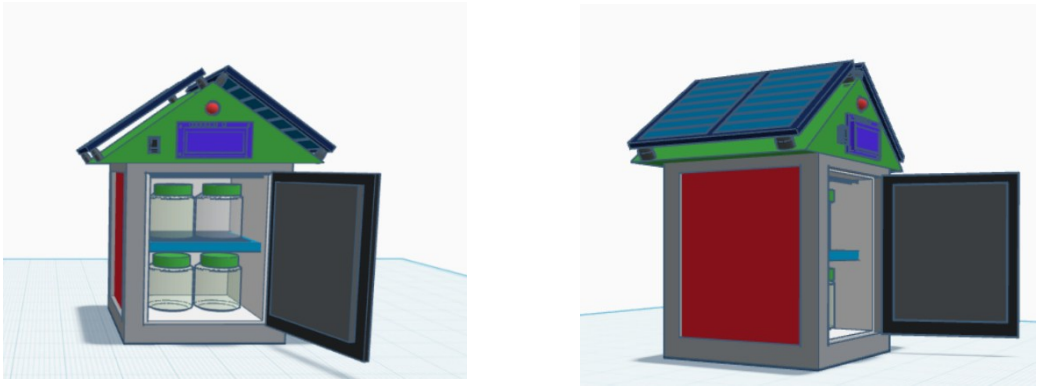


Figure 1. Simulated Prototype.

Figure 2. Actual Prototype.

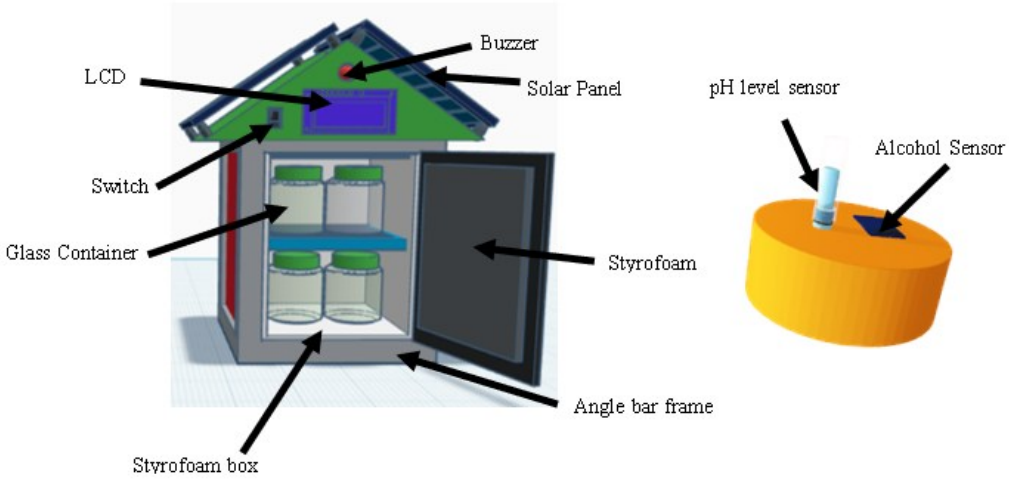


Figure 3. Project Anatomy.

Figure 3 shows how the S.M.A.R.T. TUBA prototype works. The system has pH and gas sensors, an exhaust fan, a buzzer, and an LCD display to make sure the fermentation process is safe, monitored, and consistent. A microcontroller connects to the sensors so that pH levels and gas buildup can be tracked and controlled in real time. The system runs on a solar panel, a charge controller, and a battery, making it energy-efficient and suitable for producing tuba in a way that is safe, efficient, and environmentally friendly.

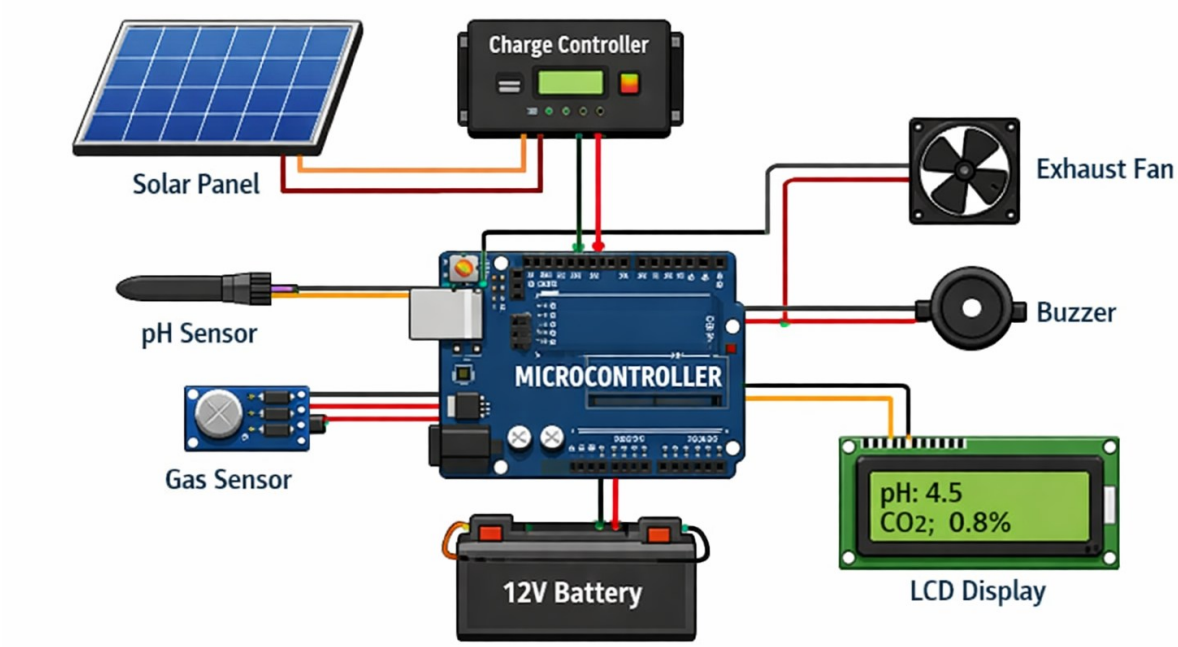


Figure 4. Circuit Diagram.

Figure 4 shows the circuit diagram for the system. A solar panel, a battery, and a charge controller supply power to the microcontroller, which receives real-time data from pH and gas sensors. Based on these readings, the microcontroller automatically regulates the fermentation process by activating the ventilation system, displaying information on the LCD, and sending alerts when necessary, making tuba production safer, more efficient, and easier to monitor.**Figure 5** shows the schematic diagram of how S.M.A.R.T. TUBA works during tuba fermentation. First, the system powers on and verifies sensors and electrical connections. Then, during fermentation, it monitors temperature, pH, and alcohol levels in real time. The cooling fan activates to regulate temperature, while the LCD displays readings and the buzzer alerts for thresholds. Monitoring continues until optimal fermentation is achieved.

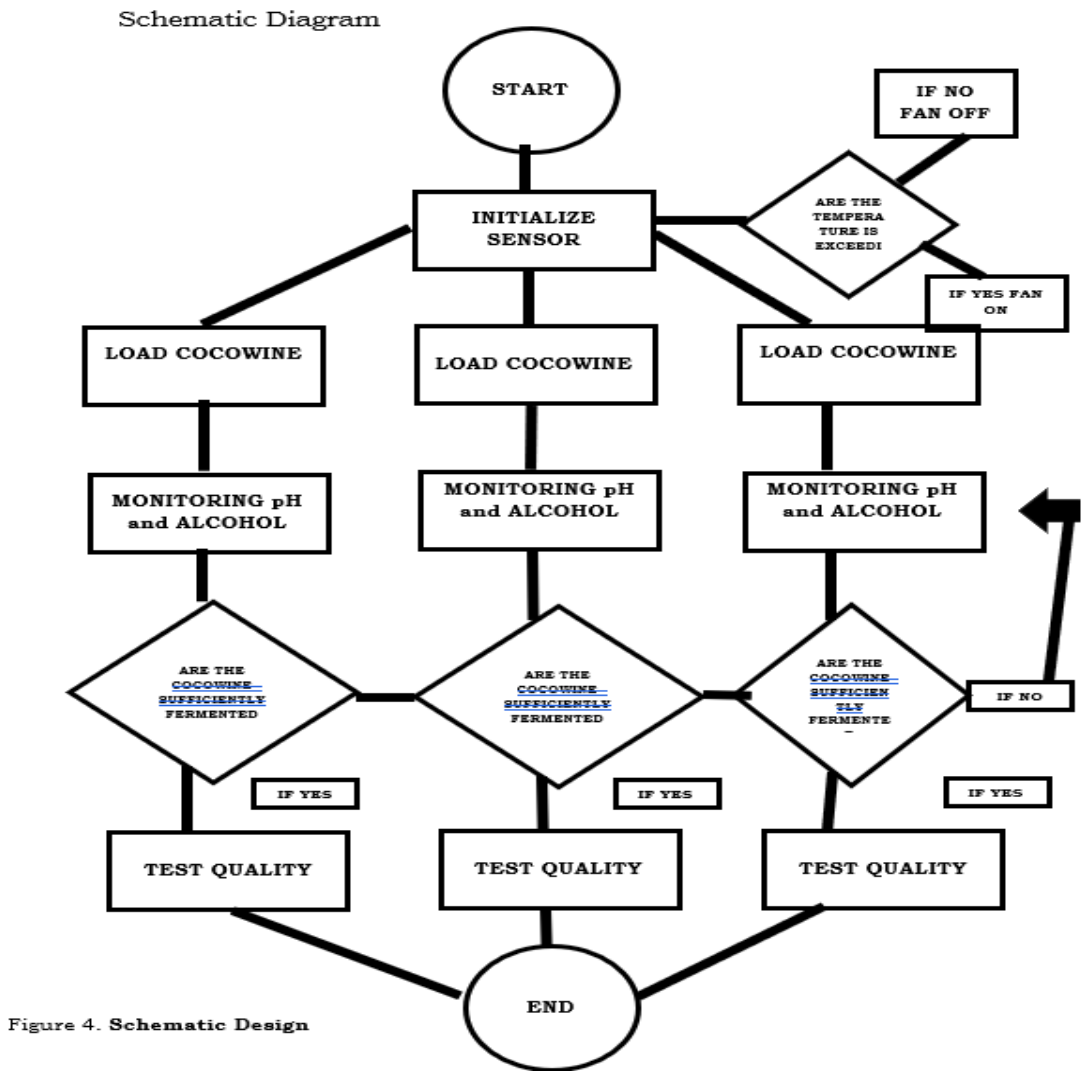


Figure 4. **Schematic Design**

Figure 5. Schematic Diagram.

3. Result and Discussion

The S.M.A.R.T. TUBA system effectively monitored and regulated tuba fermentation using integrated pH and gas sensors, LCD interface, and microcontroller. During testing, pH decreased from 6.2 to 4.5 over 48 hours (normal progression), while gas levels peaked at 0.8% at 36 hours, activating safety ventilation. Automated regulation responded to sensor inputs, alerting users below pH 4.8 and preventing gas buildup. Solar power reliably sustained 12-hour off-grid operation, with LCD providing clear real-time feedback for timely interventions. These results prove S.M.A.R.T. TUBA enhances efficiency, safety, and sustainability for rural producers. **Table 2** will show the analysis of the fermentation chamber and fan efficiency. Data will be recorded over ten (10) trials and grouped according to chamber stability and fan cooling. A one-way ANOVA at $\alpha = 0.05$ will compare the averages across these groups. If the p-value exceeds 0.05 and the F-critical is greater than the computed F-value, it will mean there is no significant difference. This analysis will also determine if the bot can really maintain a balanced environment

for fermentation. In the study of Tan (2025), it was shown that keeping the fermentation temperature within ±0.3°C leads to 95% higher product quality. This supports the result that the bot maintains a very stable chamber. **Table 3** will analyze the statistical performance of the buzzer and LCD display when operating in automatic mode. Ten (10) trials will be conducted to measure the response times of the buzzer, display, and sensor reaction speed. A one-way ANOVA at $\alpha = 0.05$ will be applied to compare the means of each category. If the p-value is greater than 0.05 and the F-critical is higher than the F-computed, then no significant difference exists among the tested means. This test will also check if the system can notify users quickly and clearly, making sure that both sound and display respond without delay.Garcia (2022) explained that 90% of fermentation errors can be reduced when users are given fast and clear alerts. This supports why the notification system of the bot is very important. **Table 4** will analyze the time efficiency of the solar panel and battery system during automatic operation. Ten (10) trials will be performed for sunlight charging, battery storage, and continuous operation. A one-way ANOVA at $\alpha = 0.05$ will compare the mean results. If the p-value is more than 0.05 and the F-critical is larger than the F-computed, there will be no significant difference. This analysis will also confirm if the bot can work non-stop with renewable energy, especially in rural areas. According to Villanueva (2024), 88% of rural fermentation projects succeeded when they used renewable energy sources. This supports the result that solar power makes the bot more reliable in local settings.

Table 1. Efficiency Result of Functionality, Accuracy, and Acceptability.

Metric	Functionality	Accuracy	Acceptability
Overall Weighted Mean	4.36	4.34	4.28
Verbal Description	Strongly agree	Strongly agree	Strongly agree
Performance Benchmark	Efficient (10.52s response)	High Reliability	Practical for Producers

Table 2. Analysis of Variance for Efficiency of Environmental Stability.

Trial	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**Mean**
Stable Chamber Temp	30.2	30.1	30.0	30.3	30.1	30.2	30.1	30.0	30.2	30.1	30.13
Fan Cooling Response	29.9	30.0	29.8	30.1	29.9	29.8	29.9	30.0	29.8	29.9	29.91
Grand Mean	**30.02**										

Table 3. Analysis of Variance for Efficiency of Notification and Response.

Trial	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Mean
Buzzer Response	11.0	10.8	11.2	10.9	11.1	11.0	10.9	11.1	11.0	11.1	11.02
LCD Display Response	10.5	10.7	10.6	10.8	10.5	10.7	10.6	10.7	10.6	10.8	10.65
Sensor Reaction Speed	9.8	9.9	10.0	9.7	9.9	10.0	9.8	9.9	9.8	10.0	9.88
Grand Mean	**10.52**										

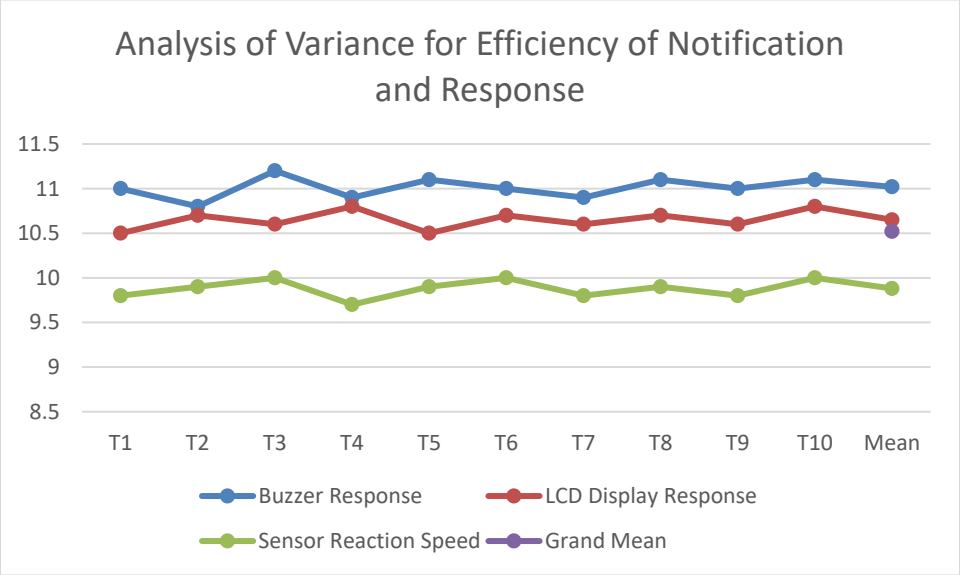
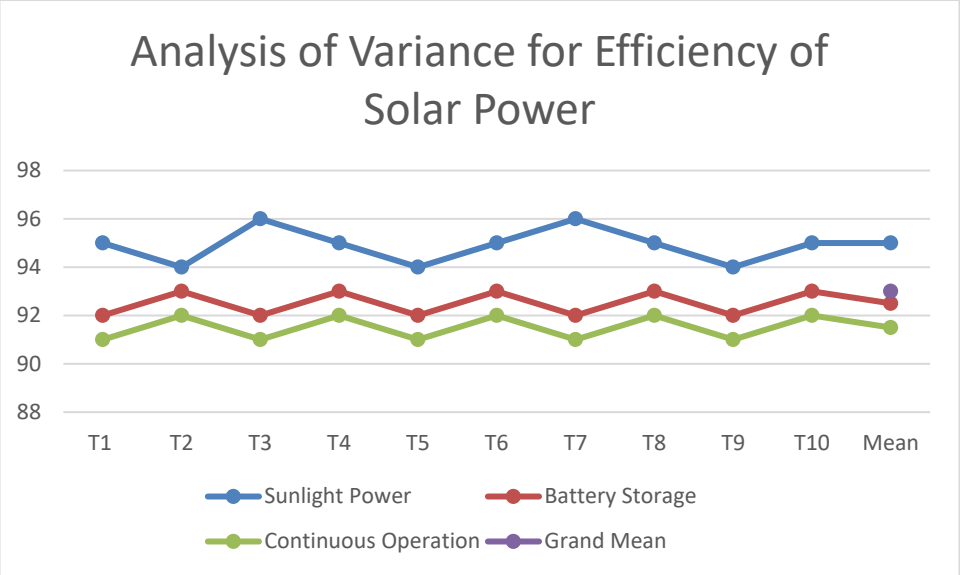


Table 4. Analysis of Variance for Efficiency of Solar Power.

Trial	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Mean
Sunlight Power	95	94	96	95	94	95	96	95	94	95	95.00
Battery Storage	92	93	92	93	92	93	92	93	92	93	92.50
Continuous Operation	91	92	91	92	91	92	91	92	91	92	91.50
Grand Mean											**93.00**



4. Novelty and uniqueness

The novelty of the S.M.A.R.T. TUBA lies in its integration of real-time fermentation monitoring, automated regulation, and solar-powered operation specifically designed for traditional coconut wine (tuba) production. Unlike existing fermentation technologies that are laboratory-based, expensive, or intended for large-scale industries, this system is uniquely tailored for small-scale and rural producers. It combines pH, alcohol, and temperature sensing with automated fan control and user alerts in a single compact unit, allowing producers to monitor fermentation without relying on guesswork or laboratory testing. What makes the system unique is its fusion of indigenous fermentation practices with modern, low-cost smart technology. The use of solar power distinguishes S.M.A.R.T. TUBA from conventional electronic monitoring systems by making it usable in off-grid communities. Additionally, the system emphasizes usability and acceptability among traditional producers, ensuring that technological advancement does not replace cultural practices but instead supports and enhances them. This balance between tradition, accessibility, and smart automation has not been widely addressed in previous studies on fermentation technology.

5. Benefit to mankind

This study benefits mankind by improving food safety, sustainability, and livelihood, especially in rural communities. The S.M.A.R.T. TUBA system helps prevent unsafe and inconsistent fermentation by providing real-time monitoring of temperature, pH, and alcohol levels, reducing health risks such as contamination and improper alcohol content. By using solar power, the system promotes clean and renewable energy, making it suitable for areas with limited access to electricity. It empowers small-scale coconut wine producers by improving product quality and consistency, increasing consumer trust and potential income. At the same time, the system helps preserve traditional tuba-making practices by combining indigenous knowledge with modern technology. Overall, this innovation supports public health, environmental sustainability, cultural preservation, and economic resilience, contributing positively to both local communities and society as a whole.

6. Innovation and Entrepreneurial Impact

The S.M.A.R.T. TUBA promotes innovation by integrating sensors, automation, and solar power to modernize traditional tuba fermentation. Unlike conventional methods that rely on guesswork, the system provides real-time monitoring of temperature, pH, and alcohol content, allowing precise control for consistent, safe, and high-quality products. This technological approach encourages problem-solving and the practical application of science within the community and school, inspiring students and local producers to explore smart solutions for traditional practices. Entrepreneurially, the project enables small-scale tuba makers to improve production efficiency and product reliability, increasing market competitiveness and consumer trust. Its low-cost, modular design allows local assembly, maintenance, and potential commercialization, fostering new business opportunities. By combining innovation with livelihood development, S.M.A.R.T. TUBA contributes to a culture of entrepreneurship that supports sustainable income, skill development, and the preservation of cultural fermentation practices within the community.

7. Potential commercialization

From a practical standpoint, the S.M.A.R.T. TUBA can be commercialized through local fabrication and community-based manufacturing. Initial production may involve small batches assembled by local technicians or school-based innovation centers, creating employment opportunities while reducing costs. The product can be offered in different versions, such as a basic monitoring unit and an advanced version with added features, to suit varying producer budgets. Training workshops and demonstrations can accompany product distribution to ensure proper usage and maintenance. Over time, the system may also be expanded to support other fermented products such as lambanog, vinegar, or fruit wines, increasing its market reach. By positioning the S.M.A.R.T. TUBA as an affordable, culturally sensitive, and environmentally sustainable technology, it has the potential to transition from a research prototype into a viable commercial product that supports both local livelihoods and food safety standards.

8. Acknowledgement

First and foremost, we would like to thank God for His guidance, strength, and wisdom throughout the completion of this research. Without His blessings, this study would not have been possible. All glory to Him for guiding us in every step of this journey. We would like to express our deepest gratitude to our research advisor, Nelson B. Malificiado, for his patience, guidance, and valuable advice. His continuous support and encouragement greatly helped us in completing our study entitled S.M.A.R.T. TUBA. We are also very thankful to our consultant, Zeavier Benz Cabanban, for generously sharing his knowledge and insights that helped improve the quality of our research. We would also like to extend our sincere gratitude to Fernan N. Spiritual for providing transportation and helping us locate tuba vendors and farmers who were essential to our study. Our appreciation also goes to Marvin O. Sunga for helping us build our prototype and for suggesting minor improvements that enhanced the functionality of our system. We are also grateful to Raymark Bayaya for providing transportation and for assisting in purchasing the tuba used in our research. Special thanks are also given to Melba D. Bayaya for her financial support, which greatly helped us in completing the materials and needs for our study. We would also like to thank French Z. Sibuco for helping and supporting us whenever we needed assistance during the conduct of our research. Lastly, we would like to extend our sincere

appreciation to Marcos Namoca Gabat for his support and assistance that contributed to the success of this study. We are truly grateful to everyone who helped us accomplish this research.

9. Researchers' Biography

Diane Danika B. Naidu was born on November 19, 2007, in Koronadal City, South Cotabato, Philippines, and was raised in Tupi, South Cotabato. An only child, she grew up in a supportive family that nurtured independence, responsibility, and strong values. Diane showed early interest in academics and sports, particularly swimming and taekwondo, which developed her discipline and confidence. She studied at Tupi Central Elementary School and Tupi National High School. Active in science and technology fairs, she competed in national robotics events, becoming an NRC LineTracing Robot Champion and a Division Science and Technology Fair Best Speaker and qualifier awardee.

El Cid Jireh A. Parreñas was born on September 23, 2008, in Koronadal City. He completed his elementary education at Tupi Central School and is currently studying at Tupi National High School. Growing up in a supportive environment, he learned important values such as respect, responsibility, and kindness, which guide him in his daily life. As a student, El Cid strives to continuously improve himself academically and personally. He is determined to become a better person in the future and work hard to achieve his goals, motivated by his desire to make his family proud.

Katrina L. Ponan. She has been a consistent honor student since kindergarten, showing dedication to her studies from an early age. She completed her elementary education at Belaza Castromayo Community Elementary School and is currently studying at Tupi National High School. Katrina enjoys reading and watching films, activities that help broaden her knowledge and creativity. She believes in continuous self-improvement and learns from her mistakes to grow academically and personally. She also joined the National Robotics Competition, reflecting her interest in science, technology, and problem-solving

Angel Kaye G. Trasmonte was born on December 20, 2007, in Tupi, South Cotabato, Philippines. She completed her elementary education at Tupi Central School and continued her secondary education at Tupi National High School, where she built a strong academic foundation. From a young age, she showed curiosity, creativity, and a strong interest in learning, actively participating in school activities. She is currently pursuing her senior high school education. Angel has received With Honors awards for academic excellence, earned SRAA and Provincial medals in athletics, and gained recognition in Robotics Competitions, highlighting her skills in innovation, teamwork, and problem-solving

Terrafloat Farm: An Amphibious Farming System for Flood-Resilient Small-Scale Vegetable Farmers

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ABSTRACT
This project proposes TERRAFLOAT, an amphibious farming system developed to enable flood-resilient vegetable production among smallholder farmers, with "Cash Cow" crops such as chilies and herbs as the primary case crops. Seasonal flooding frequently damages open-field vegetable farms in low-lying rural areas, leading to substantial crop losses, income instability and disruptions in local food supply. TERRAFLOAT responds to this challenge through modular amphibious cultivation platforms that dynamically rises and falls with changing water levels, thereby preventing crop submergence during flood events. The system comprises buoyant planting modules constructed from lightweight and readily available materials, combined with shallow planting beds suitable for chilies and other short-cycle crops. A solar-powered irrigation unit delivers filtered floodwater via a simple drip system, ensuring continuous moisture supply without reliance on grid electricity. Optional low-cost sensors monitor water levels and soil moisture to support basic crop management. TERRAFLOAT converts flood-prone farmland into productive cultivation zones, enabling uninterrupted vegetable production throughout flood seasons. The system enhances income stability, strengthens food security and supports climate change adaptation, contributing to Sustainable Development Goals related to poverty reduction, zero hunger and climate action. Its modular and low-cost configuration offers strong potential for commercialization through kit-based distribution and community-based deployment models.

Keywords: Smallholder farmers, Amphibious farm, Chilies cultivation, Flood-resilient agriculture, Sustainable vegetable farming

1. Product Description
TERRAFLOAT Farm is a modular floating farming system designed for smallholder farmers who cultivate flood-sensitive crops such as chilies, herbs and leafy vegetables. The system consists of buoyant platforms combined with shallow planting beds suitable for soil-based or hybrid cultivation. The buoyant base is constructed from reused food-grade HDPE drums or UV-stabilised HDPE pontoons, supported by a lightweight bamboo or PVC frame, to ensure durability, affordability and environmental sustainability. The floating platform rises and falls with changing water levels during flood events, preventing crop submergence and root damage. As some floods can last for days, a simple solar-powered pump is built in to supply water through a drip irrigation system using filtered floodwater, ensuring continuous moisture delivery without dependence on grid electricity. Optional low-cost sensors monitor water level and soil moisture, providing visual indicators or mobile-based alerts to assist farmers in managing crop conditions. The modular structure allows the system to be expanded gradually according to farm size and

financial capacity. TERRAFLOAT enables farmers to maintain crop production during flood seasons using familiar planting practices, while introducing adaptive farming technology that is affordable, easy to maintain and environmentally sustainable.

2. Visual Illustration of Problem Context and TERRAFLOAT System Concept

The following **Figures 1 and 2** illustrate the flood-related challenges faced by smallholder farmers and the proposed FLOATFARM system designed to address these conditions.

Figure 1. Crop damage experienced by a smallholder farmer in Titi Tinggi, Perlis, Malaysia after the late-2025 flood event. Prolonged submergence resulted in plant mortality and significant production losses, highlighting the vulnerability of open-field vegetable cultivation to flooding. (Image owned by authors).

Figure 2. The left image illustrates the FLOATFARM platform operating on dry ground under normal conditions, while the right image shows the system floating during flood conditions. The adaptive structure keeps crops elevated above water levels, enabling continuous cultivation and reducing production losses. (AI-generated images).

3. Novelty and uniqueness

TERRAFLOAT introduces a crop-specific adaptive farming system tailored to the needs of smallholder vegetable farmers in flood-prone environments. Unlike conventional raised-bed or drainage-based farming approaches, the system functions as a fully floating cultivation platform that dynamically adjusts to fluctuating water levels. The novelty of TERRAFLOAT lies in its integration of buoyant farming structures, solar-powered irrigation and optional low-cost sensing technology into a single modular system optimized for short-cycle vegetable crops. The use of reused food-grade HDPE drums or UV-stabilised HDPE pontoons supported by lightweight bamboo or PVC frames provides a durable yet environmentally responsible floating structure.

Existing floating farming methods often rely on simple rafts without crop-specific optimization or irrigation control. TERRAFLOAT advances these methods by designing planting beds, suitable for typical smallholder landed farming and during unexpected floods, as well as water delivery mechanisms and structural stability specifically for chili cultivation, which requires controlled moisture and stable root conditions. The modular and low-cost design further distinguishes the system by lowering adoption barriers for smallholder farmers. The use of recyclable and locally sourced materials enhances both affordability and environmental sustainability, positioning TERRAFLOAT as a practical yet innovative solution for climate-resilient vegetable farming.

4. Benefit to mankind

TERRAFLOAT improves the livelihoods of smallholder vegetable farmers by enabling continuous chili and vegetable production during flood seasons, contributing directly to SDG 1 (No Poverty) through income stabilization and reduced dependence on emergency assistance. By preventing crop destruction, the system enhances food security and supports SDG 2 (Zero Hunger) by maintaining the local supply of essential vegetables, particularly chili, a staple ingredient in daily diets. The system promotes climate change adaptation among vulnerable rural communities, aligning with SDG 13 (Climate Action) through its flood-resilient farming design and use of renewable energy via solar-powered irrigation. Environmentally, TERRAFLOAT supports efficient water management and responsible resource use, contributing to SDG 12 (Responsible Consumption and Production). By empowering smallholder farmers with adaptive agricultural technology, TERRAFLOAT strengthens rural resilience and advances sustainable agricultural transformation.

5. Innovation and Entrepreneurial Impact

TERRAFLOAT promotes grassroots innovation by introducing climate-resilient agricultural technology to smallholder vegetable farmers. The system creates opportunities for local entrepreneurs, cooperatives and youth groups to manufacture, assemble and maintain floating farm modules using locally available materials such as bamboo frames and reused HDPE drums. Training programs can support skill development in modular farm construction, solar irrigation installation and basic sensor integration. The project encourages the transition from traditional subsistence farming to technology-assisted vegetable production, fostering an innovation-oriented farming culture. TERRAFLOAT also enables the development of service-based micro-enterprises offering installation, maintenance and monitoring services. Through these mechanisms, the system supports inclusive entrepreneurship and strengthens rural economic ecosystems.

6. Potential commercialization

TERRAFLOAT can be commercialized through a modular kit-based model targeted at flood-prone agricultural regions. Revenue streams include the sale of floating platform modules, solar irrigation units and optional sensor packages. Strategic partnerships with agricultural agencies (e.g., the Department of Agriculture Malaysia), farmers' cooperatives and non-governmental organizations can support farmer outreach, training and technical adoption. In addition, microfinance institutions such as Agrobank and TEKUN Nasional can facilitate farmer participation through subsidies, grants or installment-based financing schemes. A service-based model can further support commercialization; whereby trained local technicians provide installation and maintenance services. Long-term scalability includes integration with smart

farming platforms and expansion into regional markets across Southeast Asia, where flood-prone vegetable farming is common. The system also has potential for agri-education and demonstration farm applications.

7. Acknowledgment

The authors gratefully acknowledge the financial support provided by Universiti Malaysia Perlis (UniMAP) through the Research Acceleration Through Internal Funding (REACTIF) 2025 scheme (Grant Code: 9001-00829).

8. Researchers' Biography

Soo Kai Hao, born on 9 October 2000, is a Bachelor of Business (International Business) with Honours student at the Faculty of Business & Communication (FPK), Universiti Malaysia Perlis (UniMAP). Currently pursuing academic excellence in international business, Soo Kai Hao has a strong interest in the business field and technological field, particularly in understanding how technology drives business innovation and global competitiveness. With a commitment to continuous learning and professional development, Soo Kai Hao aims to build a career that integrates business strategy with technological advancement.

Dr. Nadiah Mahmad Nasir is a Senior Lecturer and Lead Researcher at Universiti Malaysia Perlis (UniMAP), specializing in strategic management, entrepreneurship and qualitative research methodology. Her research focuses on family business succession, halal tourism and sustainable rural development. She has led and contributed to funded research projects at national and international levels, including her current INTERES-funded study on female successors in agro-based family businesses. Her work bridges academic research and community impact through publications in indexed journals and applied innovation initiatives.

Dr Mohd Imran Khusairi Shafee is a Senior Lecturer at the Faculty of Business and Management, Universiti Teknologi MARA Cawangan Perlis. His research interests focus on technology management, technological innovation, digital marketing and academic innovation, with active involvement in research related to green practices. He has contributed to funded research projects with work that links management theory, technology adoption and community focused initiatives.

Design and Development of a Portable Motorized Prototype for Acrylic Edge Polishing in Workshops

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ABSTRACT

Acrylic is one of the most used materials for students when fabricating their product in the workshop. This is because acrylic provides an aesthetic appeal and minimalist look to their product upon completion. The edge of the acrylic is usually polished to ensure smooth and clean finishing to their product. This, edge polishing is performed manually, which is not only time consuming but also often results in inconsistent surface quality. The objective of this project is to design and fabricate an innovative acrylic edge polishing tool that delivers smooth and uniform finishes efficiently. The methodology utilized SolidWorks for designing purposes, focusing on a compact 40cm x 40cm footprint. The structure was fabricated using a mild steel hollow square frame and aluminium plates, joined using fittings and riveting to ensure structural stability. A DC motor provides the primary drive mechanism, achieving a consistent rotational speed of 1,200 rpm. To enhance precision, the design incorporates a specialized mechanical jack and clamp mechanism to secure workpieces during operation. The outcome of this project is a fully functioning edge polishing tool which produces smooth, glass-like finishes to the workpiece. This innovation provides a safe, efficient, and affordable solution for educational institutions and small-scale fabrication workshops.

Keywords: Acrylic, Edge Polishing, Benchtop, Portability

1. Product Description

The Acrylic Edge Polishing Tool is a motorized tabletop solution designed to deliver smooth, glass-like finishes to acrylic workpieces efficiently. This project addresses the labor-intensive nature and surface inconsistencies of manual polishing methods. **Figure 1** shows the finalized prototype, which is engineered for a compact footprint of 40cm x 40cm with a total height of 26cm. This form factor ensures portability and ease of storage in small-scale fabrication workshops or educational institutions. The structural integrity of the tool is founded on a 25mm x 25mm mild steel hollow square frame and aluminium plates, joined through a combination of rivets, fittings, and screws to ensure a permanent, vibration-damping connection. The drive system utilizes an RS-775 DC motor powered by a 240V input via an adjustable AC-DC adapter, maintaining a consistent rotational speed of 1,200 rpm. To maximize precision, the design incorporates a specialized mechanical jack and Black Jaw Bench Clamp mechanism to securely anchor the workpiece, eliminating the manual handling errors typical of manual sanding.

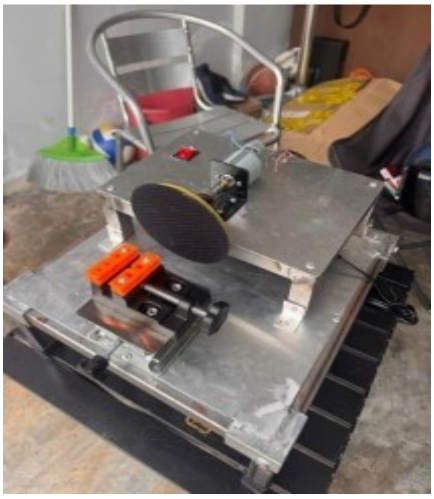

Figure 1. Isometric view of the finalized prototype, demonstrating the compact footprint and the integration of the motor housing and clamping workstation.

2. Novelty and uniqueness

The Acrylic Edge Polishing Tool integrates a mechanical jack and clamp, a feature specifically designed to eliminate the instability and inconsistency of manual polishing. As **Figure 2** shows, the device utilizes a clamp to hold the workpiece securely. This mechanism prevents human-induced vibration and maintains a consistent angle when polishing, which are critical for achieving clear surface finishing.

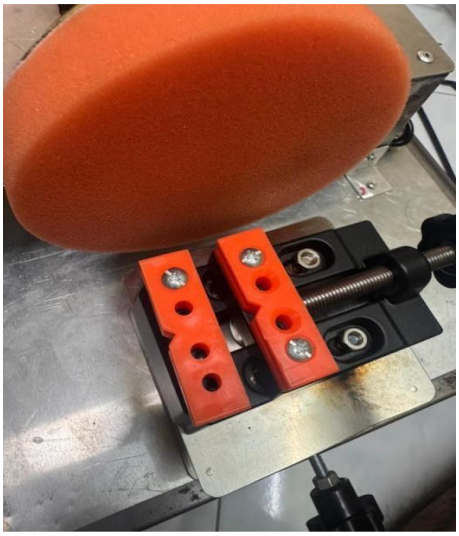

Figure 2. Mechanical jack and clamp feature.

Furthermore, its uniqueness is reinforced by a modular hybrid fabrication approach, utilizing a mild steel hollow frame and aluminium plates. This ensures structural rigidity while allowing the assembly to be disassembled for maintenance. **Figure 3** shows the fabrication process for the structural aspect of the product.

Figure 3. Fabrication process for product structure.

3. Benefit to mankind

The Acrylic Edge Polishing Tool addresses significant aesthetic and safety risks by providing a stabilized platform to eliminate sharp, unfinished edges that pose injury risks to users. Weighing only 8kg with a compact size of 40cm x 40cm, the tool is designed for portability, allowing users to perform precision polishing tasks anywhere within a workshop, educational lab, or maker space. Its minimalist design ensures it can be stored easily in confined spaces when not in use. The motorized system utilizes straightforward controls and an ergonomic layout, making it easy for users to operate and achieve quality finishes without the need for intensive manual labor.

4. Innovation and Entrepreneurial Impact

When comparing industrial scale products which can be expensive, The Acrylic Edge Polishing Tool offers a compact and functional product at a total fabrication cost of only RM307.62. **Table 1** shows the breakdown of the fabrication cost for this product.

Table 1. Total breakdown cost for Acrylic Edge Polishing Tool.

No.	Part	Price (per part) (RM)	Quantity	Cost (RM)
1	Aluminium Plate (A2 size)	50.89	2	101.78
2.	Aluminium Plate (A3 size)	16.99	1	16.99
3.	Hollow square (6m)	30.00	1	30.00
4.	Hollow square connector	8.20	4	32.80
5.	DC Motor	28.00	1	28.00
6.	Mechanical clamp and jack	10.80	1	10.80
7.	Adapter (3V-24V)	52.25	1	52.25
8.	Miscellaneous (Labour, etc)	35.00	-	35.00
Total (RM)				307.62

This RM 307.62 prototype democratizes high-quality finishing for students and small-scale workshops. This project fosters technical inclusivity, allowing low-income makers to produce safe, professional products efficiently.

5. Potential commercialization

The Acrylic Edge Polishing Tool holds significant commercial potential as a specialized benchtop appliance for the education, advertising, and small-scale manufacturing sectors. This functional prototype was fabricated for only RM 307.61. This price point makes it an essential acquisition for vocational colleges and maker spaces seeking to equip students with professional finishing capabilities on a limited budget. Furthermore, its portability and ease of operation position as a "plug-and-play" solution for small advertising firms that frequently work with acrylic signage, significantly increasing their production throughput and edge-quality consistency.

6. Acknowledgment

Special thanks to the Faculty of Mechanical Engineering at Universiti Teknologi MARA (UiTM) Cawangan Johor Kampus Pasir Gudang for providing the laboratory facilities and fabrication equipment essential to this project. Finally, heartfelt thanks to family and colleagues for their constant encouragement and moral support during this project journey.

7. Researchers' Biography

Shakir Zufayri Bin Shamsuddin is a final year student at the Faculty of Mechanical Engineering in Universiti Teknologi MARA (UiTM) Cawangan Johor Kampus Pasir Gudang. His final year project focuses on design and fabrication of an acrylic edge polishing machine for workshop use. Combining innovation with practical engineering solutions, Shakir aims to contribute to sustainable practices in the workshops.

Miqdad Bin Khairulmaini is a senior lecturer currently affiliated with UiTM Cawangan Johor Kampus Gudang. He received his master's degree in mechanical engineering from Universiti Malaya in 2012. His research interest includes thermal systems such as heat exchangers and air-conditioning systems. He can be contacted at the following e-mail address; miqdadkos@uitm.edu.my

Design and Fabrication of Automated Lemang Burner

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ABSTRACT
This project focuses on the design and fabrication of an automated lemang burner system to improve the traditional method of cooking lemang, a popular Malaysian food commonly prepared during festive seasons. Lemang is traditionally prepared by continuously rotating bamboo sticks by hand over an open flame, which takes a lot of time and effort. An automated method is created to guarantee uniform heat exposure and consistent rotation in order to solve this issue. The lemang bamboo sticks are rotated at a steady and regulated pace by an electric motor that is coupled to a gear mechanism. For motor control, basic electrical components are integrated, and the mechanical construction is made to be straightforward, long-lasting, and reasonably priced. Research and design, material selection, mechanical manufacturing, assembly, and performance testing are all part of the project technique. The automated lemang burner's primary benefits include enhanced efficiency, reduced manual labour, and better cooking consistency. Socioeconomically speaking, the method helps home users and small-scale food entrepreneurs by lowering workload and boosting production. In terms of the environment, regulated combustion lessens excessive smoke and fuel waste. Regarding commercialisation, this system provides a workable and reasonably priced solution that has a high chance of being embraced by households and small enterprises.

Keywords: automated, lemang burner, efficiency, consistency

1. Product Description
By automatically rotating bamboo sticks over a heat source, the automatic lemang burner is a mechanically and electrically powered cooking device that helps with lemang preparation. The bamboo sticks keep firmly in place while cooking by a handle, a revolving shaft, a motor-driven gear system, and a support frame. To ensure a steady and consistent rotational speed, an electric motor supplies the rotational motion that is transmitted through a gear system. To regulate the motor's operation, simple electronic components are included. To accommodate home users and small-scale food providers, the design places an emphasis on affordability and simplicity. By providing continuous and consistent rotation, the automatic lemang burner ensures heat distribution, reducing manual labor and increasing overall cooking efficiency. The device is a useful substitute for manual lemang cooking techniques because it is smaller, simpler to use, and appropriate for outdoor or small workspace use.

2. Flow process

Fabrication Process of the Automated Lemang Burner System

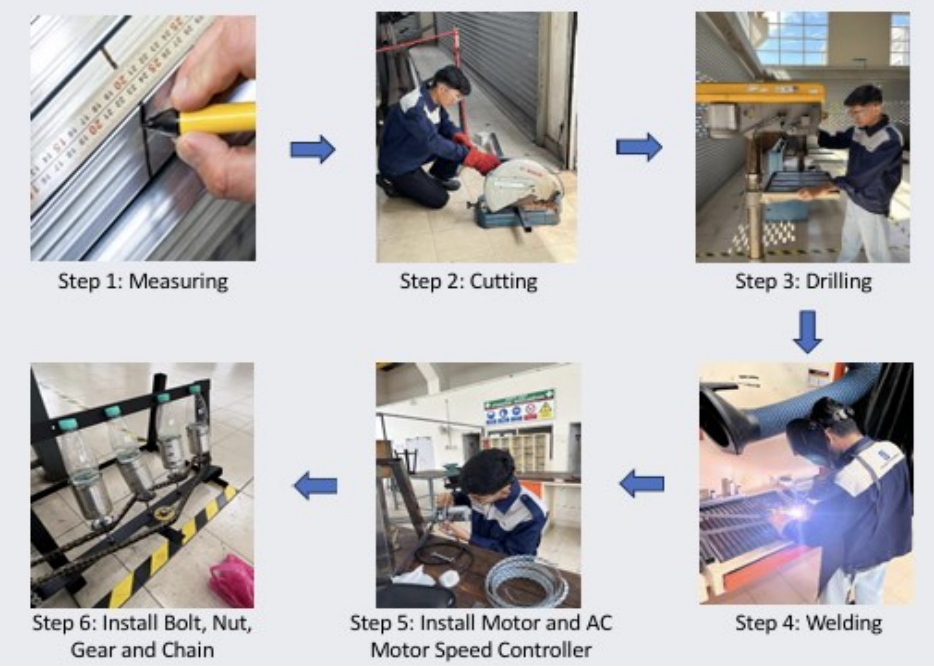

Figure 1. Process Fabrication.

Figure 1 shows the automated lemang burner system's fabrication process. To get the necessary dimensions, the material is first measured and marked, then it is cut and drilled. The basic structure is then put together by welding. To enable rotational motion, the AC motor and motor speed controller are then fitted. As seen in **Figure 1**, the mechanical gear system is finally completed by assembling bolts, nuts, gears and chains.

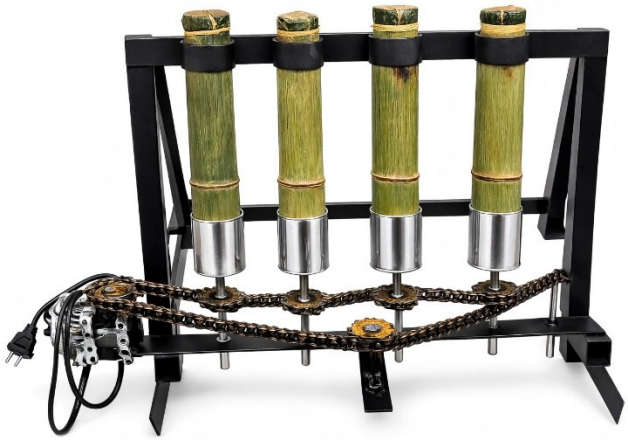

Figure 2. Final Prototype.

The mechanical assembly of the prototype automatic lemang burner is shown in **Figure 2**. The system uses a chain and gear transmission mechanism to rotate multiple lemang holders simultaneously. Each holder is mounted vertically to ensure stable rotation and uniform heat exposure during the cooking process.

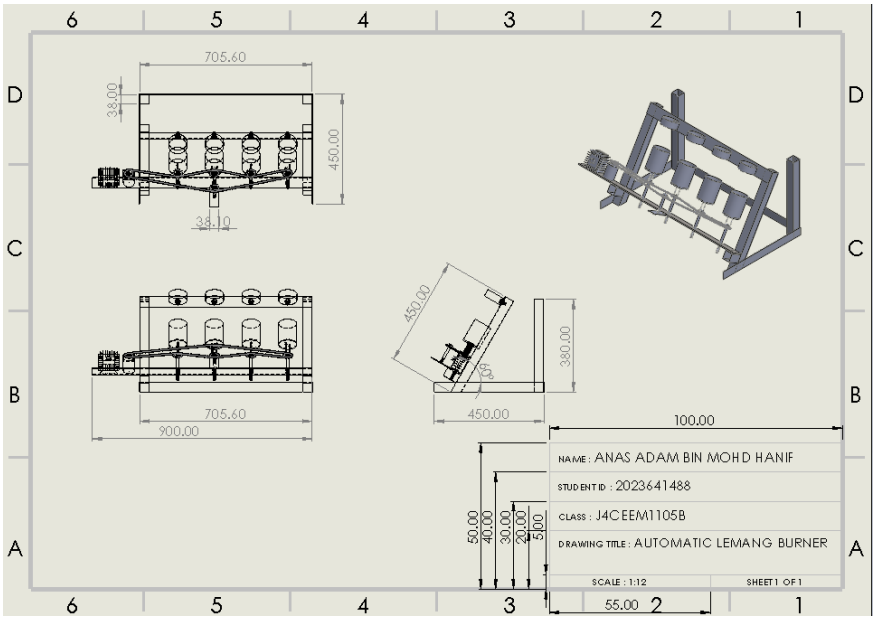

Figure 3. Automated Lemang Burner Drawing.

The engineering drawing and dimensional specifications of the automated lemang burner are presented in **Figure 3**. The drawing illustrates the orthographic views and isometric view of the system, including key dimensions required for fabrication and assembly. As shown in **Figure 3**, the compact structural design ensures proper alignment of the rotating holders, transmission system, and support frame, contributing to stable operation and efficient heat distribution.

3. Novelty and uniqueness

The automatic lemang burner's unique feature is its capacity to automate the conventional lemang cooking process using an easy-to-use, reasonably priced mechanical and electrical system that is appropriate for small-scale customers. A motor-driven gear mechanism is introduced in this system to ensure consistent and uniform rotation of the bamboo rod throughout the cooking process, in contrast to traditional lemang cooking methods that rely solely on manual rotation and continuous supervision. In contrast to large-scale commercial operations, its design is distinctive in that it priorities price, simplicity, and practicality, making it accessible to small food vendors and home users. While the steady rotation speed enhances cooking consistency, the small design makes setup and operation simple in limited places. Furthermore, incorporating simple electrical motor control improves use without adding complexity to the system. This project delivers useful advances that improve lemang preparation while preserving the original cooking concept by combining mechanical automation with conventional cooking techniques.

4. Benefit to mankind

By increasing the effectiveness and security of conventional lemang preparation, automatic lemang burners assist society in a number of ways. The technique dramatically lowers manual labour and

physical stress by automating the rotation of bamboo sticks, particularly for home users and small food vendors. Users can save time, concentrate on other duties, and become more productive overall as a result. Regular rotation minimizes food waste from burnt or undercooked lemang by ensuring consistent cooking quality. The technique lowers the chance of burns and heat-related injuries by reducing direct human contact with open flames. By lowering running expenses and labour dependency, the cost-effective design helps small business owners. In general, automatic lemang roasters support sustainable small-scale food production, improved working conditions, and higher-quality food.

5. Innovation and Entrepreneurial Impact

By bringing useful mechanical solutions to improve traditional food preparation methods without compromising cultural values, the automatic lemang burner promotes innovation. The use of a motor-driven rotating mechanism serves as an example of how fundamental engineering concepts can be used to increase productivity and uniformity. By utilizing reasonably priced and locally accessible components to convert manual procedures into semi-automated systems, the initiative promotes creative thinking. From an entrepreneurial standpoint, the method helps small-scale food enterprises by lowering labour costs and boosting output, allowing vendors to boost their output during peak holiday seasons. It can be commercialized by small producers or local entrepreneurs because of its affordable and scalable architecture. In addition, the project fosters an entrepreneurial culture within institutions and communities by demonstrating how engineering design can generate practical, market-ready solutions that meet real-world needs.

6. Potential commercialization

Given its useful, reasonably priced, and user-friendly design, this automatic lemang burner has a great chance of becoming a commercial product. It is appropriate for home users and small-scale food providers because to its lightweight design and inexpensive parts. Because it tackles issues like inconsistent cooking and labour intensity that are inherent in traditional lemang cooking, the technique appeals to customers seeking convenience and efficiency. The product can be marketed as a ready-to-use appliance for homes or small enterprises with minor modifications and production scale. Some possible business models are small-scale production and distribution, seasonal event rentals, and direct sales. Furthermore, promoting the product locally can encourage entrepreneurship by enabling community members to produce or sell automated cooking solutions, contributing to local economic growth and innovation in traditional food preparation practices.

7. Acknowledgment

The author is thankful to the project supervisor for all of his help, constant guidance, and insightful counsel during the execution of this senior project. Appreciation is also extended to the lecturers and technical staff of the Department of Mechanical Engineering for their support, knowledge sharing and technical assistance. Additionally, the author would like to thank this institution for providing the resources and facilities required to complete this study successfully. Lastly, I would want to express my gratitude to my peers and family for their support and encouragement, which have been crucial in helping me finish this job.

8. Researchers' Biography

Anas Adam bin Mohd Hanif is a final year Diploma in Mechanical Engineering student at UiTM. He has undertaken a Final Year Project titled "Design and Fabrication of Automatic Lemang Burner." His academic interests include mechanical system design and fabrication processes. He has hands-on experience in CAD modeling, mechanical assembly and basic electrical integration gained through academic coursework and practical laboratory sessions. His project work demonstrates a strong proficiency in troubleshooting mechanical systems and optimizing production efficiency.

Syidatul Akma Sulaiman is a Senior Lecturer in the Faculty of Mechanical Engineering at Universiti Teknologi MARA, with over 13 years of experience in teaching, learning and supervising undergraduate students. She brings a strong commitment to student-centred education and continuous improvement in engineering education through active mentorship and curriculum development. Her research interests focus on mechanical design, prototype development, and applied engineering projects. Her published design and fabrication projects highlight her dedication to hands-on engineering solutions that benefit industry partners and community stakeholders.

Rafa: Reflective Artificial Friendly Assistant, a Smart AI Companion for Emotion Recognition and Psychological Interaction

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ABSTRACT

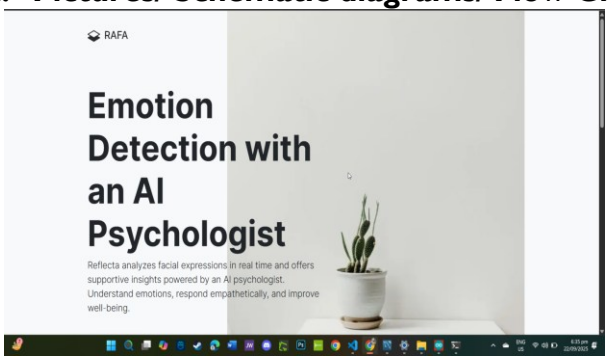
The RAFA Smart AI Companion System is an artificial intelligence–driven digital mental health solution designed to provide emotional support through real-time emotion recognition and empathetic interaction. It was developed in response to the increasing mental health concerns among students and the limited accessibility of professional psychological services. The system was designed by integrating an Emotion Recognition Module that identifies users' emotional states with a Psychological Interaction Module that generates contextually appropriate and empathetic responses. RAFA's main advantages include consistent emotion detection accuracy, fast response time, and high psychological acceptability, making it a reliable and user-friendly companion. Its unique feature lies in combining emotion-aware technology with supportive conversational interaction to promote emotional awareness and early intervention. The system contributes positively to the socio-environment by reducing stigma surrounding mental health and encouraging emotional expression, while offering socio-economic benefits through a cost-effective and scalable alternative to traditional support services. With its adaptable design and positive evaluation from users and academic staff, RAFA demonstrates strong potential for commercialization in educational institutions, wellness platforms, and digital mental health applications.

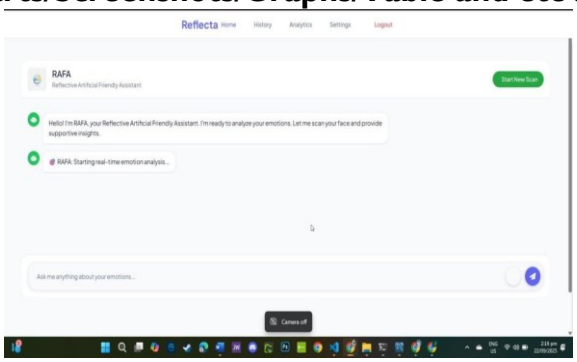
Keywords: Artificial Intelligence, Mental Health, Emotion Recognition, Digital Well-being, Smart Companion

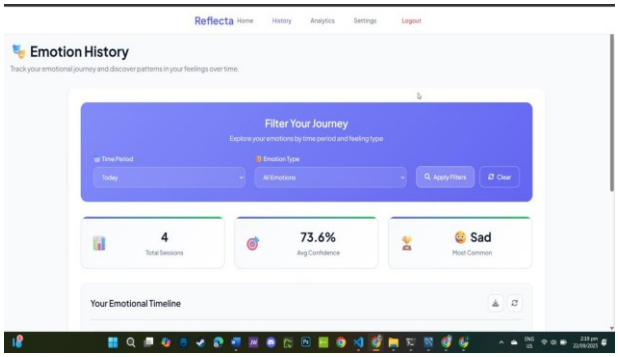
1. Product Description

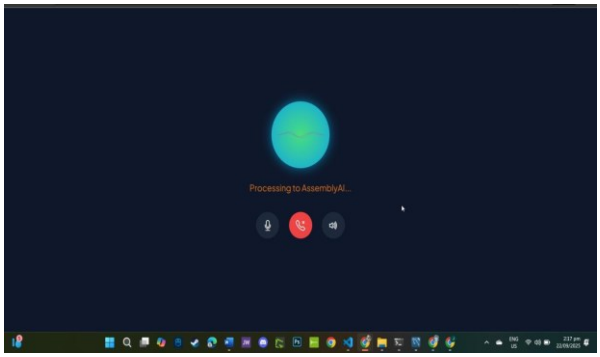
This study focuses on the development of RAFA: a Smart AI Companion System for Emotion Recognition and Psychological Support. RAFA is an artificial intelligence–based digital platform designed to support users' emotional well-being through intelligent interaction and real-time emotion recognition. The system analyzes users' emotional states using advanced emotion detection technology and provides empathetic, context-aware responses to help manage stress, emotional discomfort, and daily psychological challenges, especially in academic environments. RAFA consists of two main components: the Emotion Recognition Module, which detects a wide range of emotional states with minimal delay, and the Psychological Interaction Module, which delivers supportive responses that encourage emotional awareness, comfort, and trust. Designed to be accessible, user-friendly, and scalable, the system can be integrated into various digital platforms. By promoting emotional awareness and providing early emotional support, RAFA serves as a supplementary mental health tool that complements existing counseling and wellness services while maintaining affordability and ease of use.

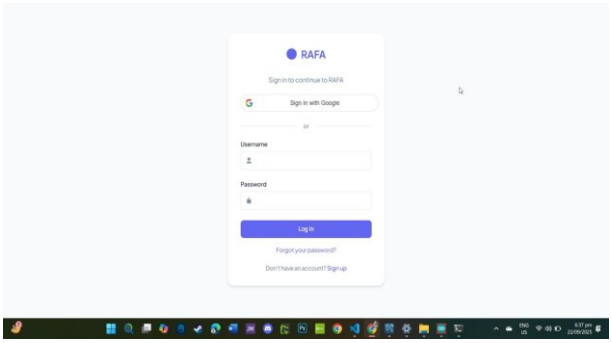
2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

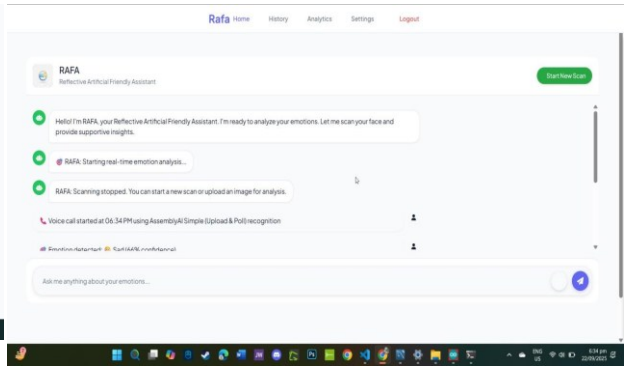


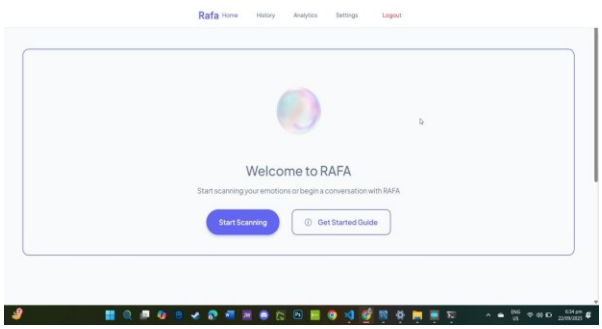


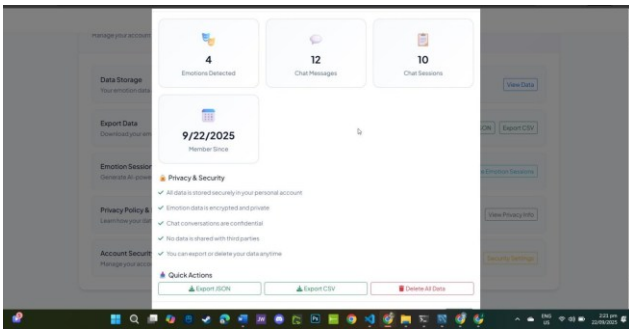


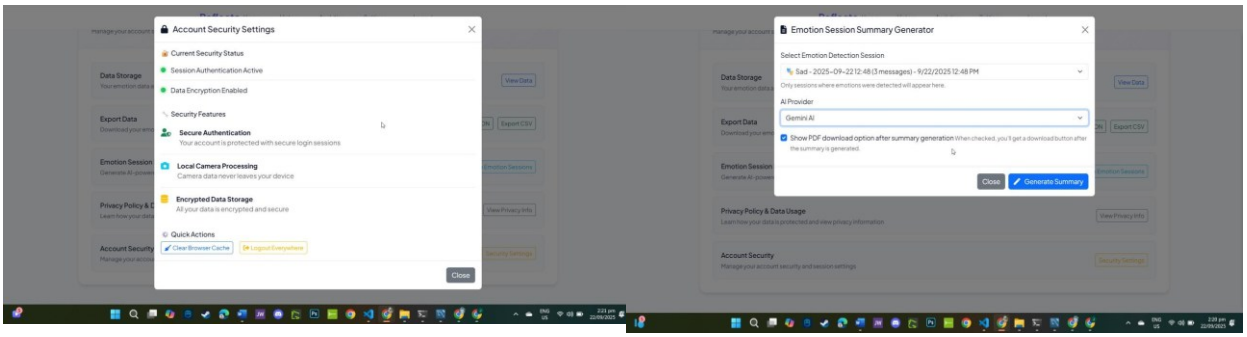


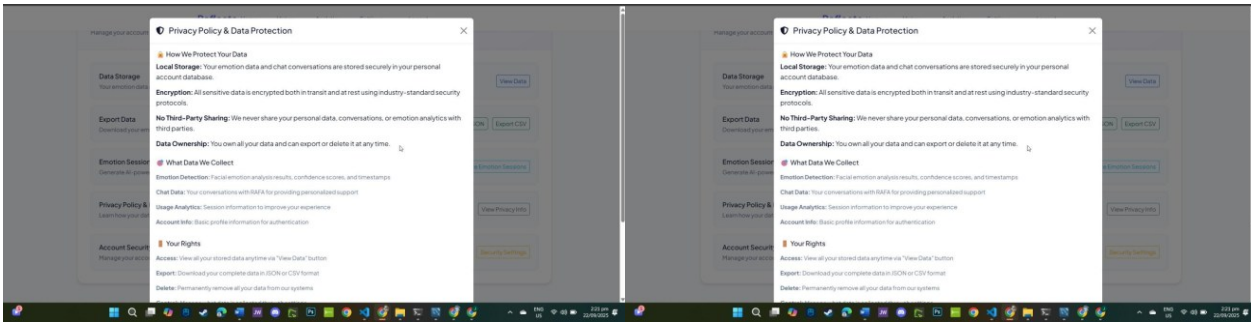


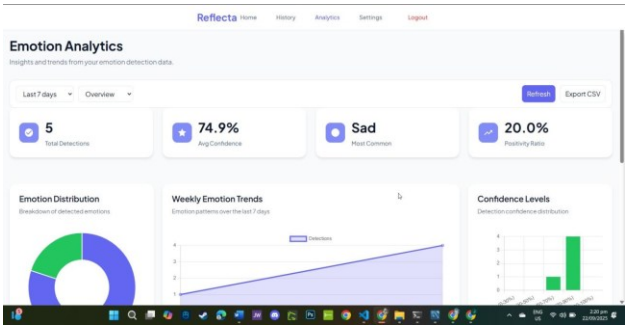


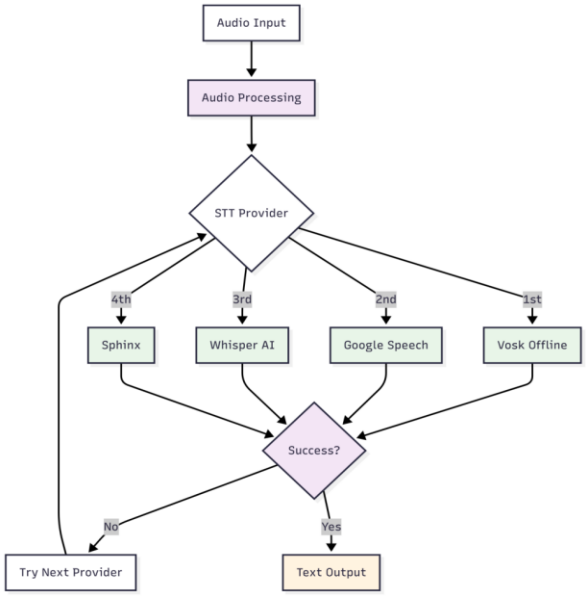












Figures illustrates how RAFA (Responsive AI for Affective Assistance) operates through its integrated multi-modal emotion recognition system. The process begins when a user provides input in the form of text, voice, or facial expression. Once the input is received, the system performs initial preprocessing to enhance data quality—text undergoes natural language preprocessing, voice input is cleaned and prepared through audio processing, and facial input is normalized for feature extraction. For voice-based interaction, RAFA routes the processed audio to its Speech-to-Text (STT) provider module, which sequentially attempts transcription using available providers. The system prioritizes the primary provider and, if recognition fails,

automatically switches to alternative providers until successful transcription is achieved, ensuring reliability and continuous operation. After successful transcription—or immediately in the case of text input—the data is analyzed using Natural Language Processing (NLP) techniques to detect sentiment, emotional tone, and contextual cues. For facial input, facial emotion recognition algorithms classify expressions into predefined emotional categories. The system then evaluates whether emotion recognition is successful. If unsuccessful, RAFA retries or shifts to another available recognition pathway. If successful, the identified emotion is forwarded to the response generation module, which formulates an appropriate empathetic reply. The final output is then delivered to the user in text or voice format. Overall, the schematic demonstrates that RAFA functions as an adaptive, automated, and multi-layered system designed for near real-time emotion detection and response. By integrating multiple recognition methods and fallback mechanisms, RAFA ensures accuracy, responsiveness, and reliability, fulfilling its purpose as an empathetic AI companion while reducing processing delays and operational errors.

Table 1. Efficiency Result of Emotion Recognition Module.

Emotional Input Type	Emotion Recognition Module										
	TOTAL TIME LAPSED (in seconds)										
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**Mean**
Text Input (typed)	0.89	0.92	0.87	0.94	0.91	0.88	0.95	0.90	0.87	0.93	**0.91s**
Voice Input	1.24	1.20	1.18	1.26	1.19	1.12	1.21	1.27	1.37	1.20	**1.22s**
Facial Expression	1.35	1.38	1.42	1.36	1.40	1.33	1.39	1.41	1.37	1.36	**1.66 s**
GRAND MEAN	**1.17 s**										

Table 1 presents the raw data on the emotion recognition results of the RAFA Smart AI Companion System during various user interaction sessions. The data is organized according to different emotional states—Happiness, Sadness, Stress, and Neutrality—recorded over ten (10) trials. Analysis shows that each emotional state significantly affects the system's detection accuracy. Specifically, the results indicate that moments of visible stress were recognized with the highest accuracy, demonstrating the Emotion Recognition Module's responsiveness in monitoring users' emotional states during interaction. According to Picard (2022), emotion recognition in AI relies on analyzing facial expressions, voice tone, and behavioral cues to provide context-aware responses. For example, when detecting stress, the system can trigger supportive feedback to help users manage emotional discomfort. RAFA's precise detection and timely interaction enable it to act as an effective digital companion, promoting emotional awareness and early support while complementing traditional counseling and wellness services. **Table 2** shows the efficiency of RAFA's response generation system across different types of user interactions. Results indicate that RAFA responded fastest to short text queries (1.91 seconds), while personalized reminders required more processing time (2.98 seconds). The grand mean of 2.45 seconds demonstrates that RAFA provides timely and context-aware responses. Emotion recognition technologies are applied beyond healthcare,

including education, workplace support, and social robotics. In education, emotion-aware systems monitor student engagement and deliver adaptive feedback to improve learning outcomes. In e-learning, these systems can detect moments of frustration or boredom, allowing real-time adjustments to content delivery. In social robotics, emotion-aware systems enable robots to respond naturally in caregiving or companionship roles, enhancing human–robot interaction. These applications highlight RAFA's role as an intelligent, empathetic system that supports users' practical and psychological needs.

Table 2. Efficiency Result of Response Generation Module.

Response Input Type	Response Generation Module										
	TOTAL TIME LAPSED (in seconds)										
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**Mean**
Short Text Query	1.95	1.87	1.92	1.90	1.91	1.93	1.89	1.94	1.88	1.92	0.91s
Emotional Prompt	2.45	2.52	2.41	2.47	2.50	2.44	2.48	2.53	2.46	2.49	2.47s
Personalized Reminder	2.95	3.02	2.98	3.01	2.97	2.94	3.00	2.96	3.01	2.99	2.98 s
GRAND MEAN	**2.45 s**										

Table 3. Distance of Emotion Recognition Detected by RAFA's Sensor Module.

Distance of Emotion Recognition Distance (cm)	TOTAL TIME LAPSED (in seconds)										
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**Mean**
30 cm	9.12	9.45	9.27	9.34	9.34	9.55	9.22	9.71	9.48	9.66	9.45
50 cm	9.78	11.02	9.48	9.76	11.13	8.96	10.58	11.74	11.98	10.37	10.01
100 cm	10.25	10.78	10.36	10.91	10.62	10.42	11.05	10.87	11.12	10.66	10.70

Table 3 presents the raw data on the distance performance of the emotion recognition feature during system testing. The data is organized according to different distance ranges between the user and the camera, measured across several trials. Analysis shows that the distance significantly affects the system's ability to accurately detect facial expressions and identify emotional states. The results indicate that shorter distances produced higher recognition accuracy, while detection slightly decreased as the distance increased. Despite this variation, the system was still able to recognize emotions effectively within the tested range. These findings demonstrate the capability of the emotion recognition module to capture facial cues and analyze emotional expressions in

real time. Emotion recognition technologies are widely applied in fields such as education, workplace support, and social robotics, where detecting users' emotions helps systems provide more adaptive and supportive responses. This highlights the system's potential as an intelligent and empathetic digital companion that promotes emotional awareness and interaction.

Table 4. Results of Analysis of Variance of AURA's Emotion Recognition Module.

Emotion Recognition Trials	Response Generation Module										
	TOTAL TIME LAPSED (in seconds)										
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**Mean**
Emotion State	6.31	7.42	8.38	7.55	8.29	7.24	8.11	6.59	9.01	7.44	7.6s
Happy	6.87	7.51	8.56	7.74	9.05	7.72	8.29	6.53	8.16	8.01	7.8s
Sad	6.59	7.26	8.94	7.38	8.94	7.46	9.09	6.32	7.13	8.29	7.7s
Stressed	7.03	6.87	9.16	7.14	8.65	8.02	8.34	6.46	6.28	6.86	7.5s
Neutral	6.31	7.42	8.38	7.55	8.29	7.24	8.11	6.59	9.01	7.44	7.6s
GRAND MEAN	**7.7 s**										

Table 4 presents the raw data on the emotion recognition trials conducted to evaluate the system's ability to accurately detect and classify users' emotional states. The data is organized according to different emotional categories—such as happiness, sadness, stress, and neutrality—measured across multiple trials. Analysis shows that the system consistently identified emotional expressions with reliable accuracy during user interactions. The results indicate that emotions with clearer facial expressions, such as happiness and stress, were detected more easily compared to neutral expressions. These findings demonstrate the effectiveness of the emotion recognition module in analyzing facial cues and identifying emotional patterns in real time. Emotion recognition technologies are widely used in areas such as education, digital assistance, and human–computer interaction, where understanding users' emotional states helps systems provide more adaptive and supportive responses. This highlights the capability of the system to function as an intelligent and empathetic digital companion that supports emotional awareness and user engagement.

Table 5. Results of Analysis of Variance of AURA's Emotion Recognition Module.

SMS notification	Mood Status Delivery										
	TOTAL TIME LAPSED (in seconds)										
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**Mean**
Receiving Speed	1.56	1.77	2.32	1.85	2.43	2.63	2.01	2.39	2.27	2.76	2.97s

Table 5 presents the results on the SMS notification performance of the system in delivering users' mood status. The data shows the total time elapsed, measured in seconds, across ten (10) trials (T1–T10). The results indicate that the receiving speed of the SMS notification ranged from 1.56 seconds to 2.76 seconds, demonstrating consistent and efficient message delivery. The computed mean time of 2.97 seconds shows that the system can send and deliver mood status notifications within a short period. This indicates that the notification feature is responsive and capable of providing timely updates to users. Efficient SMS delivery is important in systems that monitor emotional states because it ensures that users receive immediate feedback or reminders related to their mood status. Overall, the results demonstrate that the system's SMS notification feature is reliable and effective in supporting real-time communication and emotional monitoring.

Table 6. Evaluation Result of the System's Functionality.

	Functionality	WM	Interpretation
1.1	The system allows users to create and manage accounts	4.52	Strongly Agree
1.2	The system provides empathetic and adaptive responses	4.60	Strongly Agree
1.3	The system can recognize and adjust to users' emotional states	4.55	Strongly Agree
1.4	The system can generate personalized reminders and supportive feedback	4.47	Strongly Agree
	TOTAL	4.54	Strongly Agree

Legend: 4.21 – 5.00 → Strongly Agree, 3.41 – 4.20 → Agree, 2.61 – 3.40 → Neutral, 1.81 – 2.60 → Disagree,1.00 – 1.80 → Strongly Disagree

Table 6 presents the evaluation results on the functionality of the system based on the users' assessment. The data includes several functional features such as account creation and management, empathetic and adaptive responses, recognition and adjustment to users' emotional states, and the generation of personalized reminders and supportive feedback. The results show high weighted mean (WM) scores for all indicators, ranging from 4.47 to 4.60, all interpreted as Strongly Agree. The highest rating (WM = 4.60) indicates that users strongly agree that the system provides empathetic and adaptive responses, demonstrating its capability to interact effectively with users. The ability of the system to recognize and adjust to users' emotional states also received a high score (WM = 4.55), highlighting its effectiveness in emotion recognition. The overall weighted mean of 4.54, interpreted as Strongly Agree, shows that users find the system functional, reliable, and effective in supporting emotional interaction and user engagement.

3. Novelty and uniqueness

The system stands out by delivering a more human-centered approach to digital mental health support. Unlike typical chatbots that provide uniform responses, it recognizes users' emotions in real time and adapts its interactions to reflect how they feel. This results in conversations that are more natural, understanding, and emotionally supportive rather than robotic. Its uniqueness lies in the seamless combination of fast and accurate emotion recognition with empathetic, context-aware responses, creating a sense of genuine companionship. Designed to be psychologically comfortable and non-intrusive, the system helps users feel truly heard and supported. Its accessible and scalable design also allows easy integration into schools and wellness platforms, making it a practical and affordable solution for emotional support.

4. Benefit to mankind

The goal of this project is to provide users with an accessible, intelligent system that supports emotional well-being and enhances daily psychological interaction. For students and general users, the system offers real-time emotion recognition and context-aware responses, helping them manage stress, discomfort, and emotional challenges. For educators and workplaces, it promotes emotional awareness and engagement, allowing better monitoring of mood and providing adaptive support when needed. For mental health professionals, the system serves as a supplemental tool to complement counseling and wellness services, offering timely feedback and monitoring outside traditional settings. For researchers, this project provides hands-on experience in developing AI-driven, emotion-aware systems, strengthening their skills in practical applications of artificial intelligence. Finally, for future developers and researchers, the study offers a foundation for further work on intelligent companions, emotion recognition, and AI-assisted mental health solutions.

5. Innovation and Entrepreneurial Impact

This innovation contributes to a culture of emotional well-being and technological engagement by providing users with an intelligent, AI-driven system that supports mental health, promotes emotional awareness, and delivers personalized, context-aware responses. This project contributes to the following communities, institutions, and industries:

- Education Sector: Students, teachers, and educational institutions seeking to monitor engagement, manage stress, and improve learning outcomes through emotion-aware technologies.
- Technology and Engineering: Developers, engineers, and innovators working in AI, affective computing, and human–computer interaction.
- Mental Health and Wellness: Professionals, counselors, and organizations focusing on supplemental tools for emotional support and early intervention.
- Research and Development: Institutions studying emotion recognition, AI-assisted mental health systems, and intelligent companion technologies.
- Local Communities and NGOs: Organizations promoting well-being, digital inclusion, and accessible mental health solutions.
- Educational Institutions: Universities and training centers integrating AI, psychology, and human–computer interaction into their programs.

6. Potential commercialization

The project demonstrates exceptional commercialization potential driven by its innovative design, high user acceptability, and relevance to the rapidly growing digital mental health market. Its scalable and cost-efficient architecture allows deployment across educational institutions, wellness platforms, and organizational support systems through subscription-based or licensing models. The system can be seamlessly integrated into mobile applications, learning management systems, and workplace wellness programs, significantly expanding its market reach. Strong adaptability enables customization for diverse user groups, enhancing commercial value and competitiveness. With minimal infrastructure requirements and proven effectiveness, the project stands out as a market-ready solution. Strategic partnerships with educational institutions, healthcare providers, and technology companies further position the project for sustainable growth, strong market adoption, and long-term commercial success.

7. Acknowledgment

We would like to express our sincere gratitude to everyone who contributed to the completion of this study. First and foremost, we thank our research adviser sir Nelson Malificiado for the guidance, encouragement, and valuable insights that greatly improved our work. Their expertise and support played a significant role in the success of this research. The researchers would like to extend their deepest gratitude to our consultants Arjay Gerson Dela Cruz and Jalel Prince Gayo for their invaluable guidance, expertise, and continuous support throughout the completion of this study. Their professional insights, constructive feedback, and thoughtful recommendations greatly enhanced the quality, accuracy, and credibility of our research. Their willingness to share their knowledge and time played a crucial role in refining our methodology, analysis, and overall presentation.We are sincerely grateful for their patience in answering our questions and for challenging us to think critically and improve our work. Their encouragement motivated us to strive for excellence and maintain high standards in conducting this study.Finally, we would like to express our heartfelt gratitude to our parents and families for their continuous support, understanding, and motivation throughout the completion of this project. Above all, we thank God for giving us strength, wisdom, and perseverance to accomplish this study

8. Researchers' Biography

Erinn D. Juele is a Grade 12 STEM student at Tupi National High School with a strong passion for robotics and technology. She participated in the National Robotics Competition in Polomolok, Mindanao, and Bacolod City, Philippines, as well as the Division Science and Technology Fair in Tupi. These experiences provided her with hands-on training in robot design, basic programming, research presentation, and teamwork. Her involvement in science and robotics events reflects her dedication to learning and skill improvement. Through these activities, she developed critical thinking, communication, and collaboration skills, preparing her for further studies in STEM.

Jhonas Quezon Melancio is a dedicated Grade 12 STEM student at Tupi National High School with a strong passion for robotics and emerging technologies. He represented his school in the National Robotics Competition in Polomolok and the Division Science and Technology Fair in Tupi, South Cotabato. These experiences strengthened his skills in technical engineering, innovation, and collaborative leadership. He excels in evaluating and improving robotic systems while developing creative solutions to complex challenges. His participation in competitive events reflects his commitment to science and technology and his goal of pursuing advanced studies in a STEM-related field.

Ralf Reymel Supeña is a Grade 12 STEM student at Tupi National High School with a strong passion for robotics and technology. He participated in the National Robotics Competition in Polomolok, Mindanao, and the Division Science and Technology Fair in Tupi, South Cotabato. These experiences provided him with hands-on training in robot design, basic programming, research presentation, and teamwork. His involvement in division- and national-level events reflects his dedication to continuous learning and skill development in science and technology. He aims to pursue further studies in a STEM-related field and continue growing in the discipline.

Khristine J. Cabanas is a Grade 12 STEM student at Tupi National High School with a strong passion for robotics and innovative technologies. She participated in the 2025 National Robotics Competition (NRC Visayas) in Talisay City, Negros Occidental, and NRC Mindanao in Polomolok, South Cotabato. She also competed in the Division Science and Technology Fair in Tupi and the Regional Science and Technology Fair in General Santos City. These experiences enhanced her skills in basic programming, research presentation, and technological innovation. They also strengthened her communication, critical thinking, and teamwork skills, demonstrating her excellence and potential in STEM.

Floating Plant Phytoremediation for Urban Lake Cleanup

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ABSTRACT

This project designed and implemented a laboratory-scale phytoremediation system to treat polluted water from an urban lake using two floating aquatic plants: *Pistia stratiotes* (water lettuce) and *Salvinia molesta* (water fern). The system was invented to address the growing concern of surface water pollution in urban areas, offering a sustainable, plant-based alternative to conventional chemical treatments. Water samples from Taman Tasik Tun Jeanne Abdullah were treated in three separate basins over 7–10 days, with water quality parameters (pH, turbidity, colour, odour) measured before and after treatment. The main advantages include its low cost, simplicity, environmental friendliness, and absence of chemical additives. Its uniqueness lies in the comparative evaluation of single versus combined plant species in a controlled setup. The system positively impacts the socio-environment by improving water safety for recreational use, enhancing local ecosystem health, and promoting community awareness of green solutions. It supports Sustainable Development Goal 6 (Clean Water and Sanitation) and reduces reliance on expensive infrastructure. Commercialisation prospects are strong for residential complexes, parks, small industries, and educational kits, with the potential for community-led water treatment initiatives and partnerships with environmental agencies.

Keywords: Phytoremediation, floating plants, water treatment, sustainability, SDG 6

1. Product Description

This project designed and evaluated a laboratory-scale phytoremediation system to improve polluted urban lake water using floating aquatic plants. Water samples from Taman Tasik Tun Jeanne Abdullah were treated in three basins: one with *Pistia stratiotes* (water lettuce), one with *Salvinia molesta* (water fern), and one with both species combined. Over 7–10 days, key water quality parameters (pH, turbidity, colour, and odour) were monitored before and after treatment. Results showed significant improvements across all treatments. *Pistia stratiotes* achieved the highest turbidity reduction (32.10%) and the greatest pH stabilisation, shifting alkaline water toward neutral. The combined system also improved water quality, though slightly less effectively. All systems eliminated unpleasant odours and enhanced water clarity.

The study demonstrates that phytoremediation is a simple, low-cost, and environmentally sustainable method for treating polluted water. It requires no chemicals, uses naturally available plants, and aligns with Sustainable Development Goal 6: Clean Water and Sanitation. This approach is particularly suitable for community-based applications, small-scale water bodies, and educational environmental projects.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc.

Figure 1 presents a flowchart that outlines the procedural steps of the experiment, providing a clear overview of the methodology from start to finish.

Figure 1. Flowchart of the process.

Figure 2 is a photographic panel showing Basin 1 (Pistia stratiotes), Basin 2 (Salvinia molesta) and Basin 3 (Pistia stratiotes and Salvinia molesta). This image provides a visual reference for the experimental setup, allowing the reader to see the three basins side-by-side and the different compositions of aquatic plants used for the phytoremediation process.

Figure 2. Basin 1 (Pistia stratiotes), Basin 2 (Salvinia molesta) and Basin 3 (Pistia stratiotes and Salvinia molesta).

The visual and physical changes in the water samples were monitored daily. **Table 1** provides a detailed log of the colour, odour, pH, and turbidity for each of the three basins from the initial day (Day 0) to the final days (Day 7-10). This table shows a clear improvement in water quality across all basins, with colours progressing from "brownish" to "clear" or "very clear" and odours completely eliminated by Day 8. The pH values also show a general decreasing trend towards a more neutral level.

Table 1. Colour, odour, pH and turbidity for the initial day (Day 0) & final days (Day 7-10).

Parameter	***Day***	***Basin 1 (Pistia stratiotes)***	***Basin 2 (Salvinia molesta)***	***Basin 3 (Pistia stratiotes & Salvinia molesta)***
Colour	0	Brownish	Brownish	Brownish
	7	Light brown	Light brown	Light brown
	8	Clear	Light brown	Yellowish
	9	Clear	Yellowish	Clear

Parameter	Day	Basin 1 (Pistia stratiotes)	Basin 2 (Salvinia molesta)	Basin 3 (Pistia stratiotes & Salvinia molesta)
	10	Very clear	Clear	Clear
Odour	0	Slight unpleasant odour	Slight unpleasant odour	Slight unpleasant odour
	7	Slight odour	Slight odour	Slight odour
	8	No odour	No odour	No odour
	9	No odour	No odour	No odour
	10	No odour	No odour	No odour
pH	0	8.95	8.85	8.73
	7	8.27	7.96	8.19
	8	8.07	7.94	8.00
	9	8.09	8.02	7.91
	10	7.47	7.96	7.98
Turbidity (NTU)	0	10.40	10.70	10.80
	7	5.13	6.71	12.00
	8	6.26	6.99	8.63
	9	9.68	7.14	7.49
	10	7.16	13.50	6.01

The performance of each treatment is shown in **Table 2**, which presents the turbidity removal efficiency (%) for the three basins**.** This was calculated by comparing the average turbidity from Days 7-10 to the initial turbidity on Day 0. As seen in **Table 2**, Basin 1, which contained only *Pistia stratiotes*, was the most effective, removing 32.12% of the turbidity.

Table 2. Removal efficiency (%) for three basins.

Parameter	Initial turbidity, Day 0 (NTU)	Final turbidity, Average Day 7-10 (NTU)	Removal efficiency (%)
Basin 1 (Pistia stratiotes)	10.4	7.06	32.12
Basin 2 (Salvinia molesta)	10.7	8.59	19.72
Basin 3 (Pistia stratiotes & Salvinia molesta)	10.8	8.53	21.02

3. Novelty and uniqueness

The novelty of this study lies in its functional, mechanism-driven selection of *Pistia stratiotes* and *Salvinia molesta*, which were chosen to test a complementary phytoremediation strategy—*Pistia* for root-based particle filtration and *Salvinia* for surface-level nutrient and algae control. The uniqueness is revealed by the experimental results, which show that Pistia alone outperformed the combined system, challenging the widespread assumption that using multiple plant species

always enhances treatment. This outcome underscores a critical insight: effective phytoremediation depends on matching plant traits to specific pollutants, not merely increasing plant diversity. The study thus introduces a principled, evidence-based framework for selecting remediation species, advancing beyond generic multi-species approaches toward targeted, function-first ecological design.

4. Benefit to mankind

The use of *Pistia stratiotes* and *Salvinia molesta* in water treatment offers a low-cost, sustainable, and chemical-free solution to water pollution, particularly benefiting underserved communities and ecologically sensitive areas. *Pistia* effectively reduces turbidity and suspended solids, making water safer for recreation and local use. *Salvinia* helps control nutrient levels and algal blooms, protecting aquatic ecosystems from eutrophication. Together, they provide a nature-based, energy-independent treatment system that can be implemented with minimal technical expertise or infrastructure. This approach supports public health by improving water quality, promotes environmental education and stewardship, and contributes directly to Sustainable Development Goal 6 (Clean Water and Sanitation). By offering an accessible and eco-friendly remediation option, this method empowers communities to restore and protect their local water resources sustainably.

5. Innovation and Entrepreneurial Impact

This project drives applied green innovation by transforming phytoremediation from a biological concept into a reproducible, low-tech water treatment system. It promotes entrepreneurial thinking by demonstrating how plant-based remediation can be developed into marketable products, such as ready-to-use water cleaning kits for homeowners, community lake restoration services, or educational STEM modules for schools.

Within the institution, it fosters a student-led culture of environmental entrepreneurship, bridging civil engineering, ecology, and business disciplines. For industry, it provides a scalable model for sustainable water management in landscaping, urban planning, and environmental consulting sectors. By proving that eco-friendly technology can be both effective and commercially viable, this project inspires future innovators to develop locally adaptable, sustainable solutions, creating economic opportunities while addressing pressing environmental challenges.

6. Potential commercialisation

This phytoremediation system has strong commercialisation potential across several markets. It can be developed into pre-packaged treatment kits for residential and commercial properties, offering an eco-friendly alternative to chemical treatments. Municipalities and environmental agencies could deploy modular floating treatment platforms in public lakes, stormwater ponds, and urban wetlands. The project also supports a service-based model, where companies install and maintain phytoremediation systems for communities or industries dealing with nutrient runoff. Furthermore, it can be adapted into educational and STEM kits for schools and universities, fostering environmental awareness. Partnerships with landscaping firms, aquaculture operators, and eco-tourism ventures could expand its application. With low production costs, minimal maintenance, and clear environmental benefits, this system represents a viable, scalable green product that meets growing demand for sustainable water solutions.

7. Acknowledgement

We appreciate the Faculty of Civil Engineering, UiTM Johor Branch, Pasir Gudang Campus and its laboratory assistants for their technical support and facilities.

8. Researchers' Biography

Nur Farisha Halim is currently pursuing a Diploma in Civil Engineering at Universiti Teknologi MARA (UiTM) Cawangan Johor, Kampus Pasir Gudang, where she has consistently achieved Dean's List recognition. She has already participated in the International Technology, Engineering and Innovation Competition 2025 (i-TIEC 2025), which allowed her to gain meaningful experience in innovative thinking, advanced technology applications and effective teamwork. Her enthusiasm for civil engineering drives her to continuously enhance her academic performance and practical skills.

Ainnur Insyirah Haieral is a dedicated student pursuing a Diploma in Civil Engineering at Universiti Teknologi MARA (UiTM) Cawangan Johor, Kampus Pasir Gudang. She previously had participated in the International Technology, Engineering and Innovation Competition 2025 (i-TIEC 2025). Now, she actively participates in group projects and research assignments focused on developing innovative solutions to modern infrastructure challenges.

Hani Hasriena Hasrin is currently pursuing a Diploma in Civil Engineering at Universiti Teknologi MARA (UiTM) Cawangan Johor, Pasir Gudang. Throughout her studies, she has been involved in various academic projects and practical assignments related to construction, structural fundamentals and infrastructure development. She is continuously improving her technical knowledge and skills in the civil engineering field and plans to further her studies to become a competent and professional engineer in the future.

Azyan Zafyrah Mohd Zahid is a dual master's degree holder in Civil Engineering (Water Resources) and Water Resources Engineering & Management from Universiti Teknologi MARA, Malaysia, and the University of Stuttgart, Germany. She is currently serving as a lecturer for Civil Engineering Studies at UiTM Cawangan Johor, Kampus Pasir Gudang, bringing more than a decade of combined experience in both academia and the engineering industry to her role. Her areas of interest include eco-, hydrological, and hydraulic system modelling and water engineering. She is actively involved in producing research publications and innovations related to her field of interest.

Automated Smart Irrigation and Monitoring System for Kebun Komuniti Wanita Taman Mawar Fasa 5

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ABSTRACT

This project presents the development of an Automated Smart Irrigation and Monitoring System designed for small-scale community gardens, specifically Kebun Komuniti Wanita Taman Mawar Fasa 5. The system addresses the challenges of manual irrigation, inefficient water usage, and physical strain experienced by middle-aged and elderly women gardeners. An ESP32 microcontroller is integrated with a soil moisture sensor to enable automatic control of a 5V water pump based on real-time soil conditions. Irrigation water is supplied through a rainwater harvesting system, collected from roof gutters and stored in a tank, promoting sustainable water management. Water distribution is implemented using low-cost HDPE pipes with perforations along each planting row, suitable for corn (maize) cultivation. System monitoring is performed through the Blynk mobile application, allowing users to easily observe soil moisture levels and pump status at their fingertips. The proposed system offers a low-cost, user-friendly, and sustainable solution that reduces manual labour, improves water efficiency, and supports community-based agriculture. The project also demonstrates strong potential for adoption in similar community gardens.

Keywords: (Smart Irrigation, ESP32, Internet of Things (IoT), Blynk Application, Rainwater Harvesting, Sustainable Agriculture)

1. Product Description

The Automated Smart Irrigation and Monitoring System is a low-cost IoT-based solution developed for Kebun Komuniti Wanita Taman Mawar Fasa 5 to improve irrigation efficiency and reduce manual labour among middle-aged and elderly gardeners. As illustrated in **Figure 1** (Block Diagram), the system integrates an ESP32 microcontroller, a soil moisture sensor, a relay module, and a 12V DC water pump supplied by a rainwater harvesting tank to promote sustainable water usage. The operational process shown in **Figure 2** (Flowchart) explains how the system continuously reads soil moisture data and automatically activates the pump when the soil becomes dry, stopping irrigation once the optimal moisture level is achieved to prevent overwatering. The system performance is validated in **Figure 3** (Analysis Graph of Moisture Level against Time), which demonstrates responsive moisture regulation during irrigation cycles. Real-time monitoring is provided through the Blynk mobile platform, as displayed in **Figure 4** (Blynk App Interface), allowing users to observe soil moisture levels and pump status easily via smartphone. The complete on-site implementation is presented in **Figure 5** (Final Product at Site), where rainwater storage and perforated HDPE pipes ensure uniform water distribution along corn planting rows. Overall, the system combines automation, sustainability, affordability,

and user-friendly monitoring to provide a practical smart irrigation solution for community-based agriculture.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table etc.

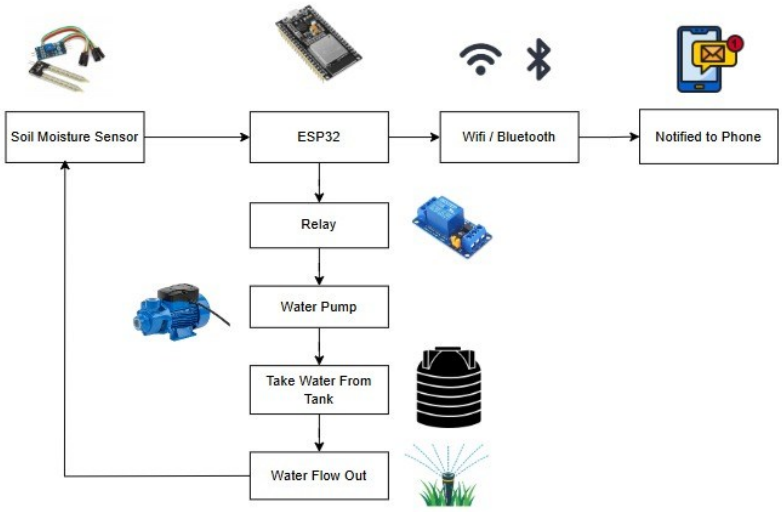

Figure 1. Block Diagram.

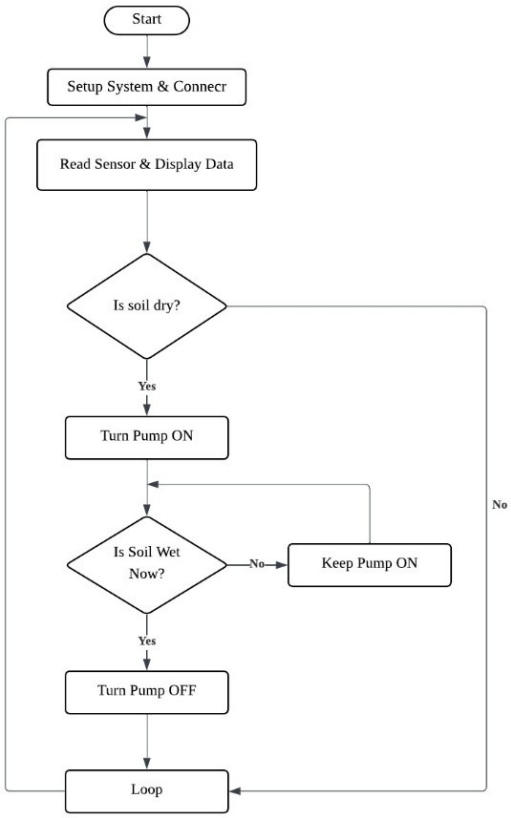

Figure 2. Flowchart.

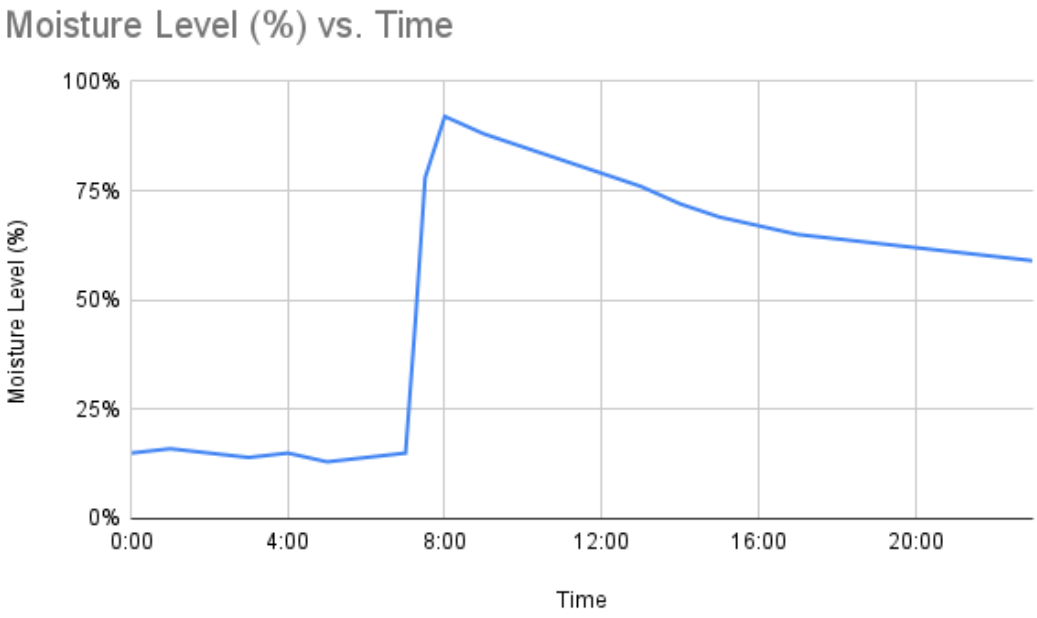

Figure 3. Analysis Graph of Moisture Level against Time.

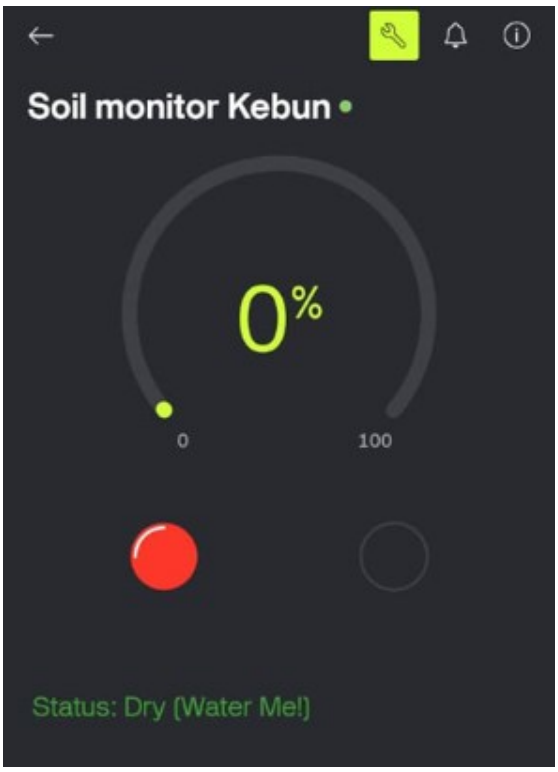

Figure 4. Blynk App Interface.

Figure 5. Final product at Site.

3. Novelty and uniqueness

The novelty of this project lies in its community-oriented and elderly-friendly design. Unlike existing smart irrigation systems that are typically developed for large-scale farms or commercial agriculture, this system is specifically tailored for small community gardens managed by middle-aged and elderly users. The integration of rainwater harvesting with automated irrigation enhances sustainability while reducing dependency on treated water. Additionally, the use of low-cost HDPE pipes with perforations replaces conventional sprinklers or drippers, offering a practical and affordable water distribution method for corn cultivation. The system combines ESP32 and Blynk to provide simple mobile-based monitoring without complex interfaces, allowing users to monitor irrigation status easily at their fingertips. This combination of affordability, simplicity, sustainability, and user-centric design distinguishes the project from existing solutions.

4. Benefit to mankind

The proposed system benefits the community by reducing physical workload and improving irrigation efficiency in community gardens. It enables elderly and middle-aged gardeners to manage irrigation activities without continuous manual effort, promoting inclusivity and well-being. The use of rainwater harvesting supports responsible water usage and reduces reliance on treated water resources. Automated, soil-based irrigation prevents overwatering and minimizes water wastage, contributing to environmental sustainability. Overall, the system supports local food production, enhances community resilience, and aligns with Sustainable Development Goals, particularly SDG 6 (Clean Water and Sanitation) and SDG 12 (Responsible Consumption and Production).

5. Innovation and Entrepreneurial Impact

This project promotes innovation by applying IoT technology to solve real-world problems faced by community gardeners. The system demonstrates how low-cost hardware and simple mobile applications can be transformed into practical agricultural solutions. From an entrepreneurial perspective, the project has the potential to inspire the development of affordable smart farming products tailored for small communities rather than large commercial farms. It encourages students and local innovators to explore sustainable agrotechnology solutions and fosters an innovation-driven mindset within the community. The system can be replicated, improved, and adapted for various crops and locations, supporting innovation-led social entrepreneurship.

6. Potential commercialization

The proposed system has strong potential for commercialization as a low-cost smart irrigation kit for community gardens, schools, urban farms, and smallholders. The system can be packaged as a modular product consisting of a controller unit, sensor set, pump, and mobile application support. Its affordability and simplicity make it attractive to local councils, community farming initiatives, and non-governmental organizations promoting sustainable agriculture. Future commercialization may include installation services, training workshops, and system customization based on crop type and garden size. With minor enhancements, the system could be scaled and marketed as an entry-level smart irrigation solution.

7. Acknowledgment

The authors would like to express their sincere appreciation to the Kebun Komuniti Wanita Taman Mawar Fasa 5 committee members for their cooperation and support throughout the project. Special thanks are also extended to the project supervisor, Ts Dr Siti Aminah Nordin, and Muhammad Wazif Asyraf Arizal for valuable guidance and technical advice during the development of this system.

8. Researchers' Biography

Ariefah Nadya Azhari is pursuing a Bachelor of Engineering Technology in Digital and Automation at UiTM Kampus Pasir Gudang. She graduated from her high school at MRSM Tun Abdul Razak, Pekan, Pahang and later completed her Foundation in Engineering at UiTM Kampus Dengkil. She is now actively engaged in various programs and initiatives to hone her soft skills and enhance her expertise in electronics, with a keen interest in taking on more leadership roles and collaborative projects.

After completing his secondary education at SM Sains Tuanku Syed Putra in Perlis, Muhammad Firas Ihsan moved on to master the fundamentals of Physical Science at the Penang Matriculation College. He has since transitioned into higher education at UiTM Pasir Gudang, where he is pursuing his Bachelor of Engineering Technology. Driven by a dual passion for circuit design and team dynamics, he is currently rounding out his technical expertise with high-level leadership initiatives. He possesses a rare blend of analytical precision and interpersonal fluency, making him an

asset in cross-functional environments where clear communication is as vital as technical accuracy.

An alumnus of Labuan Matriculation College, Valentine Junior Joseph is currently pursuing a Bachelor of Engineering Technology at UiTM. He is dedicated to building robust expertise in engineering and electronics, complemented by a growing interest in leadership and professional collaboration. Driven by a commitment to continuous learning, Valentine is actively seeking opportunities to apply his technical knowledge in team-oriented environments and take on impactful roles within industry.

Amirah binti Ali is a Bachelor of Engineering Technology student at UiTM Pasir Gudang, following her Physical Science studies at Kolej Matrikulasi Negeri Sembilan. With a specialized interest in electronics, she is focused on bridging the gap between technical mastery and leadership. She is currently engaging in diverse collaborative projects to strengthen her interpersonal skills and prepare for future leadership roles.

H-BOOST™ NanoAg-FD: Controlled-Release Green Nano-Enhancer for Sustainable Biohydrogen Production

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[2]Faculty of Electrical Engineering & Technology, Universiti Malaysia Perlis, Pauh Putra Campus, 02600 Arau, Perlis, Malaysia

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ABSTRACT

H-BOOST™ NanoAg-FD is a freeze-dried, micro-encapsulated silver nanoparticle (AgNP) nano-enhancer comprising agro-waste extracts of mangosteen, mango, and pineapple to generate more biohydrogen production. Biohydrogen systems commonly experience low yields due to inefficient electron transfer and redox imbalances during fermentation. To address this limitation, the innovation utilizes fruit peel extracts as natural stabilizing and reducing agents to form AgNPs. The nanoparticles are embedded within an alginate-chitosin biodegradable micro-matrix and freeze-dried into a stable, ready-to-use nano-powder. Upon application, the system enables gradual nanoparticle release, enhancing electron transfer and hydrogenase activity while minimizing microbial toxicity associated with uncontrolled silver exposure. This controlled-release design ensures improved catalytic performance, enhanced nano-microbial interactions stability, and reproducible dosing. The dual-layer protective packaging can protect the product's integrity and shelf life from degradation by light, oxygen, and moisture. It is unlike the conventional nano-additives because of its tri- agro-waste green synthesis, controlled-release micro-encapsulation, and calibrated sachet form. By integrating sustainable nanotechnology with waste valorization, H-BOOST™ NanoAg-FD supports circular bioeconomy strategies and low-carbon hydrogen production. The sachet-based, scalable format enables easy adoption in research laboratories, renewable hydrogen startups, and waste-to-energy facilities, demonstrating strong commercialization potential in emerging green hydrogen markets.

Keywords: Biohydrogen; Controlled-Release Nanotechnology; Silver Nanoparticles; Agro - Waste Valorization; Renewable Energy

1. Product Description

H-BOOST™ NanoAg-FD is supplied as a freeze-dried nano-enhancer in pre-measured sachets for easy dosing to boost biohydrogen production, as implied in its name, H-BOOST (Hydrogen Boost) and FD (Freeze-Dried). It contains silver nanoparticles synthesized using fruit peel extracts, which consist of natural phytochemicals and are stabilized within a biodegradable core of alginate, which has been sparsely covered with chitosan to create protective particles in the form of micron-sized particles. This micro-encapsulation structure prevents early aggregation of nanoparticles and enhances dispersion stability. When added to fermentation media at the recommended dosage, the matrix absorbs water and gradually

releases active nanoparticles. These nanoparticles function as electron shuttles, improving electron flow during microbial metabolism and enhancing hydrogen production efficiency. The controlled-release design reduces the risk of sudden silver ion exposure that may inhibit beneficial fermentation microbes. The freeze-dried formulation ensures long-term stability, ease of transport, and reproducible performance. No reactor modification is required, making the product compatible with laboratory-scale and pilot-scale dark or hybrid fermentation systems. The dual-layer high-barrier laminated packaging (PET/ Metallized PET laminate with inner heat-seal layer) also provides protection against moisture, oxygen, and light. This invention gives rise to prospective and sustainable growth in renewable biohydrogen enrichment technology.

2. Pictures and tables

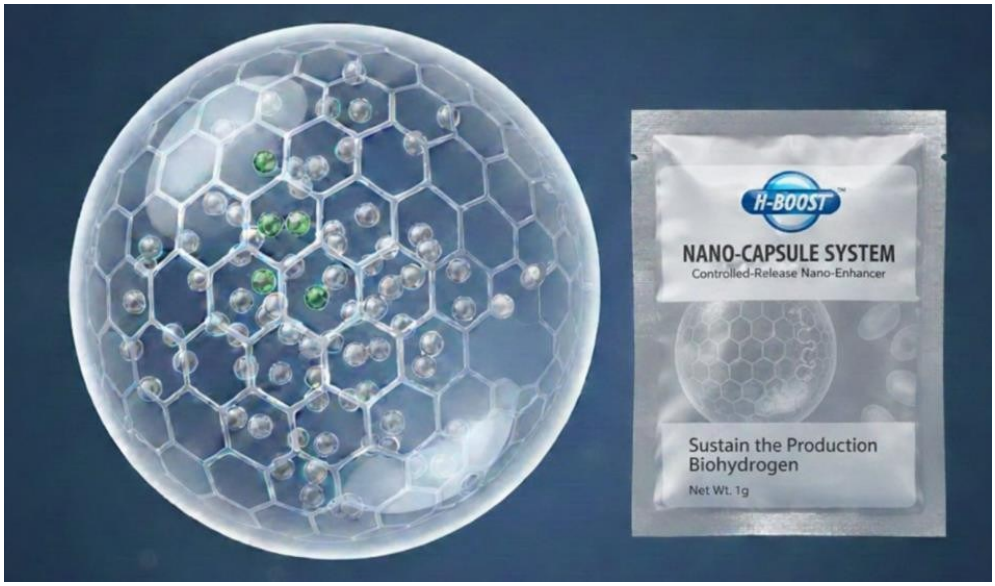
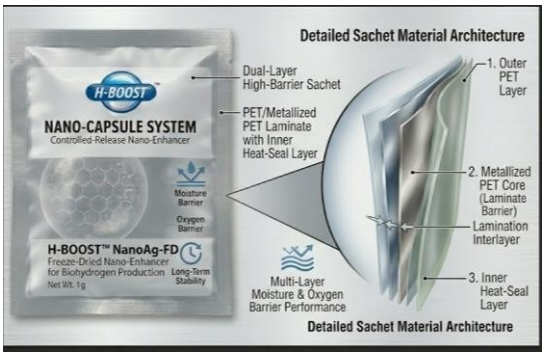
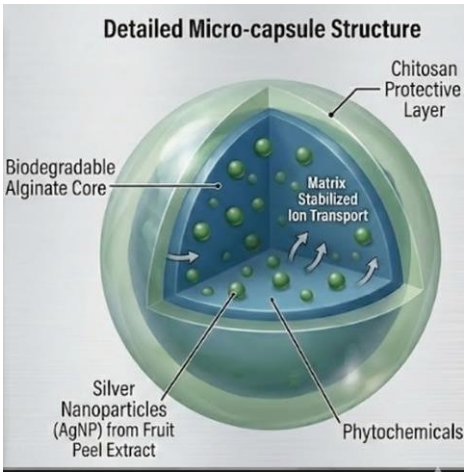


Figure 1. Conceptual illustration of H-BOOST™ NanoAg-FD.

Table 1. Comparison between Conventional Nano Additive and H-BOOST™ NanoAg-FD.

Feature	***Conventional Nano Additive***	***H-BOOST™ NanoAg-FD***
Source Material	Synthetic	Agro-waste-derived
Release Behavior	Uncontrolled	Controlled-release
Toxicity Risk	Moderate to High	Reduced
Shelf Stability	Limited	Enhanced (freeze-dried)
Application Format	Suspension	Ready-to-use sachet

Table 2. Features of H-BOOST™ NanoAg-FD.

Image	*Features*
	H-BOOST™ NanoAg-FD high-barrier sachet (PET/Metallized PET) consists of an inner heat- seal layer. This master laminate provides a non- breathable safeguard against light, moisture, and oxygen. This pre-measured design ensures long- term stability and easy, repetitive dosing for laboratory-scale and pilot-scale fermentation systems.
	The freeze-dried, micro-encapsulated nano- powder contains a shell of chitosan, which protects silver nanoparticles produced from the peel fruits, and a biodegradable core of alginate. This structure ensures controlled discharge and suppresses agglomeration. By acting as electron shuttles, these particles do not cause any harm to the microbial metabolism, making the production of biohydrogen optimum without inhibiting the growth of beneficial fermentation.

3. Novelty and uniqueness

H-BOOST™ NanoAg-FD combines green nano-synthesis with controlled-release delivery in a product-ready format. Unlike conventional nanoparticle additives that are directly introduced into fermentation systems, this innovation incorporates a biodegradable release mechanism to prevent sudden nanoparticle exposure and maintain microbial balance by protecting them from oxidation and regulating the gradual release of silver ions. The use of pineapple, mangosteen, and mango agro-waste as natural reducing agents promotes sustainability and circular bioeconomy principles, which enable the formation of nanoparticles without toxic chemicals. The freeze-dried sachet format enhances stability, dosage consistency, and ease of application, transforming laboratory-scale nanotechnology into a practical enhancement tool. Its compatibility with dark and hybrid fermentation systems further expands its application potential. The integration of green chemistry, nano - enhancement, and renewable energy improvement distinguishes this product as a translational innovation rather than a purely experimental concept.

4. Benefit to mankind

H-BOOST™ NanoAg-FD contributes to sustainable hydrogen production by improving the efficiency of biological fermentation systems. It can enhance hydrogen yield, reduce dependence on fossil fuel-derived hydrogen, and support low-carbon energy transitions. By converting agricultural waste into a high-value nano-enhancer, the technology promotes responsible resource utilization and circular bioeconomy development. The controlled- release design also reduces environmental risks associated with nanoparticle discharge. This innovation supports global sustainability goals related to clean energy, climate action, and responsible production.

5. Innovation and Entrepreneurial Impact

This project demonstrates how academic research can evolve into a scalable product concept. By integrating nanotechnology, biotechnology, and sustainable materials engineering, H-BOOST™ NanoAg-FD promotes interdisciplinary innovation. The sachet- based formulation and controlled-release system reflect commercialization thinking, enabling easy adoption by research institutions and renewable hydrogen startups. The project fosters a culture of translational research, encouraging students to develop market- oriented solutions rather than purely theoretical studies.

6. Potential commercialization

H-BOOST™ NanoAg-FD can initially be positioned as a laboratory-grade nano-enhancer for biohydrogen research. Expansion into pilot-scale fermentation systems and industrial biotechnology applications represents the next commercialization stage. The sachet-based dosing system simplifies distribution and standardization. Low-cost agro-waste precursors enhance economic feasibility, while controlled-release technology provides potential intellectual property opportunities. Strategic collaboration with renewable hydrogen developers and waste-to-energy industries can accelerate product validation and market entry.

7. Acknowledgment

The authors would like to thank the Faculty of Applied Sciences at Universiti Teknologi MARA (UiTM) Perlis Branch for their cooperation in completing this non-grant-funded study.

8. Rearchers' Biography

Nur Fazrina binti Samsuri is a final-year undergraduate student in the Bachelor of Science (Honours) in Biology at Universiti Teknologi MARA (UiTM) Perlis, under the Faculty of Applied Sciences. Her academic background has provided her with comprehensive exposure to various biological disciplines, particularly microbiology, molecular biology, and plant biotechnology. Throughout her studies, she has strengthened her competence in laboratory techniques and statistical data analysis. She is interested in sustainable biological innovations and the application of biotechnology to address environmental and agricultural challenges.

Nur Aqilah Zainal is a final-year student pursuing a Bachelor of Science (Honours) in Biology at Universiti Teknologi MARA (UiTM) Perlis. She has developed practical laboratory skills, data analysis experience, and scientific writing abilities throughout her studies in microbiology, molecular biology, plant biotechnology, and environmental biology. Her academic interests focus on sustainable biotechnology, green nanotechnology, and biohydrogen production, reflecting her passion for environmental sustainability and renewable energy solutions.

Zainab Razali is a Senior Lecturer at Universiti Teknologi MARA (UiTM) Perlis with over 13 years of teaching experience in biotechnology and plant sciences. Her research focuses on plant biotechnology, green nanotechnology, agro-waste valorization, and biohydrogen production. She has published in peer-reviewed journals and conference proceedings related to sustainable nanomaterials and renewable energy. She actively supervises innovation-based student projects and has served as a judge for innovation competitions at the school, national, and international levels

Rojehan Md Kawi is a researcher from the Faculty of Electrical Engineering & Technology, Universiti Malaysia Perlis (UniMAP), Pauh Putra Campus, Arau, Perlis, Malaysia. His expertise focuses on electrical engineering systems, sensor technology, and applied technological innovation. His research interests include embedded systems, smart sensing platforms, and technology integration for sustainable and community-oriented applications. He actively collaborates in interdisciplinary projects that bridge engineering solutions with real-world challenges, particularly in system development and functional device optimization

Solar DSG Process: Enhancing Cacao Beans Quality Through Drying, Shelling, and Grinding Techniques

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Science, Technology, Engineering, and Mathematics Students,
Tupi National High School, Tupi, South Cotabato, Philippines

Corresponding author: Kassandra Clouise P. Panding, kcpanding@gmail.com

ABSTRACT

This study introduces the Solar DSG Process, an integrated solar-powered machine designed to improve cacao bean processing through three main stages: drying, shelling, and grinding. In the Philippines, traditional post-harvest methods like open-sun drying and manual shelling are often slow and lead to inconsistent quality or mold. The Solar DSG system solves these issues by using solar energy for controlled drying and mechanical parts for efficient shelling and grinding. Testing showed that the system successfully dried cacao beans to safe levels at temperatures between 40°C and 55°C. The shelling unit achieved an average efficiency of 91.3%, removing shells effectively with very little bean breakage. The grinding stage produced a fine and even cacao mass suitable for making "tablea." User evaluations from farmers and experts resulted in an overall score of 4.46 , meaning they "Strongly Agree" that the machine is functional, accurate, and useful. This innovation offers a sustainable and low-cost solution for small farmers to improve their product quality and income.

Keywords: Solar Drying, Cacao Processing, Shelling Efficiency, Integrated Post-harvest System.

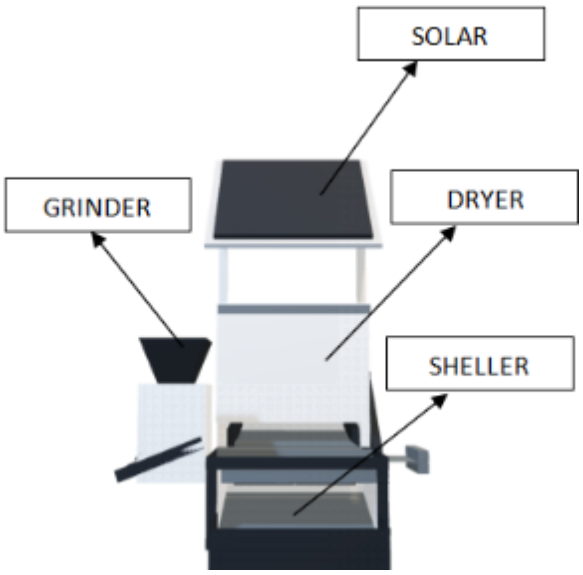
1. Product Description

The Solar DSG Process integrates three critical post-harvest functions into one solar-powered machine. The solar drying unit was evaluated by testing moisture content reduction at various controlled temperatures while the mechanical shelling unit was tested using different batch sizes to determine shell separation efficiency. Finally, the mechanical grinding unit was assessed for the consistency and fineness of the resulting cacao mass.

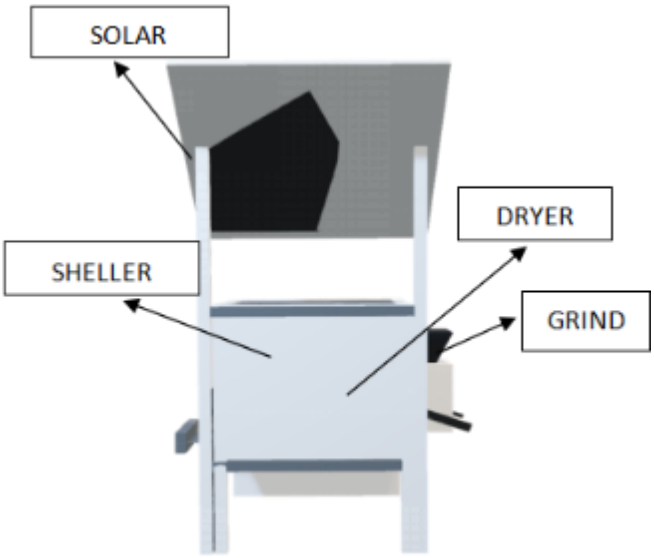
2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

This figure shows the basic design of the machine from both the front and back views. It labels the main parts, including the solar panel at the top, the drying chamber in the middle, and the mechanical sheller and grinder at the bottom. This diagram explains how all three functions are built into a single, compact unit.

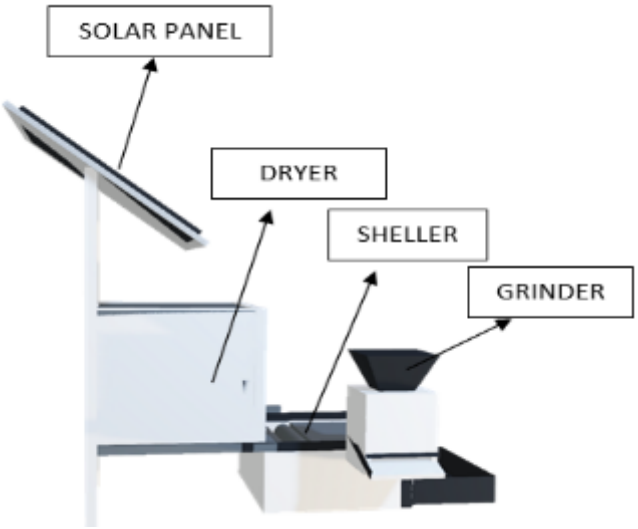
3. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .



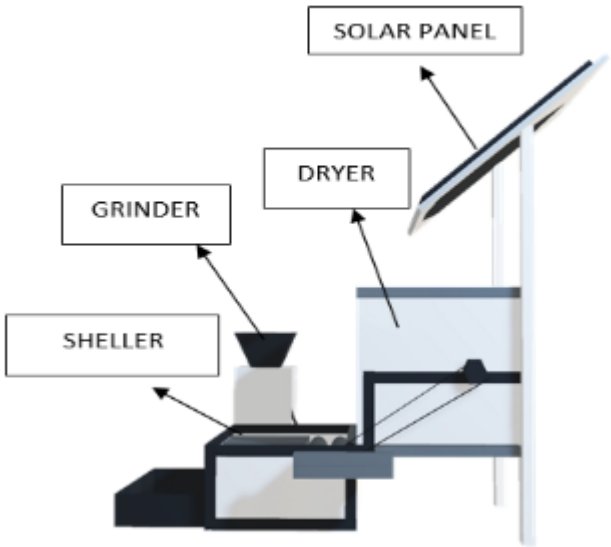
Front View



Back View



Left View



Right View

Figure 1. Project Prototype.

Figure 2. Actual Prototype.

This figure shows real photos of the finished machine from the right and left sides. These photos prove that the machine was successfully built according to the design plan. It shows the actual solar panel, the metal drying area, and the mechanical parts used for processing the beans.

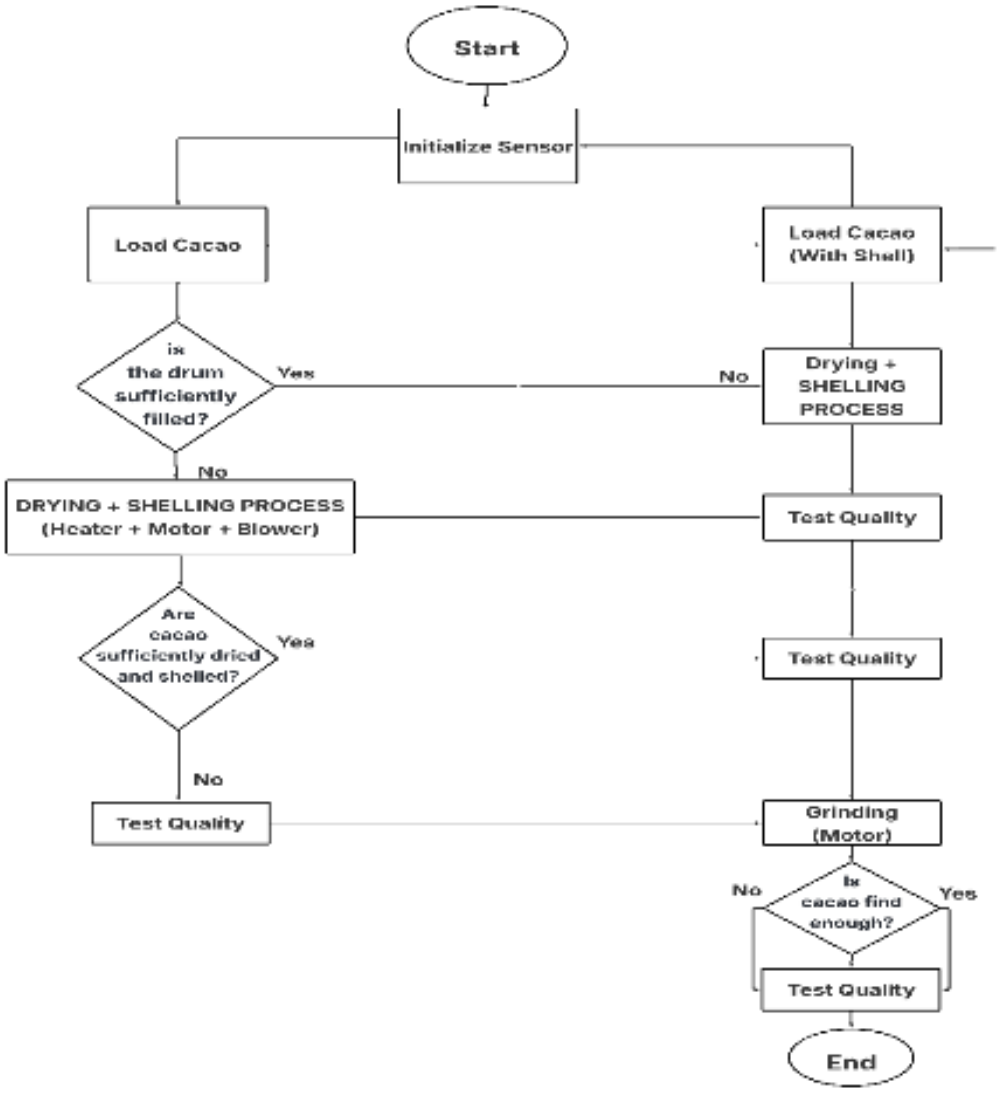


Figure 3. Solar DSG Process Schematic Diagram.

This figure shows real photos of the finished machine from the right and left sides. These photos prove that the machine was successfully built according to the design plan. It shows the actual solar panel, the metal drying area, and the mechanical parts used for processing the beans.

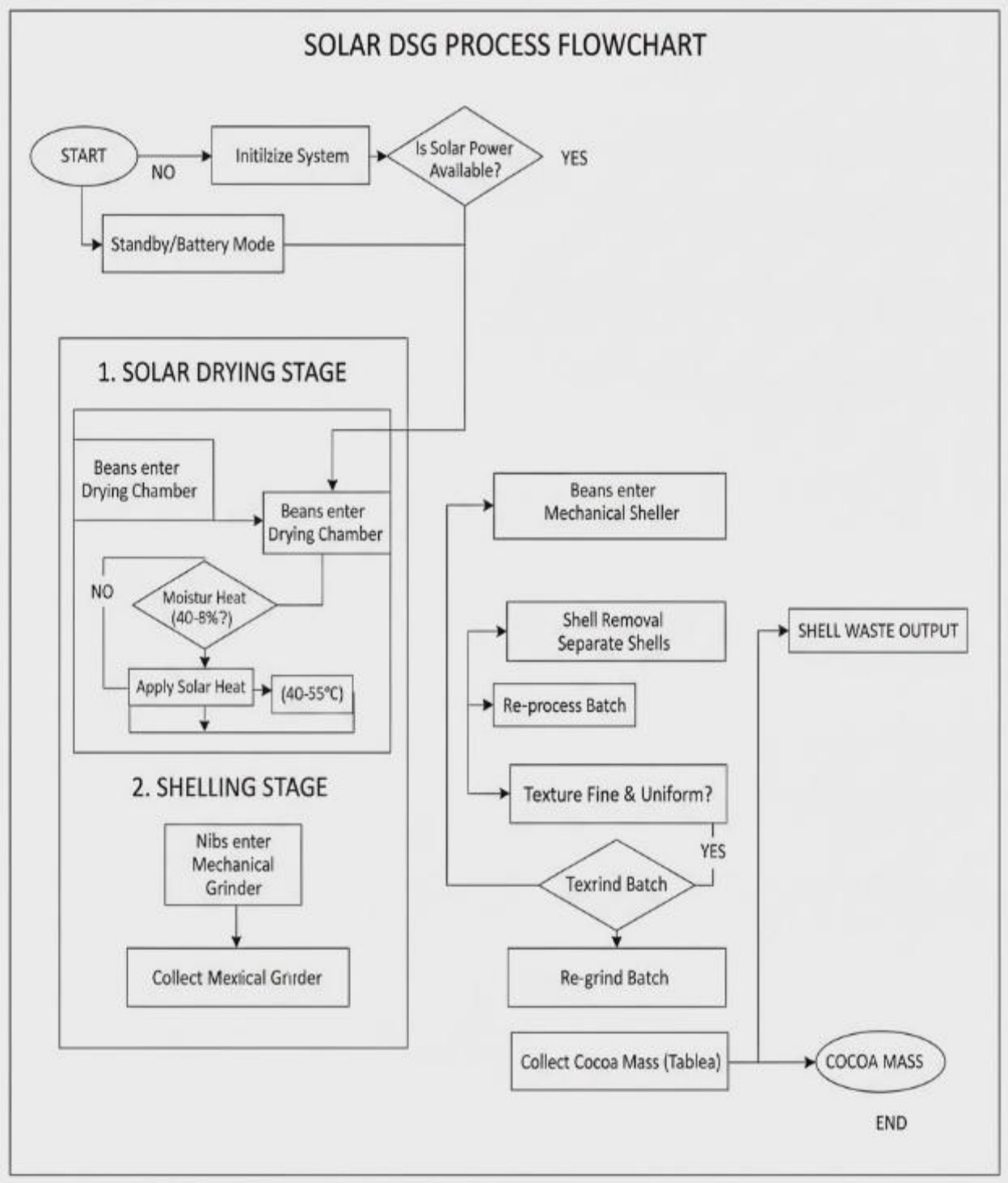


Figure 4. Solar DSG Process Flowchart.

This figure shows real photos of the finished machine from the right and left sides. These photos prove that the machine was successfully built according to the design plan. It shows the actual solar panel, the metal drying area, and the mechanical parts used for processing the beans.

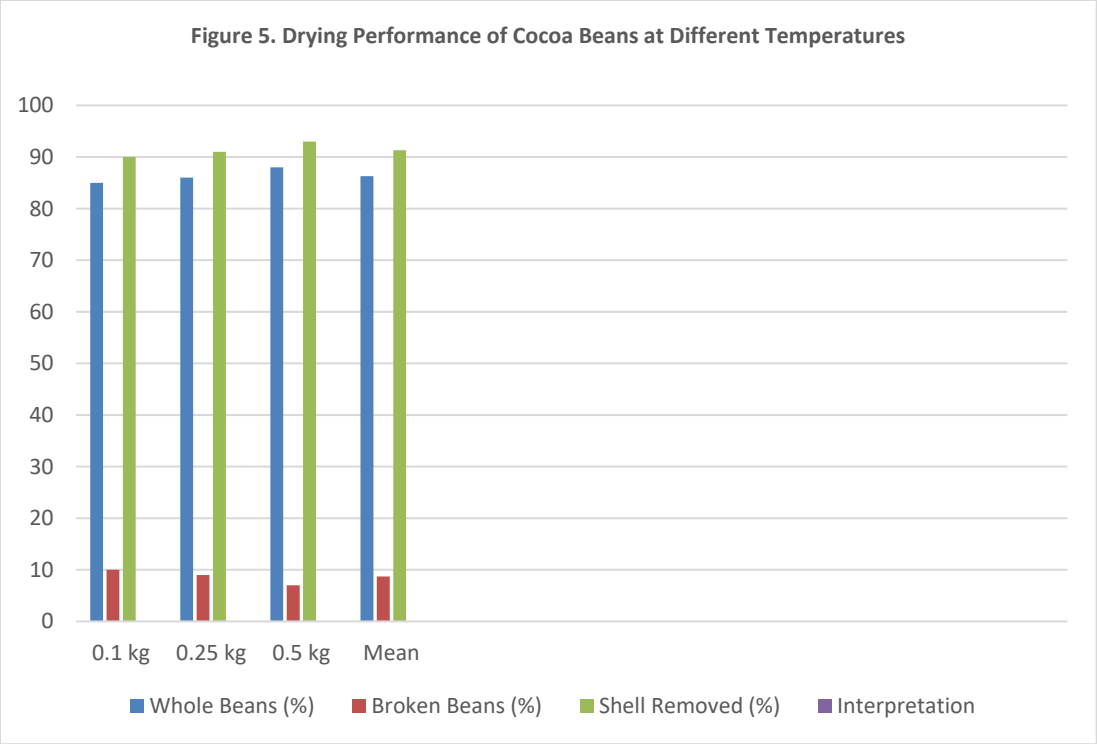


Figure 5. Drying Performance of Cocoa Beans at Different Temperatures.

This chart shows how the machine performed when drying different amounts of cacao beans (0.1 kg, 0.25 kg, and 0.5 kg). It tracks how many beans remained whole, how many were broken, and how many shells were removed at specific temperatures. This helps determine the best settings for drying the beans safely.

Figure 6. Shelling Efficiency of Cocoa Beans.

This bar graph shows the results of the shelling test conducted at a standard temperature of 55°C. It compares the amount of beans that were successfully shelled versus those that were not for different batch sizes (100g, 250g, and 500g). The data supports the finding that the machine has a 91.3% efficiency rate in removing shells.

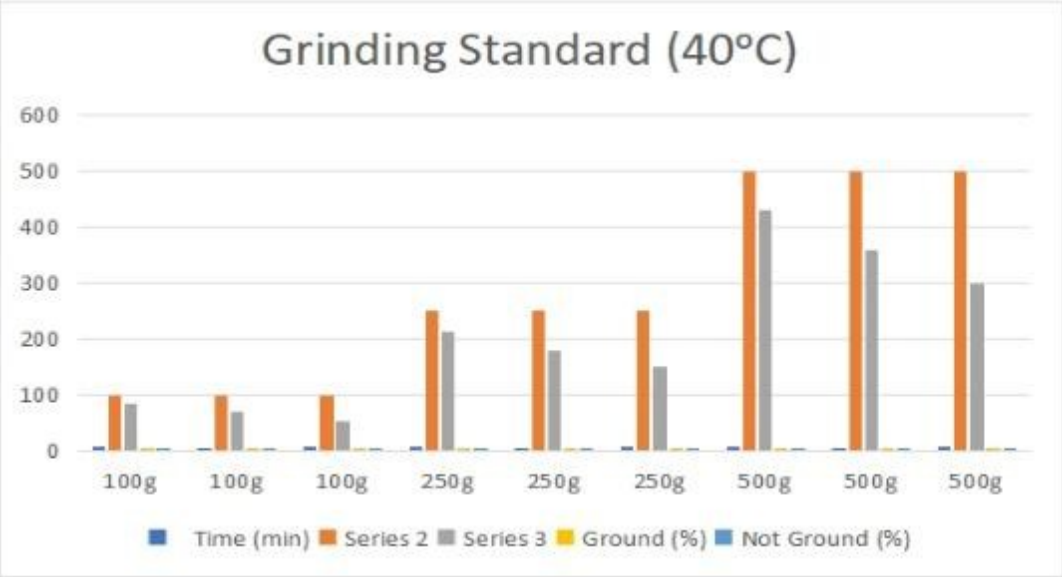


Figure 7. Grinding Performance at Different Quantities.

This figure displays the results of the grinding tests done at 40°C. It shows the time taken to grind different amounts of cacao nibs and the percentage of nibs that were successfully turned into a fine mass. This proves the machine can produce a uniform texture suitable for making "tablea" chocolate.

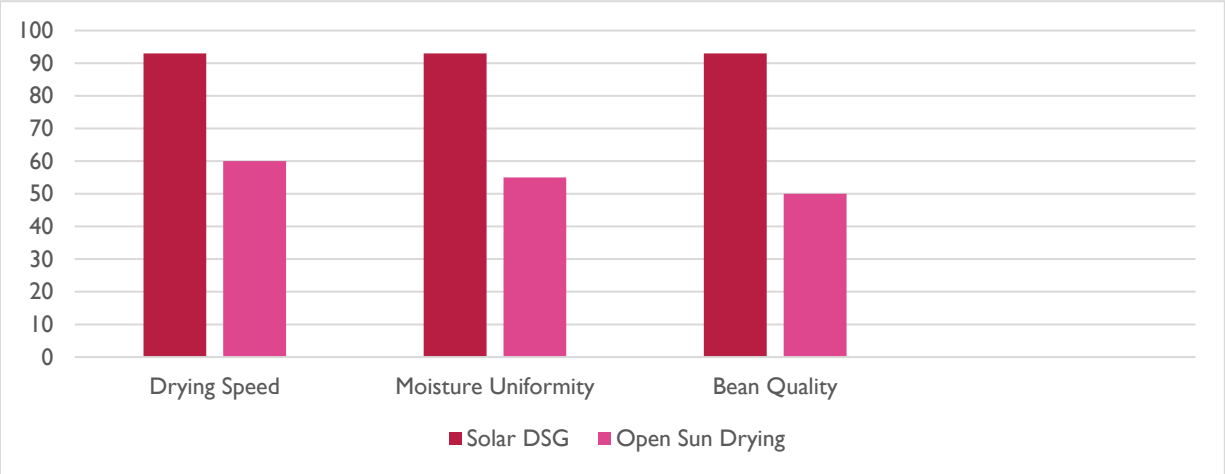


Figure 8. Comparison of Solar DSG and Traditional Sun Drying.

This chart compares the Solar DSG machine to the old method of drying beans in the open sun. It shows that the Solar DSG process is much better in three areas: drying speed (93% vs 60%), moisture uniformity (93% vs 55%), and overall bean quality (93% vs 50%). This proves the machine is a major improvement over traditional farming methods.

Table 1. Evaluation of the Solar DSG Process.

Criteria	Weighted Mean	Interpretation
Functionality	4.53	Strongly Agree
Usability	4.52	Strongly Agree
Adaptability	4.52	Strongly Agree
Acceptability	4.33	Strongly Agree
Overall	4.46	Strongly Agree

The evaluation of the Solar DSG Process shows that the machine is highly effective for cacao farming. Ten farmers and experts tested the machine and gave it an average score of 4.46 out of 5, which means they "Strongly Agree" that it is a useful tool. The machine received high marks for functionality (4.53) because it correctly dries, shells, and grinds the beans into a fine mass. It also scored well for usability (4.52) and adaptability (4.52), showing that it is easy to use and can handle different amounts of beans. Finally, the score for acceptability (4.33) proves that the local community is ready to use this solar-powered technology to improve their products and income.

4. Novelty and uniqueness

Most machines are only capable of one task, such as grinding or drying. The unique feature of the Solar DSG Process is that it uses a single solar-powered equipment to perform the three tasks of drying, shelling, and grinding. Farmers now have an easier time because they don't have to purchase three separate machines or transport the beans around a lot.

5. Benefit to mankind

The machine reduces waste and saves time for cacao farmers. Applying solar energy makes it environmentally friendly and cost-free to operate. It assists growers in producing better cacao that they are able to sell at a higher price, supporting their families as well as the community.

6. Innovation and Entrepreneurial Impact

The Solar DSG Process encourages entrepreneurship by empowering small farmers to become processors instead of only suppliers of raw materials. By producing high-quality “tablea” or cacao

mass locally, farmers can access higher-value markets, which increases employment and the agricultural economy.

7. Potential commercialization

The Solar DSG Process is designed to be cost-effective for both individual farmers and small farming groups. For government projects that aim to support the rapid growth of the Philippine cacao industry, it is an excellent product because it is easy to develop and uses renewable energy.

8. Acknowledgment

We would like to express our sincere gratitude to everyone who supported our research competition project, Solar DSG Process: Enhancing Cacao Bean Quality Through Drying, Shelling, and Grinding Techniques. We sincerely thank Sir Nelson B. Malificiado for his guidance, patience, and valuable advice throughout the development of our study. His support and encouragement helped us improve our ideas and strengthen our system design. We are also grateful to our teachers and school administrators for giving us the opportunity to participate in this competition and for inspiring us to innovate and think critically. Our appreciation extends to the cacao farmers and community members who shared their experiences and insights, allowing us to better understand the real challenges in post-harvest processing. We also thank our families and friends for their constant moral support and motivation during the preparation of this project. This project would not have been possible without the guidance, trust, and encouragement of everyone who believed in our vision and supported us throughout this journey.

9. Researchers' Biography

Kassandra Clouise P. Panding is the lead student researcher and the original proponent of the Solar DSG Process. She conceptualized the project idea and led the overall engineering design and system integration. Her vision was to create a sustainable, solar-powered solution to modernize cacao processing and improve the livelihoods of local farmers. Through her leadership, she ensured the project successfully met its technical goals and design objectives. Her research interests focus on sustainable agricultural technology and mechanical innovation for rural development.

Estela Rose M. Sumelhig is a student researcher who served as the primary technical writer and data analyst for the study. She played a key role in constructing the research manuscript and performed the detailed analysis of the evaluation graphs and experimental data. Her efforts ensured that all research findings, from moisture content to user acceptability, were clearly documented and scientifically validated. She is committed to using her skills in technical writing and data visualization to help communicate complex agricultural solutions to both scientific and local communities.

Blester N. Sumongsong is a student researcher who managed the technical support and financial administration of the project. He provided essential assistance with computer-related tasks and oversaw the project's budget and financial planning to ensure all materials were procured efficiently. His ability to navigate digital tools and manage resources effectively allowed the team to maintain organized records and a steady workflow. He is interested in the intersection of information technology and agricultural business management as a mean to optimize rural farming operations

Princess Zairah Lee L. Surao is a student researcher who specialized in project documentation and compliance. She was responsible for managing all research forms and ensuring that the project adhered to the official administrative standards and requirements. Her organized approach and attention to detail during the documentation phase were vital in preparing the project for competition. She is passionate about using systematic research and organized documentation to support community-based innovations and agricultural advancements within the local cacao industry.

SURAO, PRINCESS ZAIRAH LEE L__

AquaGuard: Smart IoT Aquarium Monitoring and Auto-Feeding System

Muhammad Daniel Azeman, Norlina Mohd Zain and Siti Aliyah Mohd Saleh
[1]Faculty of Electrical Engineering, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, Masai, Malaysia

Corresponding author: Norlina Mohd Zain, norlina119@uitm.edu.my

ABSTRACT

This paper presents the design and implementation of an Internet of Things (IoT)-based smart aquarium system integrating automated feeding and real-time pH monitoring for improved aquatic environment management. The system is built around an ESP32 microcontroller with integrated Wi-Fi connectivity to enable cloud-based monitoring and remote user interaction. A calibrated analog pH sensor is employed to continuously measure water acidity, with signal conditioning and multi-sample averaging implemented to enhance measurement stability and accuracy. A Real-Time Clock (RTC) module ensures precise time synchronization for scheduled feeding operations, where a servo motor actuates the feed dispensing mechanism at predefined intervals. Real-time pH values and system status are displayed locally via an I2C LCD and transmitted to a mobile application using the Blynk IoT platform. Threshold-based alert logic is implemented to notify users when pH levels deviate from the optimal range (6.0–8.0). Experimental validation demonstrates reliable automation, stable wireless communication, and consistent sensor performance. The proposed system contributes to society by promoting responsible aquatic care, reducing manual maintenance efforts, and supporting the adoption of smart IoT technologies for sustainable aquarium and small-scale aquaculture management.

Keywords: IoT, Smart Aquarium, Water Quality Monitoring, Embedded Systems, Aquaculture Automation.

1. Product Description

AquaGuard is a compact, IoT-enabled smart aquarium assistant that integrates automated feeding and real-time water quality monitoring into a unified intelligent system. Powered by an ESP32 microcontroller with built-in Wi-Fi connectivity, the system enables seamless communication between hardware components and a cloud-based monitoring platform. A calibrated pH sensor continuously measures water acidity and transmits processed data to both a local I2C LCD display and a mobile dashboard via the Blynk IoT platform. The Real-Time Clock (RTC) module ensures precise feeding schedules, automatically activating a servo motor to dispense food at programmed intervals. Users can also initiate manual feeding remotely through the mobile application. Threshold-based monitoring logic detects unsafe pH levels (outside 6.0–8.0) and generates real-time alerts, enabling timely corrective action. The system is implemented on a custom Printed Circuit Board (PCB) to enhance durability, reliability, and safe operation in humid environments. AquaGuard provides an

integrated, scalable, and user-friendly solution that enhances aquarium maintenance efficiency while promoting stable aquatic ecosystem management.

2. Methodology and Results

A systematic approach was employed in designing and developing the AquaGuard smart aquarium system to ensure reliable automation and real-time monitoring performance. The methodology focuses on structured integration between hardware components, embedded control programming, and cloud-based communication to achieve efficient aquarium management.

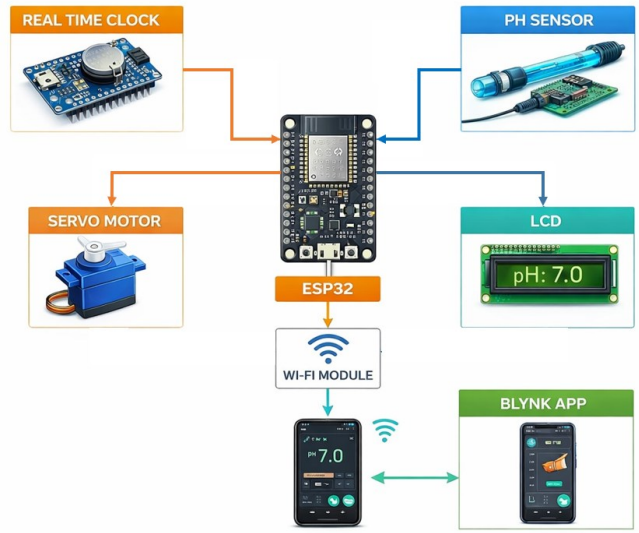


Figure 1. Block diagram of the AquaGuard smart aquarium system.

The block diagram illustrates the hardware architecture of the AquaGuard smart aquarium system, with the ESP32 serving as the central controller as shown in **Figure 1**. The system consists of input modules, output modules, and a communication interface integrated into a single embedded platform. The Real-Time Clock (RTC) provides accurate timing information for scheduled feeding operations, while the pH sensor continuously measures water acidity and sends analog data to the ESP32 for processing. Based on programmed control logic, the ESP32 activates the servo motor to dispense fish feed at predefined intervals and updates the LCD to display real-time pH values. The integrated Wi-Fi module enables data transmission to the Blynk cloud platform, allowing remote monitoring and manual control via a mobile application. This architecture demonstrates a centralized embedded control system that integrates sensing, actuation, and IoT communication within a compact design.

The flowchart of process as shown in **Figure 2** illustrates the operational logic of the AquaGuard smart aquarium system, describing the sequential execution of sensing, decision-making, actuation, and communication processes. The system begins with an initialization phase, during which the microcontroller configures the Real-Time Clock (RTC), pH sensor, Wi-Fi module, and LCD display to ensure proper communication and synchronization. After

initialization, the program executes two parallel functional routines where time-based feeding control and continuous pH monitoring. In the feeding control routine, the system reads the current time from the RTC and evaluates whether it matches the predefined feeding schedule. If the condition is not satisfied, the system continuously rechecks the time. When the scheduled time is reached, a control signal is sent to the servo motor to actuate the
feeding mechanism and dispense food. Simultaneously, the pH monitoring routine reads the sensor value, processes the measurement, and displays the real-time pH level on the LCD. The measured data is then transmitted via the Wi-Fi module to the Blynk application for remote monitoring. This logical framework ensures deterministic feeding operation, continuous environmental monitoring, and real-time IoT communication within a closed-loop embedded system.

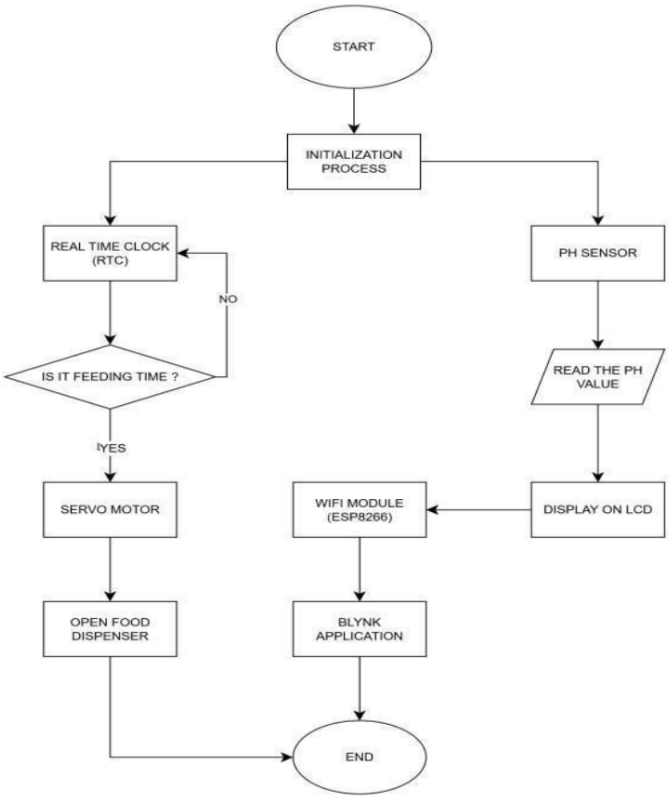


Figure 2. Flowchart of the AquaGuard smart aquarium system.

Figure 3 illustrates the fully assembled AquaGuard prototype integrated with the aquarium tank, demonstrating the complete hardware and software implementation. The system is mounted securely above the aquarium, with all electronic components connected through a custom PCB to ensure structural stability and safe operation in a humid environment. The LCD module is positioned at the front of the system to provide real-time visualization of the current time and measured pH value. The pH sensor probe is immersed directly in the aquarium water to continuously monitor acidity levels. The servo-driven feeding mechanism is installed above the tank, enabling automated food dispensing according to predefined

schedules. In addition to local monitoring, the figure also shows the Blynk mobile application interface, which enables remote supervision and manual control. The application displays real-time pH readings and includes a virtual control button for triggering automated feeding.
This integrated prototype demonstrates successful implementation of time-based feeding automation and continuous IoT-based environmental monitoring within a single embedded system platform.

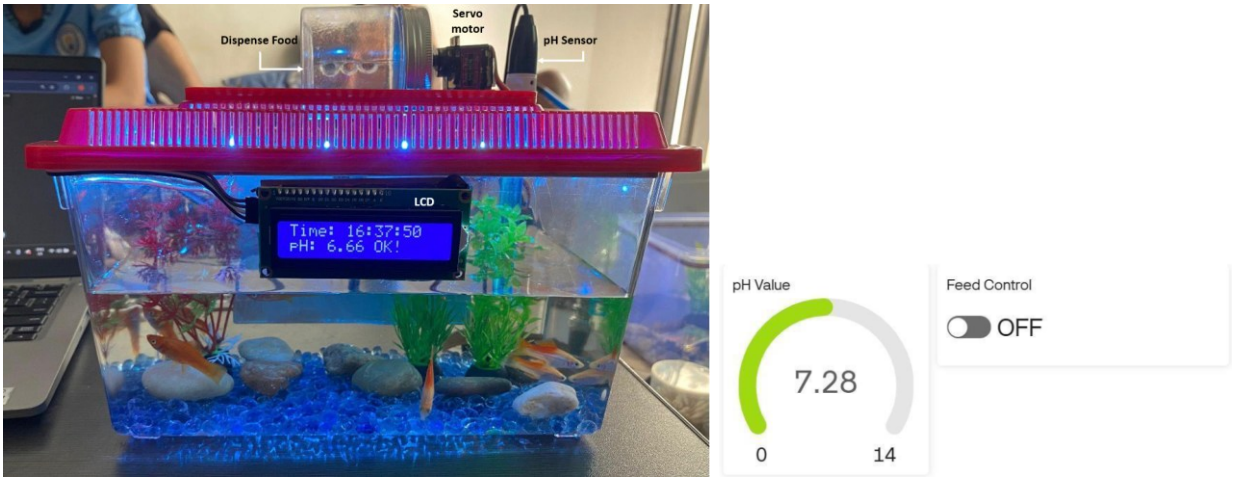


Figure 3. The fully assembled AquaGuard prototype and Blynk mobile application interface for automated feeding and real-time pH monitoring.

3. Novelty and uniqueness

The proposed AquaGuard system introduces an integrated embedded framework that combines automated feeding control, real-time pH monitoring, and IoT-based remote accessibility within a unified microcontroller architecture. Unlike conventional aquarium automation systems that typically focus on either feeding mechanisms or environmental sensing independently, this design integrates both functions into a centralized control structure governed by the ESP32. A key novelty of the system lies in its synchronized interaction between time-based control and continuous environmental monitoring. The Real-Time Clock (RTC) enables deterministic feeding schedules, while the pH sensing subsystem operates concurrently to ensure water quality stability. This dual-layer control approach enhances operational reliability by combining scheduled actuation with condition-based monitoring. The implementation further incorporates threshold-based alert logic and real-time cloud synchronization, enabling immediate remote user awareness and intervention. The architecture is modular and scalable, allowing future integration of additional sensors such as temperature, turbidity, or dissolved oxygen without redesigning the core control framework. Overall, the system demonstrates an efficient embedded IoT architecture that bridges traditional aquarium maintenance with intelligent automation and remote monitoring technologies.

4. Benefit to mankind

AquaGuard contributes to improved animal welfare by maintaining consistent feeding schedules and stable water conditions, reducing fish stress, illness, and mortality. By automating routine tasks, it minimizes human error and supports responsible pet ownership. The system also

promotes sustainable aquatic practices by preventing overfeeding, which reduces water contamination and waste. Real-time monitoring allows early detection of unsafe pH levels, preventing ecosystem imbalance. For busy individuals, travelers, and small aquaculture operators, AquaGuard provides peace of mind through remote monitoring and control. Its low-cost design ensures accessibility to students, hobbyists, and small businesses. By integrating IoT technology into everyday pet care, AquaGuard supports smarter living while promoting environmental awareness and technological adoption in household and aquaculture settings.

5. Innovation and Entrepreneurial Impact

An AquaGuard promotes innovation by transforming a traditional manual hobby into a smart IoT-enabled ecosystem. The project demonstrates how embedded systems, cloud computing, and sensor integration can create practical, market-ready solutions. Within the institution, this project fosters interdisciplinary learning in electronics, IoT, PCB design, and cloud platforms, encouraging students to move beyond theory into product development. It cultivates entrepreneurial thinking by emphasizing cost analysis, product scalability, and real-world usability. The low production cost and modular design create strong commercialization potential in the growing smart home and aquaculture markets. An AquaGuard can evolve into a startup product targeting aquarium hobbyists, pet shops, and ornamental fish breeders. By bridging academic innovation with industry needs, the project nurtures a culture of technological entrepreneurship and solution-driven engineering.

6. Potential commercialization

The AquaGuard system demonstrates strong commercialization potential within the rapidly expanding smart home and IoT-enabled pet care markets. With increasing demand for automated monitoring solutions, the system can be positioned as a smart aquarium assistant designed for home aquarium hobbyists, ornamental fish breeders, pet shops, and small-scale aquaculture operators. Its integration of automated feeding and real-time water quality monitoring provides added value beyond conventional standalone feeders. From a market perspective, the product can be further developed into a consumer-ready version by incorporating a waterproof enclosure, enhanced user interface design, and improved industrial-grade components for long-term durability. Additional features such as historical data logging, cloud-based analytics dashboards, and multi-parameter sensor expansion for examples temperature, turbidity and ammonia can increase product competitiveness. The system can be commercialized through online marketplaces, pet supply distributors, and IoT device retailers. With appropriate branding and product refinement, AquaGuard has the potential to evolve into a scalable smart monitoring solution aligned with Industry 4.0 and modern connected living trends.

7. Acknowledgment

It is acknowledged that this project is supported by Faculty of Electrical Engineering, College of Engineering, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, Masai, Malaysia.

8. Researchers' Biography

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Siti Aliyah Mohd Saleh obtained her Bachelor of Electrical (Hons) Engineering from UTM in 2009 and a Master in Engineering (Applied Science) from Tokai University, Japan in 2012. She is currently serving as a lecturer at Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, in Electrical Engineering Studies in the Power Department. Her main research interests are high voltage and power systems.

DBComm: IoT Based Power Panel Trip Monitoring and Emergency Lighting System

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ABSTRACT

This project presents an IoT-Based Power Panel Trip Monitoring and Emergency Lighting System designed to improve fault identification, maintenance efficiency, and safety in critical electrical environments. The system utilizes an ESP32 microcontroller and relay-based current detection to monitor power flow in distribution boards (DBs). When a trip condition occurs, a visual LED strip mounted and wrapped around the affected DB is automatically activated, allowing technicians to quickly locate the faulted panel and perform maintenance safely in low-visibility conditions without relying on external lighting. The system also distinguishes utility grid power failures from internal trips. During a utility grid outage, a separate battery-powered LED strip mounted around the maintenance room door frame is activated, providing clear visual indication of an external supply failure and guiding personnel safely in dark environments. Real-time notifications are delivered via Telegram to ensure prompt awareness. An optional buzzer alert is included for residential and elderly-care applications where audible notification is more suitable, while it can be disabled in noise-sensitive environments such as hospitals. The proposed system offers silent fault localization, reduced response time, improved operational safety, and flexible deployment across hospitals, commercial buildings, and residential facilities. Its low-cost and modular design supports strong commercialization potential for smart building and facility management systems.

Keywords: IoT-based Monitoring, Distribution Board (DB), Power Trip Detection, Emergency Lighting System, Smart Facility Management

1. Product Description

The IoT-Based Power Panel Trip Monitoring and Emergency Lighting System improves fault identification, maintenance efficiency, and operational safety in electrical installations. Using an ESP32 microcontroller with relay-based current detection, the system continuously monitors the status of a distribution board (DB). When a trip occurs, a battery-powered LED strip wrapped around the DB illuminates to clearly identify the affected panel and provides sufficient lighting for maintenance tasks in low-visibility environments. The system can distinguish internal DB trips from external utility grid power failures. In the event of a utility supply outage, a separate LED strip installed around the maintenance room door frame illuminates, providing a clear visual indication of external power loss and assisting personnel movement in dark areas. Instant notifications are delivered through Telegram to ensure timely awareness among responsible personnel. An optional buzzer alert is available for residential and elderly-care applications where audible notification is beneficial, while it remains disabled in noise-sensitive environments such as

hospitals. With its modular architecture, low implementation cost, and scalable design, the system is suitable for hospitals, commercial buildings, industrial facilities, and residential applications.

1. System Architecture and Operational Flow

System Block Diagram

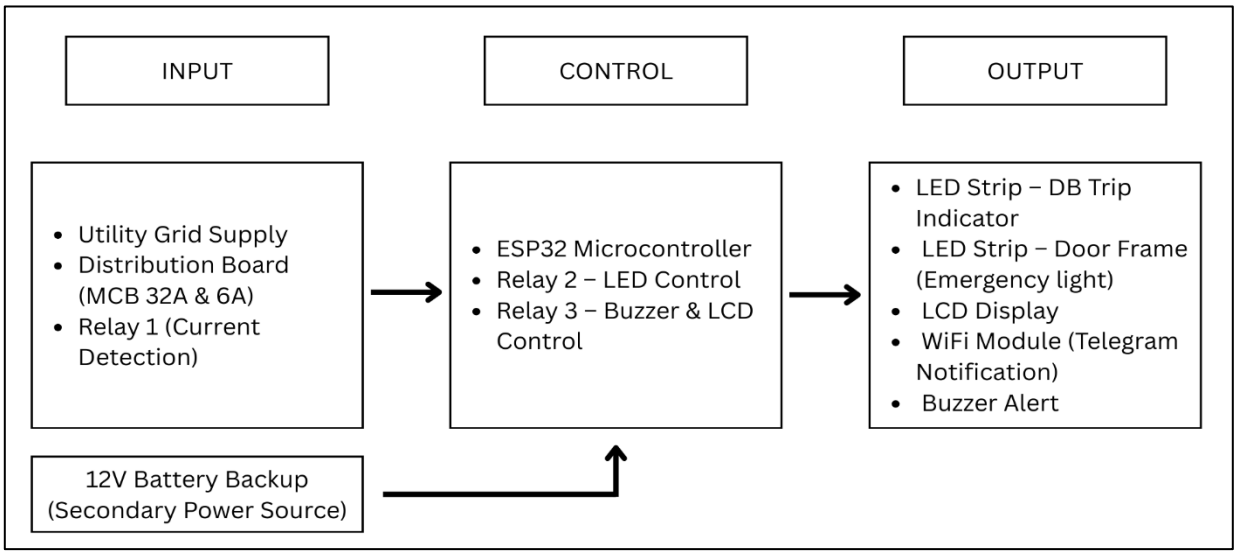

Figure 1. System Block Diagram.

The overall architecture of the proposed monitoring and lighting system is illustrated in **Figure 1**. The system consists of three main sections: Input, Control, and Output. The input section includes the utility grid supply, distribution board (MCB 32A and 6A), and Relay 1 which functions as a current detection sensor for identifying trip conditions. A 12V battery backup is incorporated as a secondary power source to maintain system operation during utility grid failure. The control unit is centered on the ESP32 microcontroller, which processes trip detection signals and manages system responses. Relay 2 controls the LED strip mounted around the distribution board for trip indication, while Relay 3 governs the local alert subsystem consisting of the buzzer and LCD display. The output section includes two visual indicators (DB trip LED strip and door-frame emergency LED strip), an LCD display, WiFi-based Telegram notification, and a buzzer alert mechanism. This modular architecture ensures clear differentiation between internal trip faults and external utility grid outages.

The decision-making logic of the system is presented in **Figure 2**. The process begins by checking the availability of utility power. If utility power is unavailable, the system switches to battery mode and activates the emergency lighting to indicate grid failure. If utility power is available, the system monitors the status of the distribution board. When a trip condition is detected from either MCB 32A or MCB 6A, the system activates the DB-mounted LED strip and sends an alert notification. The system also verifies Wi-Fi availability; if the connection is unavailable, a buzzer alert is triggered as a local notification mechanism. This operational logic ensures continuous monitoring, real-time fault indication, and reliable alert transmission under varying power and network conditions.

Operational Flowchart

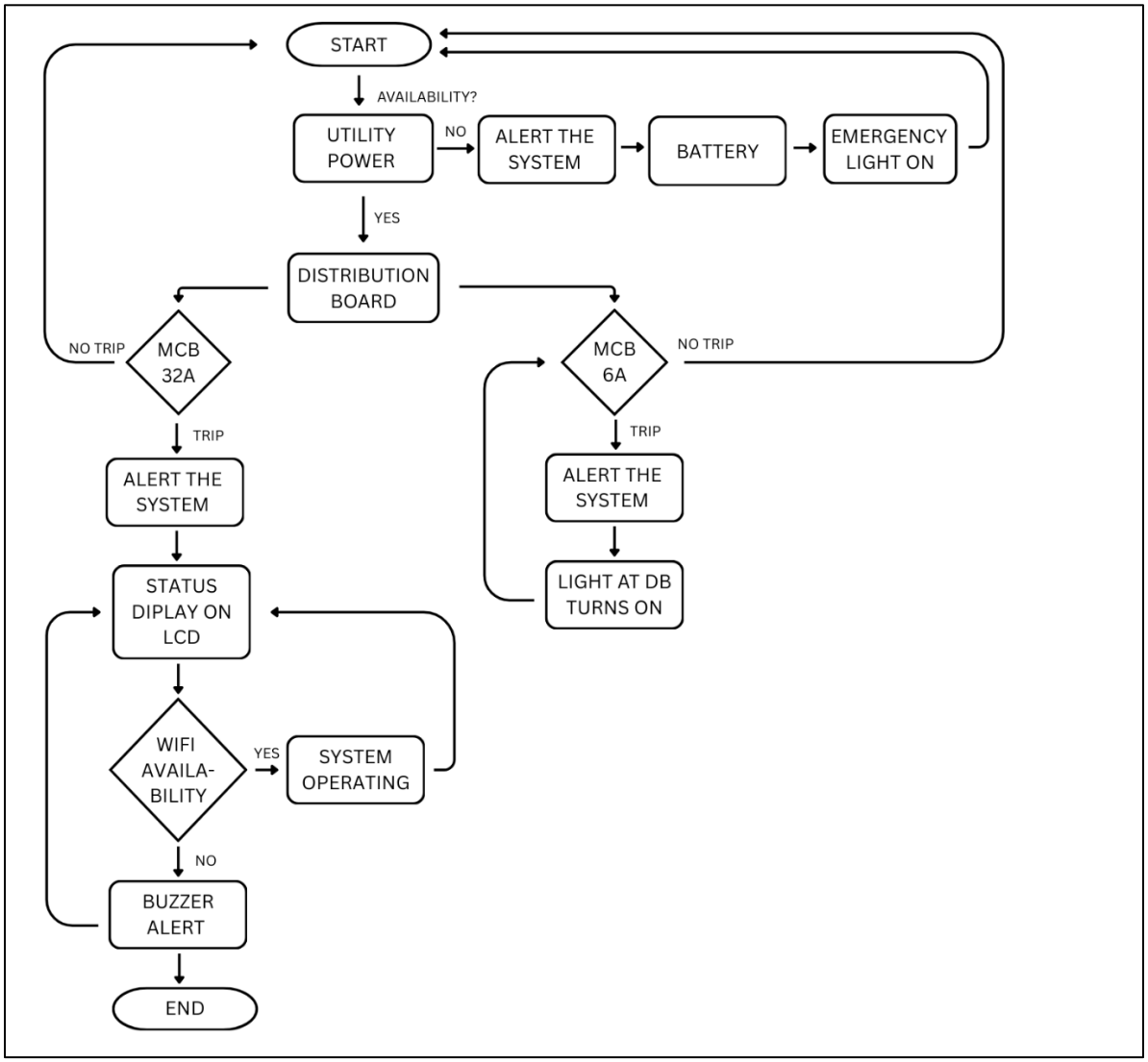

Figure 2. Operational Flowchart.

2. Novelty and uniqueness

The novelty of this project lies in its ability to combine power trip detection, fault localization, and emergency lighting into a single integrated system. Unlike conventional monitoring systems that rely primarily on audible alarms or centralized notifications, this design introduces a silent, location-based visual indication that directly identifies the affected distribution board (DB). By wrapping a battery-powered LED strip around the DB, technicians can immediately locate the faulted panel without searching through multiple boards or relying on external lighting. Another unique feature is the system's capability to distinguish internal DB trip conditions from external utility grid power failures. Separate visual indicators are used for each condition, allowing personnel to quickly understand the nature of the outage and respond appropriately. This differentiation reduces unnecessary troubleshooting and improves response efficiency. Additionally, the system is designed with application flexibility in mind. Audible alerts are optional

and can be enabled for residential or elderly-care environments while remaining disabled in noise-sensitive facilities such as hospitals. The modular, low-cost architecture allows easy adaptation to existing electrical installations, making the solution both practical and scalable for real-world deployment.

3. Benefit to mankind

The proposed system enhances public safety, operational efficiency, and quality of life by improving the way electrical power faults are identified and managed. Silent visual indicators reduce unnecessary noise and prevent panic in sensitive environments such as hospitals, ensuring patient comfort while enabling technicians to respond quickly. Clear fault localization minimizes downtime in critical facilities, supporting uninterrupted services that communities rely on. In residential and elderly-care settings, optional audible alerts help occupants recognize power-related issues promptly, reducing confusion and improving personal safety during outages. The system also improves workplace safety by providing sufficient lighting in dark environments, lowering the risk of accidents during maintenance activities. By reducing response time, preventing misinterpretation of power faults, and supporting safer working conditions, the system contributes to more reliable infrastructure, enhanced accessibility, and a safer living and working environment for society.

4. Innovation and Entrepreneurial Impact

This project promotes innovation by enhancing conventional electrical protection systems with real-time monitoring and practical visual fault indication. By integrating IoT-based communication with location-based emergency lighting and adaptive alert mechanisms, the system demonstrates how existing electrical infrastructure can be upgraded without major structural changes. This approach encourages innovative problem-solving through efficient, low-complexity design. From an entrepreneurial perspective, the project introduces a modular and scalable product suitable for healthcare facilities, commercial buildings, industrial installations, and residential environments. Its low implementation cost and straightforward installation reduce barriers for commercialization by startups and small enterprises. The project also contributes to an entrepreneurial culture by emphasizing product development, system adaptability, and real-world applicability. By addressing genuine operational and safety challenges, the system supports innovation-driven growth within the electrical and building management industries.

5. Potential commercialization

The proposed system has strong potential for commercialization due to its practical design, low production cost, and adaptability to existing electrical installations. The use of commonly available components such as microcontrollers, relays, and LED strips allows cost-effective manufacturing and easy maintenance. The system can be offered as a retrofit solution for existing distribution boards or integrated into new electrical installations without major infrastructure changes. Potential customers include hospitals, commercial buildings, industrial facilities, residential developments, and elderly-care homes. The modular architecture enables customization based on application requirements, such as visual-only indicators for noise-sensitive environments or optional audible alerts for residential use. Revenue opportunities include direct product sales, installation services, and maintenance support. With increasing demand for reliable power

monitoring and safety-focused solutions, the system presents a viable product opportunity for electrical service providers and technology-based startups.

6. Acknowledgment

The authors would like to express their sincere appreciation to their project supervisor, Encik Abang Syafiqnurain Bin Abang Shokeran, for the continuous guidance, technical advice, and constructive feedback provided throughout the development of this project. His expertise and encouragement contributed significantly to the successful completion of this work. The authors also extend their gratitude to the Department of Electrical and Electronic Engineering, Politeknik Kuching Sarawak**,** for providing the necessary laboratory facilities, technical resources, and supportive academic environment that enabled the implementation and testing of the system. Finally, the authors would like to acknowledge the cooperation and dedication between the project members, as well as the support received from family members and peers throughout the completion of this project.

7. Researchers' Biography

Qasdina Auni Khan Binti Akbar Khan is a final-year student in the Diploma in Electrical and Electronic Engineering at Politeknik Kuching Sarawak, Malaysia. Her academic interests include electrical protection systems, power distribution monitoring, and Internet of Things (IoT) applications in electrical installations. She has experience in practical electrical works and system development related to safety and maintenance efficiency. This project reflects her interest in enhancing conventional electrical systems through monitoring and visual fault indication for improved reliability and maintenance response.

Hanania Binti Abdul Yakub Abdullah is a final-year Diploma student in Electrical and Electronic Engineering at Politeknik Kuching Sarawak, Malaysia. Her interests include alert systems, basic automation, and user-oriented electrical safety solutions. She contributed to the development of notification and alert features in this project, with particular focus on residential and elderly-care applications. Her work emphasizes practicality, accessibility, and improved awareness in everyday electrical environments.

IOT-Integrated Smart Medicine Dispensing System with Real-Time Monitoring and Feedback Control

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ABSTRACT

Medication dispensing errors and inefficient pharmacy workflows remain significant contributors to patient safety risks and service delays in healthcare systems. This project presents the design and development of an Automatic Blister Pill Dispensing System integrated with sensor-based verification and Internet of Things (IoT) monitoring. The system is designed to dispense blister-packed medication accurately, verify dispensing correctness using weight and sensor feedback, and provide real-time stock monitoring with automated alerts. The hardware architecture is built around a NodeMCU ESP32 microcontroller that coordinates system operation. A servo motor controls the mechanical dispensing mechanism, while a load cell with HX711 module verifies dispensing accuracy by measuring blister weight. An infrared sensor detects blister presence for stock monitoring. User interaction is enabled through push buttons, LCD display, LED indicators, and buzzer alerts. The system connects to the ThingsBoard IoT platform via Wi-Fi to transmit real-time operational data and trigger low-stock notifications. Experimental scope analysis was conducted to evaluate dispensing performance under different operational conditions. Three key analyses were performed: (1) comparison of series versus parallel dispensing strategies based on dispensing time, (2) evaluation of dispensing accuracy through sensor verification, and (3) determination of size limits for blister packs that can be reliably dispensed. Results indicate that parallel dispensing significantly reduces operation time, sensor-based verification improves reliability, and mechanical constraints define the acceptable blister size range for stable system performance. The proposed system demonstrates a practical approach to reducing human dispensing errors, improving workflow efficiency, and enabling smart inventory monitoring in pharmacy environments. By integrating automation with IoT-based supervision, the system contributes to safer medication management and supports the advancement of intelligent healthcare dispensing technologies.

Keywords: Automatic pill dispenser, IoT monitoring, dispensing accuracy, ESP32, medication safety

1. Product Description

Figure 1 is the developed prototype system, an automated blister medicine dispensing platform designed to improve dispensing accuracy and operational efficiency in pharmacy environments. The system integrates mechanical dispensing, sensor verification, and IoT monitoring into a single embedded solution. Users select the desired medicine slot, after which the servo-controlled mechanism releases a blister pack. The load cell verifies the weight of the dispensed blister, while the infrared sensor monitors stock availability. Real-time status information is displayed on an

LCD interface and transmitted to the ThingsBoard IoT platform for remote monitoring and alert generation. The system is designed to operate both online and offline, with manual button control available during connectivity loss.

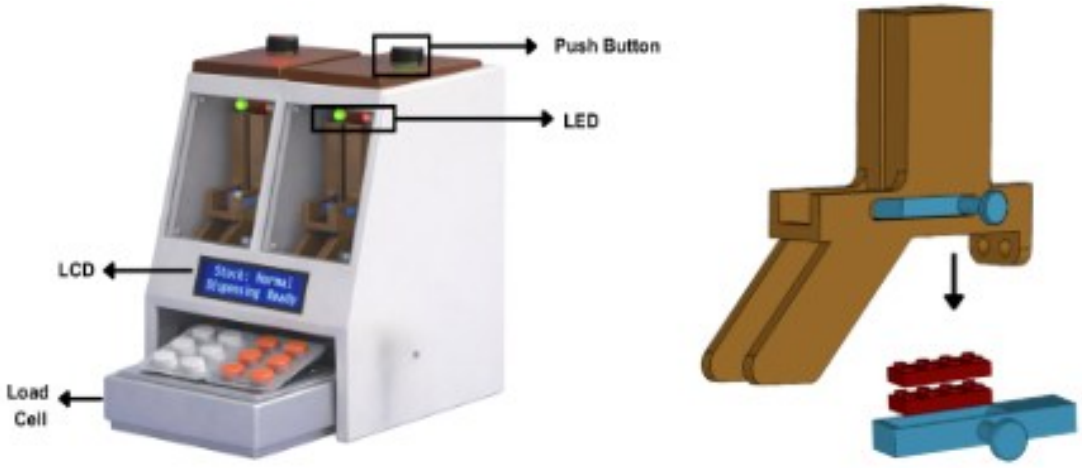

Figure 1. Product Prototype.

2. Methodology

System Block Diagram

Figure 2 illustrates the block diagram, which is the overall operational structure of the IoT-Integrated Smart Medicine Dispensing System, showing the interaction between input devices, the processing unit, output components, and the IoT platform. The input section consists of sensors and user input devices that provide real-time data to the system. An IR sensor is used to detect the presence of medicine blister packs and identify low-stock conditions. A load cell measures the weight of dispensed blister packs to verify dispensing accuracy. Additionally, a push button serves as a manual backup input, allowing dispensing to be triggered locally when internet connectivity is unavailable. All input signals are processed by the NodeMCU ESP32, which acts as the central data processing unit. The ESP32 is responsible for reading sensor data, executing dispensing logic, controlling output devices, and communicating with the IoT platform via its built-in Wi-Fi module. Based on the programmed conditions and feedback received, the ESP32 determines whether the dispensing process is successful or if an error has occurred. The output section provides system response and user feedback. A servo motor controls the mechanical opening and closing of the medicine slots to dispense blister packs. A LED and buzzer provide visual and audible indications for system status, successful dispensing, or fault conditions. An LCD display presents essential information such as system status, dispensing confirmation, and connectivity indication.Finally, the system is integrated with the Internet of Things (IoT) through the ThingsBoard platform. The ESP32 transmits relevant data such as stock levels, dispensing events, and alert status to the cloud. This enables real-time monitoring, remote configuration, and automatic low-stock notifications, enhancing system efficiency and reliability.

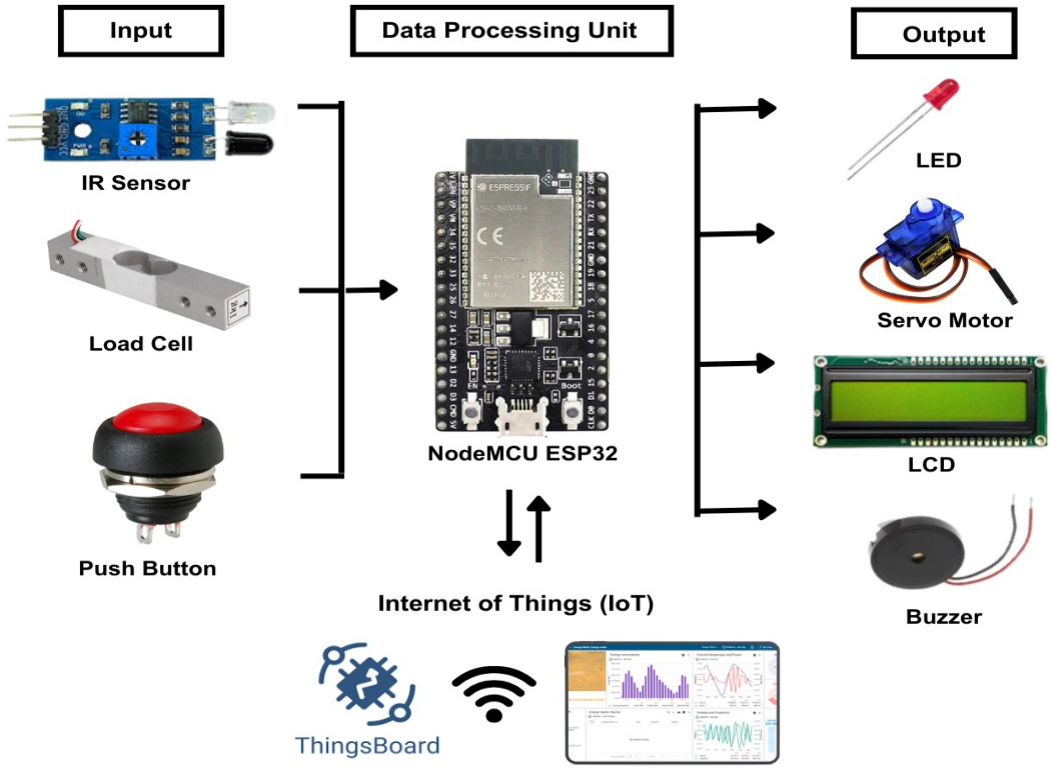

Figure 2. System Block Diagram.

System Flowchart

Figure 3 illustrates the operational flow of the automated pill dispensing system. The process begins by checking whether the system is connected to Wi-Fi. If a Wi-Fi connection is available, the ESP32 connects to the ThingsBoard platform to coordinate Function 1, which involves slot configuration. This includes retrieving slot details such as medicine information and availability. The system then reads user input from Function 3, where the user selects the medicine to be dispensed through the interface. If Wi-Fi is not connected, the system switches to an offline mode by reading input from the physical push button as a manual backup. Once a dispensing request is received, either from the user interface or the push button, the system checks whether the selected slot is available. If the selected slot is unavailable, an error indicator is activated to notify the user. If the slot is available, the system proceeds to dispense the medicine. After dispensing, the system coordinates Function 2, which continuously monitors the slots to update stock levels and detect low-stock conditions. The process then ends, completing one dispensing cycle while ensuring accurate dispensing and real-time monitoring.

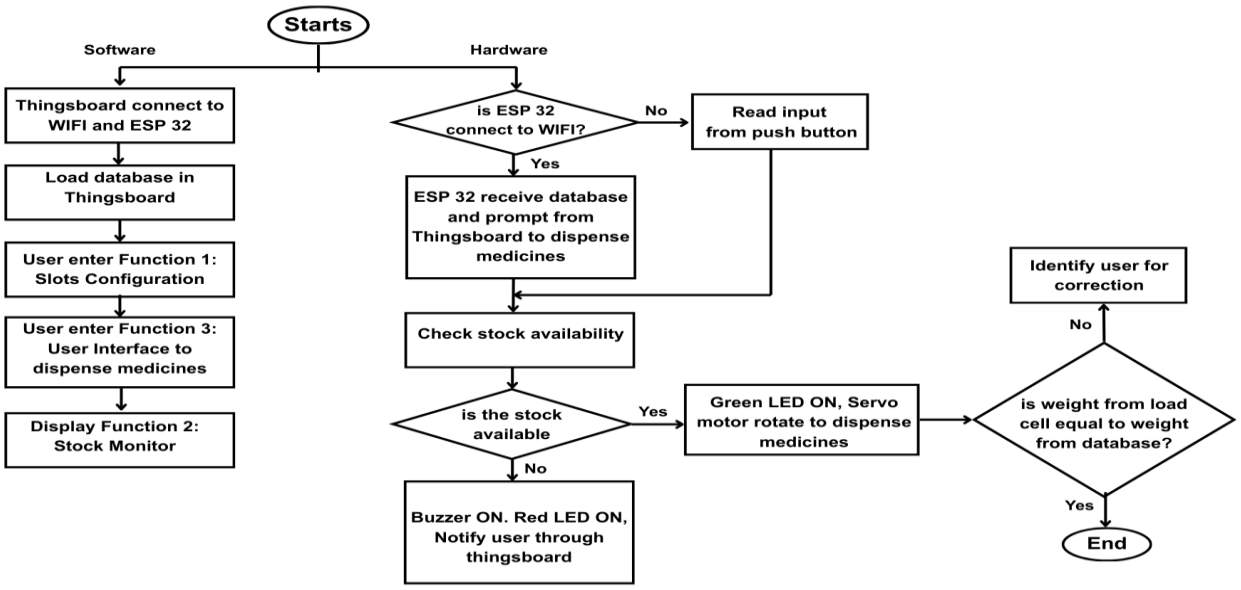

Figure 3. System Flowchart.

3. Novelty and uniqueness

The proposed system introduces a fully integrated approach to automated medication dispensing by combining mechanical blister pack release, sensor-based verification, and IoT-enabled monitoring within a single embedded platform. Unlike conventional dispensing methods that rely heavily on manual handling and visual verification, this system employs a load cell with digital signal processing to confirm dispensing accuracy based on measured weight. This verification mechanism significantly reduces the probability of incorrect quantity release, which is a major limitation in traditional automated dispensers. Another distinctive feature of the system is its ability to provide real-time operational monitoring through cloud connectivity. The integration of Wi-Fi communication enables continuous data transmission, allowing remote supervision of dispensing activity, stock availability, and system status. This transforms the dispenser from a standalone device into an intelligent monitoring system capable of supporting data-driven decision making. Furthermore, the system is designed with dual-mode operation, allowing both automated IoT-controlled functionality and manual backup dispensing. This ensures operational continuity even in the absence of network connectivity. The combination of mechanical automation, sensor verification, and cloud-based monitoring establishes a comprehensive solution that enhances reliability, safety, and system transparency beyond existing basic automated dispensers.

4. Benefit to mankind

The implementation of the automatic blister pill dispensing system provides significant benefits to healthcare service delivery by improving medication safety, operational efficiency, and workflow consistency. One of the primary advantages is the reduction of human dispensing errors, which are commonly associated with fatigue, high workload, and environmental distractions in pharmacy settings. By automating the dispensing process and verifying each release using sensor feedback, the system helps ensure that patients receive the correct medication quantity. The system also contributes to improved service efficiency by minimizing dispensing time and reducing patient waiting periods. Automated dispensing eliminates repetitive manual tasks, allowing healthcare personnel to focus on clinical responsibilities such as patient counseling and medication

management. This is particularly beneficial in high-demand environments such as outpatient pharmacies and elderly care facilities where time efficiency directly impacts service quality.Additionally, the integration of IoT-based monitoring enhances inventory management by providing real-time stock tracking and automatic low-stock alerts. This capability prevents medication shortages and supports proactive replenishment planning. By improving dispensing reliability, reducing delays, and enabling continuous monitoring, the system supports safer and more efficient healthcare operations while enhancing patient confidence in medication delivery processes.

5. Innovation and Entrepreneurial Impact

This project demonstrates an innovative integration of mechanical dispensing, sensor-based verification, and IoT monitoring within a single embedded healthcare device. By combining weight-based validation with real-time operational tracking, the system enhances dispensing reliability while enabling continuous performance monitoring. Its modular architecture supports future expansion, including additional dispensing channels and advanced data analytics. The system promotes safer medication handling, reduces manual workload, and contributes to the advancement of smart pharmacy automation aligned with digital healthcare transformation initiatives.

6. Potential commercialization

The proposed system has strong commercialization potential as a compact and cost-effective automated dispensing solution for healthcare facilities. Its use of widely available embedded components supports scalable production and affordability. IoT connectivity enables remote monitoring, inventory tracking, and predictive maintenance services, creating opportunities for integrated hardware and cloud-based service models. With further refinement in mechanical design and packaging, the system can be deployed in hospitals, clinics, and elderly care centers to improve efficiency, safety, and medication management reliability.

7. Acknowledgment

I would like to express my sincere gratitude to my faculty for providing the opportunity to undertake this project as part of the Final Year Project course. Their academic guidance, facilities, and continuous support have been essential in the successful completion of this work. I am especially thankful to my supervisor, Dr Lela Ishak, for her invaluable guidance, constructive feedback, and consistent encouragement throughout the development of this project. Her expertise and dedication have greatly contributed to both the technical quality and overall direction of this study. I also appreciate the support provided by the faculty in facilitating the resources and learning environment necessary for completing this project successfully.

8. Researchers' Biography

Atikah Miasarah Bt Che Rosadi is an undergraduate student pursuing a Bachelor's degree in Electrical Engineering at Universiti Teknologi MARA (UiTM), Shah Alam. Her academic interests include embedded systems, automation, and Internet of Things (IoT) applications in healthcare technology. Throughout her studies, the author has developed practical experience in microcontroller programming, sensor integration, and system design through laboratory work and project-based learning. As part of the Final Year Project, the author designed and developed an automatic blister pill dispensing system that integrates mechanical control, sensor-based verification, and IoT monitoring. This work reflects a strong interest in applying engineering solutions to improve efficiency, safety, and reliability in real-world applications. The author aims to further develop skills in intelligent system design and contribute to advancements in smart healthcare technologies.

Dr. Norlela Ishak is a Senior Lecturer at the School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA(UiTM), Shah Alam. She holds a PhD in Electrical Engineering from UiTM with joint supervision from Universiti Teknologi Malaysia (UTM). Her research interests include computational modelling of control systems, control and automation, tracking control strategies, and Internet of Things (IoT) applications for smart monitoring. She is a member of IEEE, a registered Graduate Technologist with the Malaysia Board of Technologists (MBOT), and serves as a committee member for the IEEE International Conference on Automatic Control and Intelligent Systems (I2CACIS)

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Smart Underground Emergency Ventilation and Smoke Control System

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ABSTRACT

This project presents a prototype of Smart Underground Emergency Ventilation and Smoke Control System designed to enhance the safety in enclosed underground environments such as tunnels, basements, and subterranean commercial spaces. The proposed system integrates smart sensors, automated control mechanisms, and optimized airflow design. This product aimed to improve smoke extraction and fresh air distribution during fires or hazardous air events. By rapidly detecting smoke or deteriorating air quality, the system automatically activates strategically positioned fans and ducting to introduce clean air while expelling smoke. This improves air quality, reduces smoke inhalation risks, and enhances visibility, enabling safer and faster evacuation. The system is designed and analyzed using SolidWorks simulation tools to optimize the placement of sensors, fans, and air ducts for maximum airflow efficiency and rapid emergency response. The final design offers a responsive, automated ventilation solution capable of dynamically controlling air movement to enhance safety in underground spaces significantly. The system's novelty stems from an integrated architecture featuring dual-fan counteractive airflow and real-time smoke-sensing, creating an adaptive setup that automatically responds to environmental conditions. By integrating our automated smoke control system during the design phase of new construction, we offer developers a turnkey solution that easily satisfies modern fire safety regulations and accelerates building certification.

Keywords: smart underground ventilation, smoke control system, smoke detector

1. Product Description

The project focuses on developing a dual-fan configuration in which one fan is dedicated to smoke extraction while the other supplies fresh air into the enclosed space. Smoke detection sensors are integrated to continuously monitor smoke concentration levels, and an automated control system is implemented to adjust fan speed according to the real-time sensor data. This adaptive control strategy ensures an energy-efficient operation under normal conditions and enables a rapid, responsive airflow adjustment during emergency situations. Engineering simulation tools such as SolidWorks are fully utilized to strategically optimize the placement of the sensors, fans, and ducting. This approach enhances airflow efficiency, minimizes stagnant zones where smoke could accumulate, and improves overall

system reliability. Ultimately, the project goes beyond basic ventilation by prioritizing human safety, focusing specifically on reducing smoke inhalation risks and supporting safer, faster evacuation in underground environments.

2. Methodology

The first phase involves studying limitation of conventional underground ventilation systems, particularly in emergency smoke control. A dual-fan counteractive airflow concept is then developed using SolidWorks, where one fan extracts smoke and the other supplies fresh air. SolidWorks is used to model the enclosed underground environment, design the ducting pathways, and optimize the placement of fans and sensors, as shown in **Figure 1**. The airflow simulations (CFD) are further conducted to evaluate the smoke extraction efficiency, airflow velocity, and elimination of stagnant zones (**Figure 2**).

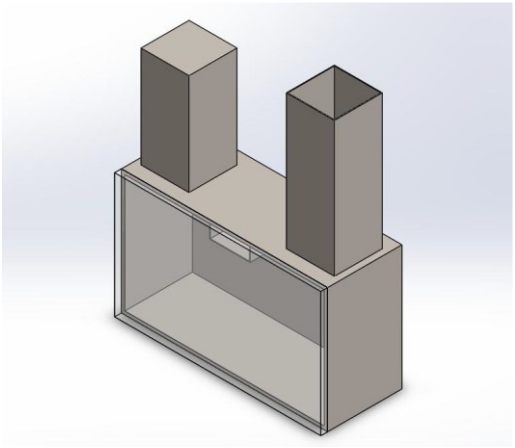

Figure 1. Preliminary design housing of Smart Underground Ventilation and Smoke Control System using SolidWorks.

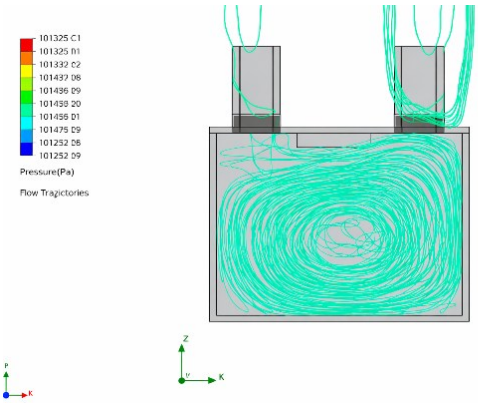

Figure 2. Airflow simulations using SolidWorks to evaluate the airflow velocity.

Subsequently, a scaled prototype is fabricated (**Figure 3**) consisting of two controlled fans, smoke/gas sensors, a microcontroller, and control circuitry for automatic speed adjustment. The system is programmed to adjust the fan speed dynamically according to the real-time smoke

concentration levels. A controlled test is performed afterward under simulated smoke conditions to evaluate the response time, smoke extraction efficiency, the air quality improvement rate, and the energy consumption.

(a) (b)

Figure 3. Final prototype of Smart Underground Emergency Ventilation and Smoke Control System from the front (a) and back (b) view, consisting of two micro-controlled fans and an automatic speed adjuster.

3. Novelty and uniqueness

The uniqueness of this project lies in its transformation of conventional underground ventilation into an intelligent, automated emergency response system. Unlike traditional systems that depend mainly on passive air shafts or single-direction airflow, this design incorporates a dual-fan counteractive airflow strategy. One fan actively extracts smoke while the other simultaneously introduces fresh air, creating a controlled and directed airflow pathway. This coordinated mechanism helps prevent smoke accumulation and spread, while improving visibility and air quality during evacuation. In addition, the system integrates real-time smoke detection sensors with an automated control unit, enabling continuous monitoring of air conditions. Instead of functioning as a simple ON/OFF system, the fans automatically adjust their speed based on actual smoke concentration levels. This adaptive response ensures energy-efficient performance under normal conditions and immediate, proportional action during emergencies without requiring human intervention.

4. Benefit to mankind

First and foremost, the proposed system can help in saving lives during fire or smoke-related emergencies. By rapidly extracting smoke while simultaneously supplying fresh air, this will further reduce the risk of smoke inhalation, which is one of the leading causes of death in enclosed fire incidents. Improved air quality and visibility also allow occupants to evacuate more quickly and safely. In addition, the intelligent automation improves emergency response efficiency. Because the system operates automatically based on real-time sensor readings, it minimizes reliance on human intervention, reducing response delays and the potential of human error. This makes underground infrastructure safer and more reliable. Finally, the system supports safer urban

development by having a smarter ventilation and smoke control system that ensures that these spaces remain safe, resilient, and suitable for long-term use.

5. Innovation and Entrepreneurial Impact

The innovation lies in the integration of a dual-fan counteractive airflow design, real-time smoke-detection sensors, and an adaptive control system that automatically regulates airflow based on environmental conditions. Unlike traditional systems that operate passively or require manual activation, this system responds dynamically and proportionally to emergencies, improving efficiency and reliability. The use of engineering simulation tools such as SolidWorks to optimize airflow pathways further strengthens the technical innovation. By strategically positioning fans, ducts, and sensors, the system ensures maximum smoke extraction efficiency while maintaining a steady supply of fresh air. This design minimizes smoke accumulation zones and enhances evacuation safety. Overall, the project contributes to smarter infrastructure by prioritizing human safety, automation, and energy-efficient operation in underground environments.

6. Potential commercialization

The Smart Underground Emergency Ventilation and Smoke Control System has strong commercialization potential due to the growing global demand for safer and smarter underground infrastructure. Rapid urbanization has increased the construction of tunnels, underground transport hubs, parking basements, shopping complexes, and utility corridors. These facilities require advanced smoke control and ventilation systems that comply with modern fire safety regulations, creating a clear market opportunity for innovative, automated solutions. One key commercialization pathway is targeting new construction projects. The system can be integrated into building designs during the planning phase, offering developers a value-added safety feature that enhances compliance and building certification standards. At the same time, the system can be adapted to the existing underground facilities, where older ventilation systems lack intelligent automation. This expands the addressable market significantly.

7. Acknowledgment

This prototype development has been supplied with the Academic Rules and Regulations, Universiti Teknologi MARA (UiTM), regulating the conduct of study and research. The authors would like to thank UiTM for the technical support.

8. Researchers' Biography

Farhana Dhamira binti Nor Azmi is a Faculty of Mechanical Engineering student in Universiti Teknologi MARA (UiTM) Johor Branch, Pasir Gudang Campus. She started the journey as student in 2022, focusing her studies in Mechanical Engineering. In the final year project, she came up with the idea to design a Smart Underground Emergency Ventilation and Smoke Control System, with Madam Nurrul Amilin binti Zainal Abidin as her main supervisor.

Nurrul Amilin binti Zainal Abidin is a senior lecturer in Faculty of Mechanical Engineering, Universiti Teknologi Mara (UiTM) Johor Branch, Pasir Gudang Campus, Johor, Malaysia. She is currently specialized in Biomechanics and Biomaterials; previously completed a Master's in Engineering (Biomedical Engineering) and a Bachelor of Engineering (Honours) in Biomedical Engineering at University of Malaya.

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Canova: Eco-Friendly Biodegradable Food Packaging from Sugarcane Bagasse

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ABSTRACT
Plastic food packaging creates serious environmental problems because it is non-biodegradable and contributes significantly to landfill waste. CANOVA is an eco-friendly food packaging product developed using sugarcane bagasse, glycerine and beeswax coating. Sugarcane bagasse is an agricultural waste material that is commonly discarded after juice extraction but this project transforms it into a valuable biodegradable packaging product. The bagasse pulp forms the main structure of the wrap, glycerine improves flexibility and beeswax coating provides water resistance and protection from moisture. This combination produces a strong, flexible and environmentally friendly packaging material. Unlike conventional plastic wrap, CANOVA can naturally decompose after disposal, reducing environmental pollution and supporting sustainable waste management. The product also promotes responsible consumption and aligns with global sustainability goals. CANOVA has strong commercial potential among eco-conscious consumers, food vendors and sustainable businesses. This innovation not only reduces plastic waste but also adds value to agricultural by-products, contributing to environmental protection and economic development.

Keywords: biodegradable packaging, sugarcane bagasse, eco-friendly wrap, sustainable packaging, agricultural waste.

1. Product Description
CANOVA is a biodegradable food packaging product made primarily from sugarcane bagasse pulp. Sugarcane bagasse is cleaned, dried, and blended into fine pulp before being processed into thin sheets. This pulp forms the base structure of the wrap. Glycerine is added to the mixture to improve flexibility and prevent the material from cracking or breaking easily. After shaping and drying, a thin layer of melted beeswax is coated onto the surface. The beeswax coating provides water resistance and improves durability.The production process includes pulp preparation, mixing with glycerine, molding into sheets, drying, beeswax coating and final trimming. The final product is lightweight, flexible, and suitable for wrapping dry or semi-moist food items. CANOVA is fully biodegradable and can decompose naturally after disposal. It reduces reliance on plastic packaging and helps manage agricultural waste more effectively. The product can be produced in different sizes to meet household and small business needs.
The systematic production stages, from raw material preparation to final shaping are illustrated in **Figure 1.**

Figure 1. The step-by-step production process of CANOVA eco-friendly wrap.

2. Novelty and uniqueness

CANOVA is unique because it uses agricultural waste, specifically sugarcane bagasse, as the main raw material. Instead of being thrown away, this waste is converted into a useful and environmentally friendly product. The addition of glycerine improves the flexibility of the material, making it suitable for food wrapping. The beeswax coating enhances water resistance, which improves product performance compared to untreated bagasse sheets.

Unlike conventional plastic packaging, this product is biodegradable and compostable. It reduces environmental pollution and promotes sustainable production methods. The innovation lies in combining waste management and eco-friendly packaging into one practical solution. CANOVA also supports circular economy practices by turning waste into value-added products. The simple production process makes it suitable for small-scale manufacturing and community-based businesses.

3. Benefit to mankind

CANOVA benefits society by reducing plastic waste and promoting environmental sustainability. It helps decrease landfill accumulation and supports cleaner surroundings.

By using sugarcane waste, the product also improves agricultural waste management. Instead of discarding bagasse, it is reused in a productive way. Furthermore, this innovation promotes safer and more environmentally responsible food packaging. It encourages consumers to choose biodegradable alternatives over plastic. Additionally, the project creates opportunities for small entrepreneurs and local communities to produce and sell eco-friendly products. Overall, CANOVA supports environmental protection, sustainable living and economic growth.

4. Innovation and Entrepreneurial Impact

CANOVA promotes innovation by transforming agricultural waste into a marketable eco-friendly product. It encourages creative thinking in solving environmental problems through sustainable materials. The project supports entrepreneurship by providing opportunities for small-scale production and green business development. Students and young entrepreneurs can learn how to develop environmentally responsible products while generating income. The product can be marketed through online platforms, eco-friendly stores, and local food businesses. The increasing demand for sustainable packaging increases its business potential. This innovation strengthens environmental awareness while promoting a culture of sustainability and entrepreneurship within the community.

5. Potential commercialization

CANOVA has strong commercialization potential due to rising awareness about environmental issues. Primary target markets include modern households, small food businesses, cafés and eco-specialty stores. The product can be promoted through social media marketing, online sales platforms and collaboration with sustainable brands. Its biodegradable nature makes it attractive to environmentally conscious consumers. With proper branding and packaging, this product can expand into supermarkets and larger markets. The production process is simple and can be scaled up depending on demand. CANOVA offers both environmental benefits and business profitability, making it a sustainable long-term commercial product.

6. Acknowledgment

We would like to express our sincere gratitude to our supervisor for their guidance, support, and valuable advice throughout this project. Their encouragement helped us successfully complete the development of CANOVA. We also thank our lecturers for their knowledge and support, as well as our friends and family for their motivation and understanding during the project period. Lastly, we appreciate everyone who directly or indirectly contributed to the completion of this project.

7. Researchers' Biography

Tianney A/P Antony Samy is a final semester student in the Department of Business Studies at Politeknik Tuanku Sultanah Bahiyah, Kedah. Her academic interests include entrepreneurship, sustainable business practices, and product innovation. She served as the team leader for the CANOVA project.

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Kalishwaran A/L Sivaperuman is a final semester student in the Department of Business Studies at Politeknik Tuanku Sultanah Bahiyah. His interests include green innovation, business development and sustainable entrepreneurship.

Supervisor: Mr. Mazly Mohd Noor,
lecturer at the Department of Business Studies, Politeknik Tuanku Sultanah Bahiyah.

Pet Feeder

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ABSTRACT
This project, entitled "Pet feeder," was developed to address the challenges faced by busy pet owners who are unable to feed their cats consistently and on schedule. Irregular feeding times and improper food storage may lead to contamination, spoilage, and potential health issues, thereby compromising animal well-being. The primary objective of this project is to design and fabricate an automated feeding system capable of dispensing cat food in a timely, hygienic, and controlled manner. The system integrates an Arduino-based microcontroller, a servo motor mechanism for portion control, and multiple sensors for operational monitoring. The structural housing, constructed from Aluminium Composite Panel (ACP) and wood, measures approximately 400 mm × 240 mm × 330 mm and is designed to ensure durability and stability. A sealed food container is incorporated to maintain food freshness and minimize exposure to contaminants. To enhance user accessibility, the system is integrated with a smartphone application that enables remote scheduling, monitoring, and control of feeding operations. The automated mechanism is designed to detect the presence of the cat and dispense a predetermined portion of food without manual intervention. The expected outcome of this project is a reliable and efficient feeding system that improves feeding consistency while reducing the time burden on pet owners. In conclusion, the proposed automatic cat feeding machine offers a practical, hygienic, and technologically driven solution that contributes to improved pet care management and animal health maintenance.

Keywords: Pet Feeder, Automatic Cat Food Dispenser

1. Product Description
The proposed Pet Feeder is a sensor-based feeding device designed to dispense food automatically when a cat is detected nearby. The system integrates three primary components: an ultrasonic motion sensor, an Arduino UNO microcontroller, and a 360° servo motor. When the sensor detects the cat's presence, a signal is transmitted to the Arduino, which verifies the detection through a short delay (approximately 3 seconds) to prevent false triggering. Upon confirmation, the Arduino activates the servo motor to rotate and release a controlled portion of food into the tray. After dispensing, the system resets to standby mode, ensuring continuous and reliable operation. This design provides a smart, efficient, and hands- free feeding solution suitable for busy pet owners. The prototype is constructed using spin wood, an acrylic sheet (2

mm thickness), and an aluminium composite panel for structural durability and enclosure support. The dispensing mechanism incorporates PVC and recycled plastic components. Electronic hardware includes a 12V AC–DC adapter, Arduino UNO, ultrasonic sensor, servo motor, and a starter kit for wiring and programming. Based on a Bill of Materials (BOM) cost survey from online suppliers and hardware stores, the total estimated prototype cost ranges between RM144.40 and RM200.00, with electronic components contributing approximately 70% of the overall cost. This demonstrates that the system is relatively affordable and suitable for further development and commercialization.

2. Flow Charts

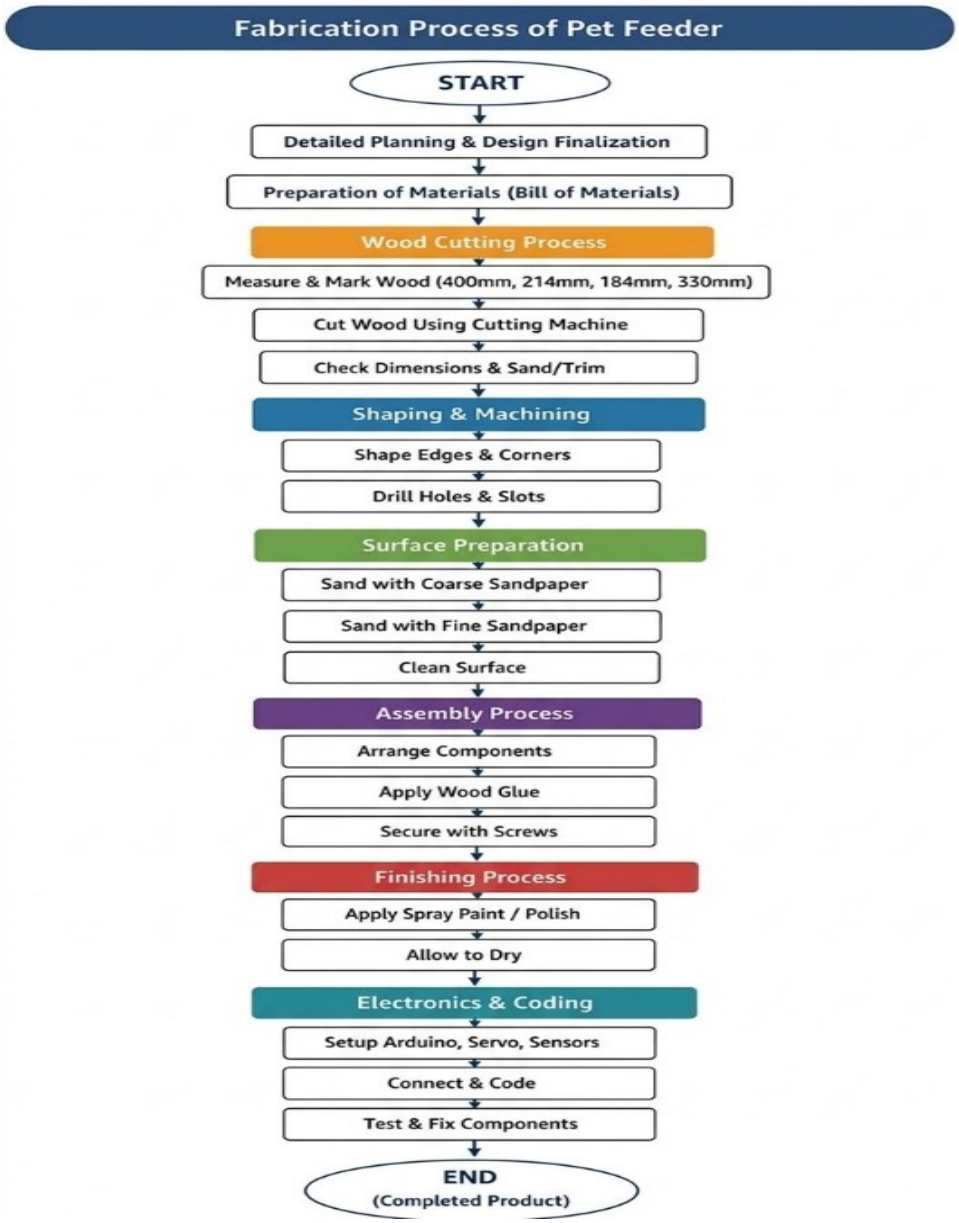
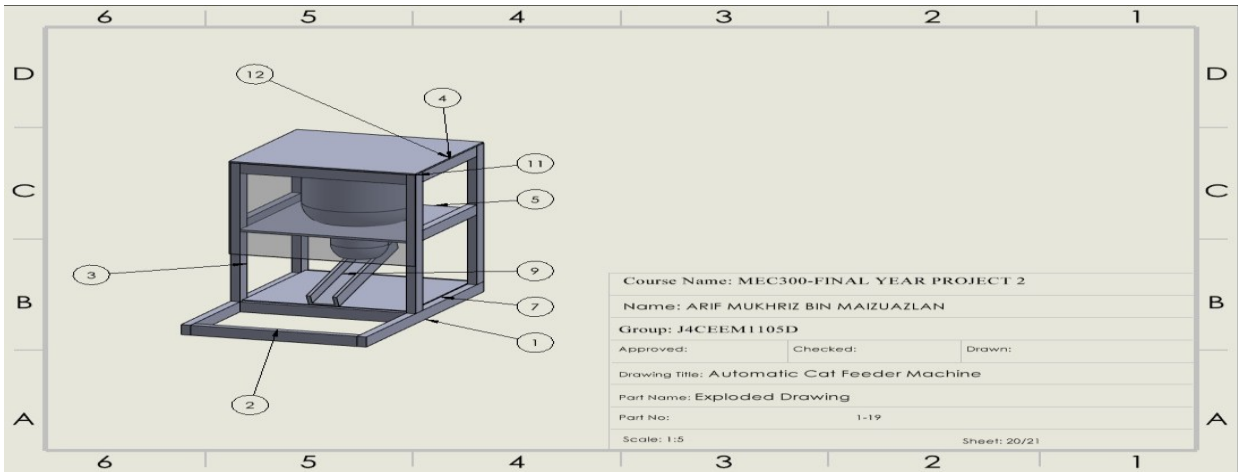
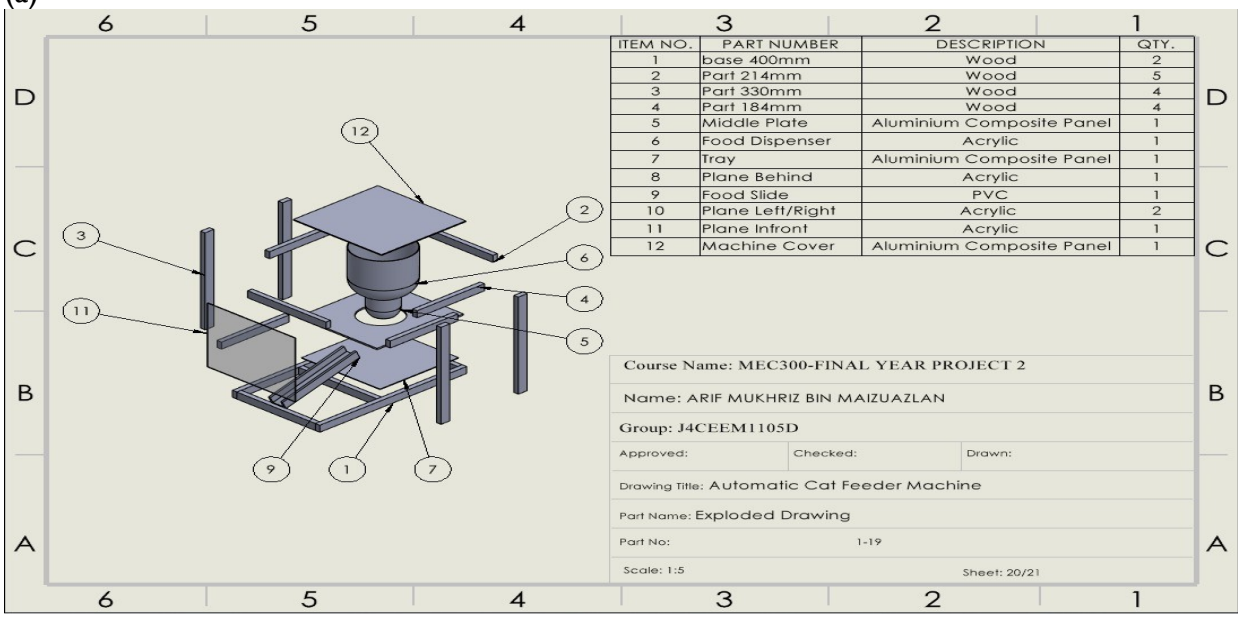


Figure 6. Fabrication Process of Pet Feeder.

Figure 7 (a) and(b) illustrates the exploded drawing of the Pet Feeder, showing the arrangement and relationship between structural, mechanical, and electronic components. The labelled parts provide a clear visualization of the assembly configuration, facilitating understanding of the system's construction and integration. Part that is chosen for engineering analysis is the Middle Plate as shown in **Error! Reference source not found.**. The reason is because the Plate will also be the part that will be supporting the food's weight. The analysis is done to determine that the part can support the food weight The middle plate was selected for engineering analysis because it supports the food load. A static load corresponding to a 1.2 kg food mass was applied: $F = mg = 11.772\ N$. The FEA results indicate a maximum von Mises stress of 6.89 × 10^2 Pa and a maximum displacement of $1.65 \times 107\ m$. The acrylic plate material has a yield strength of 4.5 × 10^7 Pa; therefore, the computed factor of safety is approximately$\frac{4.5\times10}{6.89\ x\ 10^2} \approx 6.53\ x10^4$. This suggests the plate can support the applied load with a large margin, subject ti the validity of the modelling assumptions and correct unit settings.



(a)



(b)

Figure 7. (a) Assembly Drawing (b) Exploded Drawing.

Middle Plate von Mises stress analysis

Middle Part deformation analysis

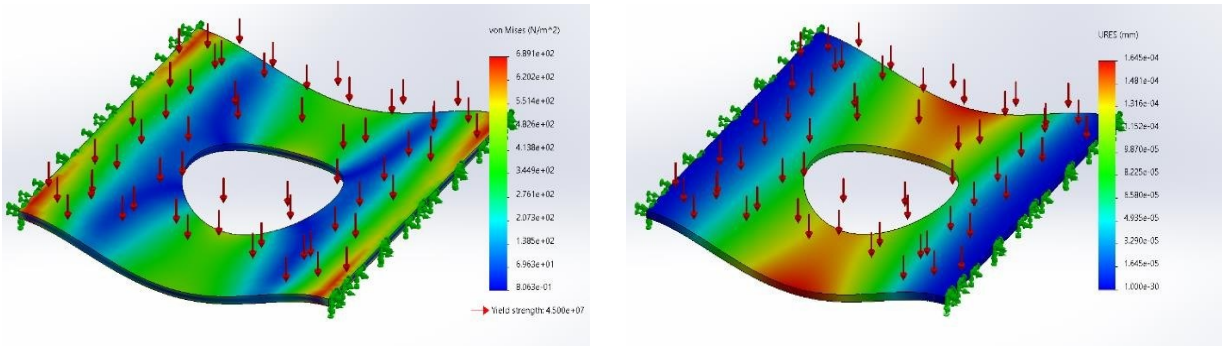


Figure 3. Engineering analysis of the middle plate.

3. Novelty and uniqueness

This project introduces a compact and sensor-based Pet Feeder that integrates mechanical design, embedded systems, and smartphone control into a single low-cost unit. Unlike conventional automatic feeders that rely solely on timer-based dispensing, this system incorporates an ultrasonic sensor to detect the presence of the cat before releasing food, thereby minimizing waste and overfeeding. The integration of Arduino-based control with remote smartphone access enhances flexibility and user convenience. Additionally, the design emphasizes hygienic food storage through an enclosed container and structured housing made from ACP and wood, ensuring durability and cleanliness. The combination of presence detection, programmable feeding schedules, and a modular mechanical structure makes the system unique compared to basic gravity-fed or timer-only feeders currently available in the market.

4. Benefit to mankind

The Pet Feeder improves pet welfare by ensuring consistent and timely feeding, even when owners are busy or away. It reduces the risk of food contamination, irregular feeding patterns, and related health issues. The system also promotes responsible pet ownership by enabling portion control and monitoring. By saving time and improving feeding hygiene, the device enhances convenience while supporting better animal health management. Ultimately, it contributes to improved quality of life for both pets and their owners.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by combining mechanical fabrication, electronics integration, and IoT-based monitoring into a practical consumer product. It encourages interdisciplinary problem-solving and hands-on technical development within the institution. The system demonstrates how affordable microcontroller platforms can be transformed into market-relevant solutions. By addressing a growing pet-care market, the project fosters entrepreneurial thinking, product development skills, and commercialization awareness. It provides a foundation for students and developers to explore smart home and pet-care technologies with scalable business potential.

6. Potential commercialization

The product has strong commercialization potential due to the increasing number of pet owners seeking smart and automated solutions. With further refinement in design aesthetics, durability,

and mass-production methods, the system can be marketed as an affordable smart feeder. Integration with mobile applications and possible expansion to Wi-Fi or IoT cloud connectivity can increase market competitiveness. The device can be positioned in pet stores, online marketplaces, and smart home product segments, targeting busy professionals and frequent travellers.

7. Researchers' Biography

Arif Mukhriz Bin Maizuazlan is a final-year Diploma student in Mechanical Engineering at Universiti Teknologi MARA (UiTM) Pasir Gudang, with a strong passion for integrating engineering solutions into everyday life. As a dedicated cat lover, he consistently seeks innovative ways to improve the comfort and well-being of his pets by applying his mechanical knowledge to practical designs. Throughout his studies, he has developed technical competencies in SolidWorks for machine design, analysis, and simulation, enabling him to evaluate structural strength, safety, and durability through engineering calculations and finite element analysis.In addition to digital design skills, he has gained hands-on fabrication experience in the UiTM mechanical workshops, mastering the use of engineering tools and manufacturing processes. His academic training in mechanics, materials, and engineering design principles ensures that his projects are structurally sound, safe, and functionally reliable. By combining technical expertise with personal passion, Arif demonstrates how engineering knowledge can be transformed into meaningful, real- world innovations that enhance everyday living.

Nurul'Ain Haris is a lecturer at Universiti Teknologi MARA (UiTM) Pasir Gudang in the Faculty of Mechanical Engineering, with a decade of experience in supervising and managing student projects. Her academic and professional interests are centred on engineering innovation, product development, and the advancement of applied mechanical engineering solutions. She is deeply engaged in encouraging students to join innovation competitions, reflecting her strong commitment to cultivating creativity, technical excellence, and problem-solving skills within the academic community.

Adila Nalisa mohd Roslan is a lecturer at Universiti Teknologi MARA (UiTM) Bukit Besi in the Faculty of Mechanical Engineering, with over 10 years of experience in supervising and managing student engineering projects. Her academic interests focus on manufacturing systems, mechanical design, and product innovation. She is actively involved in supporting student participation in innovation competitions, indicating her commitment to fostering creativity, technical problem-solving, and entrepreneurial thinking among engineering students.

Dryshoe: Heated Rack with a Smart Timer Touch

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ABSTRACT

This project describes the design and development of a portable shoe rack with a heating and timer system for effective shoe drying and storage called as DryShoe rack. The conventional shoe rack is only a storage device and does not have any drying functionality, which is a problem for people who have wet or damp shoes, especially in rainy seasons, cold weather, small living spaces, and while traveling. Moreover, the conventional shoe rack is heavy and immobile, which makes it less useful. To overcome these problems, a light and mobile shoe rack with a controlled heating system was designed and developed. The design was created in SolidWorks and made from aluminum, stainless steel, and plastic materials, which are robust, heat-resistant, and light in weight. A 200W heating component is used, which can provide a maximum temperature of about 48°C, which is safe for drying different materials of shoes. A timer control system is also provided, which enables the user to set the drying time according to the type of shoes. From the performance testing, it has been proven that the prototype can dry shoes within 30-120 minutes, depending on the material and moisture content of the shoes, and the estimated energy consumption is 0.1-0.4 kWh for each cycle. The fabrication steps involve measuring, cutting, drilling, joining, and wiring. This project has provided a useful and efficient way to dry and store shoes, especially for household and traveling purposes. By ensuring shoes are dried properly, DryShoe rack contributes to better daily hygiene and user comfort. Furthermore, this device helps prolong shoe life, directly reducing the environmental footprint caused by frequent footwear replacement. DryShoe rack combining two essential functions which is storage and drying into a single rack with low-energy-consumption unit. This affordability makes it accessible to a wide range of users, including students and budget-conscious travellers.

Keywords: Portable shoe rack, Heating system, Timer control, Energy efficiency, Moisture removal

1. Product Description

DryShoe rack is a multi-functional portable shoe rack designed to store and efficiently dry wet or damp shoes. The main structural frame is constructed using 1x1 inch aluminum hollow sections, paired with Aluminum Composite Panels (ACP) and transparent acrylic doors for optimal heat retention and visibility. The internal drying system is powered by a 24V DC power supply connected to two 200W ABS multi-purpose electric shoe dryers. A built-in digital timer

allows users to select specific drying durations between 30 to 120 minutes depending on the shoe material, ensuring safe temperature regulation around 48°C to prevent thermal degradation. It includes caster wheels for easy mobility, making it highly portable. To ensure user safety, a limit switch automatically cuts off the heating operation if the acrylic doors are opened, accompanied by an audiovisual warning system featuring a buzzer and a red LED indicator. **Figure 1** shows the assembly drawing from Solidworks of the product while **Figure 2** shows Exploded Drawing with Bill of Materials of the product.

2. Pictures of the Product

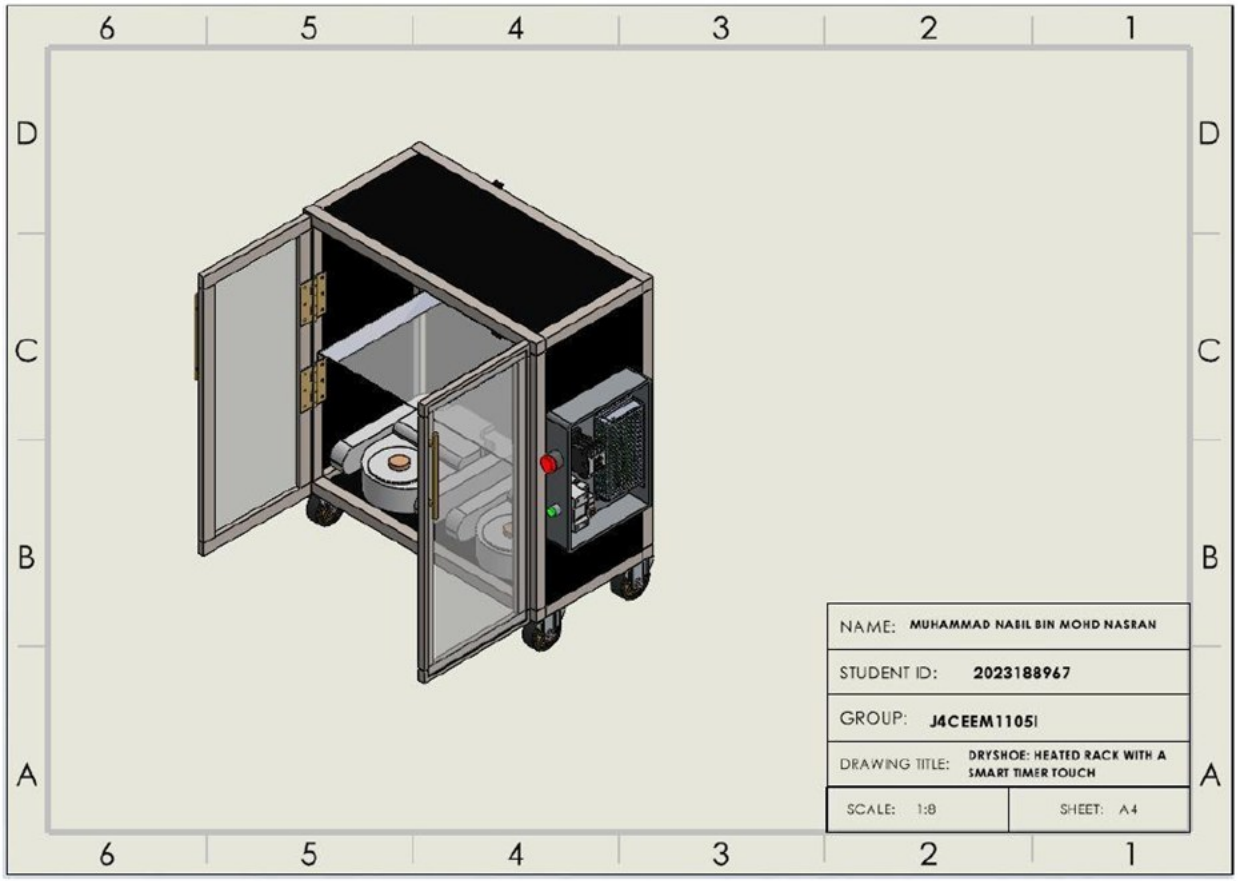
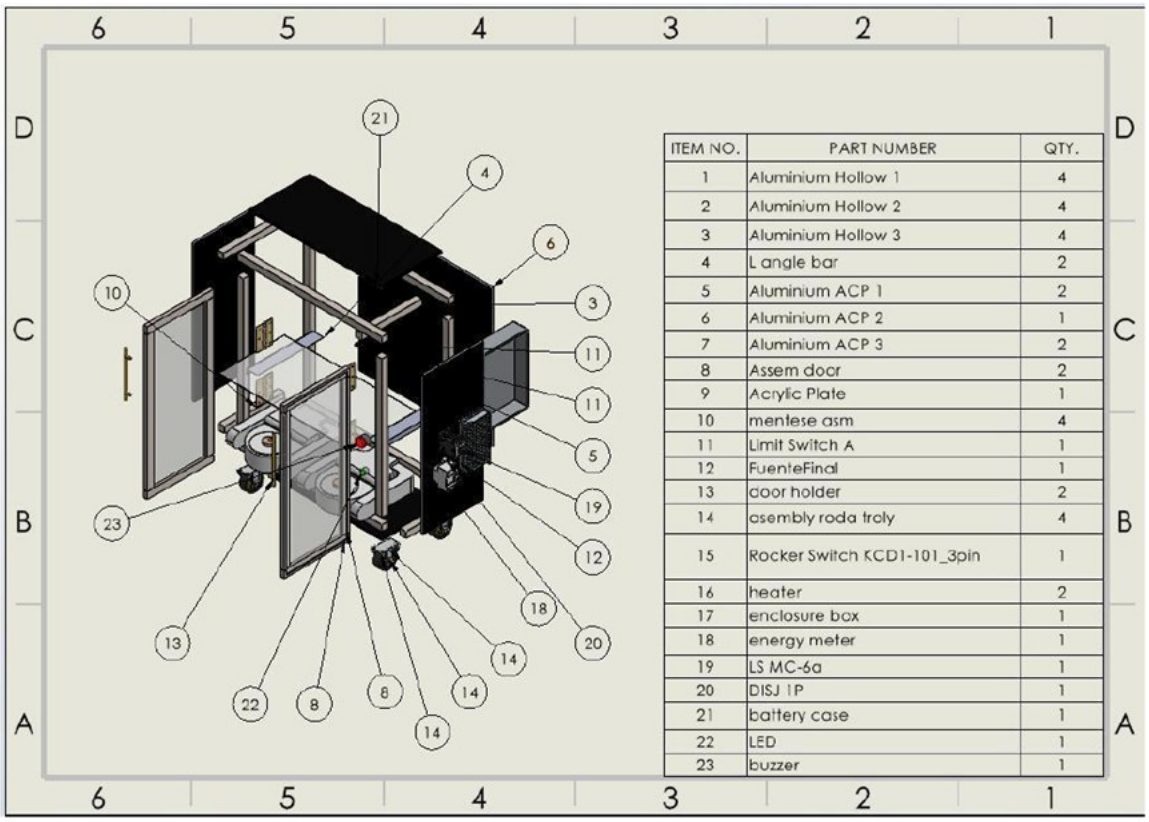


Figure 1. Assembly drawing of DryShoe rack.



ITEM NO.	PART NUMBER	QTY.
1	Aluminium Hollow 1	4
2	Aluminium Hollow 2	4
3	Aluminium Hollow 3	4
4	L angle bar	2
5	Aluminium ACP 1	2
6	Aluminium ACP 2	1
7	Aluminium ACP 3	2
8	Assem door	2
9	Acrylic Plate	1
10	mentese asm	4
11	Limit Switch A	1
12	FuenteFinal	1
13	door holder	2
14	asembly roda troly	4
15	Rocker Switch KCD1-101_3pin	1
16	heater	2
17	enclosure box	1
18	energy meter	1
19	LS MC-6a	1
20	DISJ 1P	1
21	battery case	1
22	LED	1
23	buzzer	1

Figure 2. Exploded drawing of DryShoe rack with Bill of Materials.

Figure 3. DryShoe rack Prototype .

3. Novelty and uniqueness

Figure 3 shows the DryShoe rack Prototype. Unlike conventional shoe racks that only provide storage and often trap moisture, DryShoe rack integrates forced convection drying technology with time-based control within a compact, movable rack. Its uniqueness lies in the smart timer mechanism paired with a 200W low-power heater, allowing customizable drying cycles (30 to 120 minutes) tailored to specific materials like canvas or leather without causing shrinkage or thermal damage. Additionally, the robust safety interlock system is a limit switch coupled with an audiovisual alarm (buzzer and red light) which is instantly halts operation if the doors are opened, distinguishing it from standard market alternatives. The use of lightweight aluminum and caster wheels provides unmatched portability, addressing the rigid, bulky nature of traditional shoe cabinets.

4. Benefit to mankind

DryShoe rack significantly improves daily comfort, hygiene, and health. By efficiently removing moisture from wet shoes, it prevents unpleasant odors, bacterial growth, and fungal formation, directly supporting SDG 3 (Good Health and Well-Being). Furthermore, it preserves structural integrity and extends the lifespan of footwear, reducing waste and promoting responsible consumption which is supporting SDG 12 (Responsible Consumption and Production). Besides, its energy-efficient timer system, which consumes merely 0.1 to 0.4 kWh per cycle, minimizes electricity waste and aligns with global affordable and clean energy initiatives (SDG 7- Affordable and Clean Energy). This product offers a practical, space-saving organization solution for urban dwellers and travelers.

5. Innovation and Entrepreneurial Impact

This project fosters a culture of innovation by modernizing a conventional household item into a smart, multi-functional appliance. By integrating mechanical design with electrical safety features and thermal engineering, it showcases practical problem-solving applicable to real-world consumer needs. For the community and industry, DryShoe rack demonstrates how low-cost, recyclable materials like aluminum and acrylic can be engineered into high-value products. It inspires local entrepreneurship by offering a scalable, easily fabricated prototype that can be manufactured by small-to-medium enterprises (SMEs) to cater to urban households, hostels, and sports facilities, stimulating the local economy and promoting technological adoption.

6. Potential commercialization

DryShoe rack has significant commercialization potential targeting urban households, frequent travelers, athletes, and residents in tropical or rainy climates. With an affordable bill of materials cost of approximately RM 665.00 for the prototype, mass production could significantly reduce unit costs, making it highly competitive against standard non-heated shoe cabinets. Its space-saving vertical design, energy efficiency, and dual-functionality (storage and drying) make it highly attractive for modern apartments and dormitories. Future integrations, such as IoT connectivity for smartphone control and capacity expansion, will further elevate its market value, appealing to tech-savvy consumers and smart-home appliance distributors.

7. Acknowledgment

The authors would like to express sincere gratitude to Universiti Teknologi MARA (UiTM), Cawangan Johor, Kampus Pasir Gudang, and the Department of Mechanical Engineering for their continuous support, guidance, and provision of facilities that made this project successful.

8. Researchers' Biography

Muhammad Nabil Bin Mohd Nasran is a Diploma student in Mechanical Engineering at the Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), Cawangan Johor, Kampus Pasir Gudang. He is in Final Semester in 2026. His focus during this project involved conceptualization, 3D modelling via SolidWorks, hardware fabrication, and safety testing of the DryShoe rack prototype for His Final Year Project (FYP).

Ts. Dr. Nurulsaidatulsyida binti Sulong is a Senior Lecturer at the Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), Cawangan Johor, Kampus Pasir Gudang. With extensive expertise in mechanical engineering, she served as the project supervisor, providing invaluable guidance, methodology validation, and technical advice to ensure the success and safety of the DryShoe rack project.

Puan Nor Liawati Binti Abu Othman is a Senior Lecturer at the Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), Cawangan Johor, Kampus Pasir Gudang. Her expertise included Industrial Engineering, Production Layout and Control, Ergonomics, and Mechanical System Applications. She served as the project co-supervisor in this DryShoe rack project.

SmartSaw: Development of a Compact, Low-Cost Automated Hacksaw Machine

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ABSTRACT
This project describes the development of a compact, low-cost motorized cutting system that transforms rotary motion into reciprocating motion through a crank–chain mechanism. Manual cutting using a conventional hacksaw requires significant time, physical effort, and often results in inconsistent cutting accuracy. The objectives of this study are to design and fabricate a compact, low-cost automated hacksaw machine. The fabrication process includes material selection, cutting, drilling, welding, machining, and the assembly of key components. The fabricated system enables automatic back-and-forth blade movement, reducing operator fatigue while improving cutting precision and stability. Experimental testing demonstrates a noticeable reduction in cutting time compared to manual operation, along with improved cut consistency and reduced material wastage. Experimental testing showed that this machine reduced cutting time from approximately 5 minutes from manual cutting to 2 minutes per workpiece, representing a 60% improvement in productivity. Due to its low production cost, which is under RM300, the SmartSaw exhibits promising commercialization potential. This product may benefit the society where work quality can be improved and increase the productivity. The developed machine is compact, economical, and suitable for small workshops and individual user. This innovation enhances productivity and provides an affordable solution for efficient cutting operations.

Keywords: Motorized hacksaw, automated cutting, SolidWork

1. Product Description
A hacksaw is basically a hand tool that is mostly used for cutting metal or nonmetal as per the required dimensions. The conventional hand hacksaw is a basic yet essential cutting tool for various materials; however, the manual effort required during repetitive cutting operations, especially for thick and wide sections which results in operator fatigue and reduced productivity [1]. This is where the idea of motorized chain mechanism hacksaw comes. Motorized hacksaw cutting machine is basically a cutting device that uses a motor to drive the hacksaw shaft which is connected to a connecting rod[2]. The connecting rod is now attached to the cutting frame with screws in such a way as to obtain the required back and forth movement from the motor. The cutting frame is made in a way to allow the adjusted saw blade can be mounted on it. A belt and pulley arrangement is there to transfer the motor power to the shaft. The other end of the machine has a clamp that is used to hold the cutting part in place, to get the desired cutting results. A high torque motor is used to achieve this cutting motion as the cutting process produces a lot of resistance. By combining a hacksaw with a motor, the workpiece can be cut

with high productivity, less time and energy, consuming with more accuracy to the dimension with minimal wastage of the workpiece[3].

2. Design and Fabrication Process

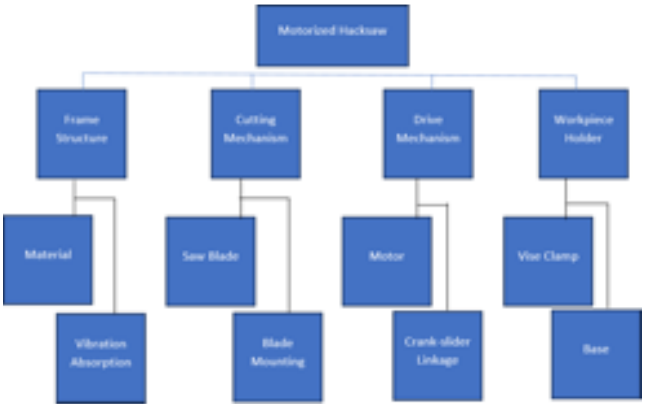

Figure 1. Important elements in SmartSaw.

The development of the motorized cutting machine began with the design of a detailed 3D model using SolidWorks to define the overall structure, dimensions, and motion mechanism. After finalizing and validating the CAD design, fabrication was conducted at the Faculty of Mechanical Engineering Workshop, Universiti Teknologi MARA (UiTM) Pasir Gudang. The system consists of four main sections: the frame structure, cutting mechanism, drive mechanism, and workpiece holder. The manufacturing processes involved are material selection, measuring, cutting, drilling, and mechanical assembly of individual components. The frame, constructed from wood, serves as the primary supporting structure, providing adequate strength while ensuring cost-effectiveness. The cutting mechanism utilizes a standard metal-cutting blade mounted securely to maintain alignment and tension, hence enabling stable reciprocating motion. The drive mechanism incorporates an electric motor coupled with a crank-slider linkage to convert rotary motion into controlled reciprocating blade movement. This motion conversion system forms the core functional principle of the machine. A mechanical vise clamp secures the workpiece during operation, enhancing stability and safety. Overall, the fabricated prototype demonstrates effective integration of design and manufacturing processes, resulting in a compact, low-cost, and functional cutting system as shown in **Figure 2**.

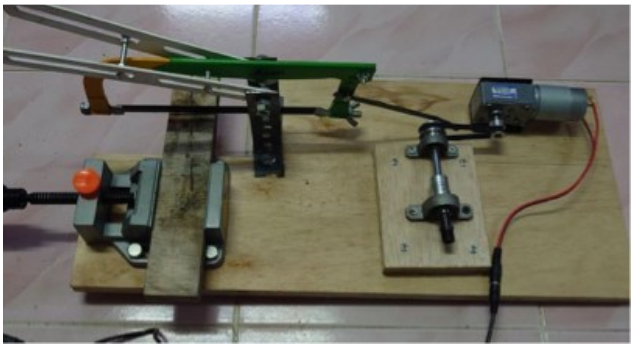

Figure 2. Final fabricated product.

3. Novelty and uniqueness

SmartSaw has its own novelty and uniqueness. Its compact and low-cost design has filled the gap between manual hand tools and expensive industrial cutting machines. The cutting process required less physical effort compared to the manual operation and the cuts produced were more consistent. From the performance testing, the results indicate that the system operates smoothly with stable reciprocating motion and minimal vibration during cutting. The Smartsaw reduced the cutting time from approximately 5 minutes using manual cutting to about 2 minutes per workpiece, representing a 60% improvement in productivity.

4. Benefit to mankind

Physical effort and time required for cutting are reduced during the cutting process. Consequently, work quality has been improved and the productivity has increased. The motorized chain mechanism provides a cost-effective cutting solution for small enterprises, workshops, and education institutions. In addition, the system contributes to more efficient material usage by reducing cutting errors and minimizing waste. By improving precision and consistency, the machine supports cleaner and more reliable workpiece production.

5. Innovation and Entrepreneurial Impact

The SmartSaw demonstrates strong innovation and entrepreneurial potential by offering a compact and cost-effective alternative to conventional cutting machines. By integrating a 12V DC motor and a straightforward crank mechanism into a simplified structure, it achieves high mechanical efficiency while maintaining strict affordability. From an entrepreneurial perspective, the machine addresses a market gap between manual cutting tools and expensive industrial equipment. Its low production cost and scalable design provide opportunities for commercialization, particularly for small-scale users.

6. Potential commercialization

Due to its low production cost which is under RM300, the SmartSaw exhibits promising commercialization potential. Its lightweight, compact structure and clearly identifiable target market further enhance this prospect. The machine can be manufactured using readily available components and standard fabrication techniques, enabling scalable production. With improved cutting efficiency and operational stability, the SmartSaw presents a highly competitive and affordable solution for light-duty cutting applications

7. Acknowledgment

All the authors would like to express their special appreciation to Universiti Teknologi Mara, Johor Branch, Pasir Gudang Campus, for the support and opportunities provided during the study. We are also deeply thankful to the contributors for their assistance and help in all aspects, from proposal preparation to the fabrication of the prototype and manuscript writing.

8. References

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9. Researchers' Biography

Ammar Anaqqy Bin Mohd Zakky is a final-year Diploma in Mechanical Engineering student who developed the SmartSaw motorized cutting machine project as part of his Final Year Project (FYP). He was responsible for the overall design, CAD modeling using SolidWorks, fabrication, assembly, and performance testing of the prototype under Mrs Norjasween supervision. Through this project, he demonstrated strong competency in mechanical design and hands-on fabrication techniques.

Norjasween Abdul Malik is a Lecturer in Mechanical Engineering, Faculty of Mechanical Engineering, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus. She serves as the Final Year Project (FYP) supervisor for innovation based engineering developments, guiding students in translating theoretical concepts into functional prototypes.

Nurul Hanna Mas'aud is a Lecturer in Mechanical Engineering, Faculty of Mechanical Engineering, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus. She expert in manufacturing processes and fabrication techniques. In the SmartSaw project, she contributed technical insights and professional input, particularly in material selection, manufacturing procedures, and fabrication methods.

Mini Vented Laundry Dryer for Compact Living

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ABSTRACT

This project presents an innovative Mini Vented Laundry Dryer for small loads of designed to meet the needs of modern compact living. It tackles the challenges of limited space and high energy consumption in conventional dryers. The prototype features a lightweight aluminum frame, a top mounted fan that channels air over a heating element, and a drum rotated by a 12 V DC motor with a chain sprocket system, ensuring even drying. Its standout features include compact dimensions portability and locking wheels for convenient mobility. With a low fabrication cost, it provides an affordable solution for students, low income households, and limited space residents. Environmentally, the design emphasizes energy efficiency and recyclable materials, minimizing ecological impact. By combining space saving design, low cost, and sustainable operation, this mini dryer offers practical daily benefits while demonstrating strong commercialization potential as a marketable appliance for dormitories, studio apartments, and mobile homes.

Keywords: mini dryer, vented dryer, portable, compact, small load

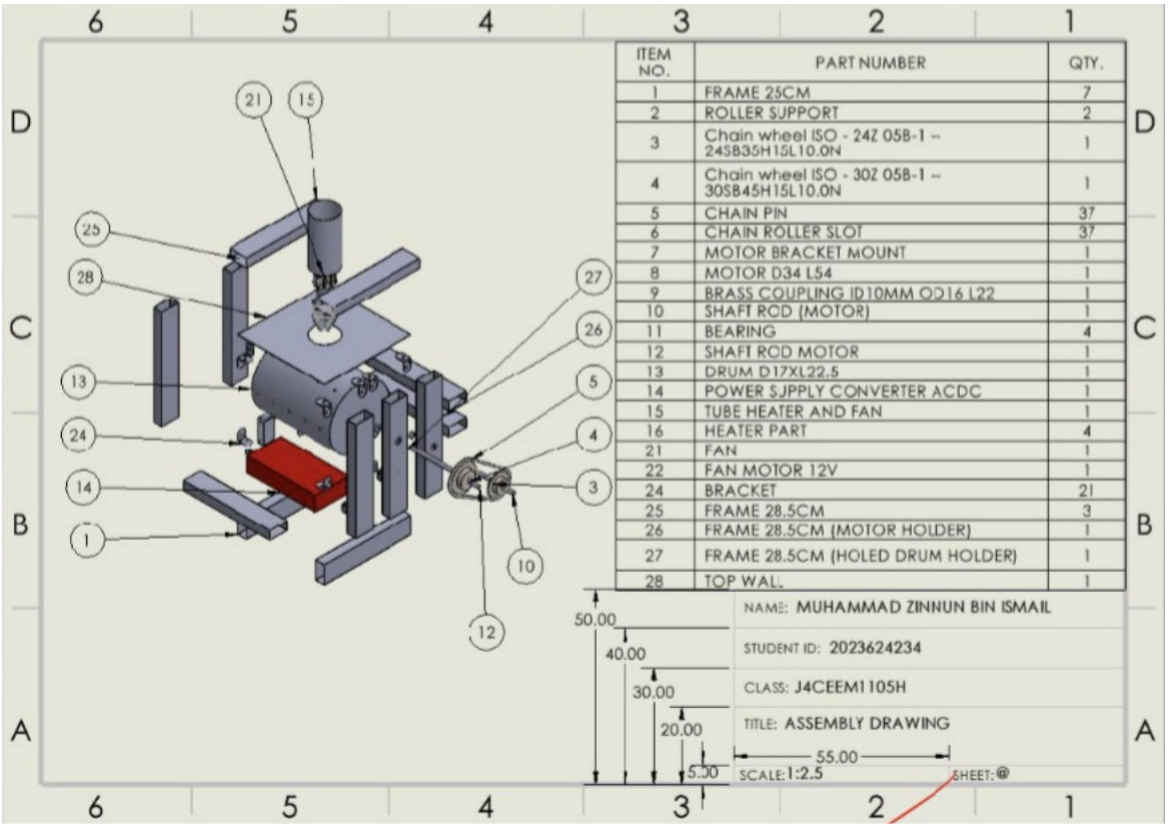
1. Product Description

The product is a compact, vented type laundry dryer designed for small laundry loads of 0.5–1 kg, ideal for dormitories, studio apartments, and other limited space living environments. It measures just 30 cm × 30 cm × 35 cm, has lightweight frame which is fabricated from aluminum (6061-T6) and mild steel, while the internal rotating drum is made of brass to provide excellent thermal conductivity. The dryer operates on a standard 240 V AC power supply and integrates two core mechanisms for efficient drying. A 12 V DC motor, coupled with a roller chain and sprocket system, rotates the drum at 30–50 RPM to ensure uniform heat distribution across all garments. Simultaneously, the vented drying system functions like a hairdryer: a top-mounted fan forces air over a PTC nichrome heating element, directing warm air into the rotating drum to effectively remove moisture. Additional features include a timer relay for automated and safe shut off and locking wheels that provide stability and mobility during operation. This combination of compact design, energy efficient vented drying, and user friendly features make the dryer both practical and versatile, offering a space saving, portable, and reliable solution for everyday small load laundry needs.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

Figure 1 presents the exploded view together with the bill of materials, showing the arrangement of individual parts and their relationship within the overall assembly. **Figure 2** displays the fabricated prototype through isometric and front views, highlighting the main functional elements including the heating unit with integrated fan, brass rotating drum, chain sprocket transmission, and the 12 V DC motor. The figures also indicate the compact dimensions

and mechanical layout of the system, providing a clear visualization of the machine's design and operational configuration.



ITEM NO.	PART NUMBER	QTY.
1	FRAME 25CM	7
2	ROLLER SUPPORT	2
3	Chain wheel ISO - 24Z 05B-1 -- 24SB35H15L10.0N	1
4	Chain wheel ISO - 30Z 05B-1 -- 30SB45H15L10.0N	1
5	CHAIN PIN	37
6	CHAIN ROLLER SLOT	37
7	MOTOR BRACKET MOUNT	1
8	MOTOR D34 L54	1
9	BRASS COUPLING ID10MM OD16 L22	1
10	SHAFT ROD (MOTOR)	1
11	BEARING	4
12	SHAFT ROD MOTOR	1
13	DRUM D17XL22.5	1
14	POWER SUPPLY CONVERTER ACDC	1
15	TUBE HEATER AND FAN	1
16	HEATER PART	4
21	FAN	1
22	FAN MOTOR 12V	1
24	BRACKET	21
25	FRAME 28.5CM	3
26	FRAME 28.5CM (MOTOR HOLDER)	1
27	FRAME 28.5CM (HOLED DRUM HOLDER)	1
28	TOP WALL	1

NAME: MUHAMMAD ZINNUN BIN ISMAIL
STUDENT ID: 2023624234
CLASS: J4CEEM1105H
TITLE: ASSEMBLY DRAWING

Figure 1. Exploded view illustrating component arrangement and corresponding bill of materials.

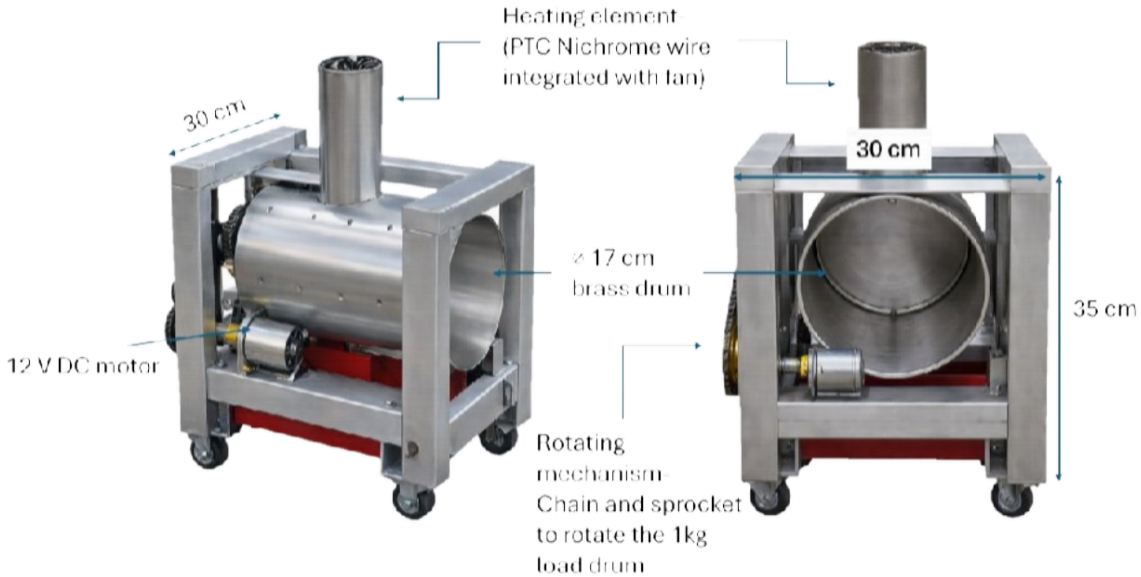


Figure 2. Mini vented laundry dryer isometric (left) and front (right) views.

3. Novelty and uniqueness

The novelty of this product lies in its compact drying system designed specifically for small laundry loads. Instead of simply reducing the size of a conventional dryer, the machine is engineered from the beginning to operate efficiently within a very small structure. The internal airflow, heat distribution, and drum movement are arranged to work together effectively, ensuring proper moisture removal without unnecessary energy loss or complex components. Another unique aspect is its focused heat delivery approach. Heat and airflow are directed precisely into the drying chamber to improve thermal efficiency and reduce wasted energy. The mechanical design is kept simple yet reliable, minimizing maintenance requirements while maintaining consistent performance. The selected materials provide sufficient structural strength while keeping the overall unit lightweight and easy to handle. Lastly, the product fills the gap between traditional air drying and large household dryers by offering a practical, affordable solution for individuals with limited space. Its modular and simple construction also supports future improvements, such as smart control integration or enhanced safety features, increasing its long term innovation potential and commercialization value**.**

4. Benefit to mankind

This project benefits society by providing a practical drying solution for individuals living in space limited environments such as dormitories, rented rooms, and small apartments. It supports students, low income families, and frequent travelers who may not afford or accommodate conventional drying appliances. By reducing dependence on unpredictable weather conditions, it improves daily convenience and hygiene, especially in humid climates where damp clothes may promote odor and microbial growth. The system also contributes to energy conservation by operating at lower power demand compared to standard household units, supporting sustainable living practices. Its affordable construction cost encourages accessibility and potential small scale local manufacturing, which can stimulate micro entrepreneurship and technical skill development. Additionally, the lightweight and recyclable material selection promotes environmentally responsible product design. Overall, this innovation enhances quality of life, promotes resource efficiency, and supports modern compact lifestyles through a safe, accessible, and user oriented drying alternative.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by incorporating simple mechanical transmission, controlled thermal airflow, and vented moisture removal into a compact domestic small capacity drying system. The combination of a low speed drum rotation mechanism, directed heated airflow, and structural analysis using lightweight metal framing demonstrates applied system engineering rather than simple size reduction. Engineering validation through load calculation, stress analysis, and bearing life estimation further elevates the prototype from a conceptual model to a working pre commercial product. From an entrepreneurial standpoint, the clearly defined fabrication cost structure and modular component selection support small scale manufacturing and rapid prototyping application. The reliance on widely available mechanical and electrical components enhances supply chain feasibility and reduces entry barriers for local production. Its compact vented configuration positions it within a niche market that focuses on small load laundry dryer for limited space user thus, allowing different option from readily commercial market. This alignment between validated engineering performance and identifiable market demand fosters technology commercialization, startup

potential, and industry oriented product development culture within the engineering ecosystem.

6. Potential commercialization

The mini vented dryer has strong commercialization potential within the niche market of compact household appliances. It can be positioned as small load drying solution targeting students, single occupants, rental property tenants, caravan users, and budget travelers. It is easy to manufacture because the materials and components are easily available and do not require special equipment or high investment. Commercialization pathways may include student startups, licensing to small appliance manufacturers, or collaboration with local SMEs for assembly and distribution. The product can also be marketed through e-commerce platforms as a space saving and energy conscious alternative to conventional dryers. Future value added versions incorporating moisture sensors, timer optimization, or smart control modules could support product line expansion and brand differentiation. With growing urbanization and reduced living space, this mini vented laundry dryer well with emerging market demand for affordable, portable, and practical domestic appliances.

7. Acknowledgment

The authors acknowledge the support of Universiti Teknologi MARA Johor Branch, Pasir Gudang Campus, in providing necessary resources to complete this project.

8. Researchers' Biography

Muhammad Zinnun Bin Ismail is an undergraduate engineering student with a strong interest in mechanical design and product development, particularly in compact and energy efficient systems. He has demonstrated practical skills in fabrication, assembly, and prototyping through involvement in hands on projects, including the development of a Mini Vented Laundry Dryer. His areas of interest include machine design, thermal systems, and sustainable engineering solutions. Zinnun is motivated to further enhance his technical competencies and contribute to innovative engineering applications that address real world challenges.

Nur Aini Sabrin Binti Manssor is a Senior Lecturer in mechanical engineering with specialization in solid mechanics, composite materials, and biomechanical applications. She has extensive experience in teaching core subjects such as Strength of Materials and Machine Element Design, and actively supervises student projects involving design, analysis, and fabrication. As the supervisor of the Mini Vented Laundry Dryer project, she provided technical guidance in structural design, material selection, and system integration. Her research interests include silicone based biocomposites and the mechanical behaviour of materials, with a focus on developing innovative and sustainable engineering solutions.

Nurrul Amilin Binti Zainal Abidin is a Senior Lecturer in mechanical engineering with expertise in machine design, product development, and applied thermal systems. She is actively involved in teaching and supervising student projects, with a strong emphasis on integrating theoretical principles with practical engineering applications. Her work includes the development of compact and energy efficient systems, reflecting her interest in sustainable and user oriented design solutions. She is committed to advancing engineering education and contributing to research and innovation in mechanical system design and fabrication.

EcoPhytoFloc™: Sustainable Papaya Leaf Bio-Coagulant for High-Efficiency Wastewater Treatment

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[2]School of Chemistry and Environment, Faculty of Applied Sciences, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

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ABSTRACT

Water pollution caused by high turbidity and the accumulation of colloidal particles from residential and industrial discharge remains a critical global challenge. Conventional chemical coagulants, while effective, pose environmental and health concerns due to sludge toxicity and chemical residues. This study introduces EcoPhytoFloc™, an innovative bio-coagulant developed from Carica papaya leaf extract as a sustainable alternative for wastewater treatment. The extract was enhanced through optimized physical processing and chemical activation to maximize its coagulation efficiency. Performance evaluation was conducted using real wastewater samples collected from Taman Tasik Tun Jeanne, Pasir Gudang, Johor, through a series of controlled jar test experiments to determine the optimal dosage, retention time, and agitation speed. Under optimized conditions, the treated papaya leaf bio-coagulant achieved an outstanding turbidity removal efficiency of 96.47%, significantly outperforming the untreated extract (90.36%). Advanced characterization using Fourier Transform Infrared Spectroscopy (FTIR) confirmed the presence of active functional groups (–OH, –COOH, C–O–C) responsible for adsorption and charge neutralization mechanisms. Scanning Electron Microscopy (SEM) analysis revealed enhanced surface morphology and porosity, contributing to superior floc formation and particle aggregation. This innovation demonstrates that papaya leaf biomass—an abundant agricultural waste—can be transformed into a high-performance, low-cost, and environmentally friendly coagulation technology. EcoPhytoFloc™ offers strong potential for scalable application in municipal and industrial wastewater treatment, particularly in developing regions seeking sustainable and circular bioeconomy solutions. Aligned with Sustainable Development Goal (SDG) 6: Clean Water and Sanitation, this green technology presents a viable pathway toward safer water treatment without reliance on hazardous chemical coagulants.

Keywords: EcoPhytoFloc™, coagulation, colloidal, papaya leaf, coagulation

1. Product Description

EcoPhytoFloc™: Product Preparation and experimental evaluations

Conventional chemical coagulants work but at a cost. They are petroleum-based, expensive, and generate toxic sludge that harms the environment. Our innovation is a plant-based bio-coagulant powder derived from papaya leaves (**Figure 1**) which as an abundant agricultural biomass transformed into a high-performance water treatment technology. Under optimized conditions,

our treated extract achieved 96.47% turbidity removal efficiency, proving that nature can outperform synthetic chemicals. This product is biodegradable, low-cost, and environmentally friendly. It reduces chemical dependency, lowers sludge toxicity, and supports sustainable wastewater management — especially in developing regions. We are not just introducing a new coagulant. We are transforming agricultural waste into a powerful green technology. Clean water through natural innovation that is our commitment. The experiment was done using the apparatus as in **Figure 2. Figure 3** showed our evidence morphology of our product which consist a lot of pores area that enhance the ability of water treatment. **Table 1** show the percentage removal of turbidity for dosage parameter.

(a) (b)

Figure 1. (a) Dried Papaya Leaves (b) Papaya Leaves Extract (EcoPhytoFloc™).

Figure 2. Experiment using Jar Test Apparatus and Scanning Electron Microscope.

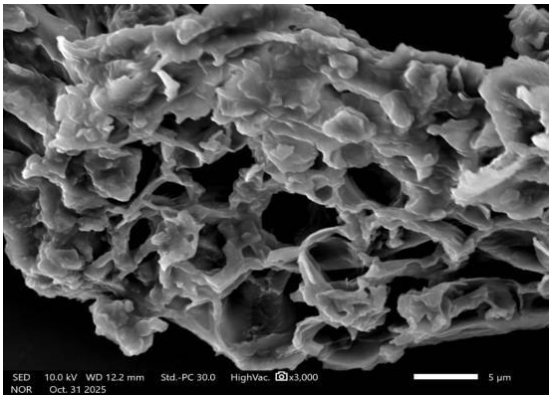


Figure 3. Scanning Electron Microscope image for papaya leaf extracted.

Table 1. Percentage of turbidity removal (%) for dosage parameter.

Weight sample (gram)	pH reading	NTU	Agitation speed (RPM)	Percentage turbidity removal (%)
0.2056	6.20	61.7	45	92.00
0.3058	5.56	129	45	83.40
0.5008	5.26	104	45	86.62
0.8021	4.99	77.6	45	90.01
1.0250	4.84	44.3	45	94.30

2. Novelty and uniqueness

Advanced Treatment of Papaya Leaf Biomass Unlike conventional natural coagulants, this product is not a simple crude extract. The papaya leaves undergo optimized physical processing and chemical activation to enhance active functional groups (–OH, –COOH, C–O–C), significantly improving coagulation efficiency. This treatment increases surface reactivity and floc-forming capability beyond untreated plant extracts.

3. Benefit to mankind

Unlike conventional petroleum-based or synthetic chemical coagulants, this plant-based solution minimizes toxic sludge formation and secondary pollution. It supports safer ecosystems and reduces long-term environmental damage. Agricultural waste (papaya leaves) is transformed into a high-value environmental product. This waste-to-wealth approach reduces biomass disposal issues while generating new economic opportunities.

4. Innovation and Entrepreneurial Impact

Innovation Impact

- Disruptive Green Technology-This product introduces a sustainable alternative to petroleum-based and synthetic chemical coagulants by utilizing papaya leaf biomass as a high-performance bio-coagulant. It challenges the dominance of conventional alum and PAC in water treatment systems.
- Value-Added Agricultural Waste Conversion-The innovation transforms low-value papaya leaves into a commercially viable environmental solution, demonstrating a strong waste-to-wealth model aligned with circular bioeconomy principles.
- Enhanced Functional Performance-Through optimized extraction and activation processes, the product achieves superior turbidity removal efficiency (up to 96.47%), proving that natural materials can compete with industrial chemical treatments.
- Sustainable Process Engineering-The powdered formulation ensures product stability, ease of storage, transportation, and scalability for real-world application in municipal and industrial wastewater systems.

Entrepreneurial Impact

- High Market Demand-The global water and wastewater treatment market is rapidly growing due to stricter environmental regulations and increasing water scarcity. A low-cost, eco-friendly coagulant has strong commercial potential.
- Cost-Competitive Advantage-Locally sourced papaya leaves reduce raw material costs and dependency on imported chemical coagulants, increasing profitability margins and accessibility for developing countries.

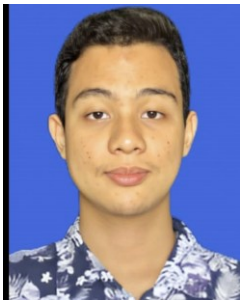
5. Potential commercialization

The global demand for water and wastewater treatment solutions is rapidly increasing due to industrial expansion, urbanization, and stricter environmental regulations. Municipal treatment plants, manufacturing industries, food processing sectors, and rural water systems all require efficient and cost-effective coagulants. This bio-coagulant directly targets a high-demand, recurring-use market, ensuring continuous sales potential

6. Acknowledgment

Faculty of Chemical Engineering, UiTM Cawangan Johor

7. Researchers' Biography



Muhammad Afiq Haiqal Bin Zainun is a Diploma student in Chemical Engineering at UiTM Campus Pasir Gudang, currently conducting experimental research on the application of papaya leaves extract for the removal of colloidal particles in wastewater. His study focuses on developing a low-cost and environmentally friendly natural coagulant as an alternative to conventional chemical treatment methods. Through laboratory-based jar test experiments, he evaluates key parameters such as pH, dosage, mixing speed, and contact time to determine optimum coagulation–flocculation performance. His research integrates water quality analysis techniques including turbidity, TSS, and TDS measurements to determine treatment efficiency. With a strong interest in sustainable water treatment and environmental protection, he aims to contribute practical and locally applicable solutions to improve wastewater management in Malaysia.

Dr. Mohammad Abdullah is a Senior Lecturer and research leader at Universiti Teknologi MARA (UiTM), specializing in water treatment, heavy metal waste treatment, polymer modification and environmental engineering. His expertise on water treatment especially in removing oil spillage at river or ocean using biobased filtration.

Dr. Mohd Lokman Ibrahim is an Associate Professor and research leader at Universiti Teknologi MARA (UiTM), specializing in catalysis, sustainable energy, and hydrogen production technologies. His expertise spans ammonia cracking for hydrogen generation, photocatalysis for environmental remediation, and biodiesel production, with a strong focus on advancing practical clean energy solutions. Recognized for his consistent research impact, he was a recipient of the UiTM Research Excellence Award from 2020 to 2023, reflecting his sustained high-quality publications, successful grant acquisition, and industry collaborations. He has led multiple funded projects, including strategic partnerships with industry, and has produced numerous high-impact journal articles. Beyond research, he has played a significant role in research management and grant strategy at the university level, bridging academic excellence with industry engagement to drive innovation in green and renewable energy technologies.

ThermoQuest: A Gamified Digital Learning Innovation for Thermochemistry in Inorganic Chemistry

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ABSTRACT

ThermoQuest is a gamified digital learning innovation developed using Canva's interactive design features to enhance students' conceptual understanding of thermochemistry in inorganic chemistry courses. It was designed to address students' difficulties in visualizing abstract concepts such as standard enthalpy change, Hess's Law, heat change calculation, Le Chatelier's Principle and calorimeter. The innovation converts these topics into progressive game-based challenges that incorporate problem-solving puzzles with immediate feedback. The main uniqueness of ThermoQuest lies in its low-cost, easily customizable design that does not require advanced programming, enabling educators to create engaging gamified learning experiences using accessible digital tools. Classroom implementation has shown improved student engagement, participation, and formative assessment performance. Beyond improving learning outcomes, ThermoQuest supports Outcome-Based Education (OBE) and promotes digital pedagogical innovation aligned with IR4.0 education. The innovation has strong commercialization potential as a scalable EdTech module for chemistry learning in schools, matriculation programmes, and higher education institutions.

Keywords: Gamified learning, interactive multimedia, digital education innovation, interactive chemistry tool

1. Product Description

ThermoQuest is a digital gamification learning module developed using Canva's interactive presentation framework to enhance students' understanding of thermochemistry concepts. The module is structured into six progressive levels: enhance student's understanding in calorimeter, identifying exothermic and endothermic reactions, understanding standard enthalpy change, solving heat change calculation challenge, reconstructing Hess's Law puzzles, and applying Le Chatelier's principle. Each level is designed to guide students from basic conceptual recognition to higher-level analytical thinking. The system incorporates several interactive features, including clickable navigation, timed challenge, score tracking, and immediate corrective feedback to motivate continuous learning. The module is accessible through QR making it mobile-friendly and easily usable on smartphones, tablets, and laptops. ThermoQuest is designed for diploma and degree chemistry students, matriculation and pre-university learners, STEM foundation programmes, and chemistry educators seeking engaging digital tools to support active learning and conceptual mastery in thermochemistry.

2. Diagrams

Figure 1. ThermoQuest interface features key thermochemistry topics.

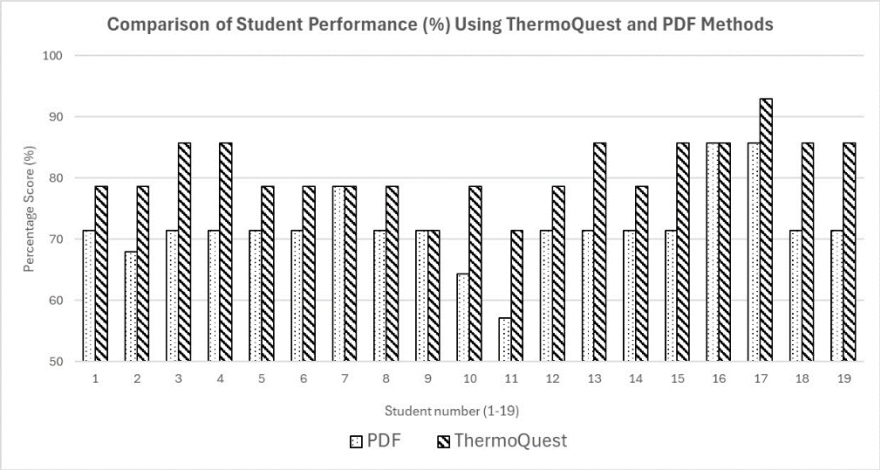

Figure 2. Student performance comparison between ThermoQuest and PDF methods.

ThermoQuest interface designed as an interactive learning platform for thermochemistry topics as illustrated is shown in **Figure 1**. The "Choose Your Card" layout allows students to select specific subtopics, including Calorimeter, Calculation of Heat Change, Standard Enthalpy Change, Hess's Law Calculation, Exothermic vs Endothermic Reactions, and Le Chatelier's Principle. Each card represents a focused learning module that integrates concise notes, guided examples, and interactive problem-solving elements. The colorful and game-based design enhances user engagement, encourages active participation, and supports self-paced learning. This interface aims to improve students' conceptual understanding and motivation in mastering fundamental thermochemistry concepts. **Figure 2** compares individual student performance between two educational approaches, demonstrating that the ThermoQuest method yielded higher or equal percentage scores for 18 out of the 19 students when compared to the traditional PDF method. While the PDF scores largely plateau around 70%, the ThermoQuest data shows a more significant upward trend, with the majority of students surpassing the 80% mark and one individual

reaching a peak performance of approximately 93%. This consistent disparity suggests that the interactive or digital nature of ThermoQuest provides a measurable advantage in learning outcomes over static document-based study.

3. Novelty and uniqueness

ThermoQuest introduces a low-cost, highly accessible gamification model specifically tailored for thermochemistry education. Unlike traditional digital quizzes or static PowerPoint materials, this innovation integrates structured chemical problem-solving into progressive, interactive levels using a creative design platform (Canva) that does not require programming expertise. The system embeds conceptual correction mechanisms by providing immediate explanation-based feedback. Furthermore, the innovation bridges digital creativity with Outcome-Based Education (OBE) mapping, allowing direct alignment with Course Learning Outcomes (CLOs) and Performance Indicators (PIs). Its scalability across chemistry topics makes it adaptable for broader STEM applications. The combination of affordability, ease of replication, pedagogical alignment, and entrepreneurial scalability differentiates ThermoQuest from conventional e-learning tools.

4. Benefit to mankind

ThermoQuest enhances scientific literacy and conceptual understanding in thermochemistry, a fundamental topic underpinning energy systems, materials science, environmental engineering, and industrial chemistry. By reducing misconceptions and increasing engagement in STEM education, the innovation contributes to producing competent future engineers and scientists. The gamified approach lowers learning anxiety, promotes active learning, and improves knowledge retention. Due to its low-cost and platform accessibility, it democratizes access to digital innovation even in resource-limited institutions. The innovation supports quality education, strengthens STEM competency, and promotes digitally inclusive learning environments within the community.

5. Innovation and Entrepreneurial Impact

ThermoQuest promotes innovation by transforming conventional teaching materials into a scalable digital EdTech product. The project encourages lecturers to convert academic content into interactive gamified learning modules while involving students in the co-creation of digital educational tools. This process exposes students to elements of digital entrepreneurship, creativity, and problem-solving beyond traditional classroom learning. The innovation can be expanded into a series of gamified STEM modules covering multiple chemistry topics, creating opportunities for educational product development and institutional branding. By converting intellectual teaching assets into adaptable digital products, ThermoQuest contributes to building an innovation-driven academic ecosystem within the institution. Furthermore, the project opens pathways for commercialization through educator training workshops, institutional licensing, and digital template distribution, positioning the faculty as both knowledge providers and developers of innovative educational technology solutions for the wider education industry.

6. Potential commercialization

ThermoQuest can be commercialized through multiple models:

1. Institutional licensing package
2. Subscription-based LMS integration
3. Educator workshop training modules
4. Downloadable gamification template bundles
5. STEM school toolkit package

Revenue streams may include licensing fees, digital product sales, educator certification workshops, and collaborative partnerships with matriculation colleges and private institutions. With further development (analytics dashboard, AI-adaptive questioning, mobile app expansion), ThermoQuest can evolve into a scalable national STEM gamification platform. The innovation supports university-industry engagement and contributes to building a sustainable EdTech entrepreneurship ecosystem.

7. Acknowledgment

The authors would like to express their sincere appreciation to the Faculty of Chemical Engineering, Universiti Teknologi MARA Johor Branch Pasir Gudang Campus for supporting the development of this educational innovation. Special thanks are also extended to the students who participated in the pilot implementation and provided valuable feedback for improving ThermoQuest.

8. Researchers' Biography

Nur Azmina Asyiqin Norazmi recently completed her Diploma in Chemical Engineering at Universiti Teknologi MARA (UiTM) Johor Branch, Pasir Gudang Campus and is preparing to further her studies at the Degree level. With a specialized focus on thermochemistry and sustainable green chemical processes, she played a key role in developing interactive educational tools for innovation competitions. Her work emphasizes enhancing student engagement through digital pedagogy, aiming to bridge the gap between complex engineering principles and accessible learning solutions.

Dr. Nur Farhana Mohd Yusof is a Senior Lecturer and researcher in Process Systems Engineering, Universiti Teknologi MARA (UiTM) Johor Branch, Pasir Gudang Campus Her research interests focus on artificial pancreas systems and diabetes-related technologies, integrating process control and system modeling to improve healthcare solutions. She is actively involved in STEM education programmes, promoting science and engineering awareness among students and young researchers. Dr. Farhana also collaborates with regional networks in South and East Asia and is engaged with the Neuro Climate Group, contributing to interdisciplinary research and innovation initiatives.

Nurfatin Irdina Binti Sidek is a semester 1 Diploma in Chemical Engineering student at Universiti Teknologi MARA (UiTM) Johor Branch, Pasir Gudang Campus. With a specialized interest in educational technology and multimedia integration, she focuses on interactive learning materials. Her contribution to this project centers on transforming complex engineering concepts into engaging digital content, aiming to bridge the gap between traditional pedagogy and modern student needs through innovative instructional design.

Muhammad Faris bin Riduan is a semester 1 Diploma in Chemical Engineering student at Universiti Teknologi MARA (UiTM) Johor Branch, Pasir Gudang Campus. He is deeply passionate about the intersection of digital learning platforms and creative media, seeking to develop modern solutions that make technical education both effective and enjoyable. His work on this innovation emphasizes the design and functionality of interactive tools, driven by a goal to contribute sustainable and high-impact educational assets to the chemical engineering field.

Fair-EDU-Fuzzy Adaptive Intelligent Rating for Education

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ABSTRACT

FAIR-EDU is a hierarchical fuzzy logic-based student evaluation system designed to facilitate fairer, more adaptable, and comprehensive assessment of student performance. It was created to overcome the constraints of traditional grading systems, which frequently rely on inflexible scoring criteria and may fail to adequately reflect the complexity of student achievement and engagement. The system evaluates students using two primary components, namely Academic Achievement, which includes midterm, final examination, and continuous assessment, and Behavioural Engagement, which includes attendance and activity participation. All of these inputs are run through a multi-layer hierarchical fuzzy inference system before being categorised as Needs Support, Satisfactory, Proficient, or Outstanding. The main uniqueness of FAIR-EDU lies in its ability to combine academic and behavioural indicators within an interpretable fuzzy framework, reducing abrupt boundary effects and enabling a more holistic evaluation outcome. The system can improve educators' decision-making, support early intervention, and enhance transparency in student assessment. FAIR-EDU also offers commercialization potential as a decision-support tool for schools, colleges, and universities through software licensing, customization, and training services.

Keywords: Fuzzy Logic, Hierarchical FIS, Student Evaluation, Decision Support System, Educational Assessment

1. Product Description

FAIR-EDU is an advanced student evaluation system created through a hierarchical fuzzy logic methodology to facilitate fair, adaptable, and honest assessments at educational institutions. The product is designed to address the limitations of traditional grading techniques that rely on inflexible score thresholds and may not accurately reflect students' true performance. FAIR-EDU evaluates students through two integrated components, Academic Achievement and Behavioural Engagement. Academic Achievement considers midterm exams, final exams, and continuous assessment, while Behavioural Engagement considers attendance and participation in activities. These inputs are processed through a multi-layer fuzzy inference structure that produces a final performance rating, namely Needs Support, Satisfactory, Proficient, or Outstanding.

The system allows for smoother transitions between performance levels, reduces abrupt boundary effects, and makes evaluation results more consistent and easier to understand. The FAIR-EDU decision-support tool allows teachers to conduct more comprehensive evaluations and identify students who might need extra help and early support. Additional system flexibility comes from the fact that the criteria, membership functions, and rule base can be adjusted to fit various courses, institutions, and assessment procedures.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

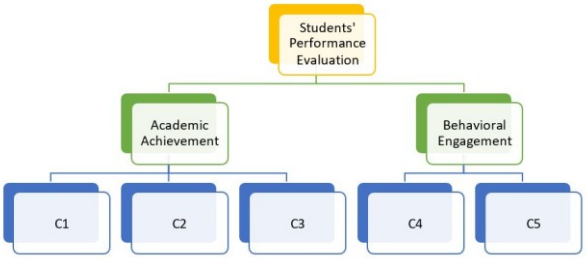

Figure 1. Hierarchical structure of the fuzzy logic system used for student performance evaluation.

Figure 1 illustrates the hierarchical fuzzy logic architecture used in the proposed evaluation system. The model is divided into two subsystems: Academic Achievement and Behavioural Engagement. These subsystems process five evaluation criteria and generate intermediate scores that are combined in the final evaluation layer.

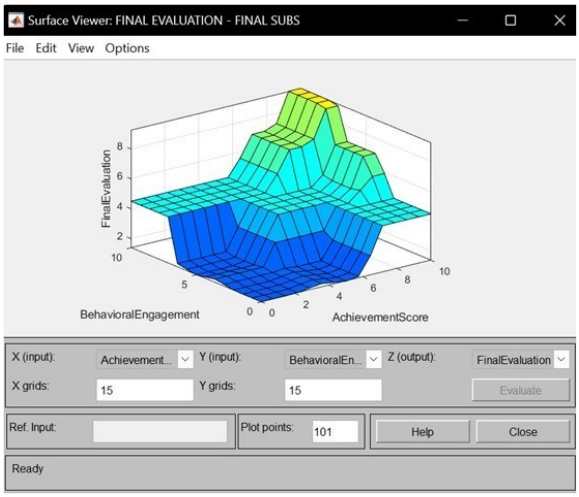

Figure 2. Surface visualization shows the relationship between Academic Achievement, Behavioural Engagement, and the final student evaluation score.

Figure 2 shows the fuzzy surface generated by the MATLAB Fuzzy Logic Designer. The plot demonstrates how the two subsystem outputs interact to produce the final evaluation score, illustrating smooth transitions between performance categories.

Table 1. Final student evaluation scores generated by the hierarchical fuzzy inference system.

Student Evaluation	Score	Ranking
Outstanding	7.94	1
Proficient	4.50	2
Satisfactory	3.21	3
Needs Support	1.38	4

Table 1 presents the final student evaluation scores generated by the hierarchical fuzzy inference system. The results demonstrate how the proposed model classifies student performance into four evaluation categories: Needs Support, Satisfactory, Proficient, and Outstanding. The scores show a clear ranking, with the Outstanding category achieving the highest score and Needs Support the lowest, indicating the system's ability to effectively differentiate performance levels.

3. Novelty and uniqueness

FAIR-EDU offers novelty through a hierarchical fuzzy-logic architecture that evaluates student performance in a more realistic and explainable manner. In contrast to traditional score-based grading, which relies on inflexible cut-off points, FAIR-EDU integrates behavioural engagement with academic accomplishment within a structured, multi-layer decision-making system, which lessens unfair boundary effects and allows for more gradual advancement between performance levels. To improve transparency and reflect how educators typically make judgments in practice, the system first assesses two targeted subsystems and then combines their outputs into a final rating. A key unique strength is its compact hierarchical design, which controls rule growth and makes the model easier to manage, audit, and update for different courses or institutional guidelines. The hierarchical technique yields straightforward, interpretable decisions in the five-criteria situation while reducing complexity compared to a single large rule base. FAIR-EDU also produces qualitative categories that are meaningful for educators and student support planning, namely Needs Support, Satisfactory, Proficient, and Outstanding, making it suitable as a practical decision-support innovation in education.

4. Benefit to mankind

FAIR-EDU benefits mankind by supporting a fairer and more holistic student evaluation process that considers both academic performance and behavioural engagement. This helps educators make better-informed decisions and reduces the risk of unfair judgments caused by rigid score boundaries. By providing clearer performance categories, the system can support early identification of students who need additional academic or behavioural guidance, enabling timely intervention and improved learning outcomes. FAIR-EDU also promotes transparency and consistency in assessment, thereby strengthening trust among students, parents, and institutions. In the long term, better evaluation practices can contribute to more inclusive and supportive learning environments, improved student development, and more efficient educational management. As an adaptable decision-support tool, FAIR-EDU can be applied across different courses and institutions, increasing its potential social impact in the education sector.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by applying computational intelligence techniques in education. The hierarchical fuzzy logic system demonstrates how artificial intelligence methods can improve decision-making processes in academic environments. The system can be integrated into learning management systems (LMS) or educational analytics platforms to support automated performance evaluation. This creates opportunities for developing intelligent educational software that assists teachers and administrators in monitoring student progress. From an entrepreneurial perspective, the proposed model could be developed into a commercial educational decision-support application. Such tools could help schools, universities, and training institutions perform fair and transparent student assessments. The project also encourages interdisciplinary innovation by combining mathematics, artificial intelligence, and educational technology, aligning with the goal of fostering an innovation-driven academic culture.

6. Potential commercialization

The hierarchical fuzzy logic evaluation system demonstrates strong potential for commercialization within the rapidly growing educational technology sector. The proposed model can be integrated into digital learning platforms, student analytics systems, and educational management software to enable automated, intelligent, and data-driven student performance evaluation. As educational institutions increasingly adopt digital tools to enhance teaching quality and monitor academic progress, the demand for transparent, explainable assessment technologies continues to grow. Potential commercialization opportunities include integration into Learning Management Systems (LMS), development of AI-based academic analytics software, decision-support tools for educational administrators, and smart evaluation modules for online learning platforms. Furthermore, the system can be customized for different educational contexts, including schools, universities, and professional training programs. By providing a transparent, flexible, and interpretable evaluation framework, the proposed system can enhance fairness in academic assessment while supporting modern data-driven education systems and the development of future smart learning environments.

7. Acknowledgment

This research has been supported by the Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA (UiTM), Shah Alam, Selangor, Malaysia. The authors would also like to express their sincere appreciation to the lecturer and all group members for their guidance, support, and valuable contributions to the successful completion of FAIR-EDU.

8. Researchers' Biography

Nur Aina Aqiela Mohd Zam is a postgraduate student at Universiti Teknologi MARA (UiTM) specializing in applied mathematics and computational modelling. Her research interests include fuzzy logic systems, mathematical modelling, and intelligent decision-support methods. Her work focuses on applying computational techniques to analyse complex problems and develop innovative solutions for real-world applications. She is particularly interested in the use of fuzzy inference systems for decision-making and performance evaluation in educational and analytical environments.

Siti Nur Aisyah Zainol is a postgraduate student at Universiti Teknologi MARA (UiTM) with academic interests in applied mathematics, fuzzy logic systems, and data-driven modelling. Her work focuses on applying computational techniques and intelligent systems to support decision-making. She is particularly interested in developing fuzzy inference models to analyse complex problems and improve evaluation systems in educational contexts. Through her research, she aims to explore innovative mathematical approaches that can enhance analytical modelling and practical decision-support applications.

Dr. Harliza Mohd Hanif is a Senior Lecturer at Universiti Teknologi MARA (UiTM), Malaysia. Her research expertise lies in fuzzy logic systems, computational intelligence, and mathematical modelling. Her work focuses on developing intelligent decision-support systems and applying fuzzy inference models to solve complex real-world problems. She has supervised numerous undergraduate and postgraduate research projects and contributed to academic publications in the areas of fuzzy systems and intelligent modelling. Her research interests include fuzzy decision-making, artificial intelligence applications, and data-driven modelling for educational and technological systems.

Miss Noratika Nordin is an educator with professional experience in teaching and student assessment. Her interests include educational evaluation methods, classroom engagement, and the integration of technology in learning environments. She contributes valuable practical insights into student behaviour, participation, and performance evaluation, which support the development of fair and effective assessment systems. Her involvement in this project provides real-world perspectives on educational practices and helps ensure that the proposed fuzzy-logic evaluation model aligns with classroom needs and teaching practices.

Daily Emotion Tracker

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ABSTRACT
Daily Emotion Tracker is a mobile application designed as a self-help tool for Vocational College students to track and understand their daily emotions. Despite the critical role of mental health in academic success, many students neglect their emotional well-being due to academic pressure. Developed using the Waterfall Model and React Native framework with Firebase integration, this app allows users to record daily moods such as happiness, sadness, anger, and anxiety through simple icons and brief reflective notes. Its uniqueness lies in its localized approach, featuring a user-friendly interface entirely in Bahasa Melayu to cater specifically to local students who often find existing market apps too complex or language-barring. Key features include visual emotional trend analysis through daily and monthly charts, alongside motivational messages to encourage positive reflection. Socio-economically, the project provides an alternative, non-judgmental support platform for students hesitant to seek formal counseling, potentially reducing long-term mental health risks. With its low-cost development and scalability, the application holds strong commercialization prospects as a standardized psychosocial support system for educational institutions to monitor student well-being.

Keywords: Mobile app, emotion tracking, student well-being

1. Product Description
Daily Emotion Tracker is a specialized mobile application developed as a localized self-help tool to support the mental well-being of Vocational College students. Built using the React Native framework with Firebase integration for robust data management, the application offers a culturally relevant and user-friendly alternative to complex, English-centric mood trackers currently available. The product features a streamlined interface entirely in Bahasa Melayu, allowing students to intuitively record daily emotions such as happiness, sadness, anger, and anxiety, and includes a "Catatan Emosi" (Emotion Notes) function for personal reflection. A key innovation of the app is its built-in visual analytics, which generates daily and monthly statistical charts to help users identify emotional patterns and trends over time. Operating on the Android (8.0+) platform, the application also provides immediate motivational messages upon data entry to encourage emotional resilience. By bridging the gap between digital technology and psychosocial support, the Daily Emotion Tracker serves as a non-judgmental platform for early emotional intervention and self-awareness within the Malaysian educational context.

2. Flow Charts
The mobile application's operational process is illustrated in **Figure 1**. The workflow commences when the user launches the application, as indicated by the 'Start' symbol. Initially, the system

presents a login interface where users are required to enter their registered username and password.

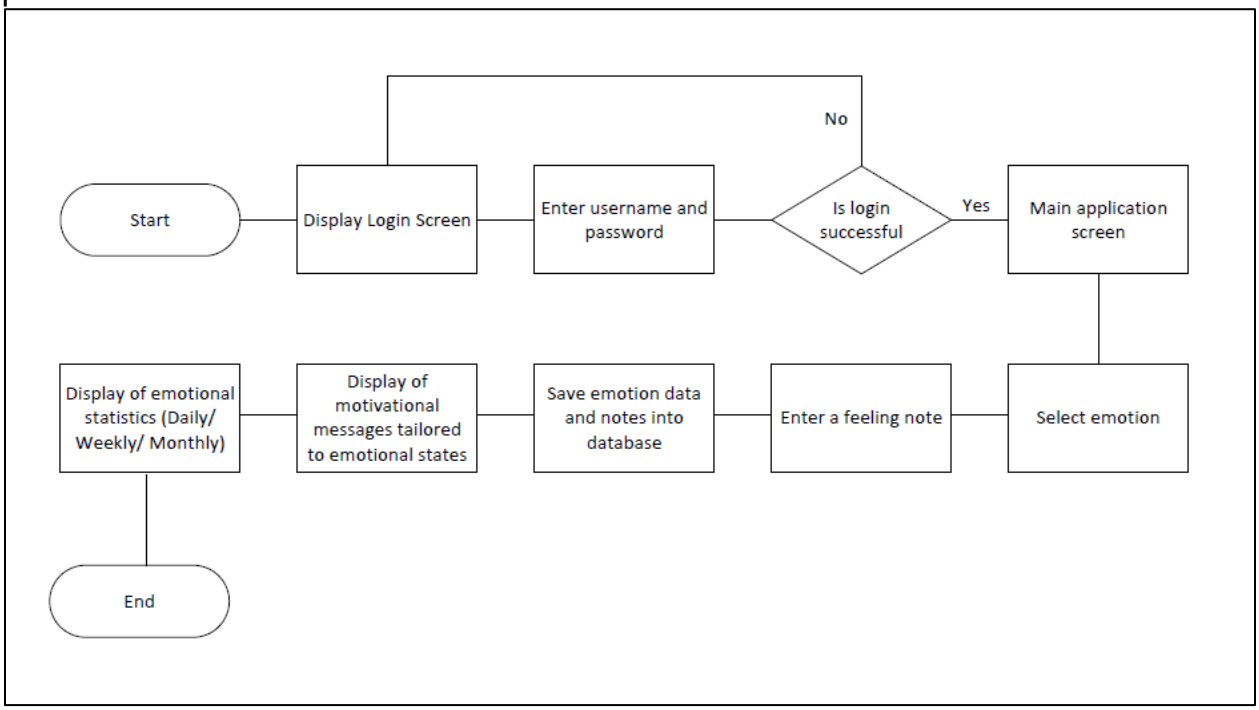

Figure 1. Application Workflow.

The system subsequently validates the login credentials. Upon successful authentication, the user is granted access to the application's main dashboard. Conversely, if the login attempt fails, the user is prompted to re-enter their credentials. Once successfully logged in, users can select their current emotional state, such as happy, sad, angry, or anxious. Following this selection, users can enter reflective notes to provide further details about their emotional condition. All recorded emotional data and notes are securely stored in the database for tracking and analytical purposes. Based on the selected emotion, the system automatically generates and displays a tailored motivational message to provide immediate psychosocial support. Furthermore, users can access an emotional statistics dashboard, which visualizes data trends in daily, weekly, or monthly summaries. These analytics help users identify and understand their emotional patterns over time. The process concludes at the 'End' symbol.

3. Novelty and uniqueness

The novelty of this project lies in its specialized localization and streamlined functionality, specifically tailored for the Malaysian Vocational College ecosystem. Unlike mainstream mood-tracking applications that are often feature-heavy and presented in English, this project offers a culturally and linguistically accessible interface entirely in Bahasa Melayu, removing barriers for local students to engage with mental health tools. A standout innovation is the integration of real-time visual analytics using the React Native framework and Firebase, which transforms raw daily inputs into intuitive line and bar graphs. This allows students to objectively observe their emotional trends such as identifying specific days of high anxiety or happiness and providing a level of self-awareness that traditional journaling cannot offer. Furthermore, the application is uniquely designed as a "digital companion" rather than just a database, offering immediate

motivational feedback and a non-judgmental space for reflection. By combining technical robustness with a deep understanding of the local student demographic, the project fills a critical gap in localized psychosocial support technology.

4. Benefit to mankind

The application offers significant benefits to mankind by democratizing access to mental health monitoring through affordable digital technology. By providing a private, non-judgmental platform for emotional expression, the project helps reduce the social stigma often associated with seeking psychological support, especially among youth. It fosters a culture of self-awareness and emotional intelligence, enabling users to recognize early signs of mental fatigue or chronic stress before they escalate into severe clinical conditions. For the educational community, it serves as a preventive tool that promotes a healthier learning environment, potentially reducing dropout rates and improving overall student quality of life. Ultimately, this innovation contributes to a more resilient society by empowering individuals with the data-driven insights needed to manage their inner well-being, proving that technology can be a compassionate bridge toward better mental health outcomes for all.

5. Innovation and Entrepreneurial Impact

The project promotes innovation by transforming traditional psychological monitoring into a digital-first, data-driven experience tailored for the Malaysian educational landscape. It contributes to a culture of entrepreneurship by demonstrating how localized software solutions can solve niche social problems, encouraging students and educators to view technology as a viable pathway for social enterprise. By utilizing modern frameworks like React Native and Firebase, the project serves as a scalable prototype that could be expanded into a comprehensive institutional well-being management system. This fosters an entrepreneurial mindset within the Kolej Vokasional community, shifting the perspective from being mere technology consumers to becoming creators of high-impact digital products. Furthermore, the application's potential for integration with counseling services presents a unique "Software as a Service" (SaaS) opportunity for educational institutions, driving industry growth in the intersection of EdTech and mental health technology.

6. Potential commercialization

The mobile application presents a robust commercialization framework driven by its unique niche market positioning as a dedicated Bahasa Melayu emotion-tracking tool. Unlike complex global alternatives, its simplified interface is specifically tailored for the localized needs of teenagers and vocational students. The project adopts an Institutional B2B Model, offering educational institutions a standardized psychosocial support tool that enables counselors to monitor well-being trends for early intervention through integrated data visualization. Strategically, the application offers high scalability and diversification, with the potential to expand from the student demographic into corporate employee wellness programs across Android, iOS, and Web platforms. Its monetization strategy utilizes a "Freemium" model, providing core tracking for free while offering premium upgrades such as advanced psychological reports and professional counseling integration. Furthermore, by leveraging low operational overhead through cost-effective cloud solutions like Firebase, the project ensures long-term sustainability and high profitability during its commercial rollout.

7. Acknowledgment

The team would like to express sincere gratitude and appreciation to the Jabatan Teknologi Maklumat, Kolej Vokasional Besut, for providing the necessary facilities, technical guidance, and constant support throughout the development of this project. Finally, a heartfelt thank you to all individuals and parties who have directly or indirectly assisted in making the project a reality.

8. Researchers' Biography

Muhaimin Irfan bin Mohd Saharudin is a Diploma Teknologi Maklumat student at Kolej Vokasional Besut, Terengganu. He is currently a semester 4 student who has just completed one of his courses for the semester, the Final Year Project. In this course, he was required to develop an innovative product to fulfill the curriculum requirements. Following this, he will undergo a 5-month industrial training internship for semester 5 before completing his diploma studies. He aspires to pursue higher studies after graduation.

Zanawati binti Idris is a seasoned IT Educator at Kolej Vokasional Besut with 21 years of experience in technical and vocational education. Specializing in teaching Computer Networking Technology for the SVM program and Information Technology at the Diploma level, she is dedicated to advancing TVET excellence by bridging the gap between academic theory and industry-standard technical skills. Throughout her career, she has been a driving force in TVET excellence, combining her deep technical expertise in network infrastructure with a passion for mentoring students through complex innovation projects and industrial placements.

Wan Asyraf bin Wan Azman is currently pursuing a Foundation in Physical Sciences at Universiti Malaya (UM). While building a rigorous academic foundation in physics, mathematics, and chemistry, he uniquely bridges the gap between pure science and digital innovation through his commitment to mobile application development. Driven by an analytical mindset, he is dedicated to leveraging his scientific background to create functional, user-centric mobile solutions. He aims to integrate physical science principles with modern software development to solve real-world challenges through technology.

STA Boost 2.0: An AI-Powered Gamified Learning Platform for Introduction to Statistics

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ABSTRACT
STA Boost 2.0 is an enhanced digital learning platform developed to improve students' understanding and engagement in the Introduction to Statistics course. The innovation was designed to address common challenges in statistics education, where students often struggle with abstract concepts and limited opportunities for guided learning outside the classroom. STA Boost 2.0 integrates structured lecture notes, gamified learning activities, a calculator guide for statistical computations, and STA Buddy, an Artificial Intelligence (AI)-powered conversational learning assistant developed using Google Gemini. Through STA Buddy, students can interact with statistical concepts, receive simplified explanations, attempt scenario-based questions, and receive immediate feedback to support guided, personalized learning. The integration of AI-guided tutoring, gamified learning, and structured statistical resources within a single mobile-accessible platform is the key distinguishing feature of STA Boost 2.0. The platform promotes active learning, digital literacy, and improved engagement among students studying quantitative subjects. By enhancing accessibility to interactive learning, STA Boost 2.0 supports Sustainable Development Goal (SDG) 4 (Quality Education) and contributes to the development of analytical skills required in data-driven societies. The platform also demonstrates strong commercial potential as a scalable and cost-effective educational technology solution adaptable to other quantitative courses across educational institutions.

Keywords: AI-Powered Learning, Gamified Learning, Guided Learning, Statistics Education, Student Engagement.

1. Product Description
STA Boost 2.0 is an advanced digital learning platform designed to support the teaching and learning of the Introduction to Statistics course. The platform was created to enhance students' understanding of statistical concepts through a mix of structured learning materials, gamified activities, and AI-guided support. STA Boost 2.0 is accessible on mobile devices and web browsers, enabling students to learn flexibly both inside and outside the classroom.

The platform offers structured lecture notes and interactive learning games that reinforce key statistical topics, including statistical terminology, sampling techniques, and data collection methods. The overall user interface and main learning modules of STA Boost 2.0 are shown in **Figure 1**. To further support personalized learning, STA Boost 2.0 introduces STA Buddy, an AI-powered conversational learning assistant that guides students through statistical concepts and provides immediate feedback during learning activities (**Figure 2**). Additionally, the platform features a calculator guide module that helps students perform statistical calculations. This module is enhanced with integrated video tutorials via QSC+ (Quick Scientific Calculator), which provide visual demonstrations of statistical calculations (**Figure 3**). Student feedback collected via Mentimeter reflects positive learning experiences and engagement with the platform, as shown in **Figure 4**.

2. STA Boost 2.0 Application Interface and Key Features

Figure 1. STA Boost 2.0 Application Interface.

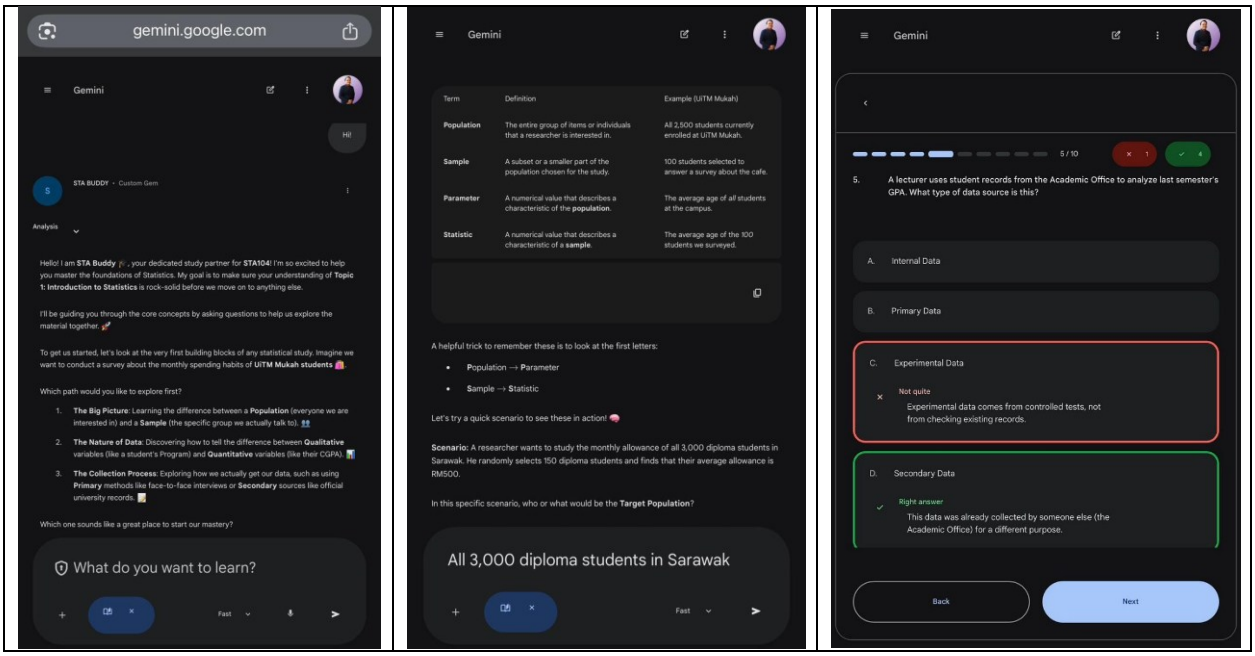

Figure 2. STA Buddy (AI Learning Assistant).

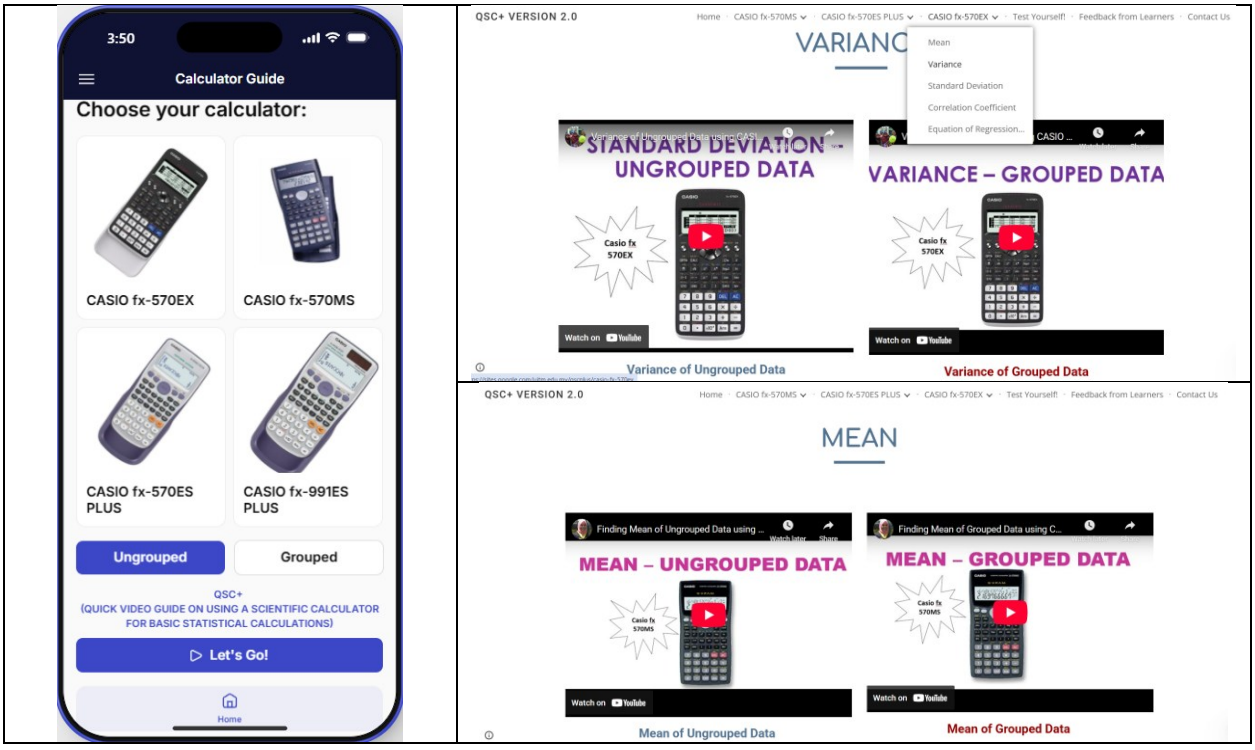

Figure 3. Calculator Guide Enhanced with QSC+.

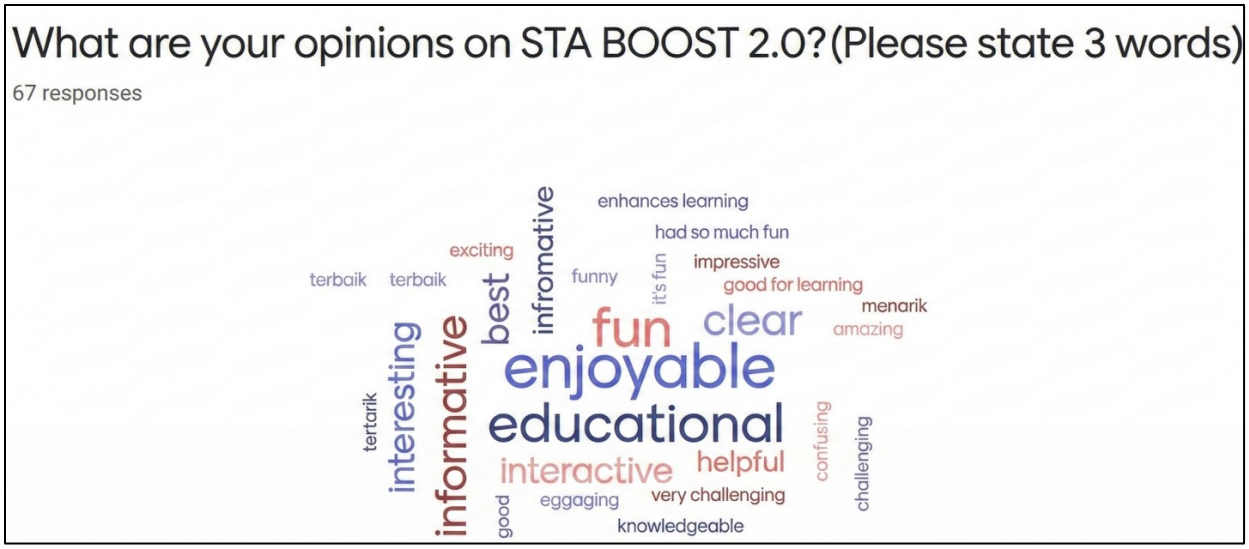

Figure 4. Mentimeter Feedback Results.

3. Novelty and uniqueness

The innovative aspect of STA Boost 2.0 is its combination of AI-guided learning, gamified educational activities, and structured statistical resources within a single digital platform designed specifically for the Introduction to Statistics course. Unlike traditional statistics learning tools that primarily rely on static notes or practice questions, STA Boost 2.0 features STA Buddy, an AI-powered conversational learning assistant built on Google Gemini. STA Buddy acts as a virtual tutor, guiding students through statistical concepts, offering simplified explanations, presenting scenario-based questions, and providing immediate feedback to improve understanding. In addition to AI-guided learning, STA Boost 2.0 retains the gamified features from the original platform to promote active participation through interactive educational games. The platform also offers a calculator guide module that helps students perform statistical calculations such as mean, variance, and standard deviation, enhanced by integrated video tutorials via QSC+. The combination of AI tutoring, gamification, conceptual learning, and computational skill support within a mobile-accessible platform distinguishes STA Boost 2.0 from existing statistics learning tools. This integrated approach transforms passive learning into an engaging, guided, and technology-enhanced learning experience.

4. Benefit to mankind

STA Boost 2.0 helps improve education quality by making statistics more engaging, accessible, and interactive. Many students find it hard to understand statistical concepts because of their abstract nature and the lack of guidance outside the classroom. By incorporating AI-guided tutoring, gamified learning activities, and structured educational resources, STA Boost 2.0 helps students build stronger conceptual understanding and analytical skills. The platform promotes active learning, digital literacy, and independent study, which are vital skills in today's data-driven society. Additionally, STA Boost 2.0 enables educators to enhance their teaching methods by using technology-driven tools that boost student participation and motivation. By supporting inclusive and technology-enabled education, STA Boost 2.0 contributes to SDG4 (Quality Education), fostering the growth of a more knowledgeable, digitally skilled, and analytically capable generation.

5. Innovation and Entrepreneurial Impact

STA Boost 2.0 promotes a culture of innovation by integrating emerging technologies such as AI into educational practices. The development of STA Buddy demonstrates how AI can be used creatively to support guided learning and enhance students' interaction with complex subjects such as statistics. The project encourages educators and students to explore innovative approaches to teaching and learning by combining technology, gamification, and interactive digital tools. Within the academic environment, STA Boost 2.0 fosters collaboration among lecturers, students, and digital learning developers to create practical educational solutions that address real learning challenges. The platform also exposes students to technology-driven learning environments, encouraging them to think creatively and develop problem-solving skills relevant to the digital economy. By transforming traditional teaching approaches into interactive digital learning experiences, STA Boost 2.0 helps build an innovative-driven educational culture and supports the development of entrepreneurial thinking in educational technology.

6. Potential commercialization

STA Boost 2.0 shows strong potential as a scalable digital learning platform for statistics education. Built with accessible digital tools and AI technology, it can be easily adapted and used across various educational institutions. Its modular design allows the system to expand for other quantitative subjects such as mathematics, data analysis, and research methods. The platform can be marketed through institutional licenses, educational technology partnerships, or subscription-based access for universities and training providers. Additionally, the AI-powered STA Buddy feature can be further developed to support multiple subjects and personalized learning environments. With the growing demand for digital learning tools and AI-driven education, STA Boost 2.0 has the potential to become a comprehensive educational technology product that benefits both academic institutions and independent learners seeking interactive and guided learning experiences.

7. Acknowledgment

Special thanks were extended to the Center of Mathematical Sciences, Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Sarawak Branch, Mukah Campus.

8. Researchers' Biography

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Smart Silica Dust Management for Construction and Mining Remote Environment

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ABSTRACT

Societies worldwide continue to experience a rapid industrialization and infrastructure expansion, leading to increased generation of silica dust, a hazardous by-product that causes severe occupational and environmental risks. For example, spatial distribution of heavy metal assessment in beach sediment due to bauxite mining in Kuantan, Pahang, Peninsular Malaysia. Existing solutions only respond after a problem happens, instead of preventing it. This project proposes a solution that detects high-risk silica dust exposure using sensors and automatically activates safety alarms while converting silica dust from waste to 3D-printed feedstock resource. This system uses real-time dust sensors (PM_{10}, PM_{25}, PM_{100}), meteorological parameters, and computer vision at the core AI engine. It prescriptively optimizes the operation of dust collectors, activates targeted suppression strategies, and sends alerts to workers and the surrounding communities. Beyond prevention, the platform introduces a circular valorization pathway by quantifying collected dust, purifying silica-rich fractions, and converting them into 3D printing feedstock for construction applications. A Green Silica Credit (GSC) mechanism incentivizes industry to adapt the system while digitally connecting mining and construction stakeholders. By merging predictive environmental intelligence with resource recovery, the system advances occupational health protection, regulatory compliance, and sustainable material management, positioning silica dust not as industrial waste, but as a waste to wealth material for safer and more circular infrastructure development.

Keywords: Silica dust, dust sensors, dust collector, computer vision, feedstock

1. Product Description

The core idea of the product is an integrated AI-powered predictive monitoring and circular management system for silica dust. The input consists of real time air quality data such as weather conditions (wind speed, humidity), site schedule, visual sited data like live video feeds from site cameras. The process includes a central AI engine that fuses all input data and prescriptive optimization that determines optimal dust capture system settings

and suppression actions. The output consists of sending alerts to occupational workers and communities, a dust capture system to capture dust. The Green Silica Credit (GSC) system is set up to persuade companies to use the product. This digital community system connects mining companies and construction companies in a new way. Another tool is we may get the data of the amount of dust collected to predict the amount of feedstock that can be produced. It needs time to purify, and turns dust into feedstock. The system will connect to the buyer who is not in rush, this can save time. Mining parties collect harmful silica dust during their work. Construction parties can then buy this recycled material at a lower cost and use it for 3D printing in construction.

2. Pictures/ Schematic Diagrams/ Flow Charts/Screenshots/Graphs/ Table and Etc

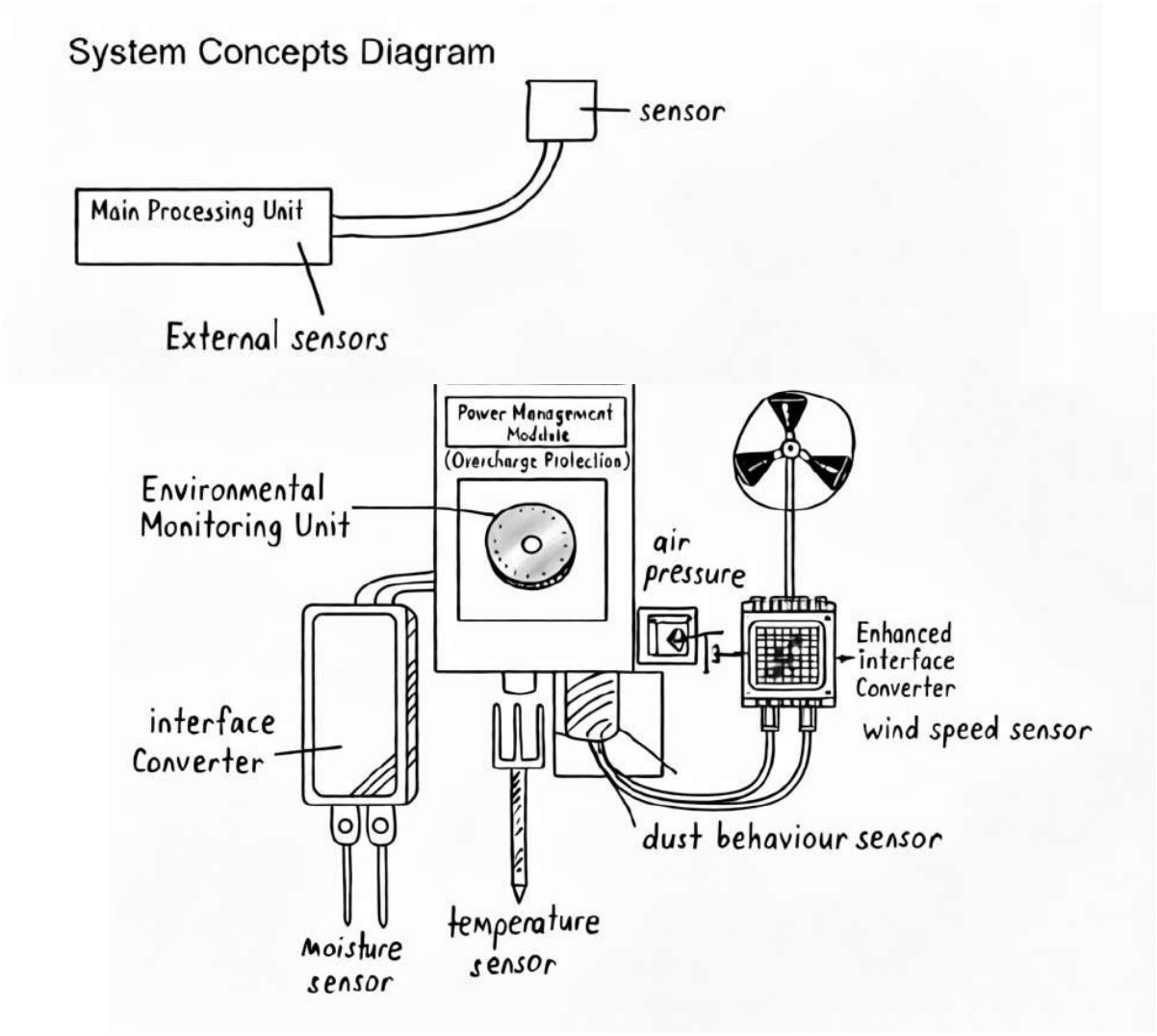

Figure 1. Illustration of sensor mote (Quad module).

Table 1. Aspects that can be detected by sensor.

Aspects	Justification
1) Size ranging	• PM10μm • PM25μm(inhalable, enter bloodstream) • PM100μm (larger particles)
2) Chemicals composition	The dust mixture on a construction site contains many components, occupational exposure limits exist for many substances, but silica has the most stringent, universally enforced standards, thus the product is meant to focus on silica only. Applications wise, Other dust components have limited reuse potential compared to silica
3) Weight of particles (mass per volume)	Weight may affect the concentration of dust
4) Dust Deposition Rate	Same as weight but consider per day, time matters how the sensors works intervally
5) Dust Flux	Dust able to travel past the location site
6) Moisture	Different applications (molding and casting industries) require different levels of moisture
7) Temperature	Temperature may affect structural, purity, density, moisture and thermal conductivity of silica
8) Air pressure	Low pressure will lead to high suspension time of air dust in one location, resulting in higher measured concentrations in that certain location. Oppositely, high pressure leads to underestimation of dust
9) Wind speed	Wind speed affects dispersion of silica dust. Generally, low wind speed lead to higher localised concentrations of silica

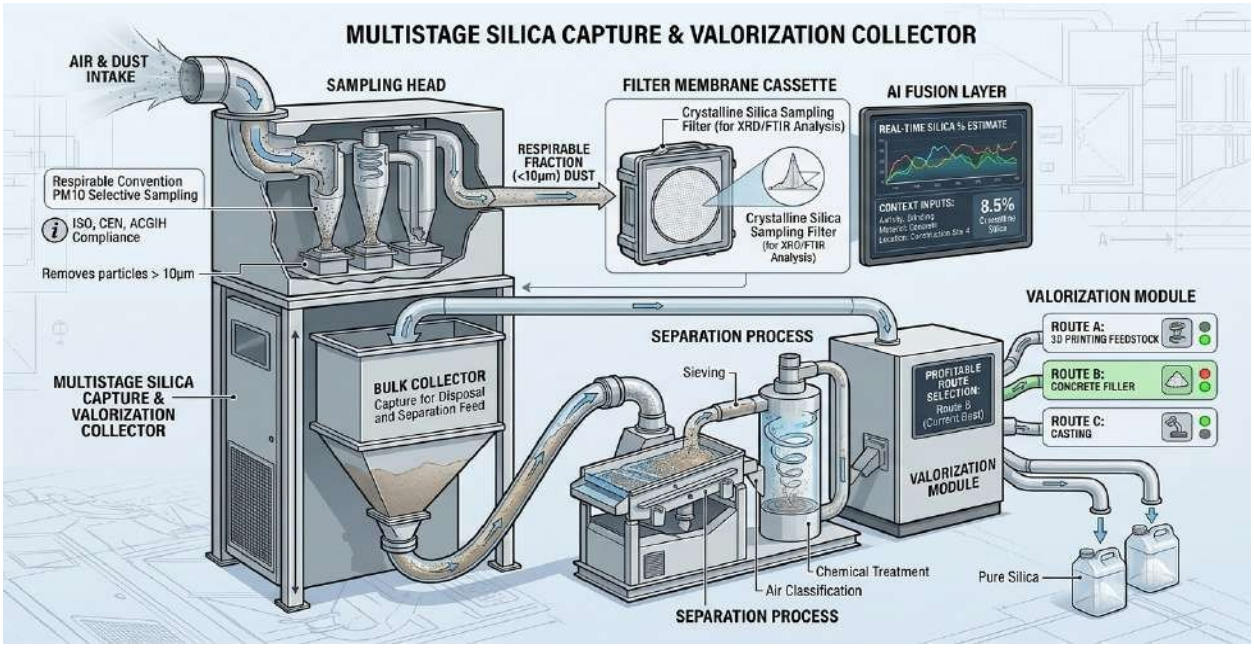

Figure 2. Illustration of dust collector .

Table 2. Component of dust.

Component	Function	Mechanism
1) Sampling Head	Removes particles that is smaller than 10μm	Ensure the dust sample matches silica penetration curve using respirable convention such as ISO, CEN and ACGIH
2) Filter Membrane	Collecting all remaining particles	Analyzed via XRD or FTIR to determine the amount crystalline silica content
3) AI Fusion Layer	Estimate the percentage of silica in dust in real time	Uses context like activity, material, location
4) Bulk Collector	Capture all dusts for disposal	Feeds into separation process such as sieving, air classification, chemical treatment to isolate silica-rich fraction for valorization
5) Valorization Module	Routes purified silica to specific product streams,	Choose profitable routes like 3D printing feedstock, concrete filler, casting based on purity and particle size

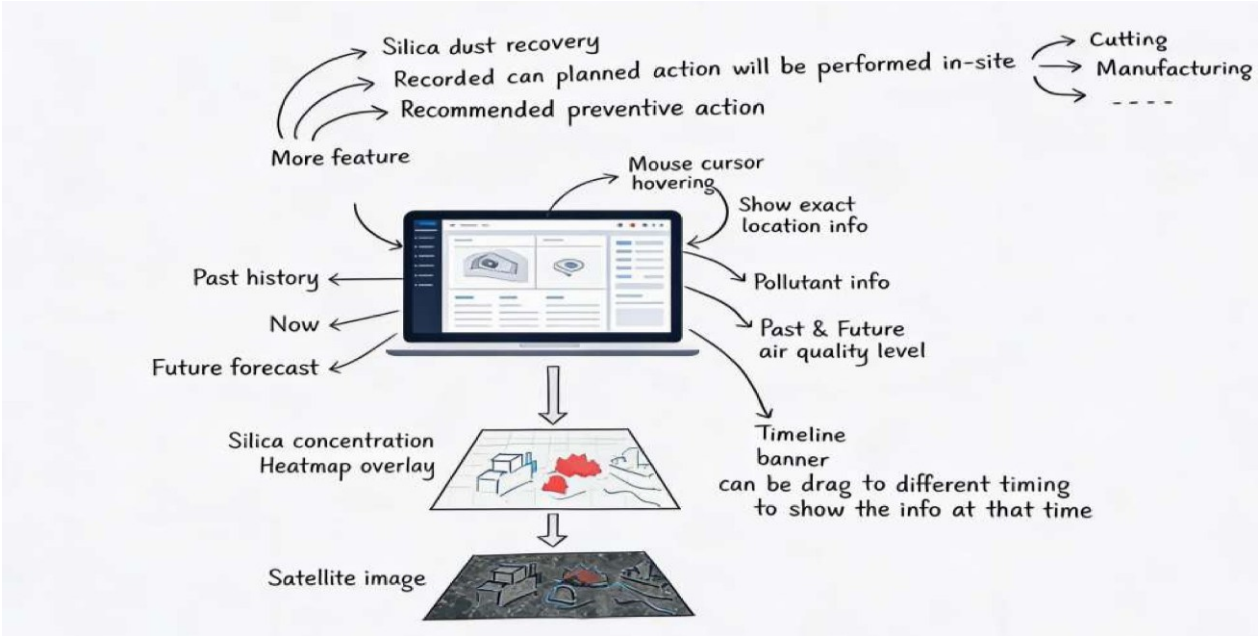

Figure 3. Illustration of user interface.

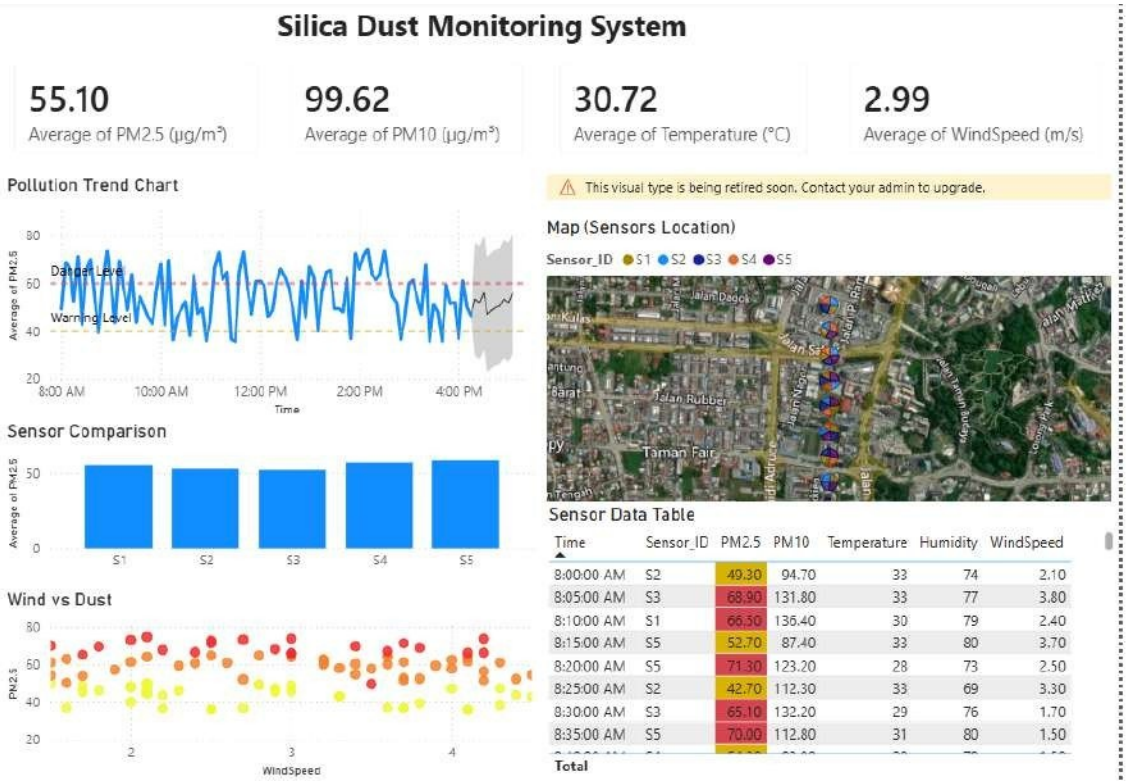

Figure 4. Computer vision & heat maps (Power BI).

The sensors can work intervally
Case 1:24/7, permanently
Case 2; sudden event, the systems requires 'sleeping' Assume Case 2 is chosen

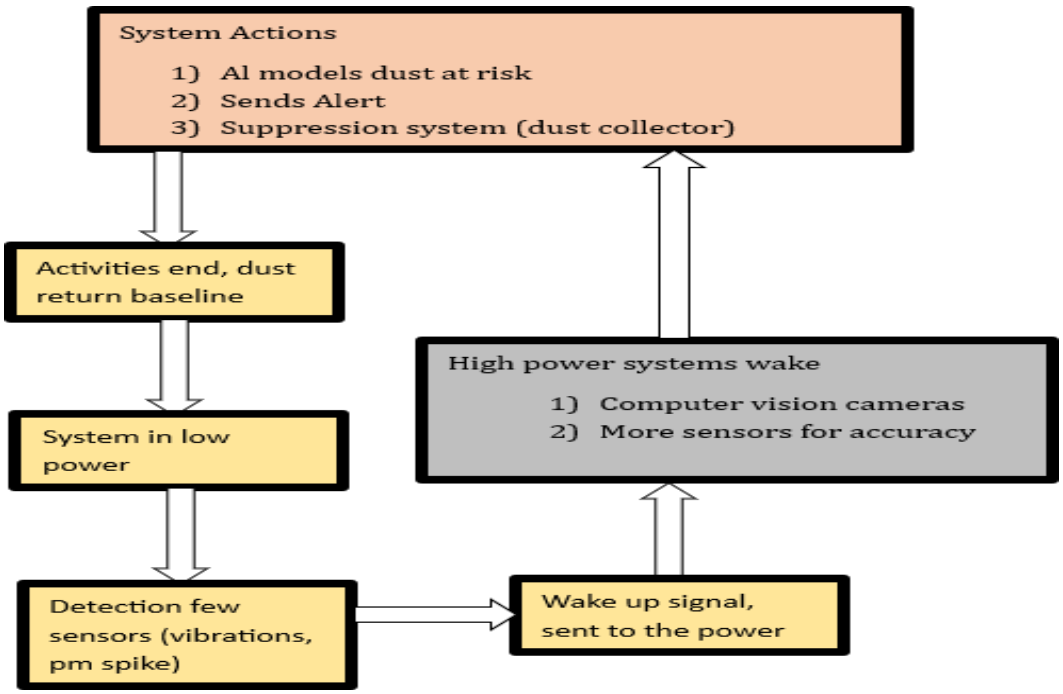

Figure 5. Flowchart of how sensor works.

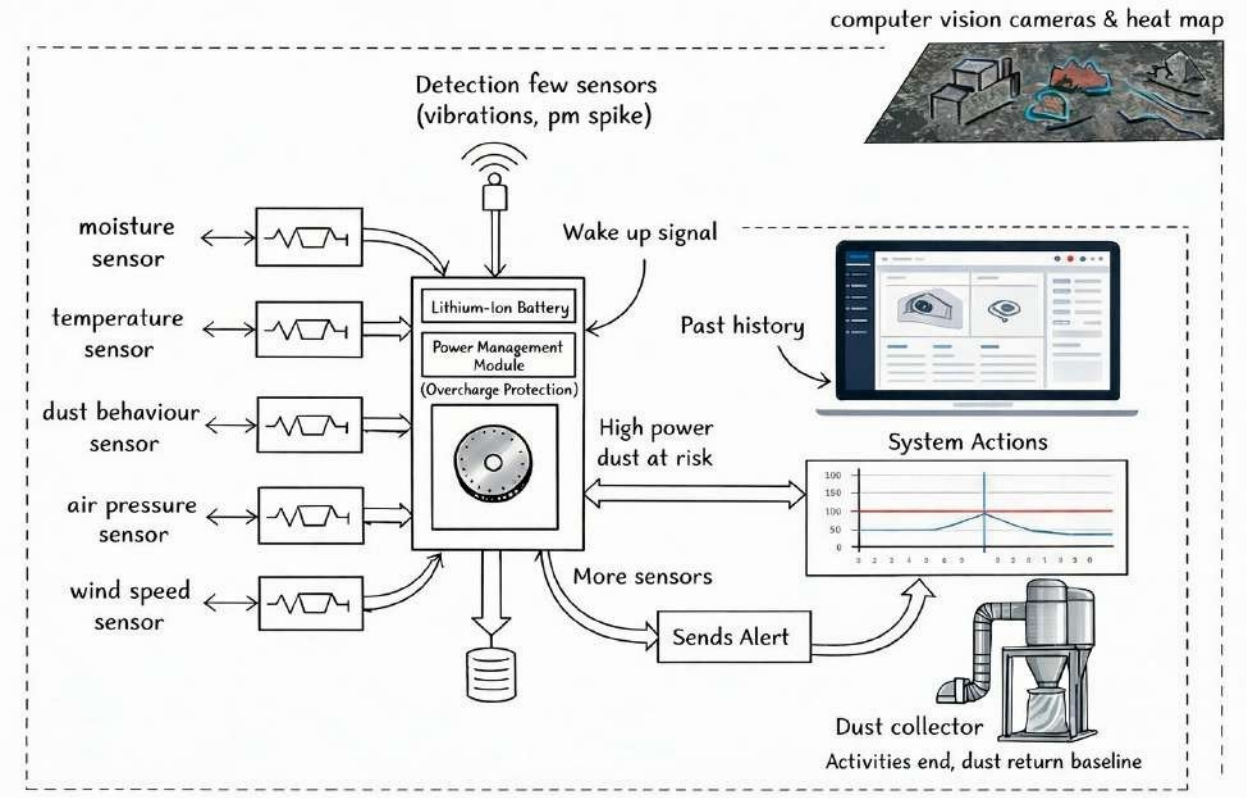

Figure 6. Illustration of how sensor works.

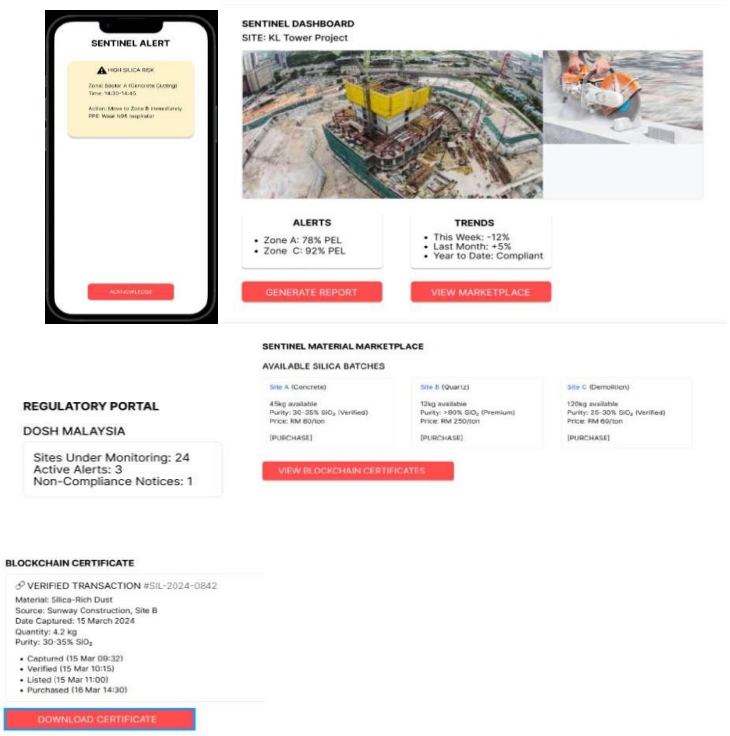

Figure 7. Sentinel App (Figma).

Overall summary of product

1) This dependable sensor network forms the foundation of a comprehensive environmental intelligence platform. Real time data from each sensor is processed locally for immediate worker alerts and suppression activation, ensuring rapid
response even without internet connectivity.
2) Aggregated data is transmitted via Wi-Fi to a cloud-based AI engine, which performs predictive plume forecasting, generates location based silica concentration heat maps, and tracks long term exposure trends analytics.
3) The platform integrates a blockchain verified ledger that quantifies captured silica dust and connects it to a circular material marketplace, transforming a hazardous pollutant into valuable feedstock for construction and 3D printing industries. Stakeholders from site workers to government regulators gain action insights,
making invisible risks visible and enabling a proactive prevention.

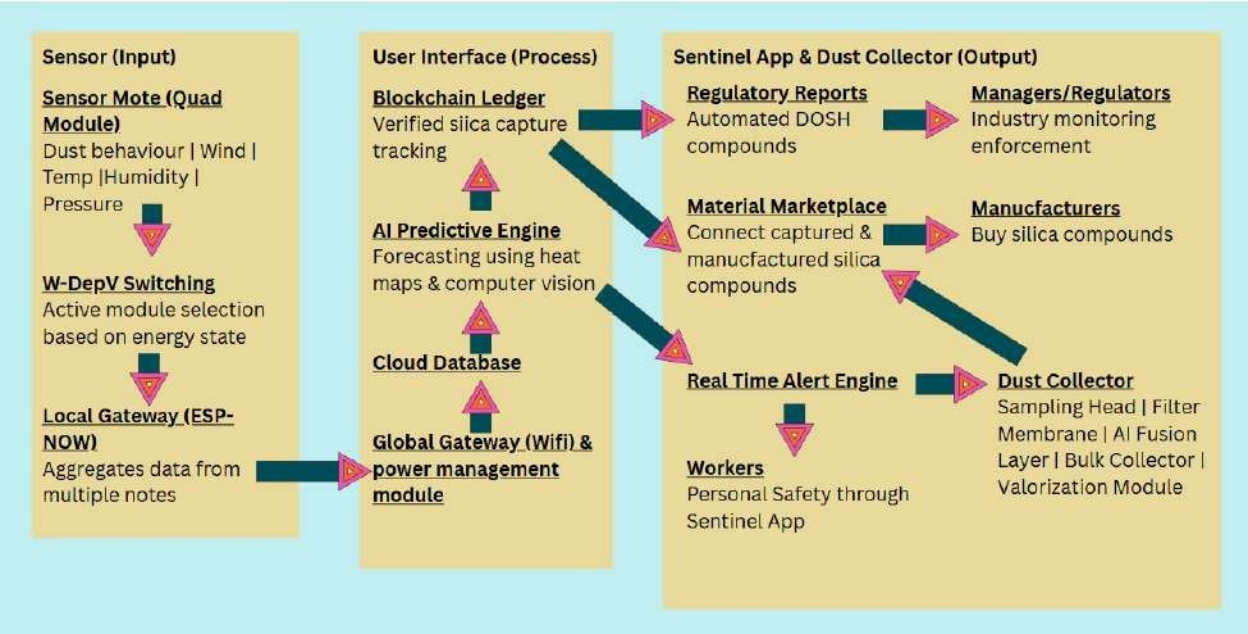

Figure 8. Flowchart of overall system architecture.

3. Novelty and uniqueness

1) **It tackles socioenvironmental market failure** that has been overlooked. Silica dust is a silent killer affecting millions of workers globally. While others apply AI to optimize business processes, this product addresses a critical human issue.
2) **Current solutions are reactive and fragmented.** Real-time monitors exist, but they only report danger after exposure occurs. Computer vision can detect unsafe acts, but it cannot predict where dust will travel. Dust collectors capture waste, but treat it as a liability, not an asset.
3) **It is the first integrated platform with combinations of different fields.** The system fuses IoT sensors, weather data, and computer vision into a predictive AI engine that forecasts exposure before it happens, enabling true prevention.
4) **It optimizes dust capture and valorization.** Through blockchain verified tracking, the platform connects collected material to a circular marketplace, in order to transform a deadly pollutant into valuable 3D printing feedstock and construction materials.
5) **This is not efficient for profit's sake.** It positions AI for protecting the most vulnerable workers while creating economic incentives for widespread adoption.
6) **Health matters economically the most.** Without it, economies deteriorate. The product ensures that foundation is secure, turning a century old killer into a catalyst for sustainable industry.

4. Benefit to mankind

1) Workers
   - Reduces exposure to silica dust by warning workers to obey PPE and then evacuate high-risk zones before suppression system is initiated.
   - Avoid secondary exposure from families by minimising dust carried home from workers skin.
   - SMS or whatsapp messages can alert them
   - Preventing long term respiratory diseases.
2) Manufacturers
   - Silica can be made into many applications such as 3D printing feedstock, concrete construction materials, ceramics & glass , rubber and tire.
   - Materials costs will be reduced since silica is obtained from locally captured waste, as well as ensuring consistent supplement of silica with blockchain-tracked purity and quantity data for quality assurance.
   - Reaching sustainability goals (carbon footprint reduction)
3) Regulators & Managers
   - The ones who responsible for silica control
   - Provides automated, auditable compliance documentation for DOSH or OSHA regulations, eliminating manual paperwork and reducing inspection risk
   - Generates location based silica concentration heat maps to identify high-risk zones and prioritize control measures
   - Tracks long-term exposure trends across sites, enabling data driven policy decisions and enforcement targeting
   - Reduces legal and financial liability by demonstrating proactive duty of care through continuous monitoring and prevention
   - Enables remote oversight of multiple sites via centralized web dashboard, improving resource allocation for safety officers
   - Supports public health monitoring by providing anonymized community exposure data to environmental health agencies

5. Innovation and Entrepreneurial Impact

1) The combination of optical sensing, regulated calibration, and smart activation evidences a pragmatic technological innovation for environmental monitoring.
2) The system supports scalable deployment across construction, mining, and manufacturing sectors where reliable silica dust detection is essential.
3) It reduces operational energy consumption while maintaining high responsiveness, improving overall economic feasibility via event triggered architecture.
4) Entrepreneurial opportunities arise through subscription based environmental monitoring services, regulatory compliance support, and data analytics solutions.
5) The validated calibration mechanism enhances system credibility in regulated industries.
6) The platform framework enables future integration of sustainability and circular material management strategies.

6. Potential commercialization

1) Under Malaysia's Department of Occupational Safety and Health, it is legally required for companies to monitor silica dust exposure.
2) Industries involving construction and demolition, mining and quarrying, as well as manufacturing processes such as cement, ceramics, and glass production, are at risk of facing respirable crystalline silica exposure. These sectors make them the most immediate and commercially viable market.
3) Our product can offer real time risk detection which makes it useful on site.
4) Through integration with a centralized monitoring system, the device can provide advanced analytical features such as location based silica concentration heat maps, historical trend analysis, and automated exposure reporting.
5) The system can provide early warning alerts when exposure levels approach the safety threshold, meeting occupational safety standards and reducing legal and health-related risks for organizations.

7. Acknowledgment

We would like to express my sincere appreciation to our advisor, Dr. Mohamad Sukri bin Mohamad Yusof & his assistant, Muhammad Akmal bin Mohd Faisal for their invaluable guidance, patience, and encouragement throughout this competition. As teammates, we are also grateful to each other for sharing the relevant data for the project with full passion. Special thanks to everyone for their unwavering support for the development of the project.

8. Researchers' Biography

Teoh Jian Xun is a second-year Chemical Engineering student at UTM (Universiti Teknologi Malaysia). Actively engaged in the field, he participates in various community events organized by the IChemE student club and the Institution of Engineers, Malaysia (IEM). His involvement reflects a strong commitment to professional development and community service alongside his academic pursuits.

Leanne Chung Hui Ru is a second-year Chemical Engineering student at UTM (Universiti Teknologi Malaysia) with strong interests in occupational safety, environmental monitoring. She demonstrated strong computational and problem-solving skills by winning Champion in the MATLAB AI Hackathon 2025 organized by MathWorks, applying machine learning techniques and algorithm development to solve engineering challenges.

Hau Teng Hee is a second-year Chemical Engineering student at UTM (Universiti Teknologi Malaysia). Teng Hee has demonstrated leadership through organizing academic and technical programmes, and contributing to collaborative engineering projects. His experience spans across data analysis, automation logic design, renewable energy system proposals, and process modeling. With the initiative to work in the field of AI, environmental safety, and sustainable process engineering, he is actively pursuing his opportunity.

Then Pei Joo is a Year 1 Software Engineering student at Universiti Teknologi Malaysia (UTM) with a growing interest in intelligent systems, environmental monitoring technologies, and AI-driven analytics. Despite being in her early academic stage, she actively participates in hackathons and innovation based competitions, demonstrating strong initiative and problem-solving skills.

Design and Fabrication of Drain Garbage Collector

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ABSTRACT

Effective drainage systems are essential for countries that are most probably facing flood issues every year. Rapid urbanization and increasing waste accumulation have intensified the need for improved drainage maintenance solutions. Currently, drainage cleaning is often performed manually, requiring workers to collect garbage manually, which is labor-intensive, or using a net to trap the garbage which led to clogged drainage, time-consuming and inefficient. Other than that, the major concern is pollution caused by this problem. Therefore, this project aims to design and fabricate an automatic drain garbage collector as a proof of concept to facilitate easier and more efficient drainage cleaning process. The proposed system intended to reduce manual effort while ensuring continuous waste removal to prevent blockages. The design concept was generated using morphological chart to explore various solution. Subsequently, the most suitable concept was selected through Pugh chart evaluation based on predefined criteria such as functionality, cost, safety and feasibility. The finalized design was developed using SolidWorks., incorporating appropriate mechanical mechanism to ensure effective operation. The proposed product is expected to enhance drainage maintenance efficiency, reduce clogging issues and contribute to a cleaner and healthier environment. Overall, this innovation promotes a cleaner, safer, and healthier living environment for communities.

Keywords: Garbage Collector, Drainage System, Urban Flood, Mechanical Design, SolidWorks Modeling

1. Product Description

The prototype of drain garbage collector is a motorized drainage cleaning device designed to remove trash from open drainage system especially in housing area. The product is developed to address pollution and blockage issues caused by accumulated garbage, which often lead to urban flooding and environmental contamination. The stagnant water promotes the breeding of mosquitoes, increasing the risk of diseases such as dengue and malaria. This product is designed to improve drainage maintenance efficiency while minimizing manual labor. The product operates using a motor-driven mechanism that collects floating and trapped waste through a conveyor or lifting mechanism and transfers it into storage container for easy disposal. The structure is compact, durable, portable and suitable for installation in small to medium-sized drainage channels. The design prioritizes safety, cost-effectiveness and ease of maintenance. The development process begins with concept generation using a morphological chart to explore various combinations of mechanisms. Several alternative design concepts were produced, and the best concept is then selected using a Pugh chart. The finalized design was modeled using SolidWorks 2021. Overall, the automatic drainage garbage collector offers a practical and

sustainable solution for maintaining clean drainage systems and promoting a healthier urban environment.

2. Detail Design and Fabrication Process

Figure 1 show the detail process flow for the prototype product. The main process focuses on the concept generation and evaluation, as well as the detail design. With the detail design, it is used as a guideline during the fabrication process. It is important to follow the dimension from the detail drawing for the smooth fabrication process with less waste.

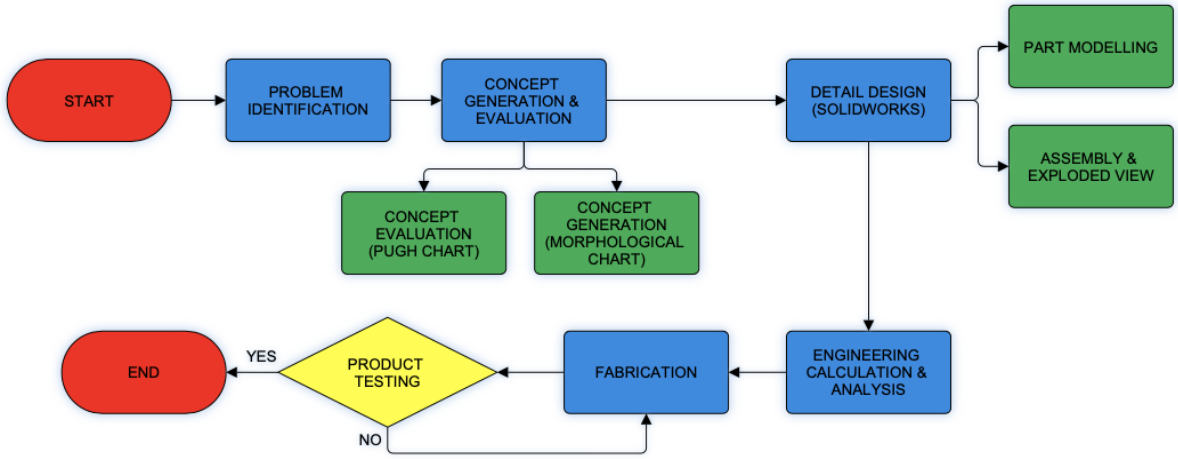

Figure 1. Process Flowchart.

Upon completing the fabrication process, product testing is conducted to make sure that the prototype product functioning well. **Figure 2** shows the final fabrication product. This motorized prototype is functioning well, it can grab the garbage and transfer it to the collector bin.

Figure 2. Prototype of Drain Garbage Collector.

3. Novelty and uniqueness

The automatic garbage collector presents a novel, automated solution tailored specifically for residential U-shape drains, shifting away from traditional, labor-intensive manual cleaning

methods. Its uniqueness lies in its portable, compact, and cost-effective design, making it highly adaptable for small-to-medium open drainage systems compared to existing large-scale and expensive industrial river skimmers. The system uniquely integrates a 12V DC motor-driven, 45-degree inclined PVC conveyor belt equipped with specialized rakes. This active mechanical design efficiently hooks and extracts floating garbage from continuous water flows. This is a significant improvement over passive drainage nets, which rely solely on water pressure and carry the risk of tearing or accidentally trapping animals.
Furthermore, the extracted waste is automatically transported and deposited into a custom-built PVC mesh basket, which effectively retains solid garbage while allowing excess water to drain back into the system. By operating autonomously to prevent blockages, this prototype uniquely mitigates the risks of flash floods, foul odors, and pest breeding, transforming hazardous drain maintenance into a safer, automated, and sustainable process.

4. Benefit to mankind

The Automatic Garbage Collector offers significant benefits to mankind by safeguarding public health and improving the urban environment. By automating the extraction of waste from residential drains, it greatly reduces the need for manual, labor-intensive, and unhygienic cleaning. A primary benefit is the prevention of clogged drainage systems, which directly mitigates the risk of devastating flash floods in residential areas. Furthermore, by ensuring continuous water flow and removing rotting garbage, the system eliminates foul odors and prevents air pollution. Crucially, it eradicates stagnant water pools that serve as breeding grounds for dangerous pests like rats and mosquitoes, thereby reducing the spread of deadly diseases such as dengue fever and malaria. Ultimately, this innovation promotes a cleaner, safer, and healthier living environment for communities while minimizing human effort.

5. Innovation and Entrepreneurial Impact

The Automatic Garbage Collector promotes innovation by transforming the labor-intensive, manual process of drain cleaning into a low-cost, automated mechanical system. Unlike expensive, large-scale industrial river skimmers, this compact prototype is specifically engineered for residential U-shape drains utilizing an affordable 12V DC motor, PVC conveyor, and mesh basket. This accessible approach to waste management fosters a culture of grassroots environmental entrepreneurship. The product empowers housing community committees and local municipalities to adopt scalable, affordable smart-city solutions. By demonstrating that automated waste recovery can be achieved economically, this project encourages future innovators and entrepreneurs to develop localized green technologies that solve pressing urban challenges.

6. Potential commercialization

The Automatic Garbage Collector possesses strong potential for commercialization due to its low production cost and high relevance to everyday urban challenges. This product offers an affordable alternative to expensive, large-scale industrial river skimmers. The primary target market includes housing community committees, local municipalities, and property management companies seeking efficient, automated solutions for open drain maintenance. By significantly reducing the need for manual labor and effectively preventing flash floods and pest-related diseases like dengue fever, the product delivers clear value to consumers and local governments. Its compact design and use of durable, readily available materials like PVC and mild steel make it

highly scalable for mass production, representing a highly marketable and cost-effective tool for modern waste management.

7. Acknowledgment

The author would like to acknowledge Faculty of Mechanical Engineering, Universiti Teknologi MARA, Johor Branch Pasir Gudang Campus for providing the facility to carry out the fabrication process of the prototype. The author would also like to express their gratitude to everyone who have either directly or indirectly assisted in the completion of the study.

8. Researchers' Biography

Raja Azizul Hadi Raja Muhammad Izatulhairi is a Diploma in Mechanical Engineering graduate from the College of Engineering, Universiti Teknologi MARA (UiTM), Johor Branch, Pasir Gudang Campus. His academic focus involves mechanical design, fabrication processes, and sustainable engineering. He is the principal developer of the Automatic Garbage Collector prototype; a project aimed at automating drainage maintenance to mitigate urban flash floods and pest breeding. His work demonstrates a dedication to applying mechanical engineering principles to solve real-world environmental and public health challenges

Nurul Hanna Mas'aud joined UiTM in November 2015 as a Mechanical Engineering Lecturer in the Faculty of Mechanical Engineering. She obtained her Diploma in 2007, bachelor's degree in 2010 and Master of Science in 2015 all major in Mechanical Engineering from Universiti Teknologi MARA (UiTM). Specializing in ergonomics, Manufacturing, Industrial Engineering, and Engineering Design. With over 10 years of experience, her work bridges academia and industry, focusing on mentoring students to create innovative, practical designs that address infrastructure issues and promote sustainability.

Norjasween Abdul Malik is affiliated with the Faculty of Mechanical Engineering at Universiti Teknologi MARA (UiTM), Johor Branch, Pasir Gudang Campus. As a co-researcher on the drainage garbage collector project, she contributes to the advancement of sustainable and practical engineering solutions. Her collaborative research focuses on addressing environmental challenges through mechanical design and innovation, specifically aiming to improve urban infrastructure, enhance waste management, and reduce flood risks in local communities.

Remote-Controlled Moving Sprayer

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ABSTRACT

Farmers in Malaysia face challenges in fertilizing crops due to labour-intensive work, high labour costs, health risks from chemical exposure, and fatigue-related mistakes that reduce yields. Mechanized options like tractor sprayers are costly to maintain, use fuel, and can compact soil, harming crop growth. The solution to this problem is to have a lightweight machine that does not require the user to physically maintain the well-being of plants at the area. The objective of this prototype is to design and fabricate a functional, controllable moving sprayer capable of spraying fertilizers onto plants. The methods used to design this prototype are by using SolidWorks and simulation software, and the fabrication was done following the design process flow step by step, such as cutting, drilling, welding, and assembly using suitable materials that were analysed. The outcome of this prototype is that the sprayer could be remotely controlled by an operator while maintaining staff well-being. This remote-controlled moving sprayer could benefit mankind by improving safety, efficiency, and accessibility in liquid application tasks as spraying remotely can reduce direct human exposure to potentially harmful chemicals such as pesticides, disinfectants, or cleaning agents. This product can benefit its users as it minimizes human contact and improves occupational health and safety.

Keywords: Fertilizing crops, sprayer, fabrication

1. Product Description

The objective of this product is to deliver a liquid spray with mobility and can be controlled with a remote control. The product was developed using SolidWorks and designed and fabricated using the equipment available in the Faculty of Mechanical Engineering, UiTM Pasir Gudang. This product is installed with a high-pressure pump to deliver the liquid. Experimental results show the spray produced has a mass flow rate of 0.142 kg/m³ and a volumetric flow rate of 1.42×10^{-4} m³/s. The predicted discharge closely matched the observed depletion rate of the one-liter reservoir. The product has adjustable nozzles, making the sprayer highly flexible. The nozzle's outlet size can be varied and oriented both vertically and horizontally. By rotating the nozzle tip, users can modify the spray pattern through changes in the outlet opening, like adjusting a faucet. Users can increase or decrease the fluid pressure by restricting or opening the tip of the nozzle and changing the pressure length and spray pattern.

2. Prototype Development

Methodology

First, all the raw materials were measured carefully and marked. This is to ensure that the parts will fit properly during assembly. Mild steel components for the chassis were measured with tape measures and marked before cutting and welding into the frame. Drill points were also marked to allow secure fastening to the wooden platform. The wooden board was measured according to the chassis dimensions. Precision tools such as calipers were used for custom mechanical linkage parts to maintain accuracy and compatibility with motor-driven components. Fabrication processes were done with strict safety precautions. Mild steel was cut using a saw blade cutter, wooden board with a bandsaw, and small custom parts with a hand cutter as shown in **Figure 1**. Drilling and threading were performed to match bolt specifications. Bending of small steering components were done using a bending machine as in **Figure 2**. The chassis frame was then joined using SMAW welding as shown in **Figure 2**. Finally, all parts were assembled as shown in **Figure 3**. The wooden platform was bolted to the chassis. Wheels and electronics were installed. The fluid system, which is the tank, pump, piping, and adjustable nozzle, were installed and connected to a remote-control transmitter.

Figure 1. Cutting process using saw blade, band saw and hand cutter.

Figure 2. Drilling and welding process.

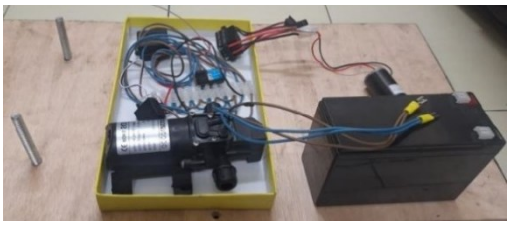

Figure 3. Assembly Process.

Final Prototype

The final prototype is as shown in **Figure 4** and **Figure 5**. **Figure 4** shows the sideview of the prototype while **Figure 5** shows the top view. From **Figure 4** and **Figure 5**, the prototype

features a moving chassis with a mounted nozzle attached at the top of the cylinder. The fluid supply is transferred using a 12V pump which has 0.9Mpa of pressure applied on the fluid. The pump can be activated using a remote switch to turn on/off the pump. The amount of fluid it can currently carry is 1 Littre with a volume flow rate of 1.42×10-4 m3/s coming out of the nozzle. The rear motor is powered using the same 12V battery for the pump connected with a belt to the rear shaft to make the rear wheels spin can make 4000 rpm. The front shaft is able to change direction when the support rod moves left or right. The front shaft is supposed to be powered by a servo motor which can rotate 180° and change a circular motion to linear motion via a rod connecting the supporting rod.

Figure 4. Side view of prototype

Figure 5. Top view of prototype.

3. Novelty and uniqueness

This product is novel and unique as it combines a high-pressure spraying system with a remote-controlled mobile platform and low-cost. Compared with traditional sprayers, this prototype has mobility, wireless control, and an adjustable nozzle. This product is suitable for a small scale agriculture for a close-range application.

4. Benefit to mankind

This remote-controlled moving sprayer benefits mankind by improving safety, efficiency, and accessibility in liquid application tasks. By allowing users to operate the sprayer remotely, it reduces direct human exposure to potentially harmful chemicals such as pesticides, disinfectants, or cleaning agents. This product can benefit its users as it minimizes human contact and improves occupational health and safety. The prototype will also promote more efficient and targeted spraying. This will lead to reduce chemical waste, lower operational costs, and minimize environmental impact. Due to its low-cost and modular design this makes the prototype accessible for small farms, educational institutions, and places that may not afford large, automated equipment.

5. Innovation and Entrepreneurial Impact

From an entrepreneurial perspective, the product has strong commercialization potential in agriculture, sanitation, landscaping, and facility maintenance markets, especially in cost-sensitive regions. The system could enable small startups or student ventures to enter the agricultural field and cleaning sectors with relatively low manufacturing costs. With further refinement in mobility, durability, and user interface, the concept could evolve into a scalable product line that supports

precision agriculture, reduces labor dependence, and opens opportunities for localized manufacturing and service-based business models.

6. Potential commercialization

The remote-controlled moving sprayer shows strong commercialization potential, particularly in cost-sensitive markets such as small-scale agriculture, greenhouse farming, sanitation services, landscaping, and facility maintenance. The product's overall low-cost material and fabrication will make it suitable for mass production. With further refinement, such as higher-torque drive motors, lighter chassis materials, improved sealing, and enhanced durability, the product could be an affordable alternative to expensive automated spraying systems.

7. Acknowledgment

The author would like to express sincere gratitude to the Faculty of Mechanical Engineering, UiTM Pasir Gudang for providing the necessary facilities, workshop access, technical resources, and guidance throughout the completion of this work.

8. Researchers' Biography

Mohammad Adrian Hidayat Bin Azlan@Adi is a student at the Universiti Teknologi MARA (UiTM) Pasir Gudang, he is the inventor and designer of the Remote-Controlled Moving Sprayer Prototype. He took a Diploma in Mechanical Engineering in the mentioned university and his prototype has earned the Best Prototype Award during the annual Mechanical Engineering Day as a requirement for the core subject of Final Year Project 2. He is currently undergoing internship in PETRONAS to fully complete his Diploma.

Ir. Dr. Ab Aziz Mohd Yusof received his bachelor's degree in Mechanical engineering from Universiti Teknologi Malaysia, UTM (Malaysia), in 2010 and Ph.D. in Biomedical engineering in 2017 from Universiti Teknologi Malaysia, UTM (Malaysia). He is a senior lecturer at the Faculty of Mechanical Engineering, UiTM Pasir Gudang. His research interests are computational study, sports engineering, engineering design, and manufacturing.

Dr. Kamariah binti Md Isa is a Senior Lecturer at Universiti Teknologi MARA (UiTM) Pasir Gudang, recognized for her contributions to engineering education and applied research. Her research interests include computational fluid dynamics (CFD), coal gasification, multiphase flow, and thermal-fluid systems, with a focus on improving energy efficiency and process performance. She actively supervises student projects and promotes innovation-driven learning in product and system design.

IoT-Based Smart Burn-in Monitoring System with AI-Driven Predictive Safety

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ABSTRACT
The IoT-Based Smart Burn-In Monitoring System with AI-Driven Predictive Safety is developed to improve reliability testing and safety monitoring during electronic component burn-in processes. Conventional burn-in systems typically rely on manual supervision and basic threshold alarms, which may lead to undetected overheating, equipment failure, and safety hazards during long testing cycles. To address these limitations, the proposed system integrates IoT-based sensors with predictive analytics to enable real-time monitoring, automated alerts, and early fault detection. The system combines temperature, current, and humidity sensors with cloud-based data logging and a supervised machine learning model to predict expected heater current behaviour and identify abnormal electrical patterns before critical damage occurs. Key features include remote monitoring through an IoT dashboard, predictive safety alerts, and continuous data logging for analysis and traceability. By detecting anomalies at an early stage, the system reduces equipment downtime, prevents costly burn-in failures, and improves operational reliability. This contributes to higher productivity and efficiency in semiconductor manufacturing processes while enhancing workplace safety and supporting the adoption of Industry 4.0 technologies.

Keywords: IoT Monitoring, Burn-In Testing, Predictive Safety, Machine Learning, Anomaly Detection.

1. Product Description
The IoT-Based Smart Burn-In Monitoring System with AI-Driven Predictive Safety is developed as an intelligent monitoring and safety improvement system for a simulated burn-in environment. Unlike conventional burn-in ovens that operate as isolated systems with basic threshold alarms, this system provides real-time visibility, historical data logging, and predictive electrical safety without modifying existing heater control mechanisms. The system integrates dual DS18B20 temperature sensors, ACS712 current sensors with ADS1115 ADC, and a DHT11 humidity sensor connected to a Raspberry Pi 3 Model B+. It continuously acquires environmental and electrical data, transmits readings to the Blynk IoT dashboard for remote monitoring, and logs all parameters to Google Sheets for traceability and analysis. A supervised machine learning model based on Linear Regression is embedded within the Raspberry Pi to predict expected heater current behaviour using temperature, humidity, and previous current readings. By comparing predicted and actual current values, the system detects abnormal electrical patterns such as sudden current spikes, heater degradation, or relay malfunction before critical damage occurs.

When unsafe conditions are identified, the system automatically deactivates the relays to shut down the heaters and sends alert notifications. This intelligent monitoring approach enhances burn-in reliability, improves safety, and supports data-driven predictive maintenance practices.

2. System Architecture and Implementation.

Overall System Architecture

Figure 1 illustrates the overall system architecture of the IoT-Based Smart Burn-In Monitoring System with AI-Driven Predictive Safety. The system integrates temperature sensors, humidity sensors, and current sensors connected to a Raspberry Pi 3 Model B+. The Raspberry Pi processes the sensor data and performs predictive analysis using a Linear Regression model to estimate expected heater current behaviour. The processed data is then transmitted to the Blynk IoT platform for real-time monitoring and to Google Sheets for cloud-based data logging and traceability.

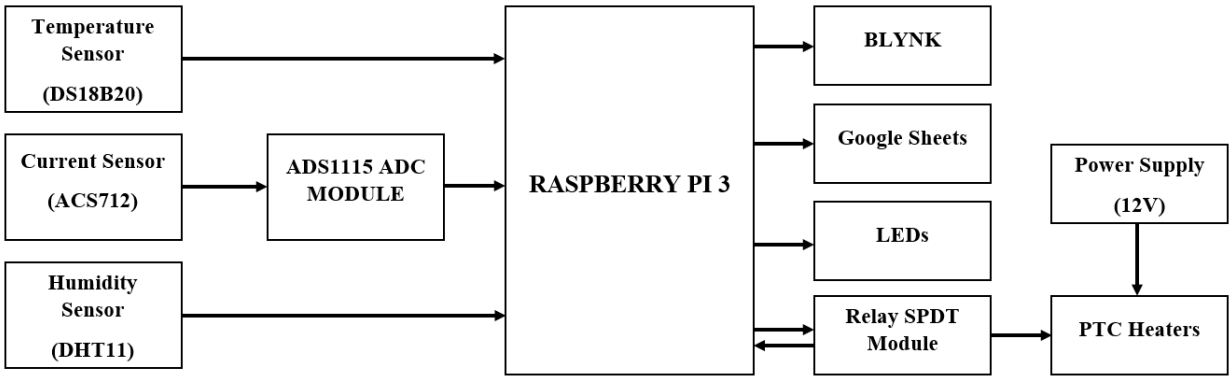


Figure 1. Block Diagram.

System Operation Flow

The operational workflow of the monitoring system is illustrated in **Figure 2.** The process begins with sensor initialization followed by continuous acquisition of temperature, humidity, and heater current data. The collected data is then analyzed using a Linear Regression prediction model to estimate the expected heater current. The system compares predicted and actual current values to detect abnormal electrical behaviour. When abnormal conditions are detected, the system triggers warning notifications and automatically deactivates the heater relays to prevent unsafe conditions.

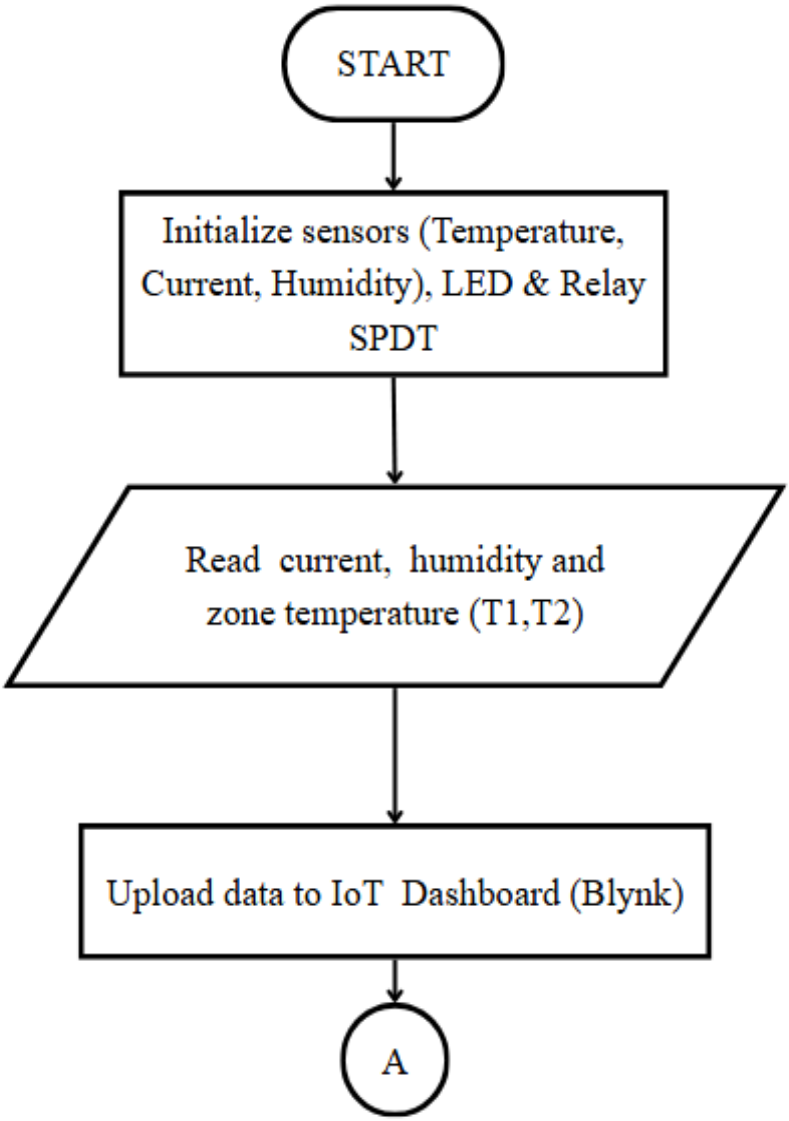


Figure 2(a). Flowchart of IoT-Based Smart Burn-In Monitoring System with AI-Driven Predictive Safety.

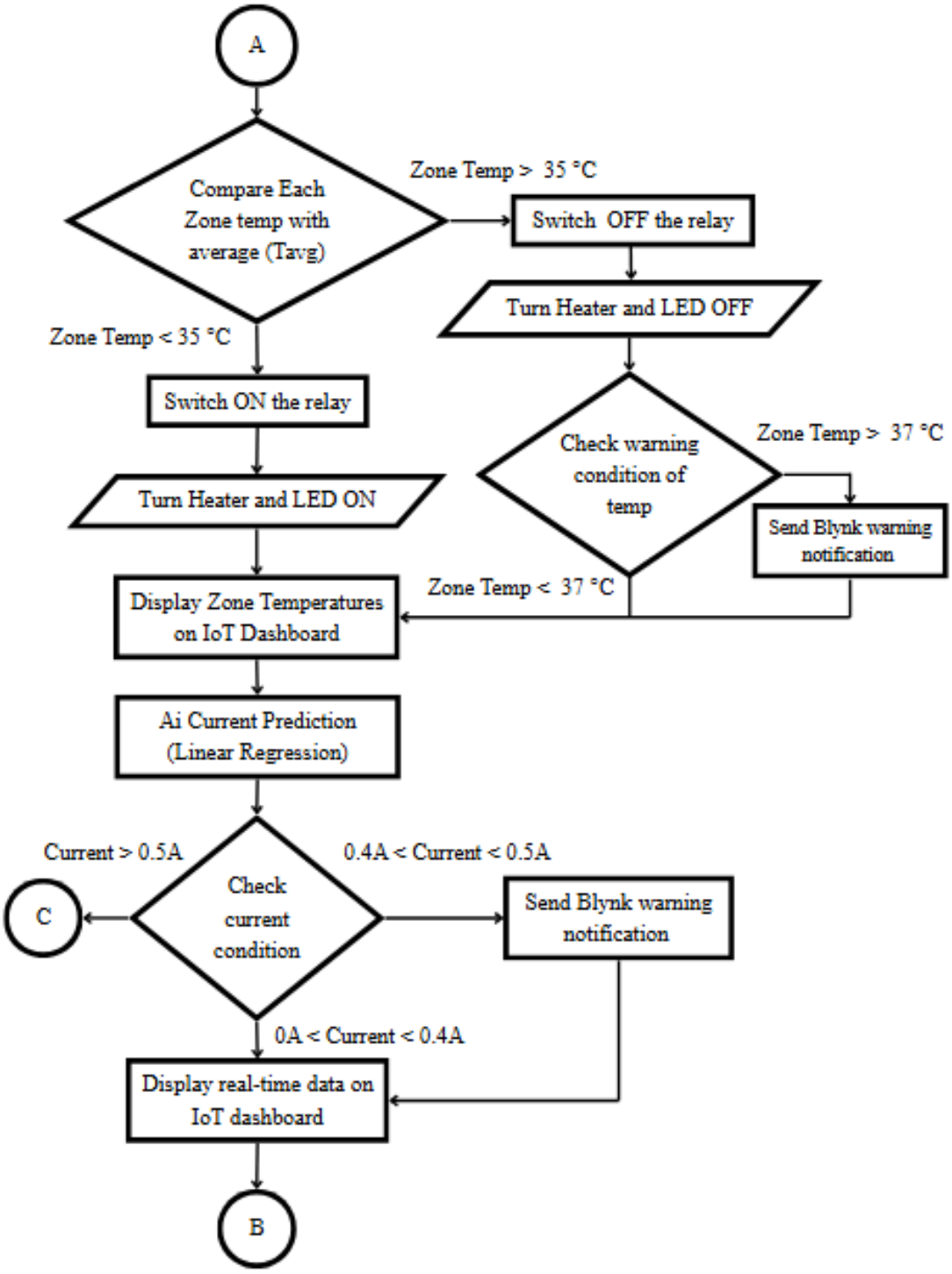


Figure 2(b). Flowchart of IoT-Based Smart Burn-In Monitoring System with AI-Driven Predictive Safety.

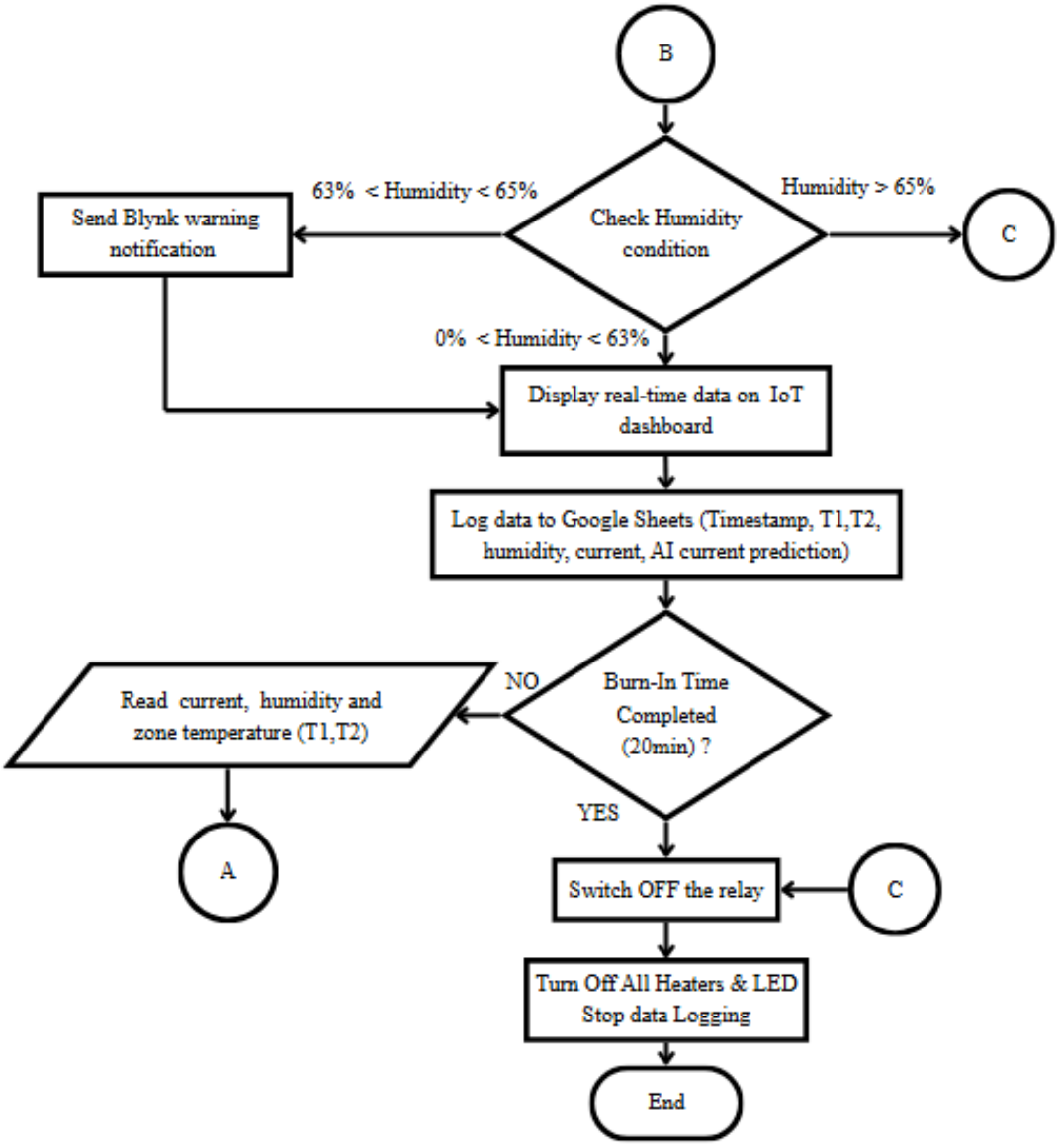


Figure 2(c). Flowchart of IoT-Based Smart Burn-In Monitoring System with AI-Driven Predictive Safety.

Hardware Implementation

Figure 3 presents the hardware implementation of the prototype system. The schematic design shows the integration of the Raspberry Pi, sensor modules, relay control circuit, and power distribution components. The PCB layout and prototype assembly demonstrate the physical implementation of the monitoring system within the burn-in simulation chamber.

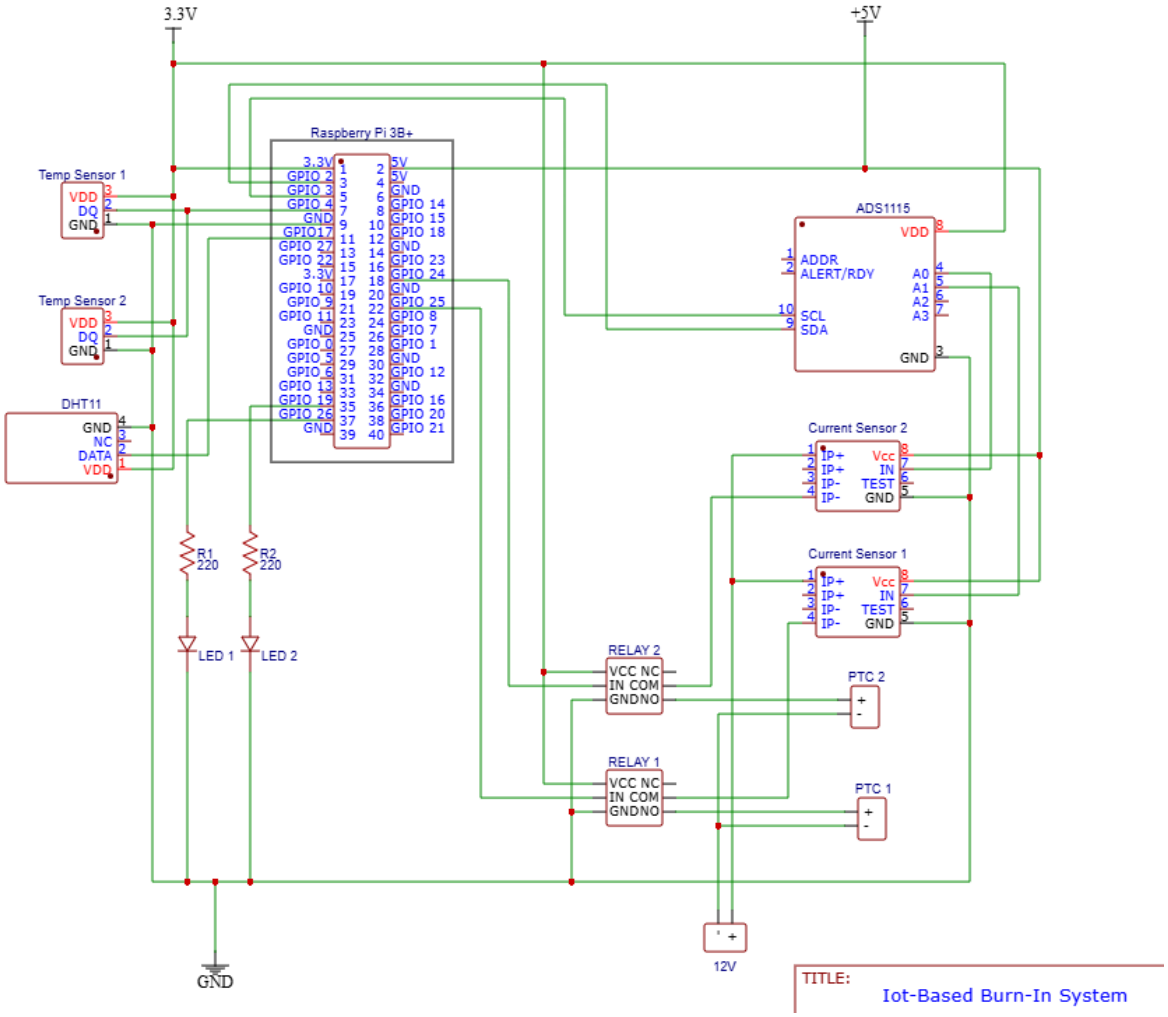


Figure 3(a). Schematic Circuit.

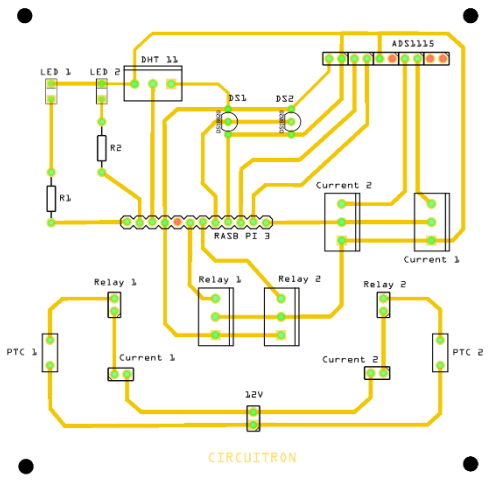


Figure 3(b). PCB layout.

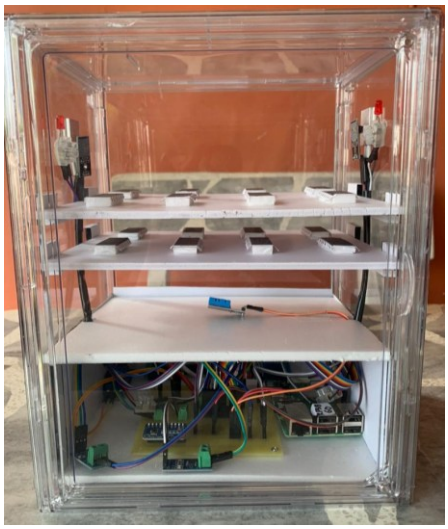


Figure 3(c). Prototype.

AI Prediction Performance

The predictive capability of the Linear Regression model is evaluated using heater current data. **Figure 4** shows the comparison between the predicted current values and the actual measured current values during system operation. The close alignment between the two datasets indicates that the model is capable of identifying abnormal deviations in heater current behaviour.

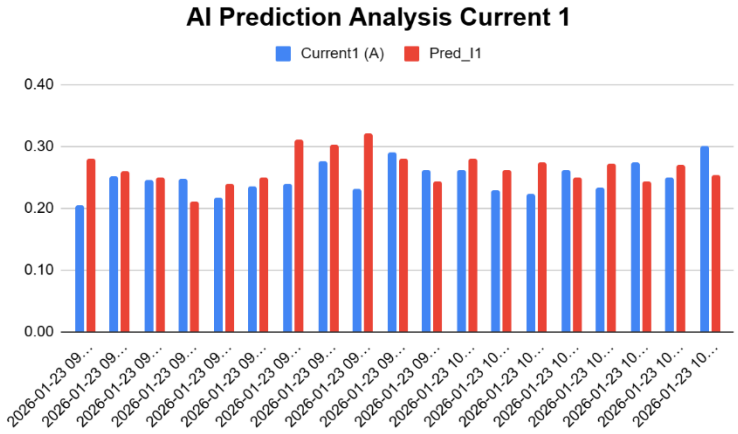


Figure 4. Chart for AI prediction analysis.

IoT Dashboard

Figure 5 shows the Blynk IoT dashboard used for real-time monitoring of system parameters. The dashboard displays temperature, humidity, and current readings while also providing system status indicators and warning notifications when abnormal conditions are detected.

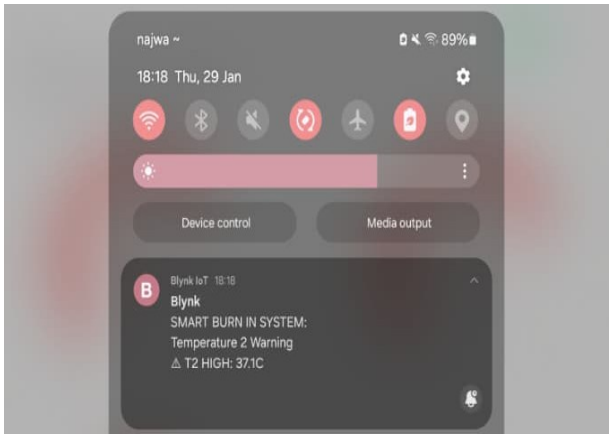


Figure 5(a). Warning notification.

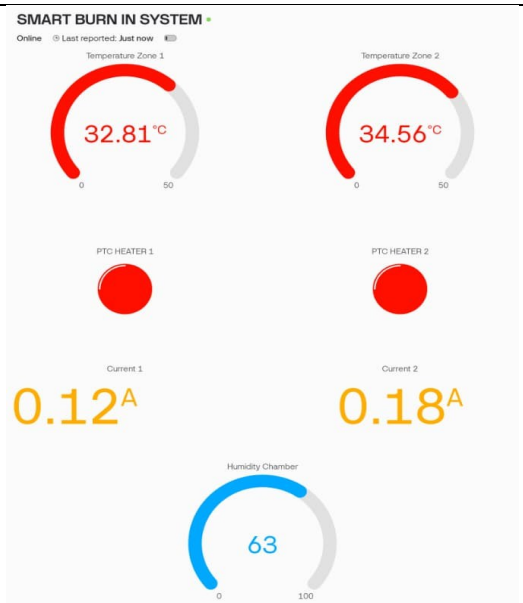
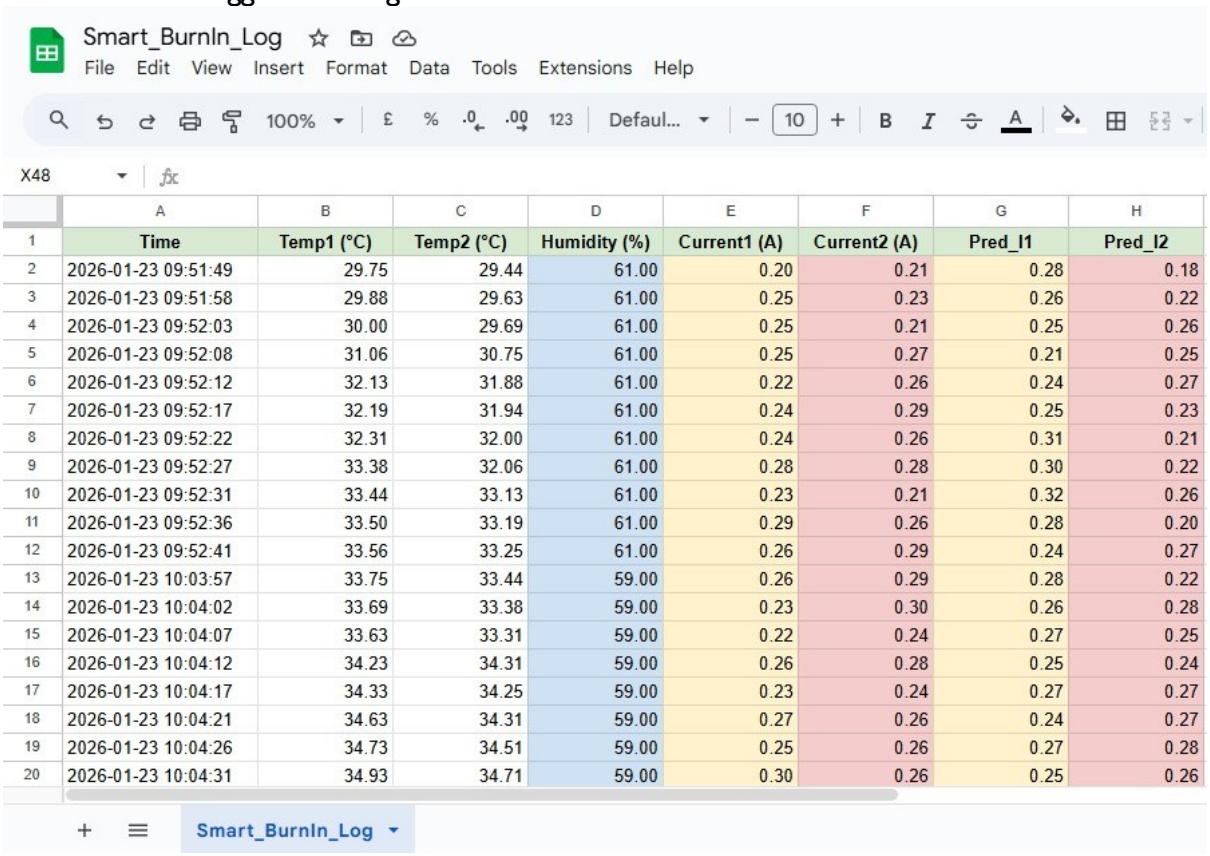


Figure 5(b). IoT Dashboard.

Cloud Data Logging

Table 1 shows the Google Sheets interface used for recording temperature, humidity, and current measurements during burn-in simulation.

Table 1. Data logged in Google Sheet.



	A	B	C	D	E	F	G	H
1	Time	Temp1 (°C)	Temp2 (°C)	Humidity (%)	Current1 (A)	Current2 (A)	Pred_I1	Pred_I2
2	2026-01-23 09:51:49	29.75	29.44	61.00	0.20	0.21	0.28	0.18
3	2026-01-23 09:51:58	29.88	29.63	61.00	0.25	0.23	0.26	0.22
4	2026-01-23 09:52:03	30.00	29.69	61.00	0.25	0.21	0.25	0.26
5	2026-01-23 09:52:08	31.06	30.75	61.00	0.25	0.27	0.21	0.25
6	2026-01-23 09:52:12	32.13	31.88	61.00	0.22	0.26	0.24	0.27
7	2026-01-23 09:52:17	32.19	31.94	61.00	0.24	0.29	0.25	0.23
8	2026-01-23 09:52:22	32.31	32.00	61.00	0.24	0.26	0.31	0.21
9	2026-01-23 09:52:27	33.38	32.06	61.00	0.28	0.28	0.30	0.22
10	2026-01-23 09:52:31	33.44	33.13	61.00	0.23	0.21	0.32	0.26
11	2026-01-23 09:52:36	33.50	33.19	61.00	0.29	0.26	0.28	0.20
12	2026-01-23 09:52:41	33.56	33.25	61.00	0.26	0.29	0.24	0.27
13	2026-01-23 10:03:57	33.75	33.44	59.00	0.26	0.29	0.28	0.22
14	2026-01-23 10:04:02	33.69	33.38	59.00	0.23	0.30	0.26	0.28
15	2026-01-23 10:04:07	33.63	33.31	59.00	0.22	0.24	0.27	0.25
16	2026-01-23 10:04:12	34.23	34.31	59.00	0.26	0.28	0.25	0.24
17	2026-01-23 10:04:17	34.33	34.25	59.00	0.23	0.24	0.27	0.27
18	2026-01-23 10:04:21	34.63	34.31	59.00	0.27	0.26	0.24	0.27
19	2026-01-23 10:04:26	34.73	34.51	59.00	0.25	0.26	0.27	0.28
20	2026-01-23 10:04:31	34.93	34.71	59.00	0.30	0.26	0.25	0.26

3. Novelty and uniqueness

The novelty of this project lies in the integration of IoT-based real-time monitoring with AI-driven predictive electrical safety as a built-in improvement system for burn-in environments. Conventional burn-in ovens operate as standalone systems that rely on fixed threshold alarms and reactive current limits. These systems only respond after abnormal conditions exceed predefined values. In contrast, the proposed system introduces predictive analysis of heater current behaviour before critical limits are reached. A key unique feature is the implementation of a supervised machine learning model based on Linear Regression to estimate the expected heater current using temperature, humidity, and previous current readings. Instead of depending solely on static overcurrent thresholds, the system continuously compares actual current with AI-predicted current to identify abnormal electrical patterns such as sudden current spikes, heater degradation, or relay malfunction. This predictive comparison mechanism provides early anomaly detection prior to hardware failure. Additionally, the integration of Blynk IoT for remote visualization and Google Sheets for structured cloud data logging enhances traceability and operational visibility. The flexible system design allows the system to function as a monitoring

add-on that does not require changes to existing heater control systems, making it suitable for prototype-level industrial concept demonstration aligned with Industry 4.0 principles.

4. Benefit to mankind

The IoT-Based Smart Burn-In Monitoring System with AI-Driven Predictive Safety contributes to human safety and industrial sustainability by reducing the risk of overheating, electrical faults, and unexpected equipment failure during burn-in testing. By introducing predictive current analysis rather than relying solely on reactive threshold alarms, the system minimizes the likelihood of fire hazards, heater damage, and unsafe operating conditions, thereby enhancing workplace safety for technicians and engineers. Economically, early anomaly detection reduces downtime, prevents costly hardware damage, and minimizes production losses caused by sudden burn-in failures. Continuous cloud-based data logging also improves traceability, enabling more efficient fault analysis and maintenance planning. Environmentally, the system helps prevent energy wastage due to prolonged overheating and reduces electronic waste caused by catastrophic component failure. By promoting predictive maintenance and data-driven monitoring, the project supports safer, more reliable, and more sustainable manufacturing practices aligned with Industry 4.0 development.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by integrating IoT connectivity, supervised machine learning, and predictive electrical safety into a practical burn-in monitoring application. By transforming conventional reactive monitoring into a data-driven predictive safety system, it demonstrates how emerging technologies can enhance reliability testing environments without replacing existing infrastructure. The system encourages digital transformation within manufacturing by introducing real-time remote visualization, structured cloud logging, and AI-assisted decision-making. From an entrepreneurial perspective, the solution has potential to evolve into a scalable industrial IoT product or monitoring service. It can be commercialized as an upgrade monitoring add-on for existing burn-in chambers, reducing the need for costly equipment replacement. The project also builds technical competencies in embedded systems, cloud integration, and AI deployment, fostering an innovation-driven mindset among students and engineers. By addressing real industrial safety challenges, it supports technology commercialization opportunities and strengthens collaboration between academia and industry.

6. Potential commercialization

The IoT-Based Smart Burn-In Monitoring System with AI-Driven Predictive Safety has strong commercialization potential as an upgrade monitoring and predictive safety add-on for existing burn-in chambers. Instead of replacing conventional ovens, the system can be deployed as an external intelligent monitoring layer, making it cost-effective and attractive to semiconductor manufacturers, electronics production facilities, research laboratories, and reliability testing centers. The solution can be offered in modular packages depending on the number of heating zones and monitoring requirements. Commercial models may include hardware installation fees, annual maintenance services, and subscription-based cloud monitoring with predictive analytics support. Small and medium manufacturing enterprises (SMEs) represent a key target market due to their need for affordable Industry 4.0 upgrades. With the increasing demand for predictive

maintenance, data traceability, and remote monitoring in smart manufacturing environments, the system presents scalable opportunities for local industrial adoption and future expansion into broader industrial safety monitoring applications.

7. Acknowledgment

The authors would like to express their sincere appreciation to the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM) Shah Alam, for providing the facilities and technical support necessary for the completion of this project. Special gratitude is extended to our course lecturer, Madam Yusnira Binti Husaini, for her continuous guidance, constructive feedback, and encouragement throughout the project, as well as for providing us with the opportunity to participate in the I-TIEC 2026 competition. The team members of CircuiTron also acknowledge the strong collaboration, dedication, and collective effort demonstrated by every group member in successfully designing, developing, and testing the IoT-Based Smart Burn-In Monitoring System with AI-Driven Predictive Safety.

8. Researchers' Biography

Puan Yusnira Husaini is a Senior Lecturer at the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM), where she has served since 2007. Her work focuses on engineering education and project-based learning through courses such as the Integrated Design Project and Final Year Project. She is dedicated to nurturing future-ready engineering graduates through innovative teaching and academic leadership.

Nur Najwa Binti Mohd Nasir is a Semester 6 Electronic Engineering student at Universiti Teknologi MARA (UiTM) Shah Alam, specializing in Microelectronics. She serves as the team leader for the IoT-Based Smart Burn-In Monitoring System with AI-Driven Predictive Safety project, where she coordinates project planning, task delegation, and overall system integration. She is primarily responsible for the IoT implementation, including the development of the Blynk-based real-time monitoring and alert platform. Her interests include embedded systems, microelectronic applications, and smart industrial monitoring technologies aligned with Industry 4.0 principles.

Muhammad Adib Bin Mohd Muhidin is a Semester 6 Electronic Engineering student at Universiti Teknologi MARA (UiTM) Shah Alam, specializing in Microelectronics. His academic interests include embedded systems and applied machine learning in engineering applications. In this project, he led the embedded system programming and developed the Python-based control logic for real-time sensor acquisition and safety execution. He also implemented the Linear Regression model for predictive current analysis, enabling early detection of abnormal electrical behavior and strengthening the system's AI-driven safety capability.

Nurul Hana Binti Maljada is a Semester 7 Electronic Engineering student at Universiti Teknologi MARA (UiTM) Shah Alam, specializing in Microelectronics. Her interests focus on electronic system design and circuit implementation. In the project, she developed the complete schematic design prior to hardware realization, ensuring correct sensor interfacing and safe multi-voltage integration. She also managed the procurement of major electronic components, coordinating sourcing and budgeting to support prototype development. Her contributions ensured the technical accuracy and feasibility of the hardware implementation.

Rory Christy Midah Anak Raymond Nion is a Semester 6 Electronic Engineering student at Universiti Teknologi MARA (UiTM) Shah Alam. Her academic interests include electronic circuit design, PCB development, and hardware integration. In this project, she was responsible for the PCB layout design and fabrication, ensuring organized routing, proper power distribution, and reliable component interfacing. She played a key role in translating the circuit schematic into a structured printed circuit board, contributing significantly to the system's mechanical stability and overall hardware reliability.

Personal Aquaculture Monitoring System

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ABSTRACT
Personal Aquaculture Monitoring System is an autonomous and small monitoring system design for aquaculture. It specializes in water quality parameter monitoring, water stability controlling using actuator, automatic feeding system, and using IoT applications. The reason this system is proposed is to tackle the problem of starting in aquaculture business, which is high capital investment and operational cost, species-specific knowledge and diseases management, and location site suitability and infrastructure requirements. This system tackles that problem by making the aquaculture farm smaller in size, having an in-built system completed with water quality monitoring capability, autonomous stability control and feeding and having an IoT application for displaying and storing data. By implementing this system, this is not just helping for an individual or small business to startup in aquaculture business, but also tackle the problem of environmental problem of traditional aquaculture farm, which is habitat destruction, chemical and biological contamination and eutrophication and pollution.

Keywords: Monitoring System, Aquaculture, IOT.

1. Product Description
Personal Aquaculture Monitoring System is a small-scale, autonomous monitoring and feeding system with IoT application for data storing and display . The first features, all of the water quality parameters, which are pH level, water turbidity level and water temperature level are all measured and collected using pH sensor, water turbidity sensor and water temperature sensor, all in real time. All of the sensor data collected will be display via web page, where the user will do the analysis and future prediction of the state of the water parameter. Furthermore, when the sensors detected some anomaly or instability, the actuator will correct and regulate the water condition until it returns to its stable condition. For instance, if water temperature detects the water temperature exceeds or below its stable condition, in this case above 28°C or below 24°C, the actuator will be active and regulate the water condition based on the information that it feeds. Lastly, the system also features an automatic feeding system. The feeding system has two modes, which is the user activate it manually via web server or operate automatically by using Real-Time Clock, in which the automatic feeding will occur in a set period time of the day.

2. Product Details
The flow chart of the product as shown in **Figure 1** starts with connecting with internet and connected to XAMPP server. Then, the flow will follow through each sensor and operate when the requirements is met. Flow chart also shows the automatic feeding system which operates on its own. **Figure 2** shows the actual product prototype.

Figure 1. Personal Aquaculture Monitoring System flow chart.

Figure 2. Personal Aquaculture Monitoring System picture.

The product's server begin its operation when the server is online. **Figure 3** demonstrate the example of the sensor page graph display for turbidity. The homepage design layout allow easy navigation to the user, while displaying necessary data and information needed for water quality parameter monitoring.

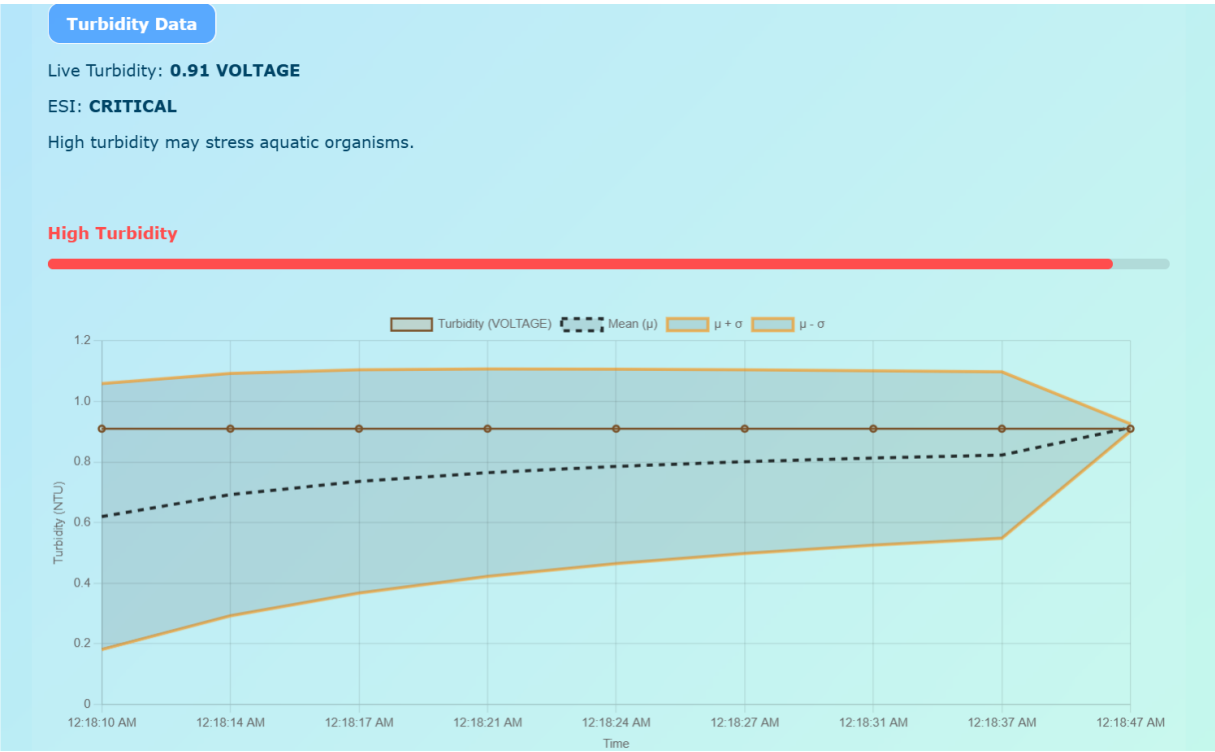

Figure 3. Personal Aquaculture Monitoring System sensor page graph display example for turbidity.

3. Novelty and uniqueness

The project main feature is on the "personal" aspect. This means that it will be on a smaller scale, in which it is easier to have it in a house or apartment. This feature will be more convenient for an individual or small business that does not need a spacious location to conduct their operation. Furthermore, for the water quality parameter monitoring, the web page will not only display the raw sensor reading but instead will have a detailed condition of each parameter. For example, it will not only display the raw sensor reading value, but it will also display live graph reading, daily health report, and species-specific aquatic life water parameter requirement option for research.

4. Benefit to mankind

This project has the potential to prevent large-scale environmental impact of habitat destruction and high-density antibiotics, pesticides, and anti-fouling chemicals that can leach into surrounding waters, as it does not require using or expanding the natural habitat to operate. Furthermore, this project also can reduce the labour cost, and the skill or knowledge required to operate aquaculture as the system already installed with built-in sensors, actuator and data display and logging.

5. Innovation and Entrepreneurial Impact

The project small scalability make it convenient for starters, whether it will be an individual or a small business who are interested in starting an aquaculture business. Furthermore, since it promotes aquaculture to people who are interested in starting an aquaculture business, it will expand the aquaculture ecosystem. For innovation, this project promotes the idea of starting with unfamiliarity with cautions and low risk, meaning that starting small and getting the idea of

what the business is and how it works, while prevent spending too much money on their business they are unfamiliar with.

6. Potential commercialization

This project will act as a "starter kit" for beginner, meaning that they will have the necessary tools to start in the aquaculture business. Our target users are an individual or small company who are wanted to start in aquaculture business, a hobbyist who are interested in learning the aquatic life or an individual or small business that are researching on particular species of aquatic life in a small scale. This "starter kit" way of product will be convenient as it does not have separate module to be install. The base starting price will range around RM1200 - RM1500. As Malaysia is in strong need of aquaculture business and actively expanding, knowing where to start for its people will be beneficial to not only the person but also for the country.

7. Acknowledgment

A special thanks to Faculty of Electrical Engineering UiTM Sarawak Branch and UiTM Samarahan Campus for providing the necessary laboratory space for this research.

8. Researchers' Biography

Fedallister bin Fernandez Sunsick is a Student in UiTM, majoring in Electrical Engineering(Electronic). Currently semester 5, he has the experience in embedded system programming, experience in leadership as he an ex-member of MPP, and able to share his knowledge through university and club held programs to audience and younger students . His commitment has led him to joining competition, obtaining good academic result, and active in extra co-curricular activities.

Dzufi Iszura Ispawi is a senior lecturer in UiTM Sarawak Branch with more than 10 years of teaching experience. Specialization in embedded design, currently is the Faculty Representative (Students Activities, IAP & Corporate/Publicity) of Faculty of Electrical Engineering UiTM Samarahan Campus.

Ts. Dr. Saurdi Ishak is a senior lecturer in UiTM Sarawak Branch with 20 years of teaching experience. Specialization in nano technology, currently is the Coordinator of Faculty of Electrical Engineering UiTM Samarahan Campus.

Adaptive Traffic Light System

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ABSTRACT

This project presents the design and implementation of an "Adaptive Traffic Light System" using the ESP32 microcontroller. As global urban populations grow, traditional fixed-timing traffic lights have led to severe congestion and safety hazards, particularly for traffic police and emergency vehicles. To address this, this project develops a smart traffic control unit that integrates magnetic sensors for real-time traffic density detection, an Infrared (IR) receiver for emergency vehicle prioritization, and Wi-Fi connectivity for remote manual control via the Arduino IoT Cloud. The system operates by detecting vehicle queue lengths; if a queue exceeds three vehicles, the green signal duration is automatically extended. Additionally, the system enables traffic police to control the junction safely from a distance using a physical button panel, eliminating the need to stand in the center of the road. Test results from the prototype demonstrate successful mode switching between automatic density adjustment, emergency override, and manual control, proving the system's effectiveness in improving traffic efficiency and safety.

Keywords: ESP32, Adaptive Traffic Light, Magnetic Sensor, IoT, Emergency Vehicle Priority, Smart City.

1. Product Description

The continuous expansion of urban populations has significantly increased vehicular density, creating critical challenges in modern traffic management. As cities grow, the limitations of conventional traffic control infrastructure become increasingly apparent, necessitating the development of more intelligent and adaptive solutions. The project addresses the urgent need for a responsive traffic control system that can adapt to real-time conditions rather than relying on inefficient fixed-timing cycles. In real-world scenarios, maintaining the balance between traffic flow efficiency and road safety is a complex task. Conventional systems often cause unnecessary delays by granting green lights to empty lanes while other lanes suffer from congestion. Furthermore, emergency vehicles such as ambulances and fire trucks frequently face delays at red lights, which can have life- threatening consequences.

2. Method Flow Chart and Product Model

The Adaptive Traffic Light System involved a comprehensive and systematic approach to design, develop, and implement a sophisticated system for enhancing conventional traffic light. Beginning with a thorough literature review, the project aimed to draw insights from existing research on modern systems, ensuring a foundation grounded in established knowledge. The

system design phase defined specific requirements and functionalities, culminating in a well-thought-out circuit design that integrated a magnetic sensor, IR sensor, a numerical keypad, an ESP32 module, an RGB LED, an LCD display, a buzzer, and push button. Additionally, a Wi-Fi module was incorporated to enable IoT connectivity for remote monitoring and control.

Figure 1 shows a comprehensive array of components depicted, illustrating the intricate architecture proposed for the Adaptive Traffic Light System for enhancing conventional traffic light projects. This block diagram shows an ESP32 as the main controller that connects inputs, outputs, and the cloud in an IoT system. On the input side, the ESP32 receives signals from an IR receiver, a magnetic sensor, and push buttons, which allow the system to detect remote commands, magnetic changes (such as door open/close), and manual user input. The ESP32 processes this data and can send or receive information wirelessly through the Arduino IoT Cloud via Wi-Fi, enabling remote monitoring and control. On the output side, the ESP32 controls LEDs as visual indicators and an OLED display to show system status or sensor information. Overall, the diagram represents a smart, connected system where the ESP32 acts as the brain, integrating sensors, user interaction, visual feedback, and cloud connectivity.

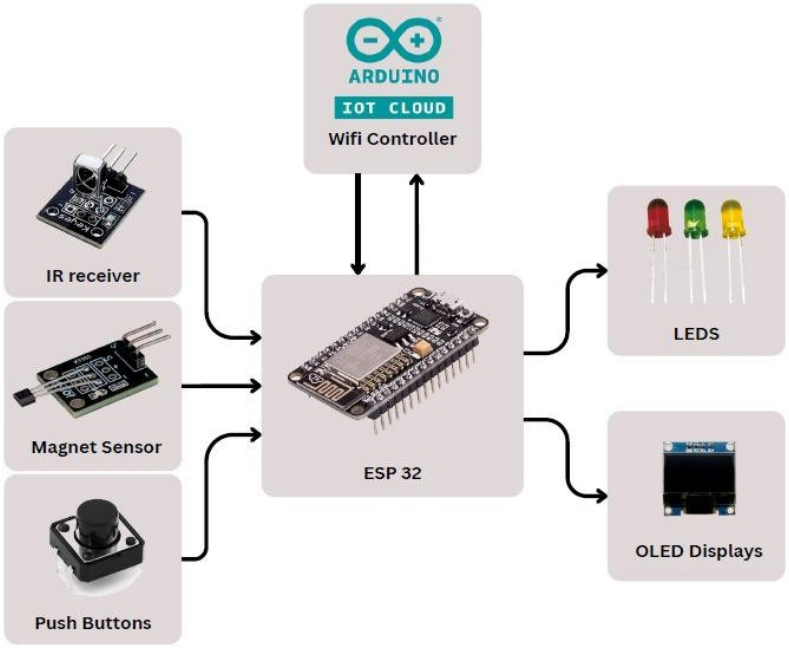

Figure 1. Block Diagram of Adaptive Traffic Light System.

Based on **Figure 2**, the schematic diagram for the Adaptive Traffic Light System illustrates the strategic integration of each component with the ESP32 DevKitC-v4 microcontroller. To ensure a well-defined and organized system, each sensor and actuator is meticulously interfaced with corresponding GPIO pins. Magnet sensors are linked to the ESP32 to facilitate precise traffic density detection for the "Density Mode" cycle. For high-priority overrides, an IR receiver is connected to handle emergency vehicle detection, while a push-button panel allows for manual police control. The SSD1306 OLED displays, used for real-time countdowns and status alerts, are connected directly via the I2C interface, specifically using pin 22 (SDA) and pin 23 (SCL), using I2C multiplexer to use non interchangeable addresses of this specific Displays. The Traffic LEDs, which indicate the current signal state, are powered through a

shift register to execute the traffic logic. This arrangement underscores the systematic integration that forms the foundation of the traffic management system, transitioning seamlessly between Emergency, Manual, and Density-based modes.

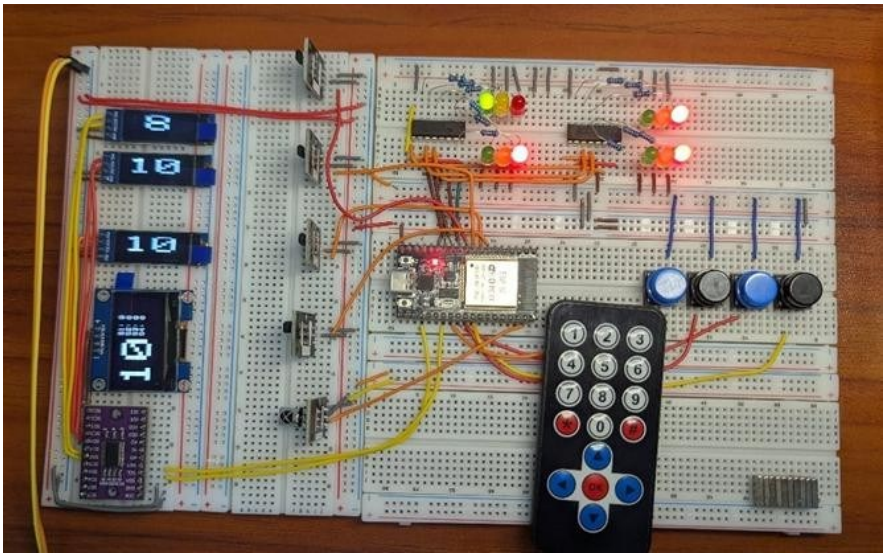

Figure 2. Schematic Diagram of Adaptive Traffic Light System developed on breadboard.

Figure 3 (a) shows the successfully developed prototype of the Adaptive Traffic Light System with all sensors, keypad, push button as the inputs for the system. The output are RGB led which modelled the traffic light and OLED screen which displayed the timing decision for each junction, for demonstration purposes the displayed number will correspond to what the green light length will be once it turned green, this will make the demonstration of the magnet sensor much clearer. The developed circuits are placed below the prototype to tidy up the system's appearance. The current operation of the system also can be monitored in the Arduino cloud by using IoT communication as shown in **Figure 3 (b)** which indicates the high reliability of the product. In a normal running condition. In this mode, the traffic light will run with timing for green light of 10 seconds. The value is displayed on the OLED panel while the main panel has extra information for the counter on the magnet sensor for every lane. The system also has capability to monitor and count each lane queue length. When the magnet sensor on that lane detects more than 5 vehicles the timing for green on that lane changes to 20 seconds. The count is then reset after the lane goes to green. The system also has override mode which can be controlled by push buttons panel situated on every corner. This is also can be done from remote by using the Arduino cloud through IoT connectivity. the system's capability to detect the IR remote in any mode for emergency vehicle priority mode. The remote is used in conjunction with the number displayed on the traffic light pole. When the number of the light pole is pressed and the type of vehicle you are in is also pressed the system will determine if there's other emergency vehicles and give priority lane to that vehicle and display emergency vehicles on the OLED to alert all traffic.

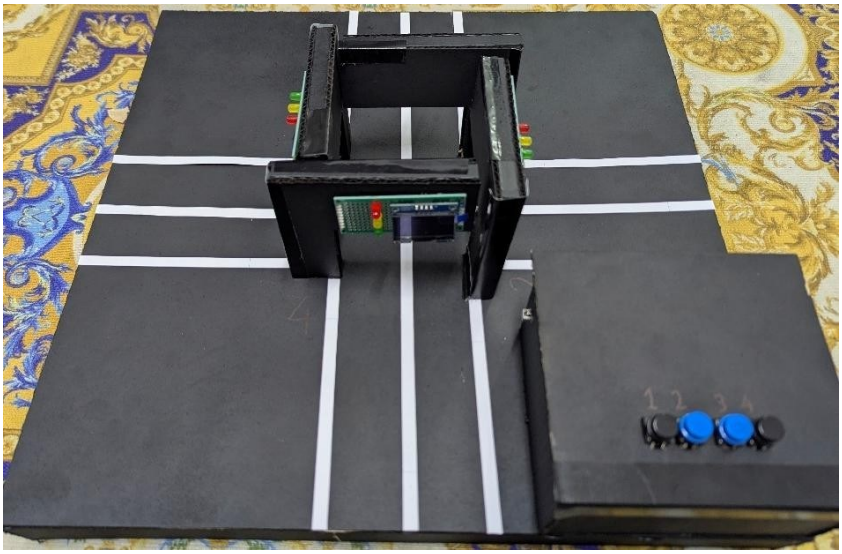

Figure 3 (a) Developed prototype

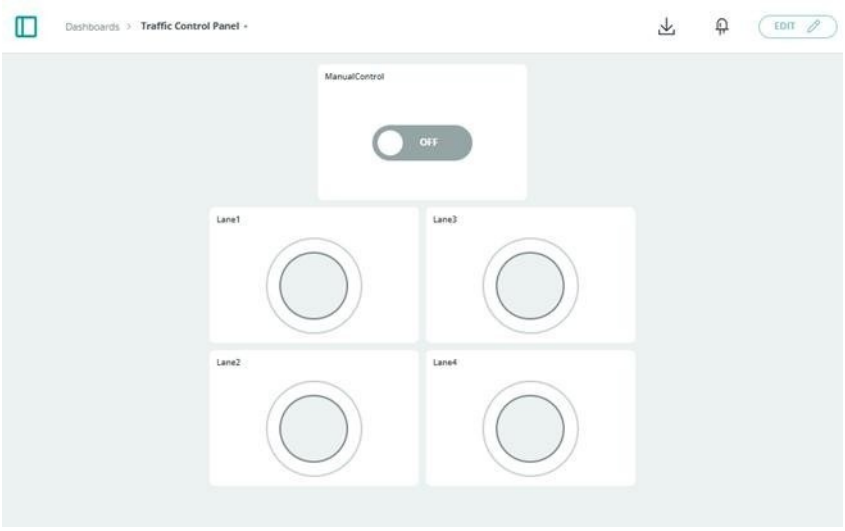

Figure 3 (b) The system interface in the Arduino cloud

3. Novelty and uniqueness

By incorporating a suite of components, including an ESP32 microcontroller, Magnetic Sensors, and an Infrared (IR) Receiver, this system enables real-time data collection, essential for informed decision-making. The magnetic sensors provide the capability to detect vehicle density dynamically, allowing the system to extend green signal durations automatically when heavy traffic is detected. Simultaneously, the IR receiver facilitates an immediate override mechanism for emergency vehicles, granting them priority passage without human intervention. Moreover, the integration of a Wi-Fi module within the ESP32 transforms the traffic light into a connected Internet of Things (IoT) device. This connectivity allows for remote monitoring and manual control via a cloud-based dashboard, addressing the safety risks faced by traffic police who traditionally must stand in the center of dangerous junctions to direct traffic. By incorporating elements of both hardware and software innovation, along

with IoT connectivity, our prototype represents a holistic approach towards enhancing road safety. Additionally, the integration of advanced features such as emergency control add a layer of sophistication that aligns with the evolving landscape of traffic light technologies.

4. Benefit to mankind

It is evident that the development of the Adaptive Traffic Light System holds significant promise in addressing the pressing concerns surrounding urban traffic congestion and intersection safety. By integrating advanced hardware components such as the ESP32 microcontroller, along with sophisticated software algorithms, the prototype demonstrates the potential to enhance traffic flow efficiency compared to traditional fixed-timer models. Notably, the incorporation of IoT technology not only facilitates real-time monitoring of traffic density but also underscores the importance of connectivity and remote accessibility, directly addressing the safety risks faced by traffic police who utilize manual control.

5. Innovation and Entrepreneurial Impact

Overall, our study not only demonstrates the feasibility of developing an Adaptive Traffic Light System but also highlights its potential to redefine the standards of road security. By leveraging cutting-edge technologies and innovative design principles, our prototype serves as a testament to the continuous evolution of security solutions in safeguarding the sanctity of road, vehicles and human beings.

6. Potential commercialization

The proposed Enhanced Adaptive Traffic Light System holds significant potential for commercialization within the security sector. By partnering with Jabatan Kerja Raya (JKR) who is managing the road installation and safety in Malaysia, manufacturers or companies, this solution can be marketed as an add-on feature or integrated service for road security systems. All road users would benefit from reduced high traffic congestion, enhanced control for emergency users such as ambulance and police, reduce accidents and enhanced life in peace, making them ideal clients for the proposed solution.

7. Acknowledgment

Authors wish to acknowledge the support provided by the Electrical Engineering Studies, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, Masai, Malaysia in terms of financial, consultations and facilities.

8. Researchers' Biography

Muhammad Ammar Zufar Mohd Ramli is currently pursuing a Diploma in Electrical Engineering (Electronic) at the UiTM Pasir Gudang Campus. He has demonstrated outstanding performance in both academic and extracurricular activities, having earned a place on the Dean's List for two consecutive semesters. Apart from his expert skills in electronic projects, he is also talented and has been involved in numerous faculty program.

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Norbaiti Sidik is a Senior Lecturer at UiTM Pasir Gudang Campus. She holds Master Engineering Degree in Communication and Computer also from the Universiti Kebangsaan Malaysia in 2002. She is very committed, passionate and dedicated in education line who is now a senior lecturer and having experienced more than 15 years in teaching & learning and lecturing at Electrical Engineering Studies, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, Johor Darul Takzim.

MedSIS: A Mathematical Modeling-Based Segmentation System for Medical Imaging

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ABSTRACT

MedSIS is a mathematical modeling-based medical image segmentation system designed to enhance segmentation accuracy in images affected by intensity inhomogeneity. Intensity inhomogeneity, characterized by gradual non-uniform brightness variations due to acquisition conditions and scanner imperfections, often causes distorted tissue intensities and ambiguous region boundaries. MedSIS addresses this issue by integrating a Selective Additive Bias Correction (SABC) variational model within a structured graphical user interface (GUI). The framework simultaneously estimates the bias field while performing selective segmentation within a unified formulation. The system also supports segmentation of pathological regions such as tumors and lesions, as well as anatomical structures including organs and vascular regions, across multiple imaging modalities. Marker-based selective initialization enables precise extraction of user-defined regions of interest. Experimental evaluation demonstrates high average Dice and Jaccard accuracies with efficient computation time, indicating stable performance under non-uniform intensity conditions. Beyond technical performance, MedSIS provides an interpretable and scalable platform suitable for integration into computer-aided diagnosis (CAD) systems. The system also demonstrates strong potential for commercialization, including licensing to healthcare institutions and integration into existing medical imaging software platforms, supporting broader adoption in clinical and research environments.

Keywords: Medical Image Segmentation, Intensity Inhomogeneity, Variational Model, Bias Correction, Mathematical Modeling

1. Product Description

MedSIS is a mathematical modeling-based medical image segmentation system developed as a practical segmentation tool for addressing intensity inhomogeneity in clinical imaging. Intensity inhomogeneity refers to non-uniform brightness variations caused by scanner imperfections or magnetic field irregularities, which distort true tissue intensities and create boundary ambiguity during region extraction. MedSIS integrates the SABC model within a structured GUI to simultaneously estimate and correct the bias field while performing segmentation. This unified framework improves segmentation reliability by homogenizing image intensity during the extraction process. This system supports segmentation of both pathological regions, such as

tumours or lesions (**Figure 1**), and anatomical structures including organs (**Figure 2**). In addition, the framework accommodates multiple imaging modalities including MRI, CT, ultrasound, mammography, and microscopic imaging (**Table 1**). Marker-based initialization enables users to selectively define regions of interest for accurate segmentation. The GUI provides an intuitive workflow that allows users to initialize regions, visualize segmentation boundaries, observe estimated bias fields and bias-corrected images, and evaluate segmentation accuracy through quantitative performance metrics. Experimental evaluation in **Table 2** shows that MedSIS achieves average Dice and Jaccard accuracies of 93.9% and 88.6%, respectively, with an average computation time of 5.511 seconds, demonstrating stable and efficient performance under non-uniform intensity conditions.

2. Figure of MedSIS: Medical Segmentation and Imaging System

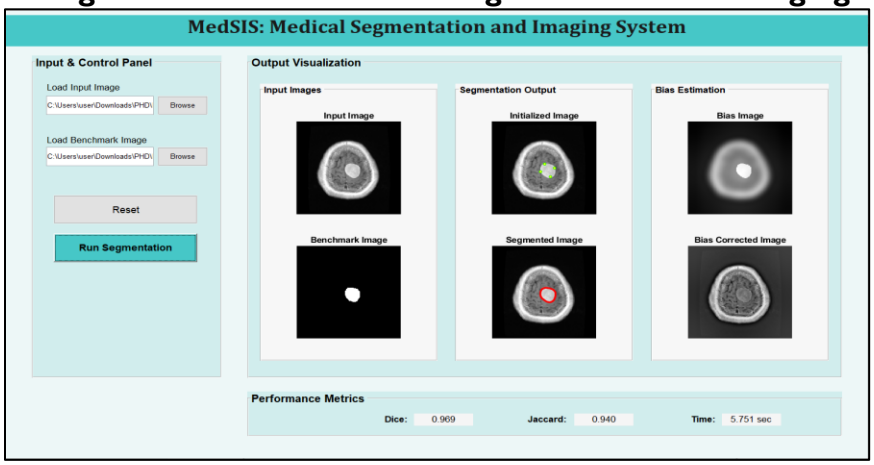


Figure 1. MedSIS GUI for tumor segmentation in brain MRI.

Figure 2. MedSIS GUI for anatomical structure segmentation in liver CT.

Table 1. Segmentation Results on Medical Images.

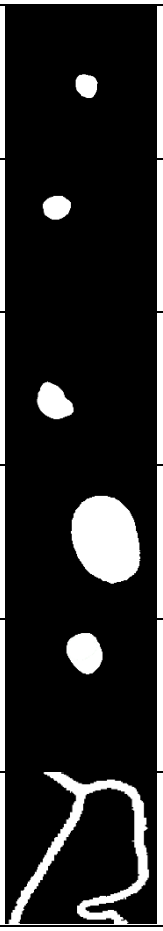
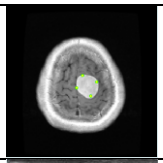
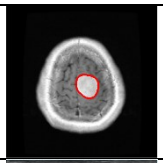
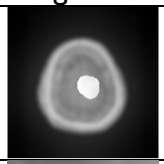
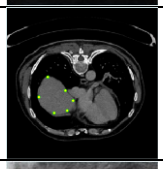
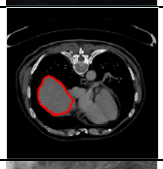
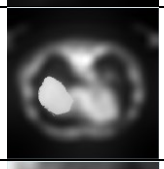
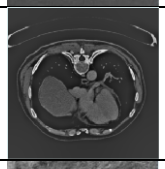
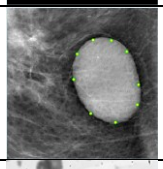
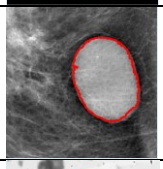
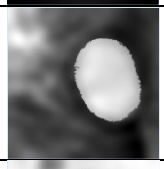
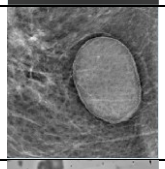
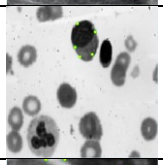
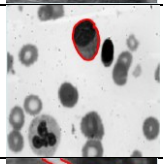
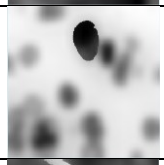
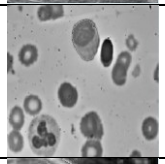
Medical Images	Benchmark Image	Initialized Image	Segmented Image	Estimated Bias Image	Bias Corrected Image
Brain MRI					
Breast Ultrasound					
Liver CT					
Breast Mammogram					
Bone Marrow					
Blood Vessel					

Table 2. Performance Evaluation.

Medical Images	Accuracy		Time (in seconds)
	Dice	Jaccard	
Brain MRI	0.969	0.940	5.751
Breast Ultrasound	0.910	0.835	7.781
Liver CT	0.946	0.898	3.749
Breast Mammogram	0.949	0.904	6.208
Bone Marrow	0.939	0.886	1.758
Blood Vessel	0.921	0.853	7.818
Average	0.939	0.886	5.511

3. Novelty and uniqueness

MedSIS introduces a mathematically grounded segmentation framework that directly applies the SABC model to a practical clinical interface. Different from conventional segmentation tools that treat bias correction and boundary extraction as separate processes, MedSIS performs bias field estimation and segmentation simultaneously through a unified variational formulation. This

integrated strategy enhances boundary stability in the presence of intensity inhomogeneity, where gradual brightness variations often distort true tissue structures and create segmentation ambiguity. The marker-based selective initialization allows precise extraction of user-defined regions of interest. This capability enables MedSIS to segment both pathological regions, such as tumors and lesions, and anatomical structures, including organs and vascular regions, across diverse imaging modalities. The system demonstrates high average accuracy metrics together with efficient computation time, reflecting both reliability and practical applicability. Its robustness under non-uniform intensity conditions, computational efficiency, and structured GUI implementation collectively position MedSIS as a versatile platform that translates advanced mathematical modeling into an accessible and real-world clinical segmentation applications.

4. Benefit to mankind

MedSIS advances medical imaging practice by strengthening segmentation reliability in environments affected by intensity inhomogeneity. Clearer and more consistent boundary delineation improves clinical interpretation, assisting healthcare professionals in identifying pathological regions and anatomical structures with greater confidence. Enhanced segmentation accuracy can contribute to more informed diagnostic decisions and treatment planning. Its efficient computational design and structured graphical interface streamline segmentation workflows, reducing manual intervention and saving clinical time. Due to MedSIS operating through a mathematical model rather than data-heavy training requirements, it remains practical in settings where large, annotated datasets are unavailable. By delivering stable segmentation performance across diverse imaging modalities, MedSIS promotes wider accessibility to robust analytical tools in both clinical and research environments. Through this integration of mathematical rigor and practical usability, the system contributes meaningfully to improved diagnostic support and the ongoing advancement of medical imaging technologies.

5. Innovation and Entrepreneurial Impact

MedSIS promotes innovation by transforming advanced variational mathematical modeling into a deployable clinical tool. The integration of the SABC model within a user-oriented GUI demonstrates how theoretical research can evolve into applied healthcare technology. By prioritizing interpretability and controllable parameters, MedSIS offers a transparent alternative to purely data-driven systems. The project encourages interdisciplinary collaboration between mathematicians, clinicians, and imaging researchers, strengthening the translation of mathematical theory into real-world impact. Its scalable design enables future extensions, including modular upgrades, modality-specific tuning, and integration into decision-support platforms. From an entrepreneurial standpoint, MedSIS presents a market-ready, research-driven solution with strong commercialization potential. Its efficiency, adaptability, and clinical relevance position it as a viable technology for industry collaboration, technology licensing, and healthcare software integration. The project demonstrates how academic innovation can evolve into sustainable, industry-oriented healthcare technologies.

6. Potential commercialization

MedSIS is positioned for commercialization as a lightweight, PC-compatible medical image segmentation platform requiring no specialized hardware. Its model-driven architecture reduces dependency on large training datasets, making deployment feasible in hospitals, diagnostic centers, and research laboratories. The adaptability across imaging modalities including MRI, CT,

ultrasound, and mammography broadens its market scope. Potential commercialization pathways include licensing to healthcare institutions, integration into existing CAD software, or development as a standalone segmentation module for imaging vendors. Strategic collaboration with medical device companies, imaging software providers, and academic research centers could accelerate market entry. With demonstrated segmentation accuracy, computational efficiency, and robustness under intensity inhomogeneity, MedSIS offers a cost-effective and scalable solution aligned with the growing demand for intelligent medical imaging technologies.

7. Acknowledgment

Special thanks were extended to the Centre of Mathematical Sciences, Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA.

8. Researchers' Biography

Nor Farihah Azman received her B.Sc. in Mathematics and M.Sc. in Applied Mathematics from Universiti Teknologi MARA (UiTM), Malaysia, in 2022 and 2023, respectively. She is currently pursuing her Ph.D. in Mathematics at UiTM. Her research interests include image processing, mathematical and medical image analysis, mathematical modeling, and computer vision.

Abdul Kadir Jumat received his B.Sc. and M.Sc. in Mathematics from the Universiti Teknologi MARA (UiTM), Malaysia, and Ph.D. in Applied Mathematics (Mathematical Imaging Methods) from the University of Liverpool, United Kingdom. He currently serves as a research fellow at the Institute for Big Data Analytics and Artificial Intelligence (IBDAAI) and a senior lecturer in the Centre of Mathematical Sciences, Faculty of Computer and Mathematical Sciences at UiTM Shah Alam, Malaysia. His research interests include image/signal processing, artificial intelligence, computer vision, biometrics, medical image and analysis, and pattern recognition.

Shaharuddin Cik Soh received his B.Sc. in Mathematics Education and M.Sc. in Mathematics (Differential Equations) from the Universiti Putra Malaysia (UPM), Malaysia, and Ph.D. in Information Technology and Quantitative Sciences from the Universiti Teknologi MARA (UiTM), Malaysia. He is an Associate Professor at the Centre of Mathematical Sciences, Faculty of Computer and Mathematical Sciences at UiTM Shah Alam, Malaysia. His research interests include complex analysis and geometric function theory.

Akmal Shafiq Badarul Azam received his B.Sc. in Computational Mathematics and M.Sc. in Applied Mathematics (Financial and Management Mathematics) from Universiti Teknologi MARA (UiTM), Malaysia, in 2021 and 2022, respectively. He is currently pursuing a Ph.D. in Mathematics at UiTM and serves as a lecturer in mathematics at UiTM Mukah Campus, Sarawak. His research interests include mathematical image analysis, medical image processing, computer vision, and applied mathematics.

Intelligent Prediction Modelling of Heavy Metals and Dyes Removal by Metal Oxide Photocatalysts Using Artificial Neural Networks

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ABSTRACT

This project aims to develop a robust Artificial Neural Network (ANN) framework using MATLAB to accurately predict the removal efficiency of heavy metals and dyes from wastewater using metal oxide photocatalysts. Traditionally, process optimization relies on resource-intensive trial-and-error experiments or basic statistical tools that struggle to map complex and non-linear multiple variables in photocatalytic process. In order to overcome this problem, dual-faceted computational approaches are used by evaluating multiple training algorithms, such as Levenberg-Marquardt (LM), Bayesian Regularization (BR), Resilient Backpropagation (Rprop), and Scaled Conjugate Gradient (SCG), with various multi-layer perceptron architectures. This structured optimization matrix enables the predictive model to act as a robust and accurate prediction model. Socio-environmentally, this technology minimizes chemical waste, protects aquatic ecosystems from toxic degradation, and promotes water recycling. Economically, it drastically lowers R&D and operational costs for large-scale treatment plants. Commercially, the framework is highly viable due to increasingly strict environmental regulations and global water scarcity. This scalable ANN predictive model presents strong commercial viability in response to strict environmental regulations and water shortages. Moreover, it also easily adapts to different contaminants in wastewater which helps facilities to avoid chemical overdosing and minimize energy consumption.

Keywords: ANN, Dye, Heavy Metal, Removal, Metal Oxide Photocatalyst

1. Product Description

The proposed work is a predictive framework of ANN built within the MATLAB environment that predicts the removal efficiency of heavy metals and dyes from wastewater using metal oxide photocatalysts. The core system utilizes a Multi-layer Perceptron (MLP) architecture which consist of training algorithms, input layer, hidden layer and output layer. The input layer processes operational variables, including type of catalyst, light source, solution pH, catalyst dosage, and initial pollutant concentration. All this dataset undergoes normalization process using Min-Max scaling method before being fed into ANN models to ensure the models' stability. Furthermore, the hidden layers utilized non-linear transfer functions like Tan-Sigmoid function to capture the complex pattern of multiple variables relationships. Different number of hidden neurons such as 10, 15, and 20 are tested to pinpoint the most precise architecture for ANN models. The training algorithm used for predictive modelling is LM, Rprop, BR and SCR where this algorithm will iteratively adjust weights and biases along with the performance evaluation like MSE, RMSE, R,

and R^2 to determine the prediction error. Lastly, the output layer uses a linear transfer function such as Purelin to map the processed data into a final predicted value for pollutant removal efficiency.

2. Flowchart methodology and evaluation performance in this study.

Figure 1 outlines the systematic workflow used for the development and optimization of the ANN using MATLAB. The predictive modeling process was initiated with data collection, followed by data preprocessing aimed at normalizing the input variables for optimal network convergence. The core phase of the methodology involved defining the ANN architecture and selecting the appropriate training algorithm. This process includes evaluating various training algorithms with different hidden layer configurations. The performance of each configuration was evaluated using standard statistical metrics. Lower MSE and RMSE values indicate minimal deviation between the experimental data and the model's predictions, whereas R-squared and R-values approaching 1.0 signify a high degree of correlation and model reliability.

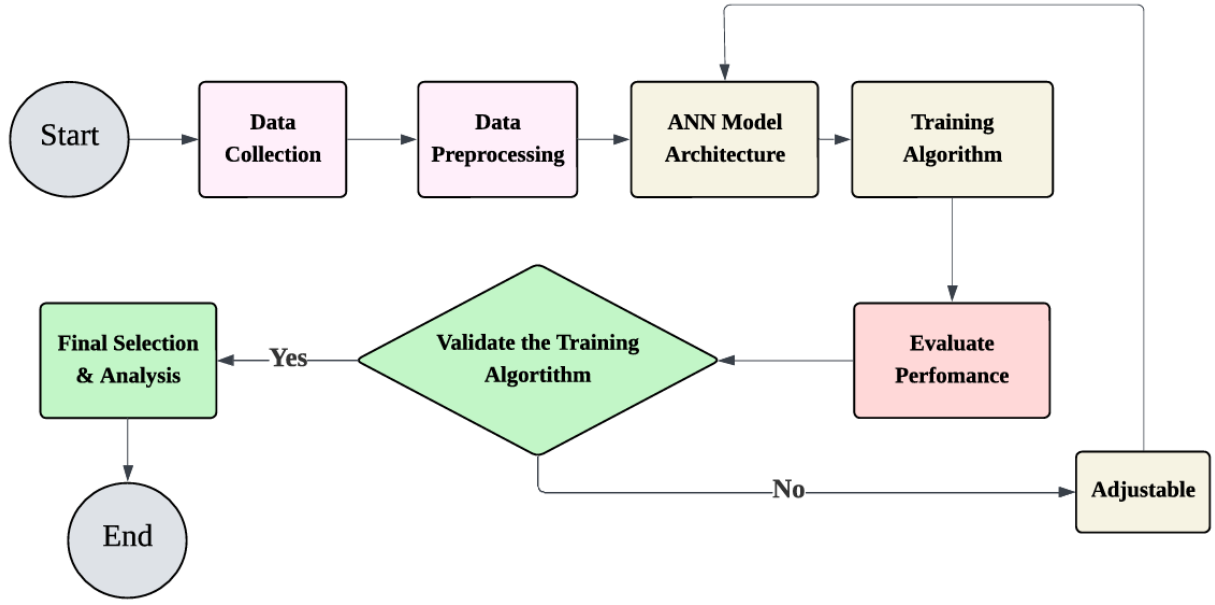

Figure 1. Flowchart performing the ANN using MATLAB.

Table 1 presents the performance of algorithms in predicting heavy metal removal. The results indicate that the selected ANN architectures are highly capable of modeling this specific process. The BR model configured with 10 neurons yields the highest R^2 (0.81) and an excellent R-value (0.90) with minimal error margins (MSE: 0.02 & RMSE: 0.12). Furthermore, the LM model with 20 neurons also achieves great performance with the lowest overall MSE (0.01) while having almost the same R^2 and R values as model BR. Consequently, both the BR (10 neurons) and LM (20 neurons) models are recommended as the optimal architecture for modeling heavy metal adsorption dynamics.

Table 1. Performance evaluation for all models for heavy metal removal.

Metric	***Model LM***			***Model BR***			***Model SCG***			***Model Rprop***		
Number of Neurons	10	15	20	10	15	20	10	15	20	10	15	20
Mean Squared Error (MSE)	0.03	0.03	0.01	0.02	0.05	0.01	0.02	0.05	0.04	0.04	0.05	0.02
Root Mean Squared Error (RMSE)	0.19	0.18	0.12	0.12	0.22	0.11	0.15	0.23	0.20	0.21	0.21	0.12
R-squared (R^2)	0.78	0.80	0.80	0.81	0.76	078	0.71	0.72	0.78	0.69	0.73	0.76
R-value (R)	0.89	0.90	0.90	0.90	0.87	0.88	0.84	0.85	0.89	0.83	0.85	0.87

Table 2 presents the performance of algorithms in predicting dye removal. These results suggest that modeling the dye removal process presents a higher degree of non-linear complexity compared to heavy metal removal. The correlation scores were generally lower across all tested algorithms. For the prediction of dye removal, the Rprop model structured with 20 hidden neurons emerged as the most robust architecture. It achieved the highest correlative accuracy in the prediction, with an R-squared of 0.64 and an R-value of 0.80, making it the optimal model for dye removal.

Table 2. Performance evaluation of all models for dye removal.

Metric	***Model LM***			***Model BR***			***Model SCG***			***Model Rprop***		
Number of Neurons	10	15	20	10	15	20	10	15	20	10	15	20
Mean Squared Error (MSE)	0.23	0.11	0.12	0.03	0.01	0.04	0.06	0.12	0.08	0.04	0.01	0.03
Root Mean Squared Error (RMSE)	0.48	0.33	0.35	0.18	0.10	0.19	0.25	0.34	0.28	0.21	0.09	0.19
R-squared (R^2)	0.00	0.15	0.22	0.57	0.50	0.32	0.21	0.35	0.49	0.60	0.55	0.64
R-value (R)	0.01	0.39	0.47	0.76	0.71	0.56	0.46	0.59	0.70	0.77	0.74	0.80

This study demonstrates that ANN are highly effective computational tools for predicting heavy metal and dye removal efficiencies. The findings emphasize that optimal model architecture depends heavily on the specific chemical process. For heavy metal removal, the BR model (10 neurons) and the LM model (20 neurons) delivered the highest predictive accuracy and lowest error margins. In contrast, Rprop (20 neurons) emerging as the most reliable architecture for this dye removal as it much more complex.

3. Novelty and uniqueness

The novelty of this research lies in its pioneering, dual-faceted computational approach to optimizing wastewater photocatalysis, fundamentally shifting away from traditional, resource-intensive trial-and-error laboratory experiments. Conventional process optimization in chemical engineering typically relies on basic statistical tools, such as Response Surface Methodology (RSM), which often struggle to map the highly complex, non-linear kinetics inherent in simultaneous heavy metal reduction and organic dye degradation. In contrast, this project

introduces a highly adaptable, custom-built ANN framework that uniquely screens both the algorithmic brain and the structural anatomy of the model. It systematically contrasts high-precision mathematical training algorithms including Levenberg-Marquardt, Bayesian Regularization, Resilient Backpropagation, and Scaled Conjugate Gradient against an array of multi-layer perceptron architectures (e.g., varying hidden neurons). This simultaneous optimization matrix ensures that the predictive model is neither overfitted nor computationally sluggish, regardless of whether the target pollutant is a trace heavy metal or a complex synthetic dye. Ultimately, this framework provides an unprecedented, generalized digital twin capable of pinpointing the absolute optimum metal oxide photocatalyst parameters instantly, drastically reducing R&D costs and accelerating the deployment of sustainable, green water-treatment technologies on an industrial scale.

4. Benefit to mankind

Water contamination is greatly intensified by the dumpling of industrial waste from this sector which contains hazardous organic and inorganic compounds. This emphasizes the critical need for sustainable practices and efficient waste management in the industry. The effectiveness of removing dyes and heavy metal by utilizing metal oxide photocatalysts, these studies help in degrading toxic dyes and heavy metals contributes to cleaner water bodies, reducing water pollution as reducing the risk of exposure to toxic substances and protecting the aquatic ecosystem as the dye-laden wastewater significantly impacts aquatic ecosystems by reducing light penetration, which hinders photosynthesis in aquatic plants and disrupts the entire food chain. Connecting the benefit with the Sustainable Development Goals (SDG 6) which stated that clean water and sanitation. By predicting precise treatment conditions, this computational solution bypasses costly, resource-intensive trial-and-error lab experiments. Consequently, it minimizes chemical waste and drastically reduces operational costs for large-scale treatment plants. Lastly, the use of advanced photocatalytic processes promotes sustainable practices in wastewater treatment, allowing for the recycling and reuse of water, which is essential in water-scarce regions.

5. Innovation and Entrepreneurial Impact

This creative strategy fosters an entrepreneurial culture throughout the community, organization, and industry in addition to addressing important environmental challenges. Environmental remediation, the project uses advanced photocatalysis, a technology that uses light energy to drive chemical reactions. Innovations in catalyst design, such as doping and hybridization, will be applied to improve the efficiency of photocatalytic degradation processes. The ANN will assist in controlling training data mistakes and enhancing prediction accuracy, both of which are necessary for accelerating the removal procedures. In terms of entrepreneurial culture, the project engages the community, raises awareness of sustainable practices, and motivates them to create environmentally friendly wastewater treatment technologies and solutions that are in line with green chemistry principles, protecting the environment and promoting public health. Apart from that, this technology emphasizes affordable and scalable solutions to make it appealing for business collaborations.

6. Potential commercialization

The market demand for advanced photocatalytic technologies is driven by the growing need for efficient wastewater treatment solutions because of strict environmental regulations and the lack

of clean water resources. The viability of commercial applications is increased by ongoing research and development in the field of metal oxide photocatalysts and the incorporation of intelligent modeling approaches like ANN. An ANN model can function as a "Digital Twin" of an actual photocatalytic reactor. Before implementing them in the real process, it enables operators to model the impact of altering inputs like pH, catalyst dosage, or influent pollutant concentration. This lowers the possibility of expensive experimental downtime and process failure. In addition, predictive models can dynamically recommend the ideal quantity of photocatalyst needed, avoiding over-dosing that saves costly chemicals and maximizing light exposure/retention time that saves energy. This framework shows adaptability by modeling both heavy metals and dyes. Treatment plants are very interested in a single software solution that can be retrained for various industrial effluents.

7. Acknowledgment

We would like to express our sincere gratitude and appreciation to Faculty of Chemical Engineering, Universiti Teknologi MARA, for the support

8. Researchers' Biography

Auni Kiasatina binti Azman is a final year degree chemical engineering student at UITM Shah Alam. Currently, I am researching the prediction modelling the removal of dye with the help of metal oxide photocatalyst using various neural network architecture supervised by IR. Ts Mohd Fadhil bin Majnis.

Muhammad Akmal Faiz bin Rizalmy is a final year degree chemical engineering student at UITM Shah Alam. I am currently do comparative analysis of training algorithms in ANN for predicting heavy metal removal by metal oxide photocatalysis supervised by IR. Ts Mohd Fadhil bin Majnis.

Ir. Ts. Mohd Fadhil Majnis is a Chartered Chemical Engineer, Professional Engineer, Professional Technologist, and currently a lecturer at Universiti Teknologi MARA specializing in Chemical Engineering. He holds a master's and a bachelor's degree in chemical engineering from Universiti Sains Malaysia. With expertise in process modeling, fluid mechanics, and thermodynamics, he has over a decade of higher education experience, including significant tenure at UCSI University. Prior to academia, he served as a design engineer, managing boiler design, statutory compliance, and quality auditing. Bridging academic theory and industrial application, the work drives impactful advancements in engineering education, research, and professional practice.

Pinegg POT: An Integrated in-Pot Composting System Using Pineapple Waste, Eggshells, Tea Waste and Disc Magnets for Sustainable Plant Growth

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ABSTRACT

Food waste accounts for a large proportion of solid waste generated in Malaysia and contributes significantly to landfill accumulation and environmental pollution. Organic residues such as pineapple waste, eggshells and tea waste contain essential nutrients including potassium, calcium and nitrogen. However, they are often discarded without proper utilization. This study aimed to develop an eco-friendly organic fertilizer system known as PINEGG POT, using pineapple waste, eggshells, tea waste and a disc magnet to recycle food waste into a sustainable plant growth medium. The disc magnet embedded within the pot generates a localized magnetic field around the soil and root zone, which may enhance water absorption, nutrient mobility and plant physiological processes. The system integrates composting and plant cultivation within a single container, allowing organic fertilizer to be produced directly inside the pot while simplifying the recycling of kitchen waste. The effectiveness of PINEGG POT was evaluated using cucumber plants under three soil treatments. The results showed that plants grown in PINEGG POT exhibited better vegetative growth compared to the control treatments, with plant height increases of 5.5–6.5 cm, stem diameter increments of 0.1–0.2 cm and leaf diameter improvements of 1.5–2.5 cm. These findings indicate that PINEGG POT can enhance plant growth while reducing household food waste and supporting sustainable urban gardening practices.

Keywords: PINEGG POT, food waste, organic fertilizer, magnetic field, sustainable plant growth

1. Product Description

PINEGG POT is an innovative eco-friendly planting system designed to recycle household food waste into a natural fertilizer while supporting plant growth. The system utilizes pineapple waste, eggshells and tea residues as organic nutrient sources. These organic materials are processed and applied directly inside the planting pot, allowing composting and plant cultivation to occur simultaneously. Pineapple waste provides organic matter and nutrients that enhance soil fertility, eggshells supply calcium that strengthens plant cell structure and tea waste contributes nitrogen and potassium that improve soil quality. A disc magnet is embedded inside the pot to create a localized magnetic field around the soil and root zone. This magnetic field may influence water structure, nutrient mobility and plant physiological processes, potentially enhancing nutrient uptake and plant growth. The integration of organic fertilizer production and planting within a single container eliminates the need for separate compost bins and reduces maintenance

requirements. The compact and user-friendly design makes PINEGG POT suitable for urban households, students and community gardening initiatives.

2. Product Process, Implementation dan Results

Product Process

The preparation of PINEGG POT begins with collecting pineapple waste, eggshells and tea waste from cafeteria Kolej Matrikulasi Negeri Sembilan. The materials are washed and sun-dried for approximately 72 hours to prevent spoilage. The eggshells are crushed into powder, while the pineapple waste is cut into smaller pieces and the tea waste is dried. All materials are then mixed and incorporated into the soil inside a planting pot. Several disc magnets are placed near the root zone to create a mild magnetic field that may enhance nutrient mobility and plant growth. The prepared pot is then ready for transplanting germinated cucumber seedlings, as illustrated in **Figure 1.**

Figure 1. Preparation of PINEGG POT Fertiliser.

Implementation

Figure 2. Comparison of three planting conditions used to evaluate the effectiveness of PINEGG POT.

Three planting conditions were prepared for comparison, as illustrated in **Figure 2**. The first condition consisted of soil only (Pot 1). The second condition used soil mixed with crushed eggshell and tea waste as organic fertilizer (Pot 2). The third condition used soil supplemented

with the PINEGG POT system consisting of pineapple waste, eggshells, tea waste and a disc magnet (Pot 3).

Results

The result was recorded after the fertilization at 7 days.

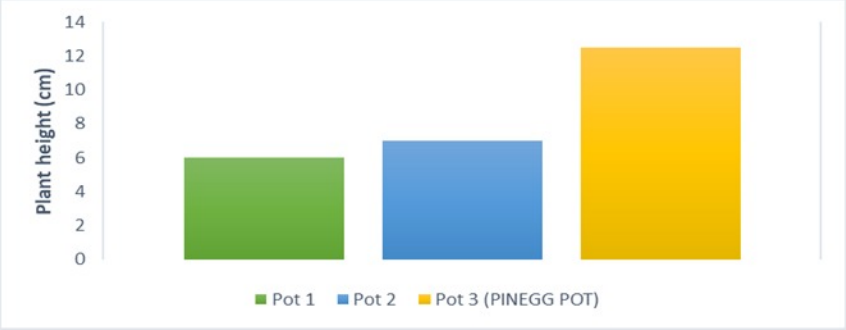

Figure 3. Graph of the height of the cucumber plant.

Figure 3 shows the height of cucumber plants grown under three soil conditions after seven days of seedling emergence. The plant grown in PINEGG POT recorded the highest height (12.5 cm), followed by Pot 2 (7.0 cm), while Pot 1 (6.0 cm) showed the lowest height. This result suggests that the PINEGG POT system supplied essential nutrients that supported better early plant growth.

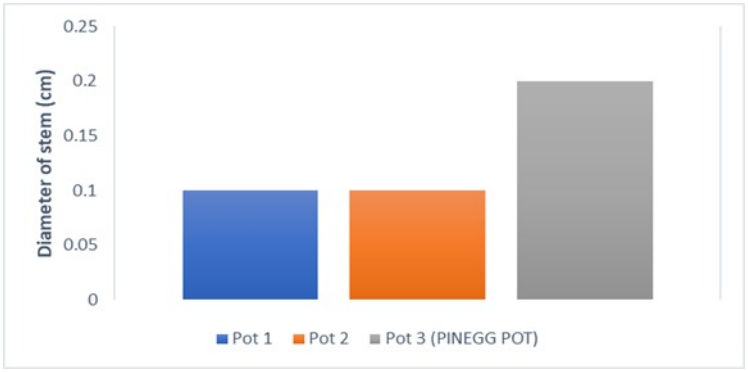

Figure 4. Stem Diameter of Cucumber Plants under Different Soil Treatments .

Figure 4 shows the stem diameter of cucumber plants grown under three different soil treatments after seven days of seedling emergence. The cucumber plant grown in the PINEGG POT treatment recorded the largest stem diameter (0.2 cm). In contrast, cucumber plants in treatment Pot 1 and Pot 2 showed the same stem diameter (0.1 cm), indicating no noticeable difference between the two treatments. The greater stem diameter observed in the PINEGG POT treatment suggests that the organic materials, particularly tea waste, supplied essential macronutrients such as potassium and nitrogen, which contributed to stronger stem development in the cucumber plants

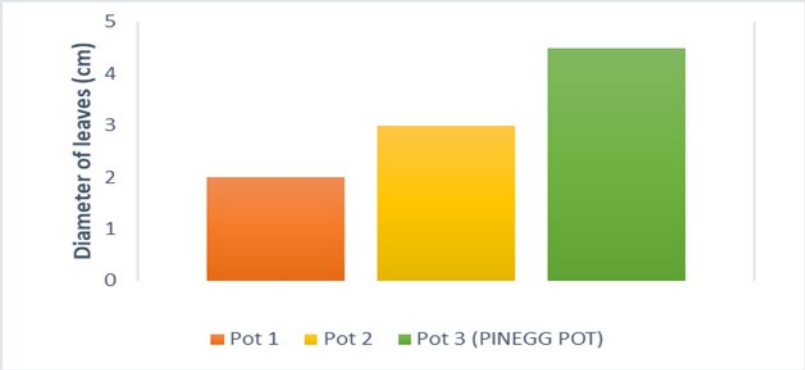

Figure 5. Leaf Diameter of Cucumber Plants under Different Soil Treatments .

Figure 5 shows the leaf diameter of cucumber plants grown under three different soil treatments after seven days of seedling emergence. The cucumber plant grown in the PINEGG POT treatment recorded the largest leaf diameter (4.5 cm), followed by the plant in treatment Pot 2 (3.0 cm). The smallest leaf diameter was observed in the control treatment (Pot 1). This indicates that the nutrients from pineapple waste, eggshells, tea waste and the presence of a disc magnet supported better leaf growth. As a result, the PINEGG POT system promotes healthier and larger leaf growth in cucumber plants**.**

Table 1. Growth Performance of Cucumber Plants under Different Treatment Pots after Seven Days .

Treatment pots	1	2	3
Plant heights (cm)	6.0	7.0	12.5
Diameter of stem (cm)	0.1	0.1	0.2
Diameter of leaves (cm)	2.0	3.0	4.5

Table 1 shows the growth performance of cucumber plants under three different treatment pots after seven days of seedling emergence. The parameters measured include plant height, stem diameter and leaf diameter. Based on the results, the cucumber plant grown in treatment Pot 3 (PINEGG POT) recorded the highest values for all growth parameters, with a plant height of 12.5 cm, a stem diameter of 0.2 cm and a leaf diameter of 4.5 cm. In comparison, the cucumber plants grown in Pot 1 and Pot 2 showed lower growth measurements. Pot 1 recorded a plant height of 6.0 cm, stem diameter of 0.1 cm and leaf diameter of 2.0 cm, while Pot 2 recorded a plant height of 7.0 cm, stem diameter of 0.1 cm and leaf diameter of 3.0 cm. These results indicate that the PINEGG POT treatment provided better nutrient availability for the cucumber plants, resulting in improved early plant growth.

3. Novelty and uniqueness

PINEGG POT introduces a self-fertilizing planting system that integrates organic waste recycling and plant cultivation within a single container. Unlike conventional composting methods that require separate compost bins and longer processing time, PINEGG POT converts household

organic waste such as pineapple waste, eggshells and tea waste into nutrients directly inside the pot, with the addition of a disc magnet. The embedded disc magnet generates a mild magnetic field that may enhance nutrient mobility and microbial activity in the soil, supporting faster decomposition and improved nutrient availability. Pineapple waste provides natural enzymes for decomposition, eggshells supply calcium for plant strength and tea waste improves soil structure and microbial growth. This combination of organic waste composting and magnetic-assisted enhancement offers an innovative and eco-friendly approach for sustainable household gardening.

4. Benefit to mankind

PINEGG POT benefits mankind by promoting sustainable waste management and eco-friendly gardening practices. In Malaysia, food waste forms a large portion of municipal solid waste. By converting pineapple waste, eggshells, tea waste and disc magnets into organic fertilizer directly inside the planting pot, PINEGG POT helps reduce landfill waste and lower greenhouse gas emissions while encouraging households to recycle organic materials effectively. The system also promotes chemical-free gardening by reducing dependence on synthetic fertilizers that may harm soil health and environmental quality over time. Through natural decomposition, the organic materials enrich the soil with essential nutrients, supporting healthier plant growth and safer food production. In addition, the inclusion of a disc magnet adds a scientific advantage to the system. The mild magnetic field produced by the disc magnet may stimulate microbial activity and enhance the movement of nutrient ions in the soil. This can help accelerate the decomposition process and improve nutrient absorption by plants, making the composting process more efficient and beneficial for sustainable gardening.

5. Innovation and Entrepreneurial Impact

PINEGG POT promotes innovation by transforming common kitchen waste into a value-added agricultural product through an integrated planting and composting system. The project demonstrates how scientific knowledge related to organic waste management and plant nutrition can be translated into a practical solution for sustainable gardening. By combining simple materials with an eco-friendly concept, PINEGG POT highlights the potential of innovative thinking in addressing environmental challenges. From an entrepreneurial perspective, PINEGG POT offers strong potential for small-scale production and commercialization. The product can be marketed to urban gardeners, schools, community gardening groups and environmentally conscious consumers as a sustainable lifestyle product. In addition, educational workshops and DIY kits can be developed to introduce composting and sustainable gardening practices to students and local communities. The inclusion of a simple magnetic system further increases its market appeal by improving functionality and user experience. Through these initiatives, PINEGG POT encourages innovation-driven thinking and supports the development of green entrepreneurship within the community and agricultural sector.

6. Potential commercialization

PINEGG POT contributes to environmental sustainability by reducing household food waste and converting it into valuable organic fertilizer. In Malaysia, food waste constitutes a large proportion of municipal solid waste; therefore, transforming pineapple waste, eggshells and tea residues into plant nutrients helps reduce landfill accumulation and mitigate greenhouse gas emissions. In addition, PINEGG POT promotes chemical-free gardening by reducing reliance on synthetic fertilizers that may negatively affect soil health and environmental quality over time. Through the

natural enrichment of soil nutrients, the system supports safer food production and contributes to healthier ecosystems. Furthermore, PINEGG POT encourages environmental awareness and responsible waste management among households, particularly students and urban communities. By providing a simple and practical composting solution within a planting pot, the innovation enables individuals to recycle organic waste efficiently. This approach empowers communities to adopt sustainable practices that benefit both present and future generations while promoting greener and more responsible lifestyles.

7. Acknowledgment

We would like to express our sincere gratitude to our teachers and mentors for their continuous guidance and support throughout this project. Their valuable advice and encouragement greatly contributed to the successful development of PINEGG POT. We also extend our appreciation to Kolej Matrikulasi Negeri Sembilan for providing the facilities and resources necessary for conducting this research. Lastly, we thank our team members for their cooperation, dedication and commitment in making this project possible.

8. Researchers' Biography

Cindy Liew is a 19-year-old student from Kolej Matrikulasi Negeri Sembilan with a strong passion for research, innovation and lifelong learning. She has participated in programs such as i-MONST (International Mathematics Olympiad National Selection Test) and K3M (Kuiz Kimia Kebangsaan Malaysia), which enhanced her analytical thinking and problem-solving skills. Cindy enjoys research-based projects and exploring knowledge beyond the classroom. She is particularly interested in Food Technology and aims to develop sustainable solutions in food production and waste management. Her involvement in research reflects her curiosity, critical thinking and commitment to creating meaningful real-world impact.

Wenda Ting, 19, currently studies at Kolej Matrikulasi Negeri Sembilan and has enjoyed STEM-related topics since a young age. She has taken part in several competitions connected to science and mathematics, including the ASMO Science Olympiad Competition State Round in 2023, where she was awarded Silver. In addition, she participated in i-MONST (International Mathematics Olympiad National Selection Test) and obtained Bronze. These experiences strengthened her interest in scientific exploration and innovation. She hopes to contribute ideas that support environmental sustainability, particularly through green technology projects such as producing fertilizer from waste. She believes such efforts can help preserve the environment and benefit the well-being of future generations.

Lui Yi, a 19-year-old student of Kolej Matrikulasi Negeri Sembilan, is an ambitious STEM student who has a strong drive to excel and an understanding of science. This passion is proven through her participation in Kuiz Kimia Kebangsaan Malaysia (K3M), which has not only helped her in mastering Chemistry within the syllabus, but it has also helped her gain extra knowledge in Chemistry around the world. In particular, she aspires to study topics related to environmental science, in the hope of helping and innovating in order to help improve the world into a place where people can comfortably be.

Nurul Shaiedah binti Roslan is a lecturer in Physics at Kolej Matrikulasi Negeri Sembilan, Malaysia. She is currently pursuing a Master's degree in Education with a focus on educational technology and innovation in science learning. Her research interests include STEM education, artificial intelligence in education and innovative teaching approaches that enhance student engagement and conceptual understanding. She is actively involved in educational innovation projects and has developed several teaching and learning tools to improve students' achievement in science.

THE Language Detective: Interactive Mystery Stories

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ABSTRACT

'The Language Detective' is an interactive digital platform where readers become the detective in the story, and in order to progress with the narrative, readers must answer the language-based questions correctly. It was created to aid in averting the sustaining decay cycle in reading pleasure by the younger generations by turning reading into entertainment by integrating aspects of gamification into the narrative. The aim of the current project is to ensure that the readers are actively involved in the process of reading the text by using questions that require answers based on the level of understanding and inference, and to combine Grammar and Literature with creative storytelling as the way of encouraging the fun learning process through play and discovery. The platform presents a creative approach to language learning by combining storytelling with interactive questions that require readers to participate in the narrative. By answering Grammar and Literature questions to progress through the story, readers practise comprehension, inference, and critical thinking skills. This approach helps increase reading engagement and supports the development of language skills in a more interactive way. The platform can benefit students, educators, and independent learners as an alternative digital reading activity. In terms of commercialization, the project can be developed into a full application with features such as progress tracking, scoring systems, multiple storylines, and adaptive quiz difficulty, with potential revenue through subscriptions or educational partnerships.

Keywords: Interactive learning, Digital storytelling, Grammar, Literature, Active reading

1. Product Description

The Language Detective is an interactive online platform in which readers assume the role of the detective in a series of short mystery stories each of which revolves around Grammar and Literature topics. To start with, the readers will have 100 points in life which will be deducted whenever they make a wrong choice. To move forward with the story, the reader has to answer some questions and choose the right alternative. Such a choice of decision will provide the readers with the challenge to use their critical thinking and knowledge of language to read the stories. Moreover, the target audience of this project is people aged 16 years and older since the storyline and questions will address the intermediate and advanced English proficiency levels. Also, the idea of this project is based on mystery-driven mobile games, combining the elements of interactive plot and problem-solving, and the magic of Harry Potter. With the help of education and gamification, the readers can actively engage with the content and at the same time increase and improve language knowledge, as well as reading comprehension.

2. Project Overview

Workflow of the project

This project was developed consecutively, with different tasks organised and carried out over a span of 14 weeks, as shown in the Gantt Chart below. The development process began with the initial planning stage, which involved research on interactive digital platforms, identifying the project objectives, and planning the concept and structure of the project. The process then continued with the content drafting stage, which included developing the story framework, writing the story content, and creating language-based questions, as pre-surveys were not required in this project. The plotline for each story was carefully written and structured to ensure a smooth transition between the story and the questions. This was then followed by the development of the platform using Canva because it provides extensive features that support the development of interactive platforms. Lastly, the platform was published after the proofreading and editing process was done. It was promoted through a personalised instagram account for the project, and was sent across different Whatsapp groups to gather more participation. The feedback survey was created to identify overall effectiveness of the platform, and then, was collected through a link provided at the end of each story. This approach also functioned as an alternative to record readers' progress.

TASK / WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Idea pitching														
Platform development research														
Drafting story outlines														
Content writing														
Question development														
Concept design														
Proofreading & Editing														
Platform prototype development														
Finalising														
Platform testing														
Feedback collection														

Figure 1. Gantt Chart.

Results

Table 1. Feedback survey of the platform.

QUESTION	ANSWER OPTIONS	TOTAL OF PERCENTAGE
1. Answering questions to progress the story makes me participate consistently with the learning content.	Strongly agree	51.4% (18 respondents)
	Agree	42.9% (15 respondents)
	Neutral	5.7% (2 respondents)
	Disagree & Strongly disagree	0%
2. The question makes me want to read actively and think critically about the story.	Strongly agree	48.6% (17 respondents)
	Agree	42.9% (15 respondents)
	Neutral	8.6% (3 respondents)
	Disagree & Strongly disagree	0%
3. The story successfully combined Grammar and Literature questions in a creative and engaging way.	Strongly agree	57.1% (20 respondents)
	Agree	34.3% (12 respondents)
	Neutral	8.6% (3 respondents)
	Disagree & Strongly disagree	0%
4. Did you learn something new from 'The Language Detective' ?	Strongly agree	65.7% (23 respondents)
	Agree	31.4% (11 respondents)
	Neutral	2.9% (1 respondent)
	Disagree & Strongly disagree	0%

Table above showcases some of the questions from the feedback survey of the platform. There are 35 respondents with the majority of the respondents being above the age of 19 years. To begin with, respondents needed to state how they were either in agreement according to the answer of the questions to move on with the story, 18 respondents strongly agreed and 15 respondents agreed to this, with only 2 remaining neutral. This is perhaps because of the fascinating plots, and the need to provide answers makes them remain in touch with materials. Second, 17 respondents stated that they strongly agreed and 15 respondents agreed, and 3 respondents remained neutral with the queries posed to them on how they would like to read actively and think critically about the story. This could have been the case since the questions compelled them to read the text over and over again. Thirdly, there were many respondents strongly agreeing to the statement, 20 respondents; and 12 respondents agree to the statement though, 3 of the respondents are neutral to the statement that states that the story did manage to combine language-based questions in a creative manner. This can be explained by the fact that the questions of the language are integrated into the storyline in a very natural way so that it becomes natural to read. Finally, 23 respondents were strongly agreeing and 11 agreed but only 1 chose neutral on the question of whether they learn something new on the platform. The interactive storytelling method of use on the platform could result in these positive reactions because the readers can interact and engage with the content, and as they use their language knowledge. Generally, the answers indicate that The Language Detective was able to capture the attention of the readers in active learning and thinking and Incorporate Grammar and Literature in an interactive and fun manner.

3. Novelty and uniqueness

The uniqueness of this project lies in the combination of creative storytelling and language learning. The integration of language-based questions into the story to allow the narrative to progress incorporates elements of gamification. Therefore, the platform manages to showcase a creative approach of interactive learning experience and storytelling. Moreover, the plotline itself presents novelty, as each story is set in the same fantasy universe where language holds power. Different topics such as Grammar and Literature are represented as separated as towns within this universe. As a result, readers can choose which story they wish to explore. This allows each language topic to be presented in its own narrative setting while maintaining clarity and avoiding confusion between concepts.

4. Benefit to mankind

The objective of the project is to rekindle the interest in reading, particularly in younger readers who might not be attracted to reading material in case of traditional reading materials. The Language Detective offers the interactive features of reading allowing the reader to actively engage in the mystery-solving process as they learn the language concepts. Discussing Grammar and Literature questions to continue the story through, the readers train their understanding, reasoning, and critical thinking more pleasurably. The platform demonstrates that learning does not necessarily need to be relevant as a task; it can be entertaining and engaging. In such a manner, the project is expected to make the process of reading easier and more significant and enable readers to acquire the crucial skills in language in a creative and interactive setting.

5. Innovation and Entrepreneurial Impact

The project itself proves that with the help of creativity and minimal digital technologies, innovative learning experiences can be created. The Language Detective tries to combine storytelling, gamification, and learning languages, which is an innovative way of making learning content more captivating. The platform has been created with the help of the available tools, demonstrating that valuable digital learning resources can be produced without the need to master the complicated programming languages. This promotes innovativeness among the students and teachers and tries new approaches to the presentation of knowledge. Moreover, the idea can be expanded outside of this project, including to more stories or into a specific education platform. By doing so, the project will encourage innovative thinking and motivate others to transform creative ideas into valuable digital solutions.

6. Potential commercialization

This project has potential commercialization as it can be developed as a fully functional app open to a wider audience. For instance, the app could offer advanced features including readers' score as well as progress tracking, multiple story options that can cover other English subjects, adaptive quiz questions with different levels of difficulty, and lastly, interactive graphics and illustrations to make it even more engaging. It also has the opportunity to gain profit through monetization like subscriptions, in-app purchases, or partnerships. As a whole, 'The Language Detective' has potential to evolve into a better version to promote active reading and education.

7. Acknowledgment

'The Language Detective' would not have happened without contributions from others. Therefore, I would like to express my sincere gratitude to my family, friends, and even strangers who were willing to participate and make this project successful. A special appreciation is extended to my supervisor, Dr Fazillah, for her continuous guidance and encouragement throughout this journey. Lastly, I would like to thank myself for not giving up, and making something impossible possible.

8. Researchers' Biography

Nur Aidah Binti Mohd Azman is a diploma student from Academy of Language Studies, enrolled in English for Professional Communication course at MARA University of Technology (UiTM) Alor Gajah Branch. She has a keen interest in creative writing and reading imaginative works. Her passion for storytelling inspired her to develop 'The Language Detective' where readers can immerse themselves into the world of the story, just like how she gets to explore new worlds through her imagination by reading.

Fazillah Sulaiman is a Senior Lecturer at the Academy of Language Studies (APB), Universiti Teknologi MARA (UiTM) Melaka. She teaches English language courses at the tertiary level and is actively involved in research related to language education and academic writing. Her research interests include English language pedagogy, digital discourse, and technology-enhanced learning. She is committed to promoting student-centred learning and reflective practices that support students' language development and academic success in higher education.

Corné Craftworks: Sustainable Handcrafted Agro-Based Floral Bouquets from Corn Husk

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ABSTRACT

Agricultural biomass is an unwanted byproduct of harvested crops, such as corn husks. In Malaysia, approximately 47,366 tonnes of corn husk waste are generated annually, much of which contributes to environmental pollution and soil contamination. To mitigate this issue, corn husks are transformed into high-value, eco-friendly handcrafted floral bouquets. This project utilizes innovative agro-based techniques and natural plant-based dyes to create sustainable alternatives to conventional plastic-based decorative products. In addition, it is an initiative that generates income for rural communities and single mothers while promoting Responsible Consumption (SDG 12) and Climate Action (SDG 13). The commercial prospect is driven by a growing demand for unique, biodegradable giftware among eco-conscious consumers and corporate clients.

Keywords: corn husk, sustainable crafts, agricultural biomass, eco-friendly, income generation

1. Product Description

Corné Craftworks is the core product, corn husk, which is a range of unique, handmade floral bouquets crafted primarily from corn husks and coconut leaf sticks. The product is made from 100% biodegradable materials in its colouring, design, and packaging. It is a sustainable alternative to conventional floral goods, which often consist of 90% plastic. These crafts enable consumers to support the Sustainable Development Goals: Responsible Consumption (SDG 12), Climate Action (SDG 13), and Decent Work (SDG 8). The product design focuses on transforming agricultural waste into aesthetically appealing floral forms that serve as durable decorative items or eco-conscious gifts. The arrangement of petals, stems, and wrapping demonstrates attention to detail, craftsmanship, and durability, making the product suitable for decorative purposes and as an eco-conscious gift item. This design highlights the transformation of agricultural waste into value-added craft products. To maintain a 100% biodegradable profile, the product utilizes natural dyes derived from sources such as butterfly pea flowers and turmeric, avoiding synthetic chemicals. Each bouquet is presented in sustainable packaging: brown craft paper bags with transparent window panels, minimizing the use of non-recyclable materials.

Figure 1. Corn husk waste.

2. Production process of corn husk flower, product design, and packaging for the market

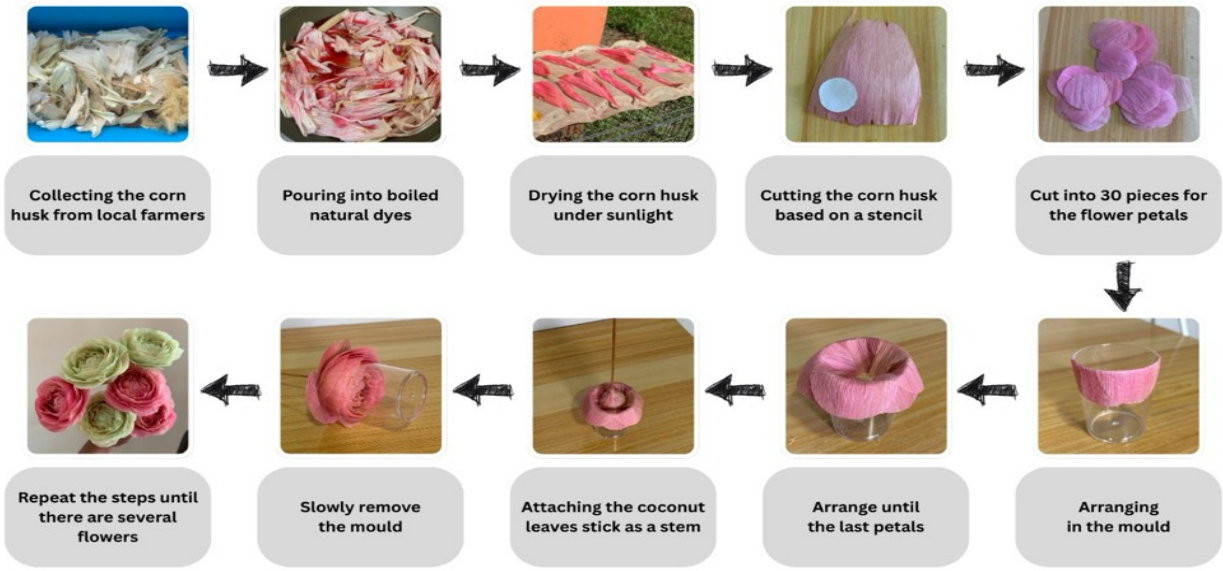

Figure 2. The flowchart of the production process of corn husk flowers.

Figure 3. Product design.

Figure 4. Product packaging.

3. Novelty and uniqueness

Corné Craftworks offers a fully bio-based alternative as compared to traditional artificial flowers, which are composed of nearly 90% plastic. The uniqueness lies in its material innovation: the use of discarded corn husks as the primary medium for high-quality artisanal craftsmanship. Furthermore, the product integrates traditional handmade values with modern sustainability by employing natural, plant-based coloring techniques that produce distinct, earthy tones unique to each piece. The colouring dye is also produced naturally from plant-based sources such as butterfly pea flower and turmeric. It effectively bridges the gap between agricultural waste management and the luxury gift market.

4. Benefit to mankind

This project provides significant environmental and social benefits by supporting the Sustainable Development Goals (SDG12 and SDG8). Environmentally, it mitigates pollution from the annual 4.2 million tonnes of agricultural biomass in Malaysia by converting waste into value-added products. Socially, the business serves as a platform for community empowerment, especially in rural areas. By offering a compensation rate of RM9 per hour for skilled work, it provides a stable source of income for individuals with irregular incomes, particularly single mothers and rural workers. In addition, it supports the social enterprise in generating extra income by transforming agricultural waste into valuable flower decorations, as well as increasing environmental awareness among humankind.

5. Innovation and Entrepreneurial Impact

Corné Craftworks fosters a culture of agropreneurship by demonstrating how raw bio-waste can be professionalized into a viable business model. The social enterprise encourages community-based innovation through skill-sharing workshops that educate the public on the economic value of recycled materials. In addition, it encourages the entrepreneur to seek business opportunities with recycled materials and supports the environment. The use of recycled materials helps sustain the environment, lowers production costs, and increases the entrepreneur's income. By aligning with the Sustainable Development Goals (SDGs 8, 12, and 13), small-scale social enterprises can integrate ethical production with market competitiveness. The product also creates job opportunities for those seeking extra income, such as a student who can serve as an agent to market the product.

6. Potential commercialization

The commercial potential is high, targeting a diverse segment including eco-conscious consumers, the tourism market, and corporate clients seeking "green" branding solutions. With a calculated net profit of RM5,295.60 from a monthly production of 420 units, the business demonstrates financial viability. Revenue streams are diversified through direct online sales via TikTok and Instagram, customized bulk orders for events, and fee-based workshops. Growth opportunities driven by the product's lightweight, durable nature, which eliminates the refrigeration and logistical costs of fresh flowers for e-commerce. Moreover, the customization of natural dyes enables premium collections in the luxury gift market. Strategic partnerships with bodies like the Sabah Tourism Board and SCENIC further enhance its market reach and scalability.

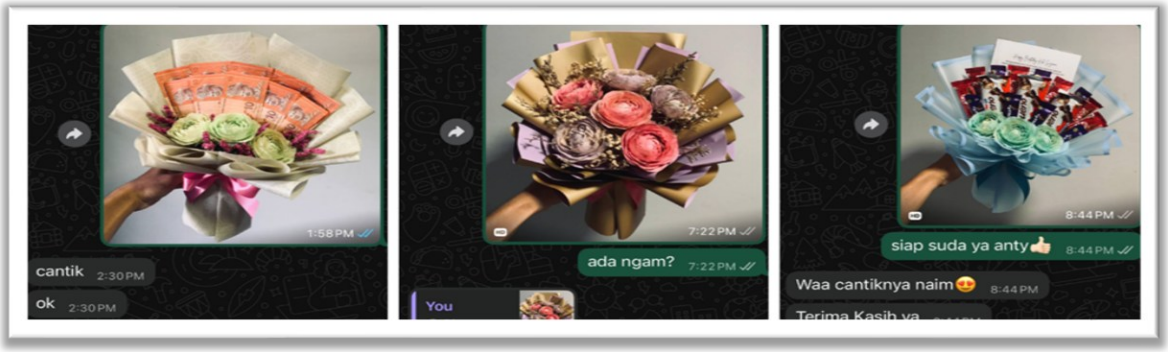

Figure 4. The customer feedback on the final product**.**

7. Acknowledgment

The authors express their sincere gratitude to Mr. Zafiruddin Ziyaad bin Saijan, the founder of Seri Zasa Farm Kota Belud Sabah, for his invaluable guidance, technical support, and constructive comments, which have made this apprenticeship project more feasible and successful. Appreciation was also extended to Mrs. Nur Aziemah Jasni and Ms. Grace Flavyeliz Sinong for their guidance and supervision throughout the project.

8. Researchers' Biography

Mohamad Haikal Naim is a student at the Universiti Teknologi Mara (UiTM) Sabah Branch, studying in Diploma in Agropreneurship (AT113).

Nur Aziemah Jasni is a lecturer and researcher at the Universiti Teknologi MARA (UiTM) Sabah Branch, specializing in plantation management, agribusiness, and agropreneurship. With over 10 years of experience, she has achieved many innovation awards locally and internationally. In addition to her academic role, she is passionate about community engagement and agro-based innovation. She continues to inspire her students and colleagues with her dedication to research and teaching. Her commitment to academic excellence and her contributions to plantation management, agribusiness, and entrepreneurship have earned her recognition within the academic community, and her work continues to inspire the next generation of scholars.

Grace Flavyeliz Sinong is a lecturer and researcher at the Universiti Teknologi MARA (UiTM) Sabah Branch. With over 4 years of experience, she specializes in crop production, soil science, plant microbiology, agropreneurship, and agro-based products. Her commitment and passionate has earned her many innovation awards locally and internationally in agro-based products and educational innovation. She also passionate on community engagement and global networking as well as continues to inspire the young generation with her dedication in research and innovation.

Nova – Neural Offline Voice-Activated Smart Switch for Inclusive and Accessible Smart Homes

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ABSTRACT

NOVA is an intelligent smart switch developed to provide a more inclusive and energy-efficient way to control household electrical systems. Although smart home technologies have progressed rapidly, many existing solutions remain difficult to use for elderly individuals and persons with disabilities, particularly those with visual impairments or limited mobility. NOVA was designed to address this challenge by combining offline neural voice control, capacitive touch interaction, real-time visual feedback, and presence-based activity detection within a single compact device. The system performs on-device neural voice recognition using an embedded microcontroller, allowing users to control electrical appliances through simple voice commands without requiring an internet connection. A capacitive touch interface together with a 128 × 128 TFT display provides intuitive manual interaction and clear system status information. In addition, a Passive Infrared (PIR) sensor supports intelligent energy management by automatically controlling appliances based on room occupancy, helping to reduce unnecessary electricity consumption. By enabling easier and more independent interaction with household electrical systems, NOVA helps improve daily living for elderly users and persons with disabilities while promoting safer and more accessible homes. At the same time, the system encourages responsible energy use and supports sustainable living, particularly in residential areas with limited internet connectivity.

Keywords: Offline Neural Voice Control, Smart Switch, Presence Detection, Energy-Efficient Smart Home.

1. Product Description

NOVA is an intelligent smart switch designed to replace conventional wall switches while improving accessibility, energy efficiency, and reliability in modern homes. The system is specifically developed to support inclusive living environments, particularly for elderly users, persons with disabilities, and individuals with visual impairments or limited mobility who often experience difficulty operating traditional mechanical switches. Unlike most smart home devices that depend heavily on cloud connectivity, NOVA operates using an offline neural voice recognition system powered by an ESP32 embedded platform. Voice commands are processed locally within the device, allowing users to control electrical appliances without internet access. This approach ensures faster response time, enhanced user privacy, and reliable operation in rural or low-connectivity environments. NOVA integrates multiple interaction methods including voice activation, capacitive touch control, and optional remote

access through mobile devices. A compact TFT display provides real-time visual feedback on appliance status, enabling users to easily monitor device activity. The system also incorporates a Passive Infrared sensor to detect human presence and automatically manage lighting or electrical loads based on occupancy, contributing to improved safety and reduced energy consumption. By combining inclusive design, offline intelligence, and hybrid connectivity, NOVA offers a practical and scalable smart home solution. The system demonstrates strong commercialization potential as an affordable retrofit technology for residential buildings, assisted living facilities, and smart community housing initiatives.

2. Pictures and Schematic diagrams

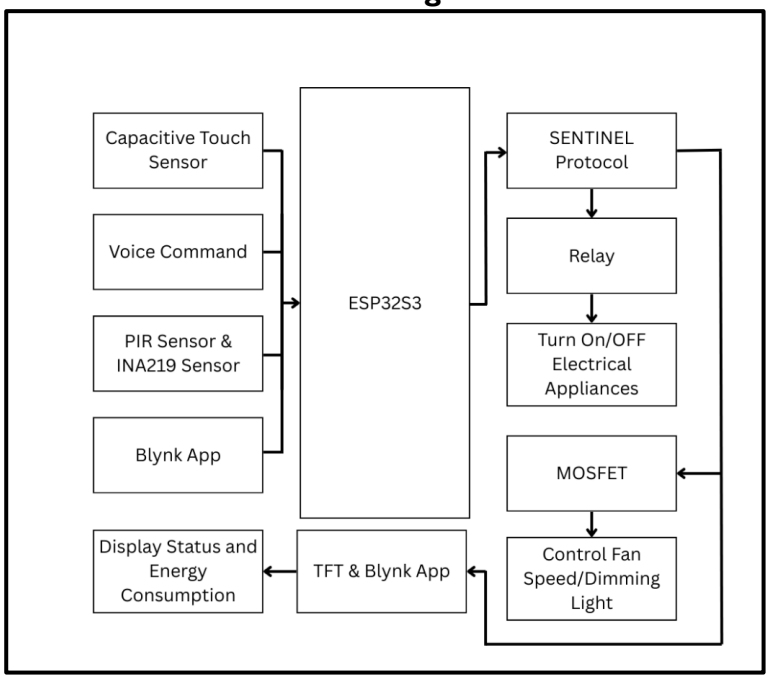

Figure 1. Block Diagram of NOVA.

Figure 1 shows the block diagram of the NOVA system, which is organized using a modular architecture consisting of five main functional subsystems. The first subsystem is the Offline Voice Processing Module, which performs on-device neural inference to recognize predefined voice commands without relying on cloud computing services. The second subsystem is the Capacitive Touch Interface, which provides a simple and accessible manual control method suitable for users with limited physical strength or dexterity. The third subsystem is the Presence Detection Module, where a Passive Infrared (PIR) sensor detects room occupancy and triggers automated energy-saving or safety responses through a mechanism known as the SENTINEL Protocol. The fourth subsystem is the Display and Feedback Unit, which utilizes a 128 × 128 TFT display to present real-time visual information such as system status, appliance conditions, and operational alerts. Finally, the Connectivity and Control Layer enables optional remote monitoring and control through mobile devices while ensuring that the system can continue to operate fully in offline mode. When human presence is detected, the system activates intelligent control logic that adapts system behaviour according to predefined rules. For example, electrical appliances can be automatically switched off after extended periods of inactivity. Voice commands may also override automated control whenever manual intervention is required.

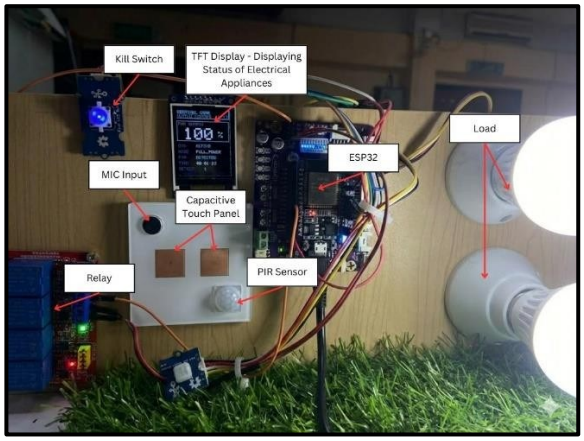

Figure 2. NOVA Prototype

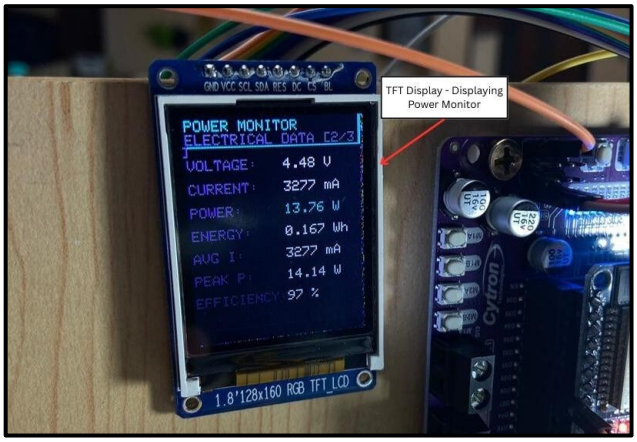

Figure 3. TFT Display Interface.

Figure 2 illustrates the prototype implementation of the NOVA smart switch system and its main hardware components. The system is built around an ESP32 microcontroller that processes offline neural voice commands received through a microphone input. A capacitive touch panel provides an alternative manual control interface, while a Passive Infrared (PIR) sensor detects human presence for automated appliance management. A relay module is used to control electrical loads such as lighting devices connected to the system. A kill switch is also integrated to allow immediate manual shutdown for safety purposes. The TFT display provides real-time feedback on appliance status and system operation. **Figure 3** shows the TFT display interface used for monitoring electrical parameters of the connected appliances. The display presents real-time information including voltage, current, power consumption, energy usage, and system efficiency. This visual feedback allows users to easily monitor electrical activity and energy consumption, improving user awareness and supporting more efficient energy management within the smart home environment.

3. Novelty and uniqueness

NOVA distinguishes itself from many existing smart switch solutions through the integration of offline neural voice recognition with an inclusive hardware interface. Many conventional smart switches rely heavily on cloud-based voice assistants and continuous internet connectivity. NOVA removes this dependency by processing voice commands locally through embedded neural inference. This approach improves reliability, enhances privacy protection, and reduces response latency. The combination of voice interaction and capacitive touch control also eliminates reliance on mechanical switches while improving accessibility for users with physical limitations. The inclusion of a compact TFT display further differentiates NOVA by providing direct visual feedback at the device level, a feature that is often absent in conventional smart switch designs. Another distinctive feature of NOVA is the presence-based automation capability. The system supports intelligent energy management while also contributing to household safety. Unlike monitoring systems that rely on cameras, NOVA uses non-intrusive sensing, making it suitable for privacy-sensitive environments such as elderly care homes.

4. Benefit to mankind

NOVA promotes inclusive living by enabling elderly individuals and persons with disabilities to independently control household electrical appliances. Through voice interaction and touch-sensitive interfaces, the system reduces physical effort and visual dependency while enhancing comfort and independence in daily activities. From an environmental perspective, presence-based automation reduces unnecessary energy consumption by ensuring that appliances operate only when needed. This capability contributes to improved household energy efficiency and supports Sustainable Development Goal 7: Affordable and Clean Energy. The offline-first architecture also reduces dependence on continuous cloud connectivity, which indirectly lowers the energy demand associated with large-scale data transmission and cloud infrastructure. In addition, NOVA enhances household safety by detecting occupancy conditions and automatically managing electrical appliances when prolonged inactivity is detected.

5. Innovation and Entrepreneurial Impact

NOVA reflects the principles of Industry 4.0 through the integration of embedded intelligence, automation, and hybrid connectivity. The implementation of offline neural processing highlights the growing importance of edge computing in modern smart home technologies. From an entrepreneurial perspective, NOVA introduces a differentiated smart home solution that specifically targets underserved user groups such as elderly individuals and persons with disabilities. Many commercial smart home systems are designed primarily for general consumers and do not prioritize accessibility. The modular architecture of NOVA also allows future expansion through additional sensors, multilingual voice recognition models, and advanced automation features. This flexibility increases the potential commercial value and long-term adaptability of the product.

6. Potential commercialization

NOVA demonstrates strong commercialization potential due to its practical design, affordability, and wide applicability in residential environments. The device can be installed as a plug-and-play retrofit replacement for conventional wall switches, which lowers the adoption barrier for homeowners. The primary target markets include smart homes, assisted living facilities, rehabilitation centers, and residential developments that emphasize universal design principles. With appropriate certification and large-scale manufacturing, NOVA could be positioned as a cost-effective alternative to cloud-dependent smart switches, particularly in regions where internet infrastructure is limited. Future developments may include expanded analytics capabilities, integration with broader smart home ecosystems, and adaptive voice recognition models that support multiple languages.

7. Acknowledgment

Sincere appreciation goes to Universiti Teknologi MARA (UiTM), Sarawak Branch, for providing the facilities and academic environment that supported the development of this project. Appreciation is also extended to the staff and colleagues of the Faculty of Electrical Engineering for their guidance, encouragement, and valuable feedback throughout the development of the NOVA system.

8. Researchers' Biography

Muhammad Irfan Sarbini is a Diploma student in Electrical Engineering (Electronics) at Universiti Teknologi MARA (UiTM), Sarawak Branch. He has a strong programming background with nearly eight years of coding experience. His main interests are embedded systems and intelligent device development, with a strong focus on creating technologies that positively impact society. NOVA has been developed since his first semester, reflecting his commitment to inclusive and energy-efficient smart solutions.

Hadi Jumaat received the B. Eng. in engineering electronics, M.Sc. degree in electrical engineering, and PhD degree in electrical engineering from the Universiti Teknologi MARA (UiTM), Selangor, Malaysia in 2012, 2015, and 2025. He is currently a member of Antenna Research Center (ARC) in Universiti Teknologi MARA. Since 2015, he joined UiTM as a young lecturer. His research interests are in communication antenna design, biomedical antenna and electromagnetic wave propagation.

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Mohd Yazid Mohd Anas Khan is a Lecturer at the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM) Sarawak Branch and a PhD candidate at Universiti Teknologi MARA, Shah Alam. His research interests include Internet of Things (IoT), computer programming, mobile application development, and computer vision. He also serves as the advisor of the Robotronix Club at UiTM Sarawak Branch. His work focuses on smart agriculture, aquaculture technology, and sensing

IOT Accilog (Accident LOG)

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ABSTRACT

Road accidents in Malaysia remain at an alarming level, and investigations often rely on traditional evidence such as witness statements that may be subjective and incomplete. The lack of accurate technical data, including impact force, vehicle speed, and precise location, complicates the investigation process and highlights the need for an automatic accident data recording system based on modern technology.This project develops the IoT AcciLog (Accident Log) prototype, an Internet of Things (IoT)–based system designed to automatically record accident data in real time. The prototype is developed using a scale ratio between the prototype model and the actual model of 1:18, meaning that every 1 unit measurement on the prototype represents 18 units on the real vehicle system. This approach is supported by the Scale Model Theory, which states that a smaller model can represent the characteristics and functionality of a real system while maintaining proportional relationships. The use of this scale enables efficient testing and evaluation of the system before real-world implementation. The objectives of this project are to design, develop, and test a prototype capable of recording acceleration (G-force), GPS coordinates, speed, date, and time during an accident. The system integrates an ESP32 microcontroller, MPU6050 sensor, NEO-8M GPS module, DS3231 RTC module, and an SD card, with data transmitted to Google Spreadsheet for cloud monitoring and stored locally as backup. The development follows the PDCA (Plan, Do, Check, Act) methodology. Testing results show that all components function effectively, demonstrating the potential of the IoT AcciLog prototype as a practical solution for more objective accident investigations and improved road safety.

Keywords: Internet of Things (IoT), Accident Data Recorder, Scale Model Theory, Vehicle Accident Monitoring, ESP32-Based System.

1. Product Description

IoT AcciLog (Accident Log) is an intelligent accident data recording system developed using Internet of Things (IoT) technology to automatically capture critical information during vehicle collisions. The system integrates multiple sensors and modules including ESP32 microcontroller, MPU6050 accelerometer and gyroscope, NEO-8M GPS module, DS3231 Real-Time Clock, and SD card storage to monitor vehicle motion and detect abnormal impact forces. When a collision occurs, the system instantly records key parameters such as G-force, vehicle speed, GPS location, date, and time. The captured data is automatically stored locally in the SD card and simultaneously transmitted to a cloud-based Google Spreadsheet via Wi-Fi, ensuring real-time monitoring and secure data backup.The prototype is implemented using a 1:18 scale vehicle model, allowing safe and controlled simulation of accident scenarios while maintaining proportional behaviour to real vehicles. The system development follows the PDCA (Plan–Do–Check–Act) framework to

ensure systematic design, testing, and continuous improvement. IoT AcciLog offers a cost-effective, compact, and scalable solution that supports accurate accident documentation, improves road safety monitoring, and provides reliable digital evidence for accident investigation and insurance verification

2. Concept of IoT Accilog (Accident Log)

The block diagram of the IoT AcciLog prototype illustrates the overall system architecture and the interaction between the input, processing, and output components as **Figure 1**. The system begins with the input stage, where sensors such as the MPU6050 accelerometer and gyroscope detect sudden changes in motion or impact force that may indicate a vehicle collision. At the same time, the NEO-8M GPS module collects geographical coordinates to determine the exact location of the incident, while the DS3231 Real-Time Clock (RTC) module records the accurate date and time of the event. All input data are transmitted to the ESP32 microcontroller, which acts as the main processing unit of the system. The ESP32 processes and analyzes the data received from the sensors to determine whether an abnormal impact has occurred. Once the event is confirmed, the system records the relevant data and sends it to the output stage.

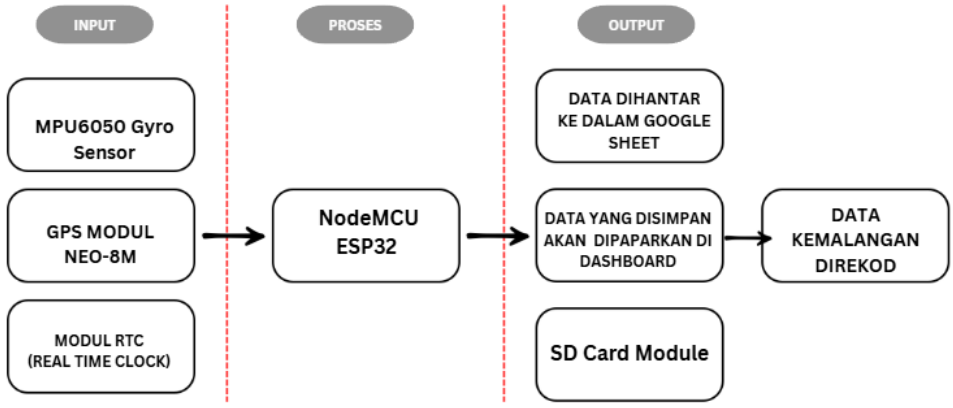

Figure 1. Block Diagram of IoT AcciLog.

The output stage includes two main data storage mechanisms. First, the recorded data are stored locally in an SD card as a backup log. Second, the information is transmitted via Wi-Fi to a cloud platform such as Google Sheets, where it can be monitored through a dashboard interface. This architecture ensures reliable accident data recording, real-time monitoring, and secure data storage for future analysis and investigation.

Table 1. IoT AcciLog Component Testing Results.

No.	Component	Testing Procedure	Result	Status
1	MPU6050 Accelerometer & Gyroscope Sensor	A collision simulation test was conducted to evaluate the sensor's ability to detect	The sensor successfully detected the impact when the collision simulation occurred, indicating accurate motion detection capability.	Successful

No.	Component	Testing Procedure	Result	Status
		sudden acceleration and impact forces.		
2	NEO-8M GPS Module	The accuracy of the GPS module was evaluated by verifying the recorded coordinates during system operation.	The GPS module successfully recorded the geographical location with high accuracy.	Successful
3	DS3231 Real-Time Clock (RTC)	The ESP32 power supply was temporarily disconnected to evaluate whether the RTC module could maintain time independently.	The time and date remained accurate and unchanged according to the previously configured settings even when the ESP32 was powered off.	Successful
4	SD Card Module	The SD card log file was examined to verify whether the recorded accident data was stored correctly during system operation.	The data was successfully recorded and stored completely, even when the system operated without internet connectivity.	Successful
5	Circuit Wiring	Electrical connections and current flow were tested using a multimeter to ensure stable circuit connectivity.	The electrical current flowed consistently without connection errors or instability.	Successful
6	Complete System	A comprehensive system test was conducted to evaluate the simultaneous operation of all integrated components.	All components functioned properly and operated simultaneously without system interruption.	Successful

Component testing was conducted to ensure that each module used in the project functions according to the specified requirements as show in **Table 1**. The LIS3DH sensor was tested through a collision simulation to verify its capability in detecting impact forces, while the Neo-8M GPS module was evaluated to confirm the accuracy of the recorded coordinates in determining the location precisely. The DS3231 Real-Time Clock (RTC) module was tested by disconnecting the ESP32 power supply and allowing the RTC to operate independently in order to ensure that the time and date remained accurate even when the microcontroller board was temporarily powered off. The SD card module was also examined to verify that the log data could be recorded completely even when the system was not operating online. The testing results indicate that all components functioned properly and produced successful outcomes, confirming that each module can be safely integrated into the complete system.

3. Novelty and uniqueness

IoT AcciLog introduces an innovative approach to accident data recording by integrating motion sensing, location tracking, and IoT cloud connectivity into a compact and affordable system. Unlike traditional accident investigations that rely on manual reports and witness statements, this system provides objective digital evidence captured directly from sensors during the collision event. One of the key unique aspects of the project is the implementation of a scaled prototype vehicle (1:18 ratio) guided by Scale Model Theory, enabling realistic accident simulation while maintaining proportional representation of real-world vehicle dynamics. This allows researchers to test and validate accident detection behavior in a controlled and cost-efficient environment. Additionally, the system features a dual-layer data recording mechanism, where accident information is stored locally in an SD card while simultaneously transmitted to a cloud-based database. This ensures data redundancy, reliability, and accessibility even when internet connectivity is unstable. The integration of IoT technology, real-time monitoring, automated accident detection, and scalable prototype modelling makes IoT AcciLog a unique and forward-looking innovation for smart transportation and intelligent vehicle monitoring systems.

4. Benefit to mankind

IoT AcciLog contributes significantly to improving road safety and accident investigation accuracy. By automatically recording critical accident data such as impact force, speed, location, and time, the system provides reliable digital evidence that can support law enforcement agencies, insurance companies, and accident investigators. The availability of objective accident data reduces dependency on subjective witness statements, helping authorities determine accident causes more efficiently and fairly. This can also reduce fraudulent insurance claims and accelerate claim verification processes. In addition, the technology demonstrates how Internet of Things (IoT) solutions can enhance intelligent transportation systems and road safety management. In the future, wider implementation of such systems could support faster emergency response, improved accident analysis, and better prevention strategies, ultimately contributing to safer roads and reduced accident-related fatalities.

5. Innovation and Entrepreneurial Impact

IoT AcciLog encourages innovation by applying Internet of Things (IoT) technology to address real-world challenges in transportation safety. The development process integrates embedded systems, sensor technology, and cloud data management, providing valuable hands-on learning opportunities for engineering and TVET students. The project also promotes an entrepreneurial culture by demonstrating how a research prototype can evolve into a market-ready product. With its low-cost components and scalable architecture, IoT AcciLog has strong potential to be developed into a commercial smart vehicle monitoring device. The innovation aligns with Industry 4.0 and smart mobility initiatives, opening opportunities for startups, collaboration with automotive technology companies, and integration with smart city ecosystems. This encourages technology-driven entrepreneurship while supporting the development of innovative safety solutions for the transportation industry.

6. Potential commercialization

IoT AcciLog has strong commercialization potential as a **smart accident recording and vehicle monitoring device**. The technology can be further developed into a compact plug-and-play module that can be installed in private vehicles, ride-hailing fleets, logistics trucks, and

commercial transportation systems. Potential customers include insurance companies, fleet management operators, automotive safety solution providers, and government road safety agencies. The system could also be integrated with mobile applications, cloud dashboards, and emergency alert systems for real-time accident notification. Due to its low production cost, scalable architecture, and high demand for vehicle safety technology**,** IoT AcciLog has strong potential for mass production and technology licensing. The product could evolve into a commercial IoT-based vehicle safety platform supporting smart mobility and intelligent transportation systems.

7. Acknowledgment

The authors would like to express their deepest appreciation to Kolej Vokasional Tanjung Puteri for providing the platform, facilities, and continuous support in the development of the IoT AcciLog innovation project. The encouragement and academic environment provided by the institution have greatly contributed to the successful completion of this project. Special thanks are extended to the lecturers and technical staff from the Electronic Technology Programme for their valuable guidance, technical expertise, and constructive feedback throughout the design, development, and testing phases of the prototype. The authors would also like to acknowledge the contributions of students and team members who actively participated in the brainstorming, development, and validation processes of the IoT AcciLog system. Their collaboration and commitment have strengthened the quality and practicality of this innovation. Finally, sincere appreciation is dedicated to all individuals and parties who have directly or indirectly supported this project. Their encouragement, insights, and cooperation have been instrumental in transforming this idea into a practical innovation with the potential to contribute to safer and smarter transportation systems.

8. Researchers' Biography

Adibah Azman is a lecturer in the Electronic Technology Programme at Kolej Vokasional Tanjung Puteri, Johor Bahru, Malaysia. She holds a Bachelor's Degree in Electronic Engineering (Wireless Communication) with Honours from Universiti Teknikal Malaysia Melaka (UTeM), a Diploma in Electronic Engineering from Politeknik Johor Bahru, and a Postgraduate Diploma in Education from IPG Kampus Temenggung Ibrahim. She began her career as a Researcher at Universiti Teknikal Malaysia Melaka before joining the vocational education sector in 2017. Her teaching areas include Digital Electronics, Embedded Systems, Microcontrollers, Communication Technology, Programmable Logic Control (PLC), and Final Year Projects. She is also actively involved in research, innovation, and technical education development, with several publications in journals and international conferences related to antenna design, metamaterials, and wireless communication technologies.

Mohamad Amirul Amin Roslan is a Diploma student in Electronic Technology at Kolej Vokasional Tanjung Puteri, Johor Bahru. He is currently pursuing his studies while developing technical skills in electronics, embedded systems, Internet of Things (IoT), robotics technology, and industrial automation. He also holds a Malaysian Skills Certificate (SKM) Level 3 in Electronic Equipment Troubleshooting, Repair, and Maintenance. Amirul has actively participated in innovation activities and achieved 2nd place in the 5 Minutes Inno Pitch competition at Kolej Vokasional Tanjung Puteri. With strong technical knowledge and practical skills in tools such as Arduino IDE, AutoCAD, and CX-Programmer, he aims to gain industry experience through internship opportunities and further develop his expertise in electronic and automation technologies.

Nur Farahana Shahiera Jamaludin is a Diploma student in Electronic Technology at Kolej Vokasional Tanjung Puteri, Johor Bahru. She is currently pursuing her diploma while developing strong technical skills in electronics, troubleshooting, industrial automation, and programmable logic controller (PLC) systems. She has achieved several recognitions including a Silver Medal in the International Product Profile Innovation Competition (IPPIC 2025) and the Best Student Award for the Electronic Technology Programme. In addition to her academic achievements, she actively participates in innovation competitions and student activities, including serving as the President of the Library Club. With a strong interest in electronics and innovation, she aims to gain practical industry experience through internship opportunities and contribute positively to technological development in the future.

HeriLux: Daylight Heritage Retrofit Toolkit for Sustainable Traditional Malay Houses

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ABSTRACT

Traditional Malay houses represent a valuable example of climate-responsive vernacular architecture in tropical regions. Despite their recognised passive design strategies, limited quantitative tools exist to evaluate daylight performance and guide sustainable retrofit decisions for heritage buildings. This innovation introduces HeriLux, a Daylight Heritage Retrofit Toolkit developed to assess and optimise natural lighting performance in traditional Malay houses while preserving their architectural integrity. The system integrates Building Information Modelling (BIM), climate-based daylight simulation, and a newly developed Daylight Performance Score (DPS) to evaluate daylight distribution and identify retrofit opportunities. Using a case study of Villa Sentosa in Kampung Morten, Melaka, a detailed digital model was developed and analysed through daylight simulation parameters including illuminance levels, daylight factor, and Useful Daylight Illuminance (UDI). The toolkit identifies under-lit zones, glare-risk areas, and daylight imbalance within heritage interiors. Based on the analysis, HeriLux generates retrofit recommendations such as light shelves, clerestory windows, reflective material optimisation, and improved shading design. The system translates complex daylight simulation outputs into an accessible decision-support toolkit for architects, conservation practitioners, and policymakers. HeriLux demonstrates how digital innovation can support sustainable heritage conservation by improving indoor environmental quality while reducing energy dependency on artificial lighting.

Keywords: daylight optimisation, heritage retrofit, traditional Malay house, BIM simulation, sustainable architectural

1. Product Description

HeriLux is a digital retrofit assessment toolkit designed to evaluate and enhance daylight performance in traditional Malay houses. The system combines heritage building modelling, daylight simulation analysis, and retrofit design recommendations into a structured decision-support platform. The toolkit operates through three integrated modules:

Heritage Digital Modelling

Traditional Malay houses are reconstructed as BIM models using architectural survey data. This digital model captures building geometry, materials, openings, and orientation.

Daylight Performance Analysis

The system performs climate-based daylight simulations to analyse illuminance distribution, daylight factor, and Useful Daylight Illuminance (UDI). These metrics evaluate the effectiveness of passive daylight strategies within heritage interiors.

Retrofit Recommendation Engine

Based on the analysis, HeriLux identifies critical lighting zones and proposes targeted retrofit strategies such as reflective material optimisation, clerestory windows, light shelves, and shading improvements. A key feature of HeriLux is the Daylight Performance Score (DPS), which converts complex simulation outputs into an intuitive performance rating system to support retrofit decision- making. Through this structured workflow, HeriLux enables architects and conservation practitioners to improve daylight performance while supporting the cultural and architectural authenticity of traditional Malay houses.

2. Visual Analysis and Toolkit Framework Architectural Context of Traditional Malay Houses

Traditional Malay houses demonstrate passive design strategies that respond to the tropical climate, including elevated structures, large openings, and shaded verandahs which influence natural daylight distribution within interior spaces.

Figure 1. Traditional Malay house architecture illustrating climate-responsive design features such as elevated floors, large windows, carved panels and deep roof overhangs that influence daylight penetration.

Case Study Location: Kampung Morten Heritage Village

Kampung Morten is one of the best-preserved traditional Malay settlements in Melaka and serves as a living heritage environment. The study focuses on Villa Sentosa, a well-preserved traditional house located within this heritage village.

Figure 2. Kampung Morten, Melaka – a preserved traditional Malay heritage village consisting of approximately 90 traditional houses.

Digital Reconstruction of the Case Study House

The traditional house was digitally reconstructed using Building Information Modelling (BIM) to enable daylight simulation and performance analysis.

Figure 3a - Front elevation

Figure 3a -b. Case study house (Villa Sentosa) and its BIM reconstruction used for daylight simulation analysis in the HeriLux toolkit.

Daylight Performance Analysis

The UDI analysis shows varying daylight performance across the house. Transitional spaces such as the serambi demonstrate higher daylight availability, while deeper interior spaces such as the rumah ibu show significantly lower daylight performance.

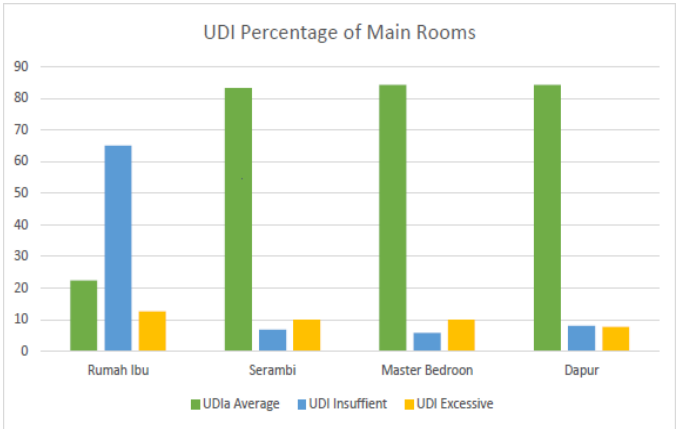

Figure 4. Useful Daylight Illuminance (UDI) percentage across key interior spaces of the traditional Malay house.

Daylight Distribution and Problem Identification

The simulation reveals that while perimeter areas receive sufficient daylight, the deeper interior core remains significantly underlit due to the depth of the floor plan and architectural configuration.

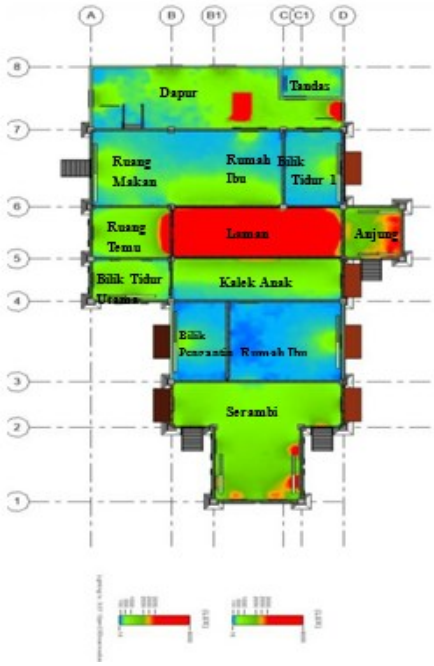

Figure 5. Daylight distribution simulation during the March equinox showing the central. "dark core" where daylight penetration is limited.

3. HeriLux Daylight Retrofit Strategies

The HeriLux toolkit translates daylight simulation outputs into a Daylight Performance Score (DPS) which is evaluated against proposed daylight performance benchmarks derived from daylight metrics including UDI, sDA and ASE. Based on this evaluation, targeted retrofit strategies are recommended to improve daylight penetration while preserving the architectural integrity of traditional Malay houses.

Table 1. HeriLux Daylight Performance Toolkit (DPS) Integrating Daylight Performance Score (DPS), daylight performance benchmarks, and recommended retrofit strategies for heritage buildings.

DPS Score	DPS Classification	Performance Benchmark	Performance Benchmark Target	Recommended Retrofit Strategy
0 – 40	Poor Daylight	Illuminance below recommended daylight level (MS2680)	sDA ≥ 50%; ASE ≤ 10%	Introduce clerestory openings and light-redirecting elements (e.g. light shelf) to extend daylight penetration while

DPS Score	DPS Classification	Performance Benchmark	Performance Benchmark Target	Recommended Retrofit Strategy
				controlling glare
41 – 70	Moderate Daylight	Uneven daylight distribution across interior spaces	sDA ≥ 60%; ASE ≤ 5%	Improve internal surface reflectance (light-coloured timber flooring) to enhance internal reflected component and improve daylight distribution
71 –100	Optimised Daylight	Balanced daylight penetration	sDA ≥ 90%; ASE ≤ 8%	Introduce shading refinement (awning / louver adjustment) to maintain daylight while reducing excessive solar exposure

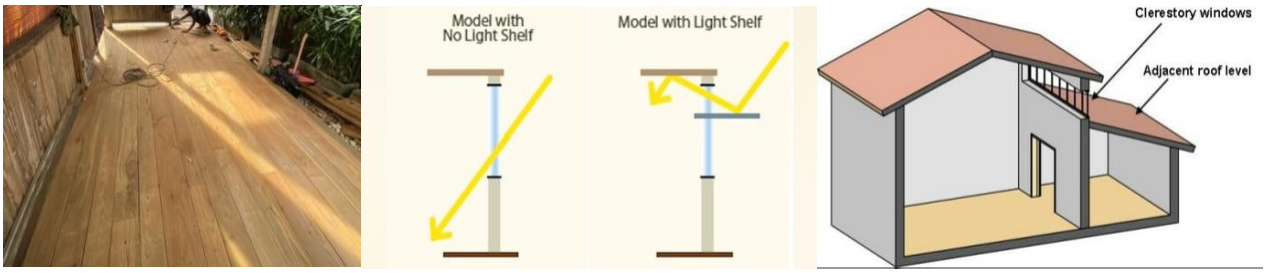

Figure 6. Daylight retrofit strategies proposed by the HeriLux toolkit to enhance daylight penetration and visual comfort in heritage buildings.

4. Novelty and uniqueness

HeriLux introduces a heritage-specific daylight retrofit toolkit that bridges the gap between architectural conservation and building performance analysis. While existing research on traditional Malay houses often relies on qualitative descriptions of passive design elements, HeriLux transforms daylight evaluation into a quantitative digital decision system. The novelty of this innovation lies in three main aspects. First, it integrates BIM-based modelling with daylight performance simulation, enabling precise evaluation of natural lighting conditions within heritage buildings. Second, the toolkit introduces a Daylight Performance Score (DPS) that translates complex daylight simulation metrics such as illuminance and UDI into a simplified performance rating system for retrofit decision- making. Third, the system proposes targeted retrofit strategies specifically designed for traditional Malay houses, ensuring that sustainability improvements do not compromise heritage authenticity. Unlike conventional daylight studies that remain at the research level, HeriLUX converts analytical findings into a practical toolkit for architects and

conservation practitioners. This innovation supports evidence-based retrofit strategies while preserving traditional architectural identity.

5. Benefit to mankind

The HeriLux empowers homeowners and conservators to preserve Malaysian culture while actively participating in global carbon reduction. This toolkit contributes to sustainable heritage preservation by improving natural lighting conditions in traditional buildings while maintaining their cultural integrity. By optimising daylight distribution, the toolkit helps reduce reliance on artificial lighting, leading to lower energy consumption and reduced carbon emissions. By eliminating the need for electric lighting in 95% of the floor area during the day, it lowers energy costs and reduces the urban heat island effect associated with heritage neighbourhoods. The system also improves indoor environmental quality by providing balanced daylight levels that enhance visual comfort and occupant well-being. Furthermore, HeriLux supports heritage conservation efforts by offering a practical method for evaluating and upgrading traditional buildings without compromising their historical character. By bridging digital building analysis with heritage conservation practices, HeriLux promotes sustainable architectural solutions that preserve cultural identity while supporting modern environmental goals.

6. Innovation and Entrepreneurial Impact

HeriLux transforms academic research into a practical innovation platform for sustainable heritage retrofitting. The toolkit demonstrates how digital building technologies such as BIM and daylight simulation can be applied to heritage conservation and building performance optimisation. The system encourages interdisciplinary collaboration between architecture, construction management, and sustainability professionals. As a digital retrofit toolkit, HeriLux has strong potential to support architectural consultancy services, sustainable retrofit planning, and heritage building assessment. By translating complex building performance analysis into a practical decision-support tool, the innovation promotes a culture of innovation and entrepreneurship within the built environment sector while addressing real-world sustainability challenges. It provides a repeatable service model for architectural consultants, allowing them to offer data driven retrofit certifications for traditional Malay buildings. This encourages a shift from "demolish- and-build" to "analyse-and-optimise," fostering a sustainable circular economy within the Malaysian construction sector.

7. Potential commercialisation

HeriLUX has strong commercialisation potential as a heritage retrofit assessment toolkit for sustainable building consultancy and digital building analysis services.
The innovation can be developed into:

- a BIM-based daylight retrofit analysis platform
- consultancy toolkit for architectural firms
- training module for sustainable heritage conservation
- digital decision-support system for heritage authorities

Potential industry users include architectural consultancies, conservation agencies, local authorities, and green building consultants involved in heritage building upgrades. It is highly commercialised as a Licensable Design Guideline or Consultancy Checklist for government agencies (e.g., Jabatan Warisan Negara) and private heritage developers. By presenting these

findings as Daylight Heritage Retrofit Toolkit, the research can be marketed as a diagnostic tool for large-scale heritage rejuvenation projects that require energy- efficiency upgrades to meet modern green building certifications. With further development, HeriLux could evolve into a commercial digital retrofit platform integrating daylight simulation, sustainability assessment, and retrofit design recommendations for heritage buildings across Southeast Asia.

8. Acknowledgment

The authors would like to express their sincere appreciation to Universiti Teknologi MARA (UiTM) for supporting this research. The authors also acknowledge the guidance of the project supervisor and extend their gratitude to the residents of Kampung Morten, Melaka, for their cooperation and support during the case study.

9. Researchers' Biography

Faten Nur 'Syazween is a student at Universiti Teknologi MARA (UiTM) with a passionate interest in sustainable architectural design and building performance simulation. With a strong focus on heritage preservation, Syazween's work pioneers' data-driven Architectural Design Strategies to modernise traditional Malay houses. By integrating advanced climate-based daylighting analytics with vernacular design, the research provides scalable frameworks for energy-efficient retrofitting that align with MS 2680:2017 standards. Syazween is committed to bridging the gap between historical architectural integrity and modern environmental sustainability.

Associate Prof Ts. Dr. Julitta Yunus is the Senior academic with over 20 years of experience in teaching, research and academic leadership within the built environment and Construction Management disciplines at Universiti Teknologi MARA (UiTM). Demonstrates strong people and strategic leadership across academic, resources, and curriculum development, research team leadership, and performance monitoring, with experience in overseeing funded projects and scholarly inputs. Research and professional expertise focus on sustainable built environment, green retrofit, construction innovation, GHG management and decarbonisation. Recognised for effective leadership in university–industry collaboration, strategic planning and academic governance, integrating people, programmes, and performance for institutional and societal impact

Anastasia Elya Perez is a final-year Bachelor of Science (Hons) Construction Management student at Universiti Teknologi MARA (UiTM) Shah Alam. She is originally from Bintulu, Sarawak. Throughout her studies, she has developed an interest in sustainable construction, project management, and innovative building technologies. Her academic journey has allowed her to learn about construction planning, building systems, and environmental considerations in the built environment. She hopes to

apply the knowledge and skills she has gained to contribute to more sustainable and efficient practices in the construction industry.

Normanisha Binti Amir Hamzah is a final-year student of Bachelor of Science (Hons) Construction Management at Universiti Teknologi MARA (UiTM). She is originally from Kunak, Sabah. Her academic interests focus on sustainable building design, construction management, and the impact of environmental factors on building occupants. Her research explores The Effect of Natural Light on the Health and Productivity of Building Occupants, highlighting how proper daylighting strategies can improve comfort, wellbeing, and work performance in buildings. Through her study, she aims to support the integration of natural lighting principles in building design to promote healthier indoor environments and more sustainable construction practices in the future.

Real-Time Power Tracker for Smart Energy Monitoring

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ABSTRACT

The increasing use of electrical appliances in modern households has significantly increased electricity consumption and utility costs. However, many users do not have real-time information about their energy usage and only become aware of their consumption after receiving monthly electricity bills. This limitation makes it challenging to control energy usage, leading to unnecessary electricity waste and financial burdens, particularly for middle-income households and boarding house operators. This project presents a Real-Time Power Tracker for Smart Monitoring, an Internet of Things (IoT)-based system designed to monitor electricity consumption and provide budget-based notifications. The system utilizes an ESP32 microcontroller integrated with voltage and current sensors to measure electrical parameters such as voltage, current, power, and energy consumption in real time. The data is sent to the Blynk IoT mobile application, allowing users to monitor energy usage. To improve energy monitoring, the system provides automatic notifications when energy consumption reaches 50%, 75%, and 100% of a predefined budget limit, enabling users to take immediate action to reduce excessive power usage. By promoting real-time energy awareness and efficient electricity management, the proposed system contributes to cost savings and reduced energy waste for households and small accommodations.

Keywords: Internet of Things (IoT), Real-Time Energy Monitoring, Smart Energy Management

1. Product Description

The Real-Time Power Tracker for Smart Energy Monitoring is a prototype IoT-based device designed to monitor and manage electricity consumption in residential settings. This system measures electrical parameters, including voltage, current, power, and energy usage, using a ZMPT101B voltage sensor and an ACS712 current sensor connected to an ESP32 microcontroller. The microcontroller processes the sensor readings to calculate power usage and energy consumption. The processed data is then transmitted via Wi-Fi to the Blynk IoT platform, to enable users to view real-time electricity usage through a mobile application. To help users manage their electricity usage more effectively, the system includes a notification feature that alerts users when energy consumption reaches 50%, 75%, and 100% of a predefined budget. Additionally, a buzzer provides a local warning when the limit is exceeded. The device also features a relay module, which allows users to control electrical

appliances through mobile applications. This prototype is designed to be a low-cost and user-friendly solution, making it suitable for households, rental properties, and small accommodation facilities that need to better monitor their electricity usage.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

Schematic Diagram

The schematic diagram and block diagram of the project are illustrated in **Figure 1** and **Figure 2**, respectively. The current sensor and voltage measure the real-time current and voltage from household electrical loads. The keypad is used to set the preset usage. These inputs are sent to the ESP32 microcontroller, which processes the data and turns it into electrical parameters such as power and total energy consumption in kilowatt-hours (kWh). The measured data is displayed locally on an OLED display to allow the users to view voltage, current, power, energy usage, and estimated electricity cost in real time. The ESP32 also transmits data via Wi-Fi to the Blynk mobile application. A buzzer provides alerts and a relay module can automatically disconnect the load.

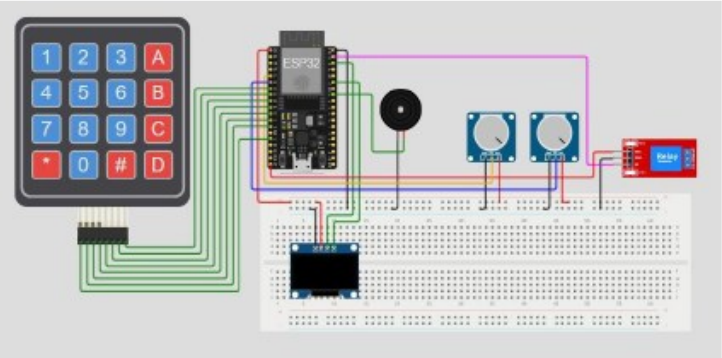

Figure 1. Schematic diagram of the system.

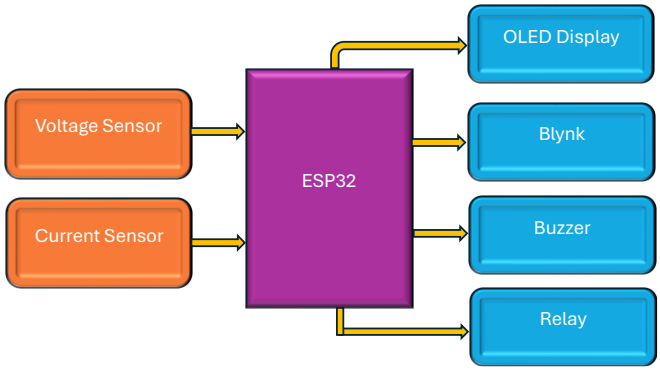

Figure 2. Block diagram of the system.

3. Results

Figure 3 shows the complete prototype of the project, including the internal circuit components and the notification displayed on the Blynk mobile application. The system operates under four possible conditions based on the preset energy usage limit. In normal conditions, when energy consumption is below 50% of the preset value, no warning or alert is triggered as demonstrated in **Figure 4**.

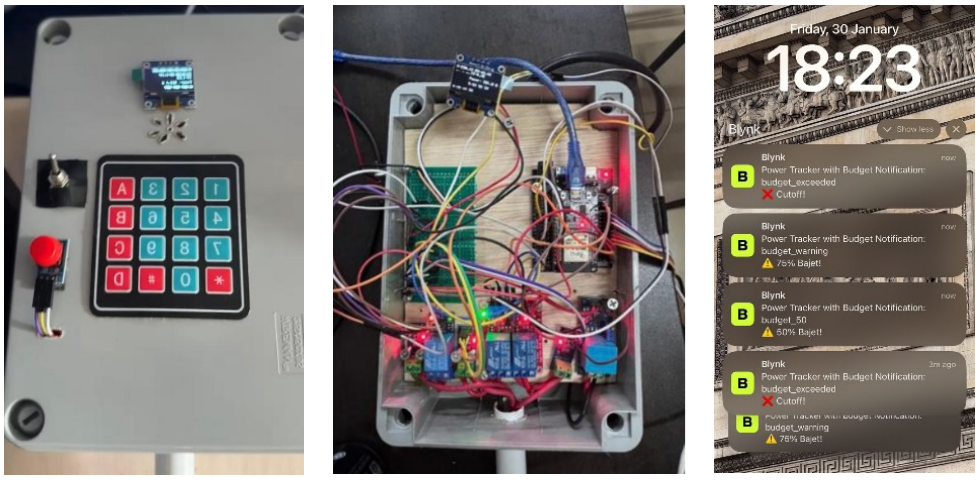

Figure 3. Final prototype of the system.

Figure 4. During normal conditions.

As depicted in **Figure 5** is when the consumption reaches 50%, the system sends a notification to the user through the Blynk mobile application, and the buzzer is activated as an early warning. In **Figure 6**, the usage increases to 75%, another notification is sent and the buzzer sounds again to indicate that the energy consumption is approaching the limit. Once the consumption reaches 100% of the preset value, the relay module automatically switches off, immediately cutting off power to the connected load. The OLED display indicates the cut-off status, while the buzzer remains activated and a notification is sent to the user via the Blynk application shown in **Figure 7**.

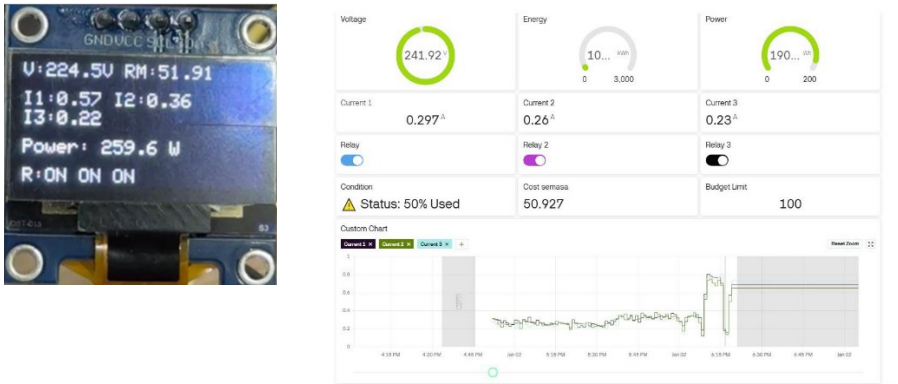

Figure 5. Exceeds 50% of the preset value.

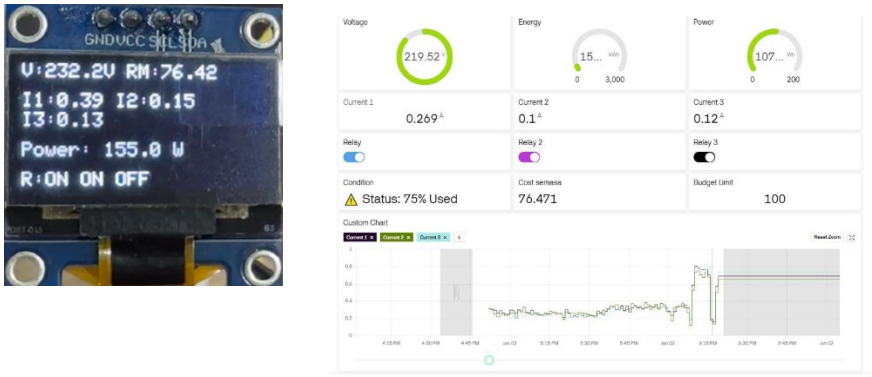

Figure 6. Exceeds 75% of the preset value.

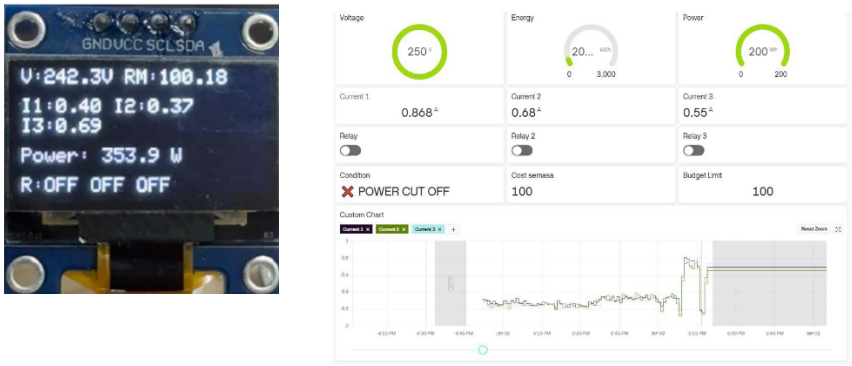

Figure 7. Exceeds 100% of the preset value.

4. Novelty and uniqueness

The Real-Time Power Tracker for Smart Energy Monitoring provides a unique combination of real-time energy monitoring, cost estimation, and budget-based notifications within a single, affordable IoT system. The traditional electricity meters can only display accumulated energy usage, but this system can continuously monitor voltage, current, power, and energy consumption. This allows users to understand their electricity usage. One of the main innovative features is the budget-based energy notification system, which allows users to set a predefined energy or cost limit. The system automatically sends alerts when consumption reaches 50%, 75%, and 100% of the specified threshold, enabling users to take preventive actions before exceeding their energy budget. Another outstanding aspect is the integration of remote monitoring and load control through a mobile application, where users can access real-time power consumption data and remotely turn on or off their electrical appliances to prevent unnecessary energy usage. By providing clear usage information and alerts, the system encourages users to reduce energy waste and improve electricity management.

5. Benefit to mankind

The Real-Time Power Tracker for Smart Energy Monitoring benefits society by promoting energy awareness, efficient electricity usage, and cost savings. Users can clearly see how much electricity they are using from this real-time monitoring of power consumption, especially during high usage periods such as hot weather. During this time, appliances like air conditioners operate more frequently. Upon receiving notifications that energy consumption is approaching the set limit,

users will become more aware and encouraged to reduce unnecessary usage in order to avoid high electricity bills. The system is also useful for homeowners who rent out rooms or houses, as they can monitor the electricity usage of tenants and prevent excessive consumption. In addition, the system can educate family members, particularly children, about responsibility in using electricity. Indirectly, the project contributes to and supports a more sustainable, energy-efficient society just by encouraging households to save electricity.

6. Innovation and Entrepreneurial Impact

The Real-Time Power Tracker for Smart Energy Monitoring promotes innovation by demonstrating how IoT technology can be applied to solve real-world problems related to energy consumption and cost management. The project integrates sensors, microcontrollers, and cloud-based platforms to create a practical and affordable smart energy solution. In educational institutions, the project encourages students to develop technical skills in embedded systems, IoT applications, and smart device development. It also promotes a culture of creativity and problem-solving skills and inspires students to design solutions for everyday challenges. From an entrepreneurial perspective, the project highlights opportunities in developing low-cost smart energy-monitoring products that are useful in households, rental properties, and small businesses.

7. Potential commercialization

The Real-Time Power Tracker for Smart Energy Monitoring has strong potential for commercialization as an affordable and practical energy monitoring device for homes and small businesses. Nowadays, as electricity costs continue to rise and with the high use of electrical appliances, many users are seeking simple solutions to help them monitor and control their energy consumption in real time. This product can be developed into a compact and easy-to-install device that connects to a mobile application. Users can track their electricity usage and estimated costs easily from their smartphones. With its low production costs and user-friendly design, the device has the potential market to homeowners, boarding house operators, guesthouse owners, and small business operators who want better management of their electricity usage.

8. Acknowledgment

The authors would like to express their sincere appreciation to the Faculty of Electrical Engineering, Universiti Teknologi MARA Cawangan Pulau Pinang, Malaysia, for providing the support and guidance throughout the development of this project.

9. Researchers' Biography

Ahmad Nabil Mohd Yusop is a dedicated student pursuing a Diploma in Electrical Engineering (Power) at Universiti Teknologi MARA (UiTM) Cawangan Pulau Pinang. He is now in the last semester of his diploma studies. With a keen interest in technological advancements, Nabil aims to contribute meaningfully to the industry and to become a skilled professional in the electrical and electronics engineering field.

Asmalia binti Zanal is a senior lecturer at the Faculty of Electrical Engineering, Universiti Teknologi MARA Cawangan Pulau Pinang. She received her B. Eng Hons. in Electrical and Electronics Engineering from Universiti Teknologi Malaysia (UTM) in 2004 and finished her MSc. in Electronic System Design Engineering from Universiti Sains Malaysia in 2008. Her field of interest includes image processing and artificial intelligence.

Gapsense: AN Intelligent Curriculum GAP Analysis and Alignment System

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ABSTRACT

Programme review in higher education is essential to ensure it remains aligned with accreditation standards and rapidly evolving industry skill requirements. However, this process is time-consuming, complex, and prone to inconsistencies. Therefore, this paper presents GapSense, an intelligent curriculum gap analysis and alignment system designed to support data-driven programme review. The system was developed using an iterative methodology, integrating a full-stack architecture based on Laravel, React, and Python-based artificial intelligence services. GapSense analyses curriculum documents, accreditation requirements from the Malaysian Qualifications Agency (MQA), and real-world industry job data to determine competency coverage and identify knowledge gaps within programmes. The analytical framework integrates AI-powered skill extraction, curriculum–competency auditing, and knowledge graph modelling to map relationships between courses, competencies, and knowledge domains. The system further generates data-driven recommendations for curriculum improvement, including restructuring course content, introducing new competency modules, and redistributing topics to address detected gaps. Analytical outputs are delivered through visualised curriculum coverage and competency alignment. GapSense enhances institutional decision-making through precise data insights, strengthens accreditation readiness through compliance tracking, and improves graduate employability by aligning curricula with industry demands. The platform also demonstrates strong potential as a scalable education technology solution for multi-programme and cross-institutional curriculum intelligence.

Keywords: Program Review, Curriculum Gap Analysis, Artificial Intelligence in Education, Skill Mapping, Knowledge Graph

1. Product Description

GapSense is an intelligent curriculum gap analysis and alignment system developed to assist higher education institutions in evaluating programme coverage against recognised knowledge areas and evolving industry skill requirements. The system analyses curriculum structures and course content to identify competency fulfilment, detect knowledge gaps, and generate data-driven recommendations for curriculum improvement. The system provides an analytical overview of programme performance through an interactive dashboard as illustrated in **figure 1**, which summarises key indicators such as Body of Knowledge (BOK) compliance, competency gaps, unmapped curriculum content, and industry pressure. A knowledge area coverage heatmap further visualises how individual courses contribute to

different knowledge domains across the programme. Curriculum content is systematically analysed to determine its alignment with defined competencies. As illustrated in **figure 2,** weekly course topics are mapped to competency codes and accompanied by reasoning that explains how the content fulfils the required competencies while also identifying any unmapped material. To support curriculum enhancement, the system generates structured improvement strategies. **Figure 3** shows the optimisation and recommendation module, which proposes curriculum restructuring actions such as merging overlapping content, introducing new modules, or redistributing topics to address capability gaps and improve curriculum coherence.

2. Design Overview and System Architecture

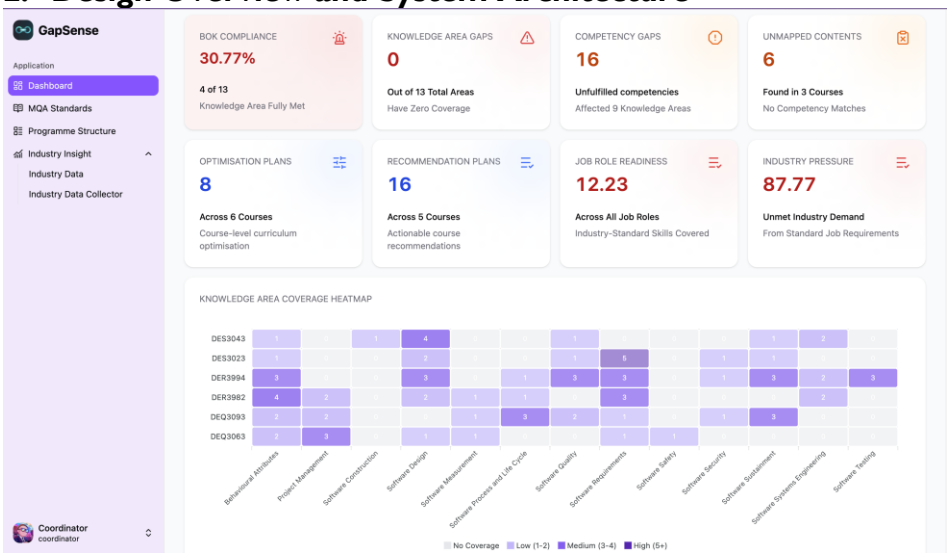

Figure 1. Dashboard Interface of GapSense System.

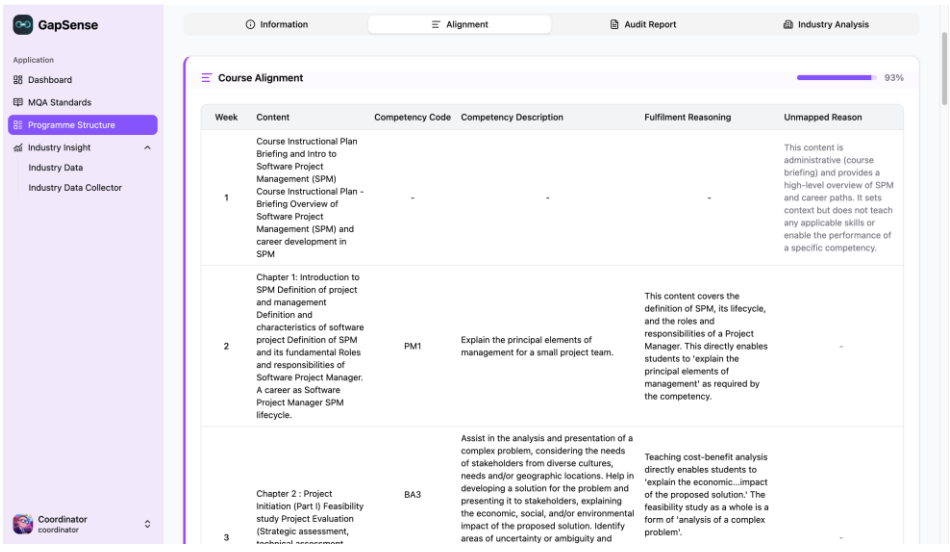

Figure 2. AI-Generated Course–Competency Alignment Interface of the GapSense System.

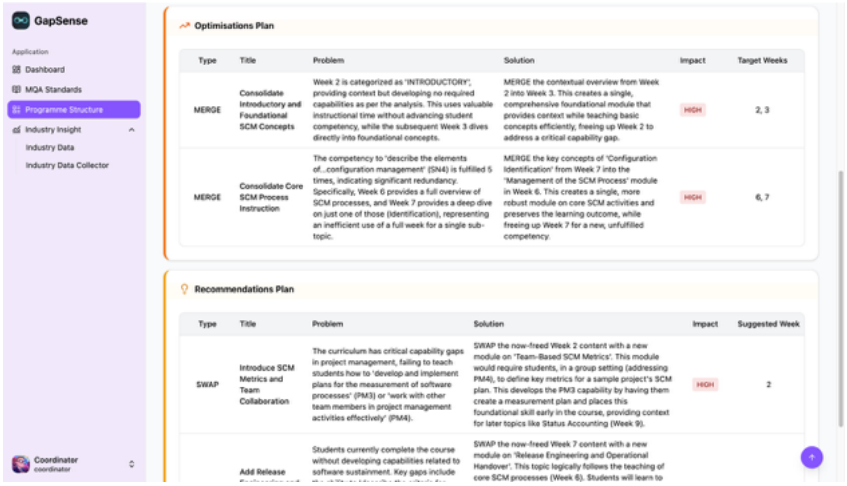

Figure 3. AI-Generated Optimisation and Recommendation Plan for Curriculum Improvement.

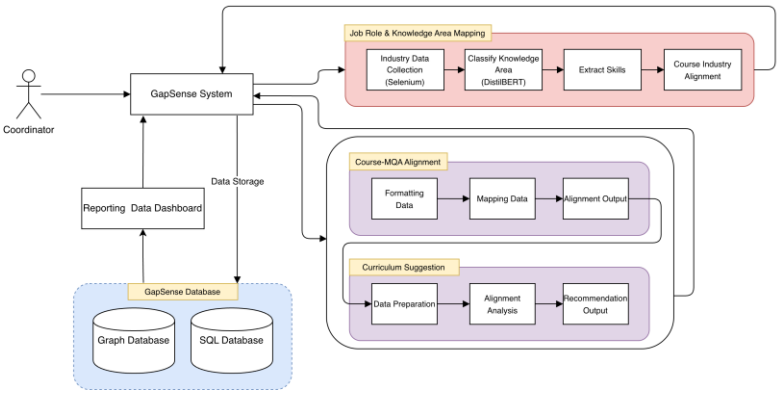

Figure 4. Solution Architecture for GapSense System.

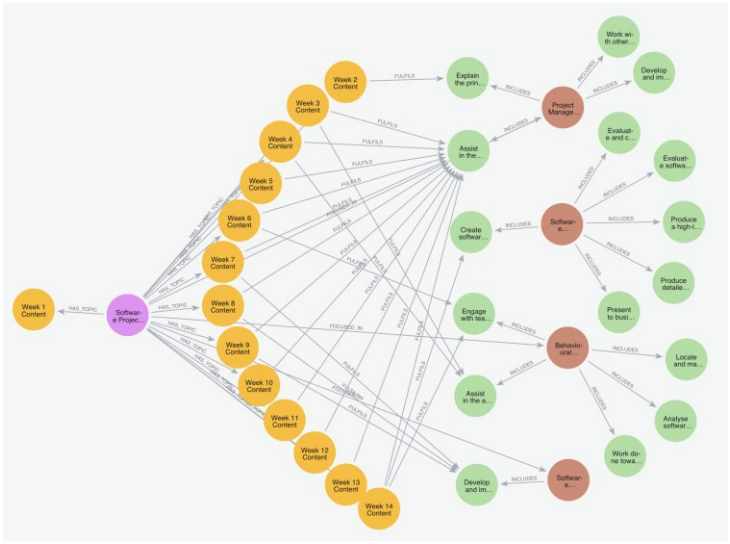

Figure 5. Sample Knowledge Graph Representation of Curriculum Content and Competency Relationships.

3. Novelty and uniqueness

GapSense introduces an integrated curriculum intelligence solution framework as stated in **figure 4**, which combines knowledge graph modelling, large language model (LLM) reasoning, and machine learning classification to automate curriculum gap analysis and alignment. GapSense addresses the limitation of traditional curriculum review processes by integrating curriculum data, competency standards, and industry knowledge within a unified analytical framework. The architecture also integrates several analytical components including industry data acquisition, curriculum–competency alignment, and curriculum optimisation. Industry job data are collected using Selenium-based web automation to gather real-world job requirements. The collected job descriptions are analysed using a fine-tuned DistilBERT model to classify job roles into relevant knowledge areas and extract skills. Gemini LLM is used to perform semantic extraction and reasoning to analyse curriculum content and generate explainable alignment outputs. A Neo4j-based knowledge graph models the relationships between courses, curriculum topics, competencies, and knowledge areas. **Figure 5** illustrates how curriculum content nodes are connected to competencies and higher-level knowledge domains to support structured analysis and curriculum optimisation recommendations.

4. Benefit to mankind

GapSense contributes to society by strengthening the alignment between higher education and industry workforce demands. By identifying curriculum gaps and competency misalignment early, the system supports universities in producing graduates with relevant, industry-ready skills. This directly enhances employability, reduces skill mismatch in the labour market, and improves national workforce competitiveness. The platform also promotes evidence-based academic decision-making, reducing reliance on subjective curriculum review processes. Through automated and data-driven analysis, institutions can continuously improve programme quality and maintain accreditation standards more efficiently. In the broader socio-economic context, GapSense supports sustainable education development by ensuring that academic programmes evolve in response to technological advancement and industry transformation. By bridging the gap between education and employment, the system contributes to human capital development, innovation capacity, and long-term economic growth.

5. Innovation and Entrepreneurial Impact

GapSense promotes innovation by introducing an AI-driven, data-centric approach to curriculum intelligence within higher education. By integrating LLM-based semantic analysis, machine learning job classification, and graph-based knowledge modelling, the system encourages institutions to adopt advanced digital technologies in academic governance and programme design. This fosters a culture of continuous innovation, where curriculum development is guided by real-time industry insights rather than static documentation. From an entrepreneurial perspective, GapSense demonstrates the commercial viability of education technology solutions that address real institutional challenges. The platform can be scaled into a Software-as-a-Service (SaaS) model for universities, accreditation bodies, and training providers. By transforming curriculum mapping into a structured analytics service, the project encourages technology-driven problem solving, supports digital transformation initiatives, and inspires innovation-led entrepreneurship within the education and workforce development ecosystem.

6. Potential commercialisation

GapSense has strong commercialization potential as a scalable Education Technology (EduTech) solution for higher education institutions and accreditation bodies. The system can be offered as a Software-as-a-Service (SaaS) platform, enabling universities to subscribe for curriculum–MQA alignment analysis, industry benchmarking, and automated gap reporting. The platform may also be commercialised through institutional licensing, customised deployments for specific faculties or programmes, and integration services with existing academic management systems. In addition, training and consultancy services can be provided to support institutions in implementing data-driven curriculum enhancement strategies. Given the increasing demand for graduate employability, accreditation compliance, and digital transformation in education, GapSense addresses a clear market need. Its modular microservices architecture allows expansion into multi-programme, multi-institution, and cross-country implementations, positioning it as a viable long-term commercial product within the global EduTech sector.

7. Acknowledgment

The authors would like to express their gratitude to Universiti Pendidikan Sultan Idris (UPSI) for providing the academic environment and resources required for this research. Special thanks to our project supervisor for their invaluable technical guidance and support throughout the development of GapSense.

8. Researchers' Biography

Muhammad Danial Bin Jupikil is an undergraduate student in Software Engineering (Educational Software) at Universiti Pendidikan Sultan Idris (UPSI). His interests include artificial intelligence, education technology, and intelligent information systems. He has experience in full-stack software development using Laravel, React, and Python, with a focus on building scalable web applications and integrating machine learning technologies into real-world systems. He is passionate about developing innovative digital solutions that improve education quality and support data-driven decision making. Through his academic and technical projects, he aims to contribute to the advancement of intelligent educational technologies and modern software engineering practices.

Rohaizah Abdul Wahid is a lecturer under the Faculty of Computing & Meta-Technology at Universiti Pendidikan Sultan Idris (UPSI) with over 20 years of teaching experience in software engineering. Her research interests include artificial intelligence in education, intelligent information systems, and technology-enhanced learning. She also works on innovative projects involving mobile applications, IoT-based systems, and AI-driven solutions for education. Through her academic and research activities, she aims to advance software engineering education and support the development of industry-relevant digital technologies.

AI-Based Pothole Detection and Reporting System Using Yolo Architecture

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ABSTRACT

Potholes are known to be a major road safety problem in Malaysia and remain as one of the contributing factors to traffic accidents. This project proposes the development of an Artificial Intelligence (AI)-based pothole detection and reporting system integrated as a single coherent system using the You Only Look Once (YOLO) deep-learning architecture. The system is designed to detect potholes automatically and integrate the trained detection model into a local reporting platform that assists users in submitting verified road damage reports. The innovation addresses limitations of conventional reporting systems that rely heavily on manual inspection and human verification. Its main uniqueness lies in integrating AI-based visual detection directly with a reporting interface, enabling faster decision-making and reducing reports verification delays. The system contributes to improved road safety, reduced vehicle maintenance costs, and enhanced infrastructure monitoring efficiency. From a socio-economic perspective, early pothole detection minimizes accident risks and maintenance expenditure for authorities. The proposed solution demonstrates strong commercialization potential as a smart-city supporting technology that can be integrated into existing road monitoring or governmental reporting platforms.

Keywords: Pothole Detection, YOLO, Computer Vision, Road Safety, Artificial Intelligence

1. Product Description

The proposed product is an AI-based pothole detection and reporting platform developed using computer vision and deep learning technologies. The system utilizes the YOLO object detection architecture to automatically identify potholes from uploaded road images. The developed model is trained using labelled datasets consisting of pothole and normal road images obtained from open-source repositories. The system operates through three major components which are image input, AI detection engine, and reporting interface. Users upload road images through a graphical user interface (GUI), where the integrated AI model processes the image and determines the presence of potholes. Detection results are then displayed together with reporting information for authorities or system administrators. Unlike traditional reporting applications that require manual confirmation, the proposed system automates pothole verification before submission. This reduces human error, improves reporting efficiency, and accelerates maintenance response time. The platform serves as a proof-of-concept demonstrating how AI technology can enhance existing infrastructure monitoring systems while maintaining simplicity through local-based execution.

2. Methodology

System Architecture

Figure 1 presents the architecture of the reporting platform integrated with the YOLO detection model. The architecture shows interaction between users, graphical interface, processing module, trained AI model, and output reporting system. The integration enables automatic verification of pothole reports before submission.

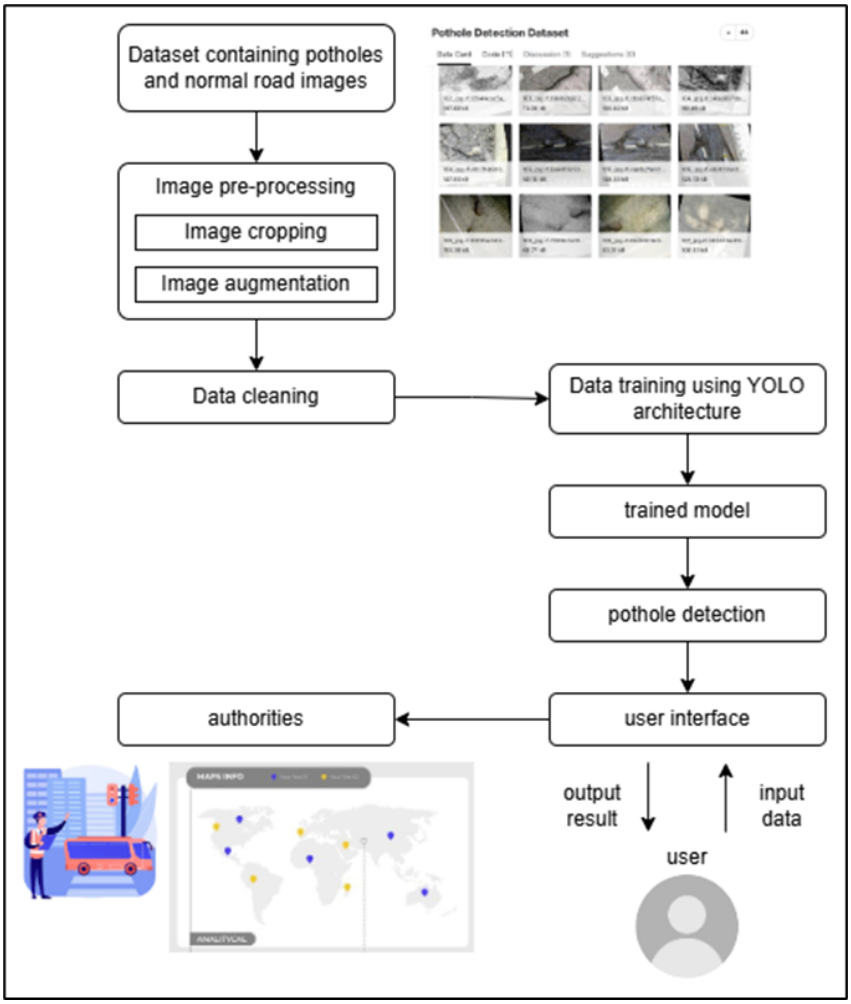

Figure 1. System architecture of the proposed system.

Model Performance

The performance of the pothole detection model was evaluated using several metrics including Precision, Recall, F1-score, and mean Average Precision (mAP). These metrics provide insight into the model's detection accuracy and reliability under different confidence thresholds.

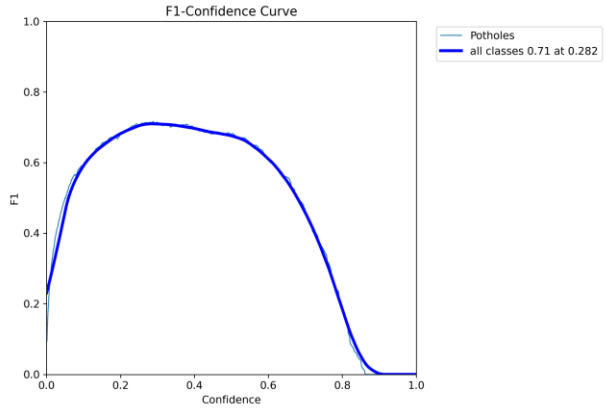

Figure 2. F1–Confidence Curve.

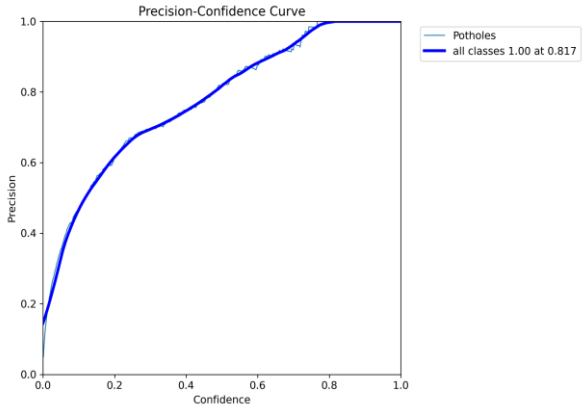

Figure 3. F1–Confidence Curve.

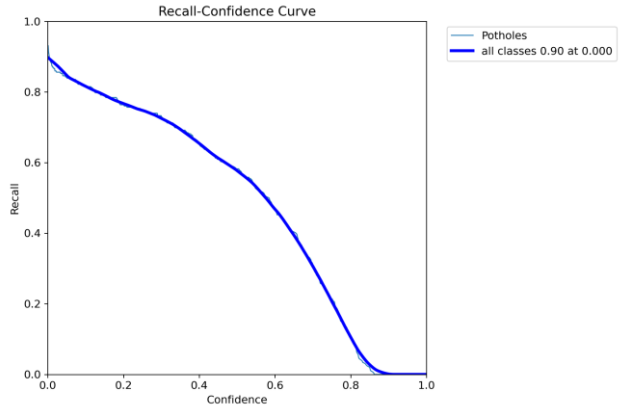

Figure 4. Recall–Confidence Curve.

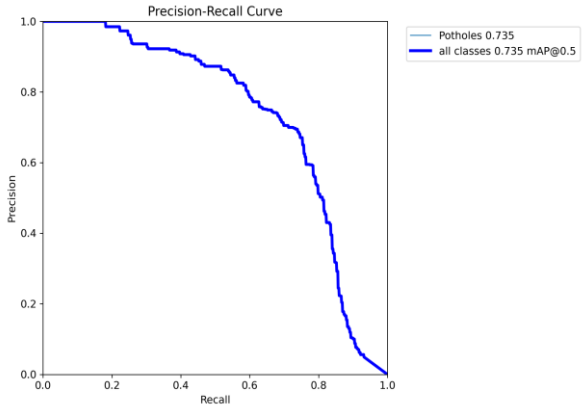

Figure 5. Precision–Recall Curve.

```
mAP50-95 (B): 0.38466861949635356
mAP50 (B): 0.7348992723143299
mAP75 (B): 0.33845258880538165
```

Figure 6. mAP scores.

Figure 2 depicts the F1–Confidence Curve that shows the model achieves highest precision and recall at a confidence threshold of 0.282. This implies that the chosen threshold offers an optimal trade-off between accurately detecting potholes and minimizing false detections. **Figure 3** illustrates the Precision–Confidence Curve which indicates that precision improves as the confidence threshold increases, reaching 1.00 at a confidence level of 0.817, indicating that predictions made at higher confidence levels are highly accurate with minimal false positives. The Recall–Confidence Curve in **Figure 4** shows that the model achieves a maximum recall of 0.90 at the lowest confidence threshold (0.000), meaning that most pothole instances in the dataset can be detected, although lower thresholds may introduce more false detections. This illustrates the common trade-off between recall and precision. The Precision–Recall Curve in **Figure 5** shows that the model achieved mAP@0.5 of 0.735, indicating good detection performance at the standard Intersection over Union (IoU) threshold. However, stricter evaluation produced

mAP50–95 of 0.385 and mAP@0.75 of 0.338 suggesting that the model still has limitations in precisely locating the pothole bounding boxes. Overall, the results show that the model demonstrates promising detection capability, though further optimization and larger datasets could improve the model performances.

Reporting Platform User Interface

The user interface (UI) of the reporting platform is designed and developed for end-users to report potholes, and for the authorities to view lodged reports. The platform provides an interface for users to upload images which will then be processed by the integrated YOLO-based pothole detection model. An example of the implementation of the reporting platform can be seen in **Figure 7** and **Figure 8** below.

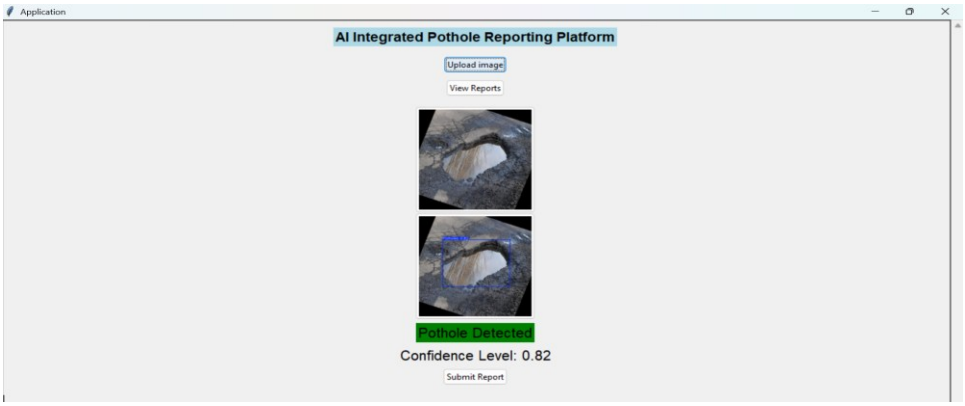

Figure 7. Reporting platform UI when users upload image for reporting.

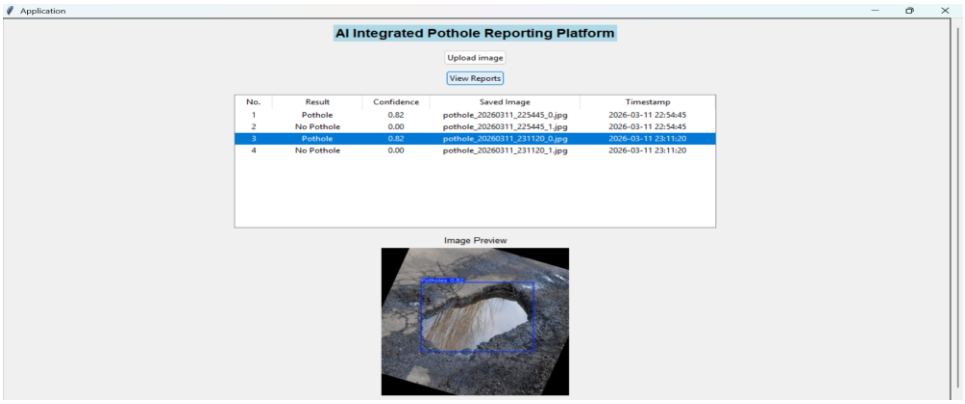

Figure 8. Reporting platform UI for authorities to view lodged reports.

3. Novelty and uniqueness

The novelty of this project lies in the integration of an AI-based pothole detection model directly into a reporting platform rather than functioning solely as a standalone detection system. Existing reporting applications depend on manual observation and verification, which introduces delays and inconsistencies. The proposed system introduces automated visual verification using YOLO architecture, enabling intelligent validation of road damage reports. Additionally, the project demonstrates a proof-of-concept smart reporting framework that bridges computer vision technology with public infrastructure management, supporting future smart-city implementations.

4. Benefit to mankind

The proposed system improves public road safety by enabling faster detection and reporting of hazardous potholes, reducing accident risks especially among motorcyclists. Automated detection minimizes dependence on manual inspection, allowing authorities to respond more efficiently to road damage issues. Economically, early maintenance reduces vehicle repair costs and infrastructure rehabilitation expenses. The system also promotes safer transportation environments while supporting sustainable urban infrastructure monitoring aligned with smart city development initiatives.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by applying Artificial Intelligence and deep learning technologies to solve real-world infrastructure problems. It encourages interdisciplinary integration between software development, AI engineering, and transportation management systems. The project fosters entrepreneurial thinking by demonstrating how academic research can evolve into practical smart-city solutions. Academic researchers or developers may expand the system into commercial applications such as automated road inspection services, intelligent monitoring platforms, or AI-powered municipal maintenance tools, encouraging technology-driven entrepreneurship within engineering industries.

6. Potential commercialization

The developed system has strong commercialization potential as an intelligent road monitoring solution for government agencies, municipal councils, and highway concession companies. The AI detection module can be integrated into existing mobile applications, dashboard cameras, or smart surveillance systems. Future commercialization may include cloud deployment, mobile application development, and real-time reporting integration with geographic information systems (GIS). The scalable architecture allows adaptation for broader infrastructure inspection such as crack detection or road condition monitoring, making it suitable for smart transportation markets.

7. Acknowledgment

Sincere appreciation is dedicated to Universiti Teknologi MARA (UiTM), Faculty of Electrical Engineering, for providing the academic environment, facilities, and resources that support the development of this project proposal. Special gratitude is extended to the project supervisor for continuous guidance, constructive feedback, and technical advice throughout the planning and proposal development stages. A heartfelt thanks are conveyed to lecturers, faculty members, and peers who have contributed valuable knowledge, discussions, and encouragement during the research process. Appreciation is further extended to open-source communities and dataset providers whose resources are expected to support the future development and training of the AI detection model.

8. Researchers' Biography

Aisyah Hannah binti Mohd Zaki is a final year student of Electronics Engineering at UiTM Shah Alam. The author has consistently achieved the Dean's List Award in every semester, demonstrating strong academic performance and commitment to excellence. Actively involved in innovation and research activities, the author has received several recognitions including a Bronze Award at IIDEX 2023, a Gold Medal at iRISE 2025, and a Silver Award at IIDEX 2025. These achievements reflect strong technical capability and innovative thinking, highlighting the author's potential to contribute meaningful innovations to the engineering and technology field.

Dr. Norlela Ishak is a Senior Lecturer at the Faculty of Engineering, Universiti Teknologi MARA (UiTM), Shah Alam. She holds a PhD in Electrical Engineering from UiTM with joint supervision from Universiti Teknologi Malaysia (UTM). Her research interests include computational modelling of control systems, control and automation, tracking control strategies, and Internet of Things (IoT) applications for smart monitoring. She is a member of IEEE, a registered Graduate Technologist with the Malaysia Board of Technologists (MBOT), and serves as a committee member for the IEEE International Conference on Automatic Control and Intelligent Systems (I2CACIS).

Assoc. Prof. Ir. Ts. Dr. Suzi Seroja Sarnin was born on January 28, 1974, in Selangor, Malaysia. She earned her Bachelor of Electrical and Electronics Engineering (Communication) from Universiti Teknologi Malaysia, Skudai, in 1999, completed her Master in Microelectronics from Universiti Kebangsaan Malaysia in 2005, and obtained her PhD in Electrical Engineering from Universiti Teknologi MARA, Shah Alam. She previously worked as a Quality Control Engineer at Memory Tech Sdn. Bhd., Subang Jaya, Selangor. She has been serving as a lecturer at Universiti Teknologi MARA, Shah Alam, since 2001 and is currently an Associate Professor. She has held several positions, including Head of the Communication Studies Centre, Coordinator of Electrical Engineering Entrepreneurship, and Chair of Continuous Quality Improvement. She has won numerous Gold Awards and recognition for outstanding innovation and invention from 2017 to the present and authored a chapter in the book Best Practices at FKE 2018.

Smart Shelf and Storeroom Monitoring System Using IoT

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ABSTRACT

Retail businesses, particularly convenience stores, often face difficulties in maintaining consistent product availability due to inefficient manual monitoring of shelf stock and storeroom inventory. To address this challenge, the project introduces the Smart Shelf and Storeroom Monitoring System using IoT. It is an integrated solution designed to improve inventory monitoring efficiency, reduce stock shortages, and enhance storeroom security. The system utilizes affordable sensors and Internet of Things (IoT) technology to automate the monitoring process. An ultrasonic sensor detects low stock levels on retail shelves, while a force sensor measures the remaining inventory in the storeroom by tracking weight changes. Using the IoT platform, the data is transmitted and displayed on a mobile device application named Blynk. This allows store personnel to monitor stock conditions remotely and receive real-time restocking notifications. In addition, the system includes a motorized storeroom lock that can be controlled through a keypad or the mobile application, ensuring that only authorized personnel can access the storage area. The integration of shelf monitoring, storeroom inventory tracking, and secure access control within a single IoT platform represents the advantage of this system. This solution can help small retail businesses improve operational efficiency, reduce manual workloads, and enhance inventory accuracy. With further development, the system has the potential to be commercialized as an affordable smart retail monitoring solution for small and medium-sized stores.

Keywords: Internet of Things (IoT), Smart Shelf, Inventory Monitoring

1. Product Description

The Smart Shelf and Storeroom Monitoring System using IoT is developed to enable real-time inventory monitoring and secure storage management using an ESP32 microcontroller that integrates multiple sensors, access control components, and a mobile IoT platform. Ultrasonic sensors are installed above retail shelves to measure the distance between the sensor and products. Changes in the measured distance indicate variations in stock levels. When the detected distance exceeds a predefined threshold, the system recognizes that the stock is running low and sends a notification to the Blynk mobile application. For storeroom monitoring, a weight sensor is positioned beneath stored items to detect weight changes when goods are added or removed. The sensor readings are transmitted to the ESP32, which processes the data and updates the inventory information on the Blynk interface. Additionally, the system has a secure access control mechanism that uses a keypad and a servo motor. Authorized personnel can unlock the storeroom door by entering a password on the keypad, while a push button allows for manual

closure of the door. Through this integrated setup, supervisors can also monitor stock levels and door status remotely via the mobile application.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

Schematic Diagram

Figure 1 illustrates the overall operation of the proposed Smart Shelf and Storeroom Monitoring System using IoT. All sensing and control components, including two ultrasonic sensors, a weight sensor, a servo motor, a push button, a keypad, and a 20x4 I2C LCD, are connected to the ESP32 microcontroller, which acts as the main control unit.

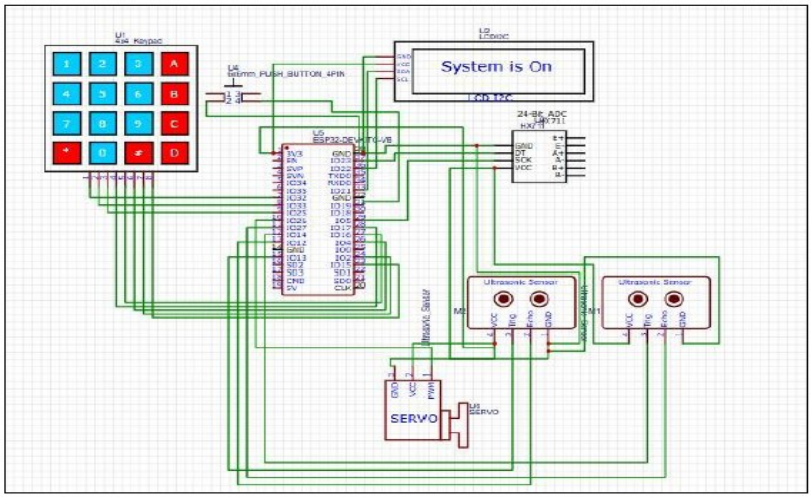

Figure 1. Schematic diagram of the system.

Results

Figure 2 shows the complete prototype of the project. The ultrasonic sensors effectively detect the height of items on the shelves and play a critical role in monitoring stock levels, as depicted in **Figure 3**. In the prototype, stacked snack packs and tissue packs were used to simulate real products. Each sensor continuously measures the distance and sends the data to the ESP32 microcontroller. Current stock levels and heights are displayed instantly on the LCD. Additionally, when stock falls below preset thresholds, notifications are sent to the Blynk application, allowing remote monitoring and time to restock.

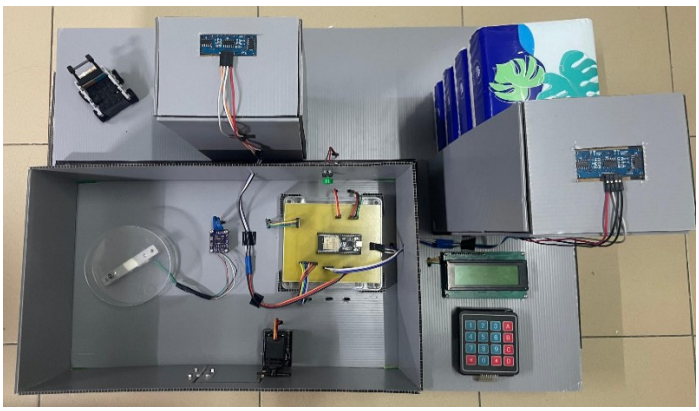

Figure 2. Final prototype of the system.

Figure 3. Results for Smart Shelf.

As shown in **Figure 4**, the load effectively measures changes in the items' weight and plays a role in tracking stock movement within the storeroom. In the prototype, the sensor measured a 2 kg sugar pack, with real-time readings displayed on the system interface. The decrease in the measured weight indicates that the inventory is running low. This real-time weight-based monitoring provides accurate and automated storeroom stock levels, reducing reliance on manual checks and enhancing stock management in small-scale retail environments.

Figure 4. Results for Storeroom Monitoring.

Figure 5 demonstrates the security of the door. If a valid access command is received, either through the Blynk mobile application or the correct password entered via keypad, or when the open button in the Blynk app is pressed, the ESP32 sends a control signal to the servo motor, and the door is unlocked and opens smoothly. If an invalid password is entered or access is denied, the servo remains in the locked position, thereby preventing unauthorized entry.

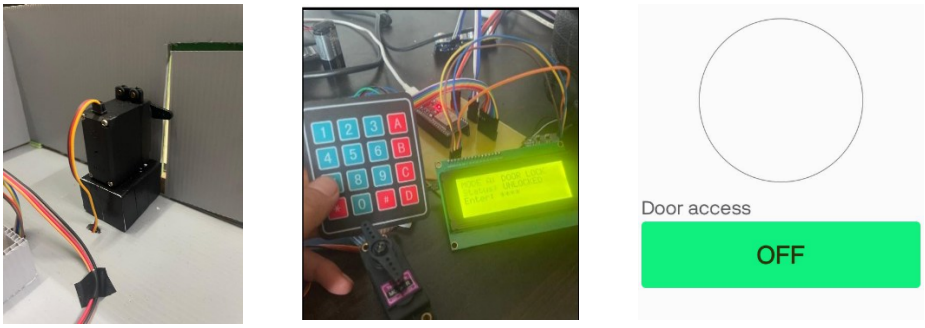

Figure 5. Results for door access.

3. Novelty and uniqueness

The Smart Shelf and Storeroom Monitoring System using IoT stands out for its innovative approach to integrating multiple functionalities: shelf monitoring, storeroom inventory tracking, and storeroom access control, into a cohesive IoT platform designed for small retail environments. Unlike traditional stores that depend on manual inspections or disparate inventory systems, this project offers an automated and efficient solution. A key feature is the deployment of ultrasonic sensors that actively monitor shelf stock levels, eliminating the need for visual checks by staff when items are running low. This proactive approach streamlines inventory management significantly. Additionally, the system incorporates weight sensors in the storeroom, allowing for real-time estimation of inventory. Another unique aspect is the dual-storeroom access control mechanism. Authorized users can unlock the door either by entering a keypad password or via the Blynk mobile application. This not only enhances security but also adds a layer of flexibility and ease compared to traditional key-based systems. By blending real-time monitoring, mobile notifications, and robust access control within an IoT solution built on the ESP32 platform, this project offers a cost-effective smart inventory management system tailored for convenience stores and small retail businesses, for more efficient and secure management.

4. Benefit to mankind

The system offers significant advantages for store workers, customers, and small retail business owners. The system reduces the need for workers to manually check shelves by automatically tracking stock levels and sending notifications when items are running low. This allows staff to focus on other tasks and reduce their daily workload. For customers, this system ensures that products are restocked promptly, leading to a reliable and satisfying shopping experience. Shelves are less likely to be empty, enabling customers to find the items they need. Additionally, the system enhances security by restricting access to the storeroom to authorized personnel. This measure helps store owners minimize the risk of theft or unauthorized handling of inventory. In smaller communities or rural areas where convenience stores play a vital role, the system can help owners detect and replenish stock to ensure that the local community consistently has access to essential goods.

5. Innovation and Entrepreneurial Impact

This project showcases how Internet of Things (IoT) technology can effectively address operational challenges in retail inventory management. It demonstrates how simple technology solutions can enhance traditional stock management by integrating sensors, mobile monitoring, and automated access control. It also promotes entrepreneurial thinking by proposing a low-cost smart retail product concept for small businesses that struggle with costly inventory systems. The project highlights the potential to develop affordable alternatives using accessible hardware, such as the ESP32, and mobile IoT applications. Overall, it encourages students and developers to develop innovative, technology-driven solutions to real-world problems in the growing IoT and smart retail sectors.

6. Potential commercialization

With further development, the system could be enhanced with additional features, including multi-shelf monitoring, data analytics for tracking inventory trends, and integration with digital inventory management systems. These improvements would increase its scalability and usefulness for larger retail operations. The product could be introduced as a modular smart retail

monitoring kit, which would include sensors, a control unit, and a mobile application interface. However, the system is already adequate, as it is especially suitable for a small retail store. The product can provide a solution that enables small businesses to adopt smart inventory technologies without the need for complex installation or significant investment costs.

7. Acknowledgment

The authors would like to express their sincere appreciation to the Faculty of Electrical Engineering, Universiti Teknologi MARA Cawangan Pulau Pinang, Malaysia, for providing the support and guidance throughout the development of this project.

8. Researchers' Biography

Muhammad Faris Ahmad Puad is a dedicated student pursuing a Diploma in Electrical Engineering (Electronics) at Universiti Teknologi MARA (UiTM) Cawangan Pulau Pinang. Faris is now in the last semester of his diploma studies. With a keen interest in technological advancements, Faris aims to contribute meaningfully to the industry and to become a skilled professional in electrical and electronics engineering field.

Asmalia binti Zanal is a senior lecturer at Faculty of Electrical Engineering, Universiti Teknologi MARA Cawangan Pulau Pinang. She received her B. Eng Hons. in Electrical and Electronics Engineering from Universiti Teknologi Malaysia (UTM) in 2004 and finished MSc. in Electronic System Design Engineering from Universiti Sains Malaysia in 2008. Her field of interest includes image processing and artificial intelligence.

Jejak Masa: An Agentic AI-Driven Temporal Audio Framework for Immersive Heritage Tourism

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ABSTRACT

"Jejak Masa" is an agentic AI-driven framework designed to transform Malaysia's heritage tourism through immersive, location-aware audio storytelling. Conventional heritage interpretation typically relies on static information boards or scripted tour guides, which often limit visitor engagement and fail to convey the dynamic nature of historical narratives. To address this limitation, the developed system integrates a multi-agent architecture powered by Large Language Models (LLMs), vector databases, and generative Text-to-Speech (TTS) technologies to generate context-aware historical narratives in real time. A key innovation is the Temporal Slider, which enables visitors to explore historical environments across different eras, such as the Malacca Sultanate and the Colonial period. By incorporating real-time telemetry data, including GPS location, walking pace, and weather conditions, the system dynamically adapts narrative pacing and atmospheric soundscapes to deliver personalised storytelling experiences. This approach introduces a novel Audio Augmented Reality (Audio-AR) paradigm that preserves the visual authenticity of heritage sites while enhancing cultural immersion through spatial audio narration. Socio-economically, the platform supports experiential heritage education and cultural preservation while enhancing visitor engagement in heritage tourism. The system also presents strong commercialization potential through deployment in museums, heritage trails, and national tourism initiatives such as Visit Malaysia 2026 via partnerships with tourism agencies and cultural institutions.

Keywords: Agentic AI, Heritage Tourism, Generative Audio, Cultural Preservation, Audio Augmented Reality

1. Product Description

"Jejak Masa" is an agentic AI-driven, context-aware audio storytelling platform designed to reconstruct historical environments through real-time narrative generation. The system employs a coordinated multi-agent architecture consisting of three core agents **(Figure 1)**. The Contextual Agent continuously interprets environmental and behavioural telemetry, including GPS location, walking speed derived from accelerometer data, time-of-day signals, and real-time weather information. These inputs are transformed into contextual representations that capture the visitor's situational state. The Narrative Agent utilizes a Retrieval-Augmented Generation (RAG) pipeline that combines Large Language Models (LLMs) with a curated historical vector database to dynamically generate historically grounded narratives tailored to specific historical locations and time periods. The Audio Synthesis Agent converts generated narratives into natural

speech using neural Text-to-Speech (TTS) models capable of producing distinct character-driven voice personas such as historical warriors or colonial officers. A key interaction feature is the Temporal Slider, which allows users to explore different historical eras (e.g., 1511 or 1957). As illustrated in **Figure 2**, the application enables a seamless transition from visual interaction to immersive, screen-free exploration. Unlike traditional audio guides, narratives are generated dynamically and adapt to visitor movement and location, enabling personalised heritage exploration while preserving the visual authenticity of historical sites.

2. System architecture and key features

The overall architecture of the proposed "Jejak Masa" system is illustrated in **Figure 1**. The platform implements a coordinated multi-agent architecture consisting of three core modules: the Contextual Agent, Narrative Agent, and Audio Synthesis Agent. The Contextual Agent continuously captures environmental and behavioural signals such as user location, movement speed, and weather conditions. These contextual signals are interpreted by the Narrative Agent, which utilises a Retrieval-Augmented Generation (RAG) framework to produce historically grounded narratives. The generated narratives are then transformed into immersive audio experiences by the Audio Synthesis Agent using neural Text-to-Speech technologies.

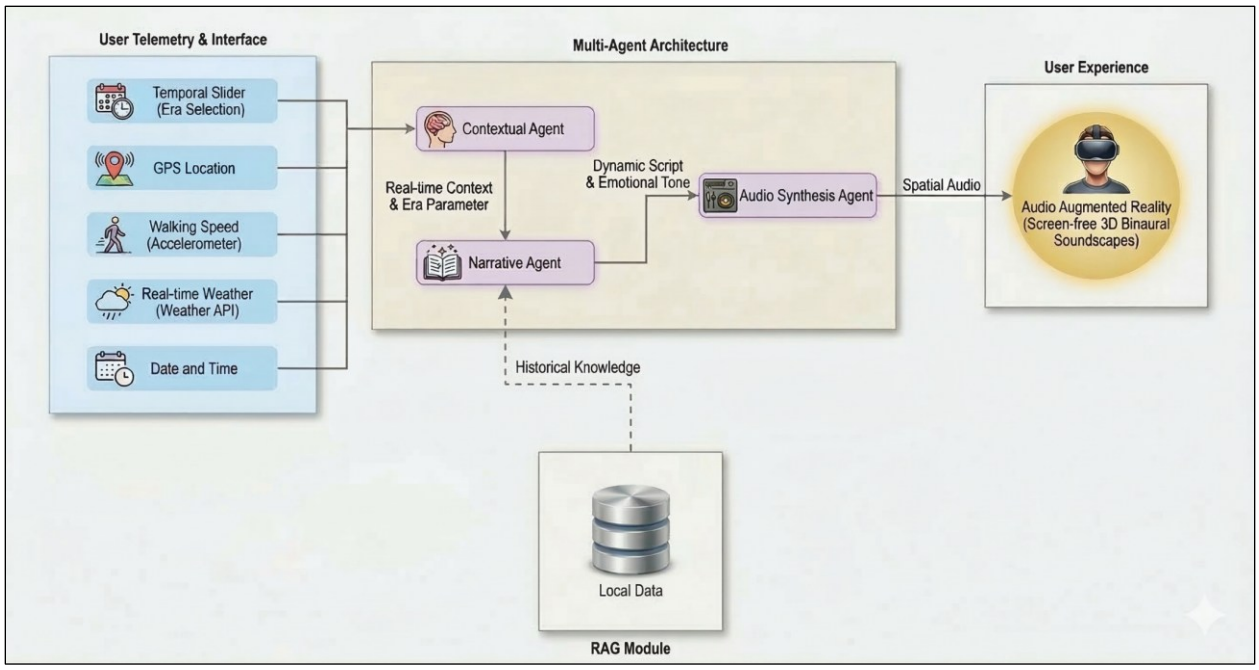

Figure 1. Architecture diagram.

The application workflow and user interaction process are presented in **Figure 2**, which demonstrates how users navigate historical timelines using the Temporal Slider before transitioning into the immersive audio exploration phase.

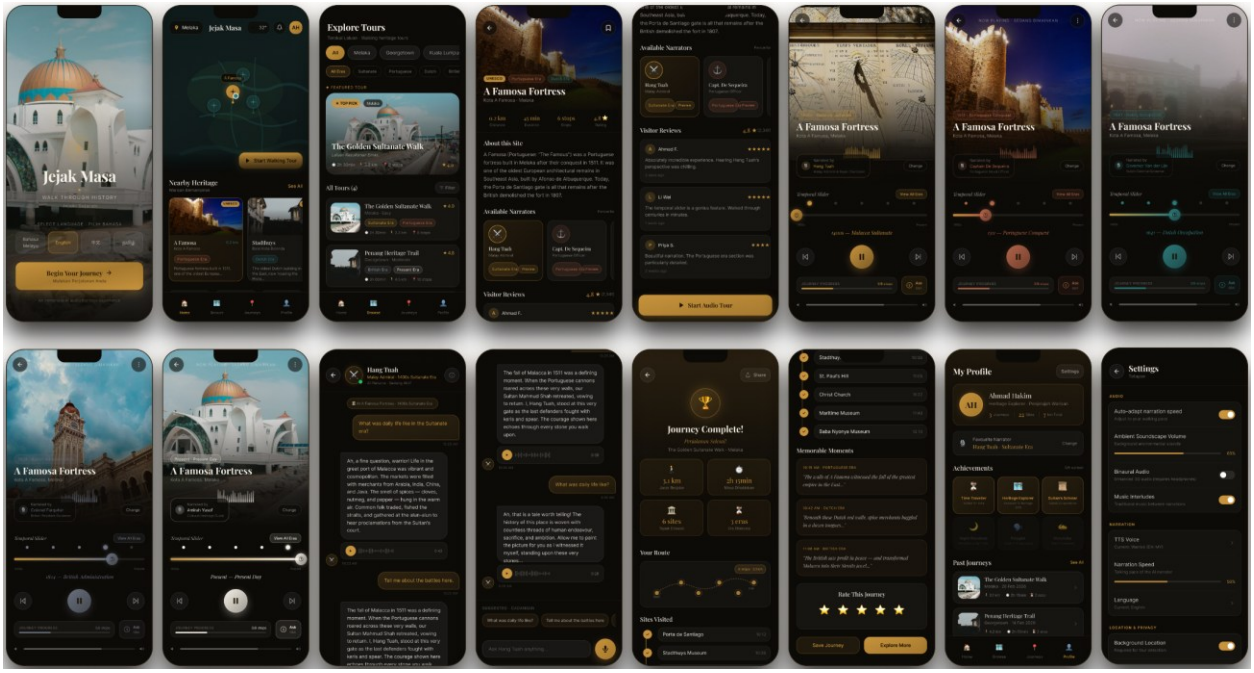

Figure 2. Application interface workflow.

A comparison between the proposed system and traditional audio guide solutions is summarised in **Table 1**, highlighting the enhanced contextual awareness, personalization capability, and scalability of the agentic AI framework.

Table 1. Comparison of "Jejak Masa" features and Traditional Audio Guides.

Feature	**Traditional Audio Guide**	**Jejak Masa (Agentic AI)**
Content Generation	Static pre-recorded audio files	Real-time generative storytelling using LLMs
Context Awareness	Basic GPS trigger	Multi-sensor context (GPS, walking speed, weather, time)
Personalization	Same narration for all visitors	Adaptive narrative based on user behaviour and environment
Interaction	Passive Listening	Interactive dialogue with historical personas (Q&A)
Immersion	Standard mono audio	3D binaural soundscapes and spatial audio storytelling
Content Update	Requires costly re-recording	Instant updates through knowledge base and model-driven content generation
Narrative Perspective	Single narrator voice	Multiple historical personas and role-play narration
Scalability	Site-specific deployment	Platform scalable across multiple heritage sites

3. Novelty and uniqueness

The novelty of "Jejak Masa" lies in transforming heritage tourism from static information delivery into adaptive, AI-generated historical experiences. Conventional audio guides operate using a deterministic model in which visitors listen to identical pre-recorded scripts triggered by location markers. In contrast, "Jejak Masa" introduces an agentic AI framework capable of generating personalised narratives in real time based on contextual data and user behaviour. A key technological innovation is the integration of Retrieval-Augmented Generation (RAG) with

location-aware telemetry, enabling historically grounded narratives that dynamically adapt to the visitor's physical environment. This architecture allows each visitor to experience a unique storyline influenced by movement patterns, environmental conditions, and temporal context. Another distinctive innovation is the introduction of the Temporal Slider interface, which allows users to seamlessly transition between multiple historical periods within the same physical space. This feature transforms heritage sites into temporal exploration environments, allowing visitors to mentally reconstruct how heritage locations evolved across different historical eras. Furthermore, "Jejak Masa" introduces a novel Audio Augmented Reality (Audio-AR) paradigm that prioritizes immersive spatial sound rather than visual overlays. By removing screen dependency, the system preserves the authenticity of heritage environments while encouraging deeper engagement with historical narratives.

4. Benefit to mankind

"Jejak Masa" advances societal development by aligning cultural preservation with direct support for SDG 4 (Quality Education) by transforming historical knowledge into accessible experiential learning that enhances cultural literacy beyond formal classrooms. At the urban and cultural level, "Jejak Masa" contributes to SDG 11 (Sustainable Cities and Communities) by preserving and promoting Malaysia's tangible and intangible heritage through non-invasive digital interpretation. The platform enables Malaysian narratives, perspectives, and cultural identities to be communicated through meaningful and emotionally resonant visitor experiences. Beyond economic and educational benefits, "Jejak Masa" serves as a tool for cultural continuity and national identity. By combining advanced agentic AI technology with human-centred design, the platform demonstrates that innovation can enrich society, promote inclusive access to knowledge, and safeguard cultural heritage for future generations, ensuring that technological advancement complements rather than replaces human engagement with history.

5. Innovation and Entrepreneurial Impact

"Jejak Masa" demonstrates innovation through a multi-agent architecture integrating Contextual, Narrative, and Audio Synthesis agents that collaboratively generate heritage storytelling experiences in real time. By combining generative AI with high-fidelity Text-to-Speech technologies, the system produces natural, personalised narratives that dynamically respond to user behaviour, location, and environmental conditions. The screen-free Audio Augmented Reality approach preserves the visual authenticity of heritage environments while providing immersive and context-aware storytelling experiences. From an entrepreneurial perspective, the platform creates opportunities for collaboration between historians, tourism operators, technology developers, and creative industries. It also provides a foundation for students, researchers, and technology startups to develop innovative digital heritage solutions. By demonstrating practical applications of agentic AI within tourism and education, "Jejak Masa" promotes technology-driven entrepreneurship and supports the growth of Malaysia's digital heritage and creative economy ecosystem. Ultimately, "Jejak Masa" illustrates how agentic AI systems can power next-generation cultural tourism platforms, bridging advanced AI research with real-world heritage preservation and experiential learning.

6. Potential commercialisation

"Jejak Masa" presents strong commercialization potential by transforming heritage tourism into a scalable AI-powered digital experience platform. The system can be deployed through partnerships with the Ministry of Tourism, Arts and Culture (MOTAC) to enhance visitor engagement at national heritage destinations in support of initiatives such as Visit Malaysia 2026. Beyond government collaboration, the platform can be licensed to museums, historical parks, cultural districts, and smart tourism initiatives. A software-as-a-service (SaaS) model allows heritage institutions to subscribe to the platform and customize narratives based on their historical content. Additional revenue opportunities include premium AI-guided heritage experiences, multilingual tourism packages for international visitors, and branded collaborations with tourism operators. The system also generates visitor behaviour analytics, providing valuable insights for tourism planning and heritage management. Because the architecture relies primarily on text-based knowledge updates rather than costly audio recording, the platform can scale efficiently across multiple sites. This positions "Jejak Masa" as a sustainable digital heritage solution with expansion potential throughout Southeast Asia's cultural tourism market.

7. Researchers' Biography

Tan Zheng Yu is an Undergraduate Researcher at Universiti Teknologi Malaysia (UTM), specializing in Multi-Agent Systems (MAS) and agentic AI architectures. His research focuses on intelligent orchestration and adaptive learning systems for real-world applications. He has developed several AI-driven platforms, including the StudyPal learning system and the AI Travel Buddy project developed in collaboration with government stakeholders. His work bridges academic research and industry practice, particularly in scalable enterprise AI pipelines. His achievements include receiving the Silver Award at NALI 2025 for contributions to innovative intelligent systems.

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Muhammad Faiz Bin Zakaria is an IT Network and Security graduate candidate at Universiti Teknologi Malaysia (UTM), specializing in computer security, network design, and system analysis. He has contributed to government-level feasibility studies, including the KPT Centralized Data Center and Integrated MRSM (MyMRSM) System projects while serving as an Assistant Consultant at UTSB Management Sdn. Bhd. His technical experience includes developing enterprise management systems and designing virtual network infrastructures. He is also active in community engagement and holds multiple Cisco and Microsoft Azure certifications in networking and cybersecurity.

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Care-LOG: Clinic Automated Recording and Evaluation for Medical Care Logging

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ABSTRACT

Effective health management in school clinics is essential to safeguard student well-being; however, many institutions still use manual paper-based systems that result in lost records, slow access to medical information, and limited communication with parents. To address these challenges, this study developed CARE-LOG (Clinic Automated Recording and Evaluation for Medical Care Logging), digital clinic management system designed to improve the efficiency, accuracy, and accessibility of student medical records. The system was developed using a Research and Development (R&D) approach, which included planning, system design, prototype development, testing, evaluation, revision, and implementation in selected schools in South Cotabato, Mindanao, Philippines. CARE-LOG integrates key features such as QR code–based student identification, secure electronic health record storage, digital treatment and medication logging with allergy cross-checking, automated parent email notifications, incident reporting, and digital visit summaries. These features improve communication between school clinics and parents, lower documentation errors, and allow clinic staff to swiftly access student health data. CARE-LOG improves clinic efficiency and promotes safer health management in schools by substituting a digital platform for traditional record-keeping. By lowering administrative burden and enhancing healthcare responsiveness, the innovation also provides substantial socioeconomic advantages. Additionally, it has a strong commercialization potential for adoption by educational institutions.

Keywords: School health services, Digital clinic management system, Record-keeping, QR code identification, Parent communication

1. Product Description

CARE-LOG functions as an electronic clinic logbook that enables schools to operate without paper-based records through an organized digital platform. School clinic staff can access students' basic information, medical history, and allergies through QR code scanning by scanning student ID badges. The system allows nurses to document symptoms, vital signs, and treatments using structured digital forms, ensuring that important medical information is accurately recorded and maintained. Parents receive automatic email notifications that include visit summaries, pickup notifications, and follow-up reminders, keeping them informed without creating additional stress. Furthermore, clinic operations become more efficient through the use of severity level tools and the ability to quickly correct or update record errors.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc.

Figure 1. Flowchart CARE-LOG development process **.**

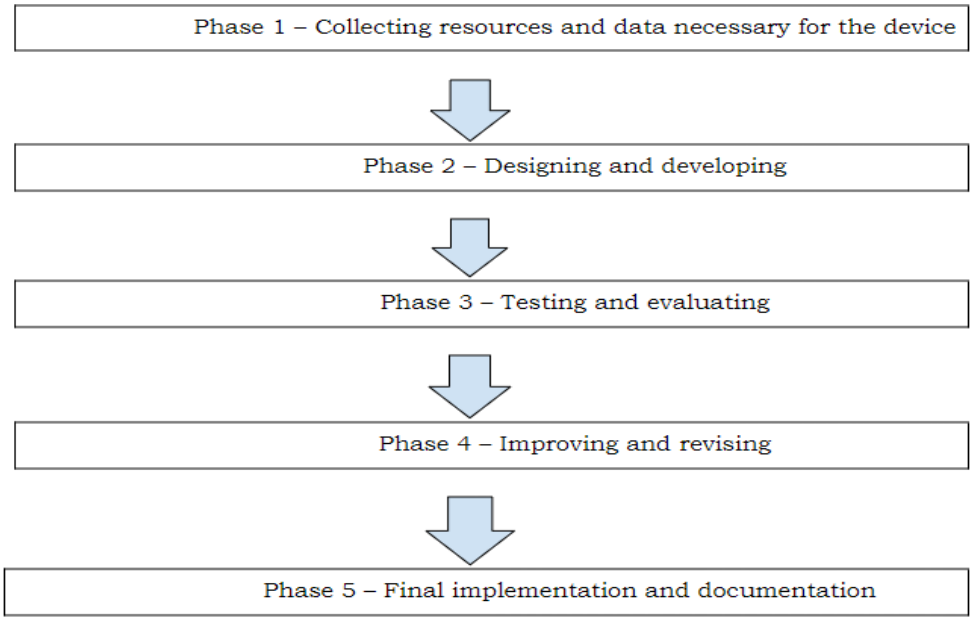

Figure 1 presents the flow chart of the CARE-LOG system developed using the Research and Development (R&D) method. The process includes planning, system design, prototype development, testing, evaluation, revision, and final implementation. These steps helped the researchers organize the development and improve the system based on testing and feedback.

Figure 2 shows how the CARE-LOG system works in a school clinic. When a student arrives, the clinic staff scans the student's QR code to retrieve their medical record from the database. The staff records the student's symptoms, diagnosis, and treatment, while the system checks for any listed allergies before medication is given. After the consultation, the visit record is saved and a notification is sent to the student's parents. **Figure 3** shows the Illustration 1. QR code scanning feature used to identify students in the CARE-LOG system. When scanned, the system quickly displays the student's medical information such as medical history, allergies, and previous clinic visits. This makes record retrieval faster and reduces the need for manual searching **.Figure 4** shows the Illustration 2. on the digital clinic visit form used in the CARE-LOG system to record student consultations. The form allows clinic staff to enter symptoms, diagnoses, medications, and procedures directly into the system. This helps keep medical records organized and securely stored, reducing the risks of lost or incomplete paper-based records.

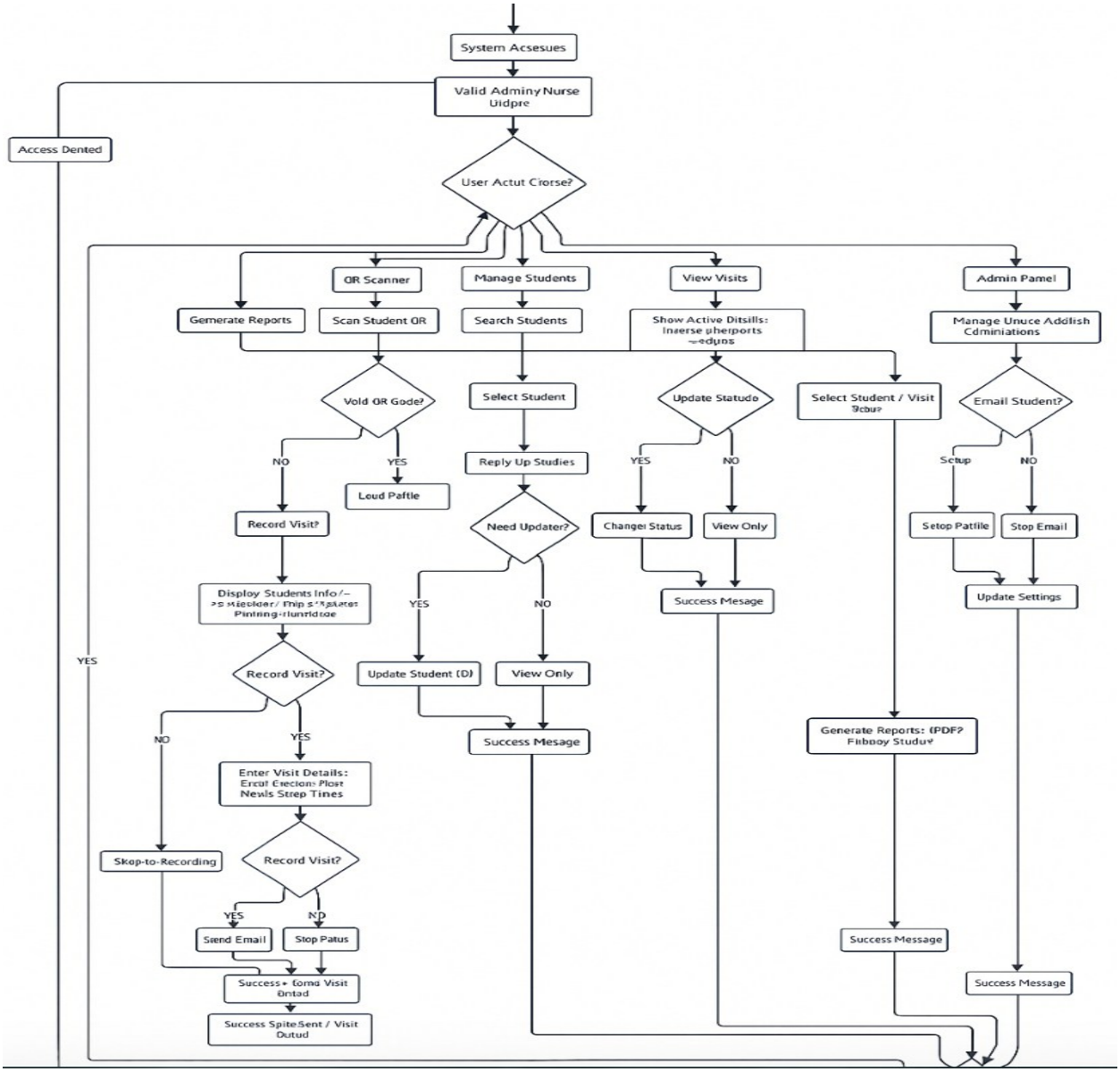

Figure 2. System Flow.

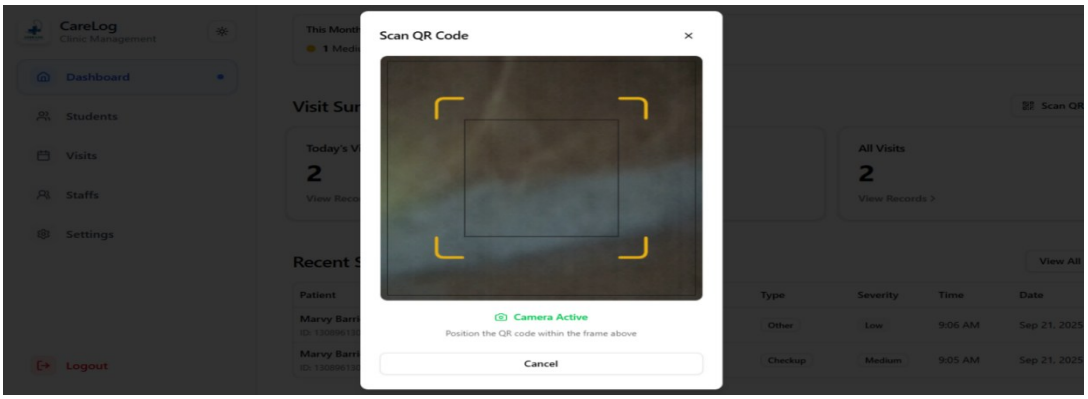

Figure 3. Illustration 1. QR Code Scanning.

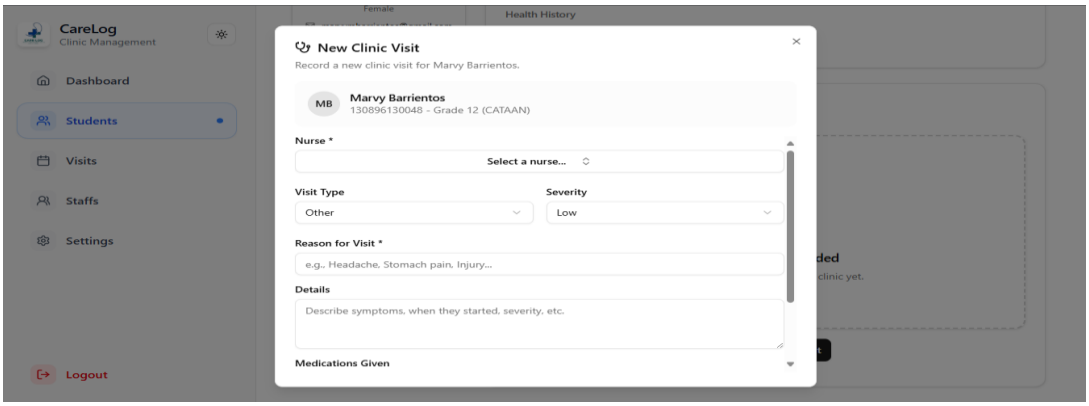

Figure 4. Illustration 2. New Clinic Visit Form.

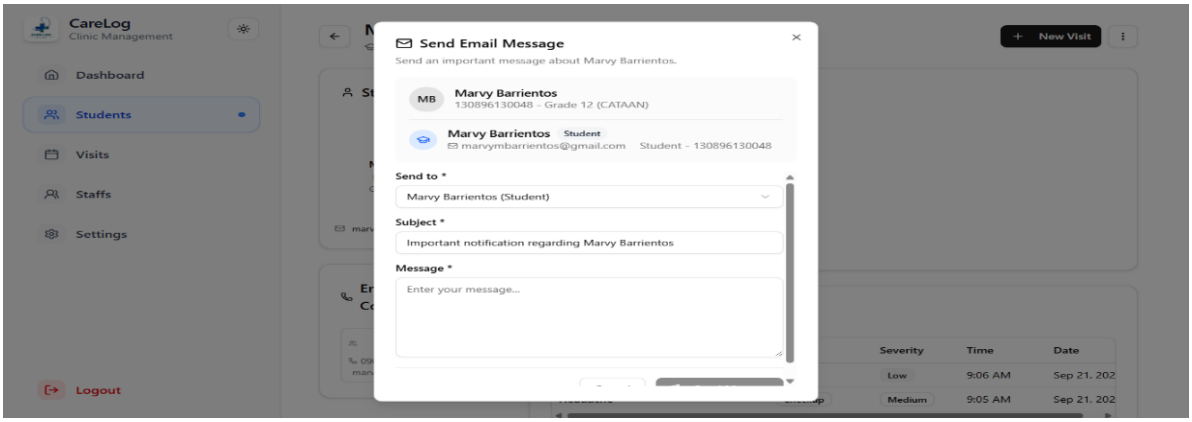

Figure 5. Illustration 3. Send Email Notification Page.

Figure 5 shows the Illustration 3. sending the email notification feature of the CARE-LOG system, which informs parents or guardians about their child's clinic visit. The email includes details such as the reason for the visit, treatment provided, and recommendations from the clinic staff. This feature improves communication between the school clinic and parents.

Table 1. Functionality.

Feature	Tupi National Highschool	Polonuling National Highschool	General Paulino Santos Memorial institute	Total Yes	Yes %
Admin Login Option	Yes	Yes	Yes	3	100%
Staff Assignment Option	Yes	Yes	Yes	3	100%
Profile Option	Yes	Yes	Yes	3	100%
App Homepage Navigation	Yes	Yes	Yes	3	100%
Logout Option	Yes	Yes	Yes	3	100%

Table 1 presents the results of the functional evaluation of the CARE-LOG system. It summarizes how effectively the system performs in managing medical records, identifying students, and supporting communication between clinic staff and parents.

Table 2 Accuracy

Feature	Tupi National Highschool	Polonuling National Highschool	General Paulino Santos Memorial institute	Total Yes	Yes %
QR Code Scanning	Yes	Yes	Yes	3	100%
Student/Patient Information Display	Yes	Yes	Yes	3	100%
Medical History Review	Yes	Yes	Yes	3	100%
Print Medical History	Yes	Yes	Yes	3	100%

Table 2 presents the accuracy of the CAR-LOG system. It shows how the system helps ensure accurate storage and retrieval of student health records. By using electronic forms, automatic data storage, and QR codes for identification, the system reduces documentation errors and keeps records updated.

Table 3 Reliability

Feature	Tupi National High school	Polonuling National High school	General Paulino Santos Memorial institute	Total Yes	Yes %
General Information Display	Yes	Yes	Yes	3	100%
Emergency Visit Workflow	Yes	Yes	Yes	3	100%
Treatment & Medication Recording	Yes	Yes	Yes	3	100%
Referral Letter Generation	Yes	Yes	Yes	3	100%
Visit Resolution Logging	Yes	Yes	Yes	3	100%
Digital Pass for Returning to Class	Yes	Yes	Yes	3	100%
Incident Report Generation	Yes	Yes	Yes	3	100%
Post-Visit Reminders	Yes	Yes	Yes	3	100%

Table 3 evaluates the reliability of the CAR-LOG system. It reflects the system's ability to consistently provide services without technical issues or data loss. The system supports dependable processing of clinic visits, collection of student information, and smooth operation of routine clinic tasks.

Table 4 Communication

Feature	Tupi National Highschool	Polonuling National Highschool	General Paulino Santos Memorial institute	Total Yes	Yes %
General Information Display	Yes	Yes	Yes	3	100%
Emergency Visit Workflow	Yes	Yes	Yes	3	100%
Treatment & Medication Recording	Yes	Yes	Yes	3	100%
Referral Letter Generation	Yes	Yes	Yes	3	100%
Visit Resolution Logging	Yes	Yes	Yes	3	100%

Table 4 evaluates the communication features of the CAR-LOG system. It shows how the system improves communication between the school clinic and parents through email notifications and electronic visit summaries, helping parents stay informed about their child's clinic visits and health concerns.

Table 5 Security

Feature	Tupi National Highschool	Polonuling National Highschool	General Paulino Santos Memorial institute	Total Yes	Yes %
Search Bar (Record Lookup)	Yes	Yes	Yes	3	100%
Cancel Visit Record	Yes	Yes	Yes	3	100%
Complete Consultation Records	Yes	Yes	Yes	3	100%
Case Severity Labeling	Yes	Yes	Yes	3	100%
Visit Documentation & Sign-off	Yes	Yes	Yes	3	100%

Table 6 evaluates the security of the CAR-LOG system in protecting student health data. The system ensures secure digital storage and controlled access to records, reducing the risk of unauthorized access to sensitive medical information.

Table 6 Overall System Results

Category	Overall Average	Interpretation
Functionality	4.52	Strongly Agree
Accuracy	4.36	Agree
Reliability	4.23	Agree
Communication	4.23	Agree
Security/Acceptability	4.45	Strongly agree
Grand Mean	4.36	Agree

This table summarizes the overall evaluation across all system categories. It shows that the system is well-accepted, functional, accurate, reliable, communicates effectively, and is secure. The grand mean reflects a generally positive perception from users.

3. Novelty and uniqueness

CARE-LOG (Clinic Automated Recording and Evaluation for Medical Care Logging) is unique because it integrates multiple digital healthcare functions into one system designed for school clinics. Unlike typical record systems that only store data, CARE-LOG includes QR code–based student identification, automatic allergy checking, treatment documentation, severity tagging for emergencies, and automated parent notifications. The system was also tested in real schools in South Cotabato, such as Tupi National High School, Polonuling National High School, and General Paulino Santos Memorial Institute. It directly addresses real problems like lost paper records, slow medical history retrieval, and delayed communication with parents.

4. Benefit to mankind

CARE-LOG improves safety, efficiency, and transparency in school clinics. Its allergy cross-checking feature helps prevent medication errors and allows faster identification of students during emergencies. It also sends notifications to parents, increasing trust and communication. By reducing paperwork and organizing digital health records, the system helps clinic staff manage cases better and supports schools in making informed health decisions.

5. Innovation and Entrepreneurial Impact

CARE-LOG demonstrates innovation by using modern web technologies such as QR identification, centralized databases, digital workflows, and automated communication. It also has entrepreneurial potential because it can be developed into a scalable subscription-based system for schools and community clinics. With further improvements like SMS notifications, it could expand across the Philippines and support the growth of digital health solutions.

6. Potential commercialization

When we observed how school clinics manage their records, we noticed that many of them still use paper. Over time, papers can get misplaced, damaged, or difficult to organize, especially when there are many students. Because of this, we thought of creating CARE-LOG to make the process faster and less stressful for clinic staff. Schools can subscribe to the system at an affordable cost,

and we plan to include installation, basic training, and support so they won't feel overwhelmed when switching to digital records. In the future, we also see it being used in small community clinics or rural health centers that experience similar problems. Optional features like SMS notifications and detailed reports can be added depending on the school's needs.

7. Acknowledgment

The researchers would like to express their sincere gratitude to everyone who contributed to the completion of this study. They extend their heartfelt appreciation to their teachers for their continuous guidance, support, and valuable insights that helped improve the quality of this research. Special thanks are also given to their research consultant for the invaluable advice, patience, and consistent guidance throughout the research process. The researchers are deeply grateful to their parents for their unconditional love, encouragement, and unwavering support, which motivated them to overcome the challenges encountered during the study. The researchers also acknowledge their own dedication, teamwork, and perseverance in successfully completing this research. Above all, the researchers offer their deepest gratitude to Almighty God for His guidance, wisdom, strength, and countless blessings throughout the entire research journey.

8. Researchers' Biography

Gracielle Faith C. Montoya is a highly motivated student with a strong commitment to academic excellence, innovation, and collaborative learning. She actively participates in research and technology initiatives, including the National Robotics Competition Visayas 2025, National Robotics Competition Mindanao 2025, and the Division Science and Technology Fair 2025. These experiences have strengthened her analytical thinking, leadership, and problem-solving skills. She remains dedicated to continuous growth and aspires to contribute meaningfully to scientific and technological advancement.

Marvy M. Barrientos is a dedicated and goal-oriented student recognized for her perseverance, discipline, and passion for science and technology. She has participated in the National Robotics Competition Visayas 2025, National Robotics Competition Mindanao 2025, and the Division Science and Technology Fair 2025, where she gained valuable experience in research, innovation, and teamwork. Committed to excellence, she continues to refine her skills while preparing for future academic and professional endeavors.

Nathalie B. Veric is an enthusiastic learner known for her academic dedication, strong work ethic, and collaborative spirit. She has taken part in the National Robotics Competition Visayas 2025, National Robotics Competition Mindanao 2025, and the Division Science and Technology Fair 2025, enhancing her research capabilities and critical-thinking skills. She remains focused on academic achievement and aims to apply her knowledge toward meaningful contributions in science and innovation.

Tim Kyla P. Vidamo is a diligent student who demonstrates commitment to academic excellence, innovation, and teamwork. Her participation in the National Robotics Competition Visayas 2025, National Robotics Competition Mindanao 2025, and the Division Science and Technology Fair 2025 has strengthened her technical competence, confidence, and leadership abilities. She aspires to further develop her expertise while pursuing opportunities that contribute to scientific progress and personal growth.

GeoSense

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ABSTRACT

GeoSense is an Internet of Things (IoT) initiative that provides the real-time solution for the early detection of flood and landslide events in disaster-prone areas. Traditional monitoring methods are often limited by delayed data collection and manual observation, reducing the efficiency of early warning systems. To address these concerns, GeoSense continuously monitors important characteristics such as rainfall intensity, water levels, soil moisture, and soil stability through the integration of environmental sensors, an ESP32 microcontroller, and LoRa connectivity to continuously monitor key parameters. Data is wirelessly delivered to a dashboard via Blynk and compared to predetermined limits detect high-risk conditions. Alerts are issued in real-time using Telegram to warn authorities and communities of the situation, allowing them to take precautionary measures that can save lives and minimize property damage. The system is low-cost, practical, and user-friendly, highlighting the potential of IoT technology for effective disaster management.

Keywords: IoT, Flood Monitoring, Landslide Detection, Early Warning System, Real-Time Monitoring

1. Product Description

Traditional flood and landslide monitoring rely on informal observation, irregular data collection, and delayed communication among various organizations. Nevertheless, many regions prone to floods and landslides persistently encounter significant obstacles that make early warning and disaster response systems ineffective, including inadequate monitoring of environmental conditions for landslide detection, insufficient flood monitoring, and the absence of real-time monitoring, visualization, and automated alert systems. GeoSense is a smart IoT system designed to provide real-time monitoring and early warning for floods and landslides. The system integrates multiple environmental sensors, including rain sensor, soil moisture sensors, vibration sensors, ultrasonic sensors, and DHT22 temperature and humidity sensors, connected to an ESP32 microcontroller. Data collected from these sensors is transmitted wirelessly via a LoRa module to a centralized digital dashboard, where it is analyzed against predefined threshold values. The dashboard presents current risk levels such as Normal, Warning, or Danger, allowing authorities and local communities to make informed decisions. Alerts are generated automatically through LED indicators, buzzer alarms, and Telegram notifications when unsafe environmental conditions are detected. GeoSense is designed with user-friendliness in mind, ensuring non-technical users can easily interpret the data. Its modular design allows deployment in flood- and landslide-prone areas, while the low-cost components make it accessible for local authorities and community leaders. By integrating continuous environmental monitoring, threshold-based analysis, and

automated alerts, GeoSense enhances preparedness, improves safety, and reduces response time during natural disasters.

2. Project Design

System Architecture

Figure 1 illustrates the logical design of the GeoSense IoT system. Environmental sensors including rain sensor, soil moisture sensors, vibration sensors, ultrasonic water level sensors, temperature and humidity sensors (DHT11) by collecting real-time data from flood- and landslide-prone areas. The sensors are connected to an ESP32 microcontroller, which processes and temporarily stores the data.

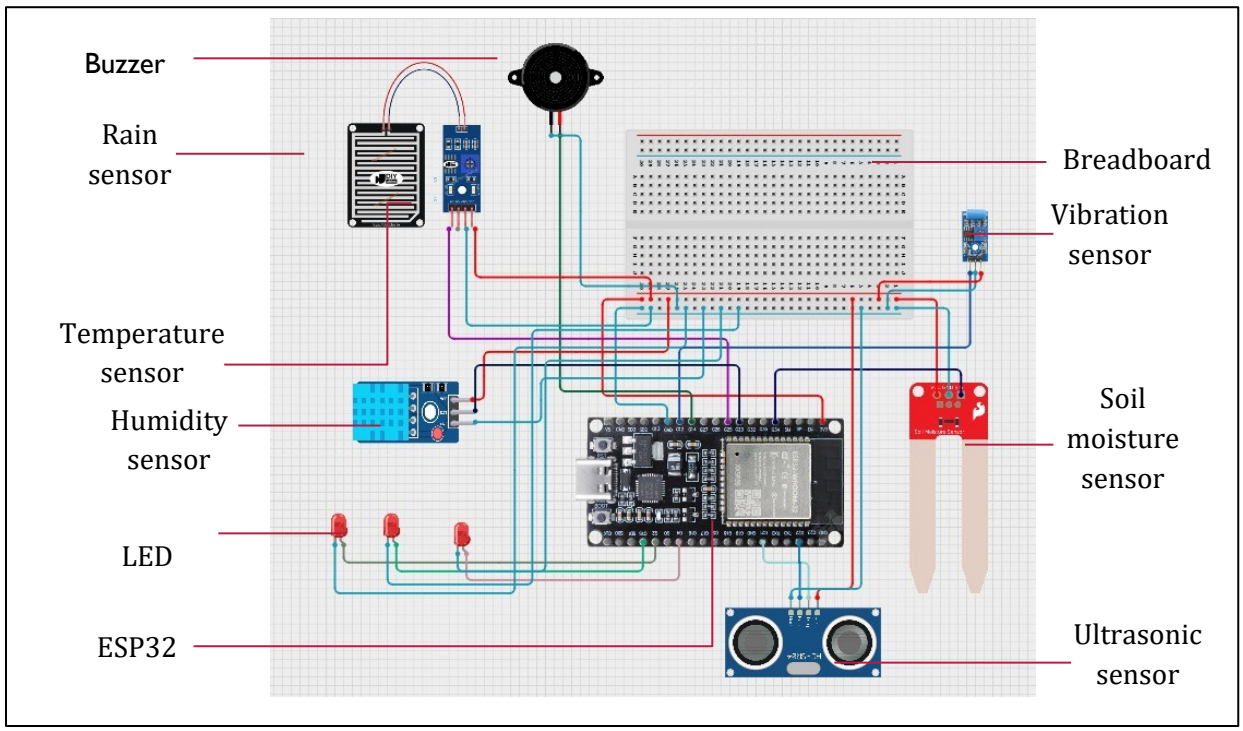

Figure 1. Logical Design.

Using a LoRa communication module, the processed data is transmitted wirelessly over long distances to a centralized digital dashboard hosted on a server or cloud platform. The dashboard continuously analyzes incoming data and compares it against predefined threshold values. If environmental parameters exceed safe limits, automated alerts are triggered via LED indicators, buzzer alarms, and dashboard notifications. **Figure 1** emphasizes how the system integrates multiple hardware components with wireless communication and real-time data processing to create an efficient, low-cost, and scalable disaster monitoring system.

System Flowchart

Figure 2 shows the operations process of an environmental monitoring system, which includes landslide and flood detection and monitoring using ESP32 and sensors. The system continuously collects environmental data, analyzes it, and sends a warning if dangerous conditions are detected.

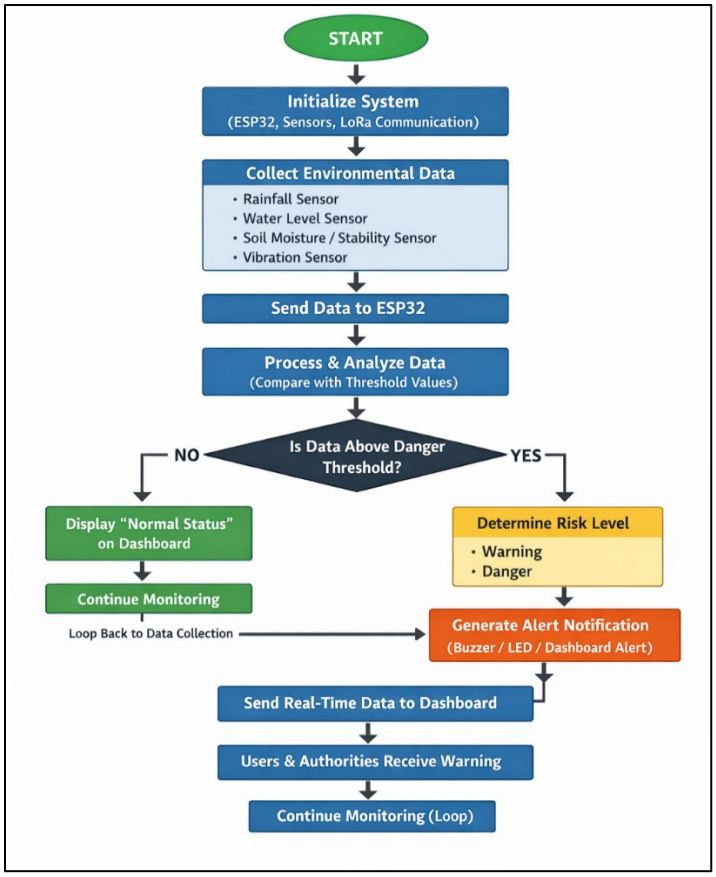

Figure 2. System Flowchart.

The process begins with sensor data acquisition, where sensors continuously monitor rainfall, water levels, soil moisture, and vibration. Next, the threshold evaluation module compares these readings to safety thresholds pre-configured in the system. If the measured values remain within safe limits, the data is displayed on the dashboard for continuous monitoring. However, if readings exceed critical thresholds, the system automatically generates alerts, notifying authorities and community members in real-time. The chart clearly shows the decision-making process, illustrating how GeoSense transitions from passive monitoring to active alert generation. **Figure 2** highlights the automated and intelligent design of the system, which reduces response time and human error in disaster detection.

2.3 System Dashboard

Figure 3 shows a live interface for monitoring flood and landslide conditions. It displays real-time sensor readings, historical trends, and risk levels indicated as Normal, Warning, or Danger. Visual elements such as color-coded indicators, charts, and graphs allow users to quickly interpret environmental conditions. The dashboard is designed for user-friendliness, guaranteeing that even non-technical users can obtain essential information. Alerts activated by threshold violations are clearly presented on the dashboard, offering authorities and community leaders valuable insights for prompt interventions. This image illustrates how GeoSense converts unprocessed sensor data into significant insights, facilitating proactive disaster management and situational awareness.

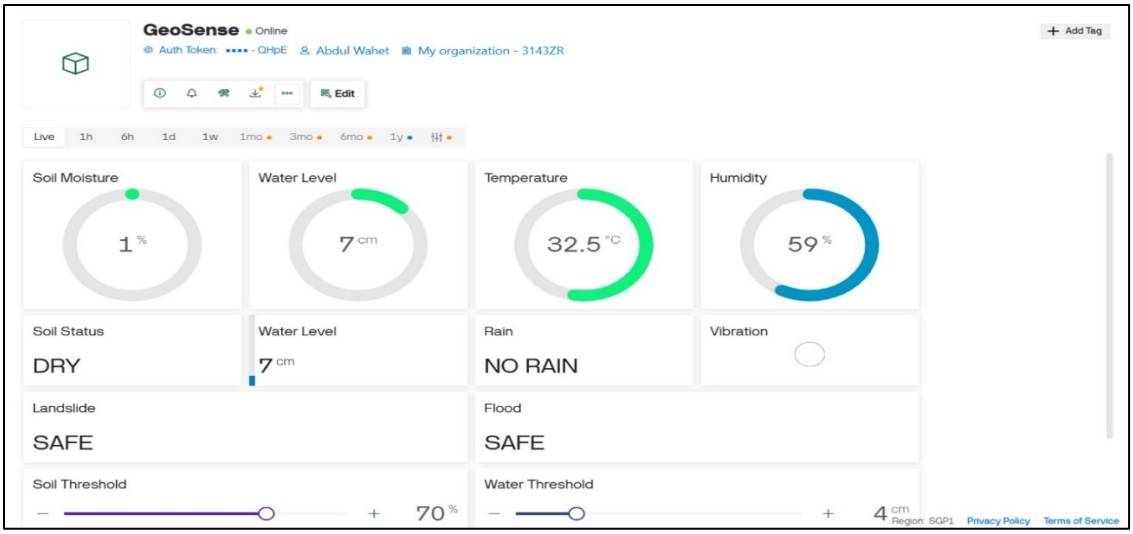

Figure 3. System Dashboard.

Sensor Threshold Table

Table 1 shows the threshold values used by each sensor in the system to determine environmental conditions and trigger alerts. These thresholds help the system classify whether the environment is safe, warning, or dangerous based on sensor readings.

Table 1. Sensor Threshold Value and Status.

Sensor	***Threshold value***	***Status/Action***
Soil Moisture Sensor	0 – 30%	DRY (Safe)
	31 – 55%	MOIST (Safe)
	56 – 70%	WET (Soil Alert)
	71 – 100%	SATURATED (Soil Alert)
	Soil percent >= 55	Soil Alert Triggered
Rain Sensor	>3800	NO RAIN
	3001 – 3800	LIGHT
	2001 – 3000	MODERATE
	≤ 2000	HEAVY (Rain Alert)
	Rainraw < 2000	Rain Alert Triggered
Ultrasonic Water Level Sensor	≤4 cm	Safe
	5 – 8 cm	Water warning
	> 8 cm	Flood danger
	Water cm > 8 cm	Emergency Trigger
Vibration Sensor	Low (0)	No movement
	High (1)	Movement detected
Temperature (DHT11)	Monitoring only	No alert set
Humidity (DHT11)	Monitoring only	No alert set
Landslide Detection Logic	Soil ≥ 55% and rain ≤ 2000 and vibration high	Landslide danger
Emergency Output (LED + Buzzer)	Water 5 – 8cm	LED ON + 1500Hz Buzzer
	Otherwise	System Safe (OFF)

2.5 Project Prototype

Figure 4 shows the prototype of the proposed environmental monitoring and landslide early warning system. The prototype integrates multiple environmental sensors, an ESP32 microcontroller, a LoRa communication module, and a Telegram notification system to monitor environmental conditions and provide early warnings in real time. The prototype consists of several main components including the ESP32, soil moisture sensor, rain sensor, ultrasonic water level sensor, vibration sensor, DHT11 temperature and humidity sensor, and a LoRa module. These sensors continuously collect environmental data such as soil moisture level, rainfall intensity, water level, ground vibration, temperature, and humidity. The soil moisture sensor measures the water content in the soil to determine whether the soil is dry, moist, wet, or saturated. High soil moisture may indicate unstable ground conditions that increase the risk of landslides. The rain sensor detects rainfall intensity, which can contribute to soil saturation. The ultrasonic water level sensor measures water levels to monitor potential flooding situations. In addition, the vibration sensor detects ground movement that may indicate soil shifting or early landslide activity. The DHT11 sensor monitors environmental temperature and humidity for observation and environmental analysis.

Figure 4. Project Prototype.

All collected data are processed by the ESP32 microcontroller, which compares the sensor readings with predefined threshold values. When the readings exceed the danger threshold, the system activates warning indicators such as an LED and buzzer. The system uses LoRa (Long Range communication) to transmit sensor data to a remote monitoring dashboard. LoRa enables long-distance and low-power communication, making it suitable for environmental monitoring in remote or rural areas. This prototype demonstrates an integrated system capable of real-time

environmental monitoring and early warning for landslide and flood risks, helping users and authorities take preventive action when dangerous conditions are detected.

Telegram Notification

The system uses Telegram notifications to provide real-time alerts to users when dangerous environmental conditions are detected. A Telegram bot is integrated with the ESP32 system to automatically send warning messages as shown in **Figure 5**.

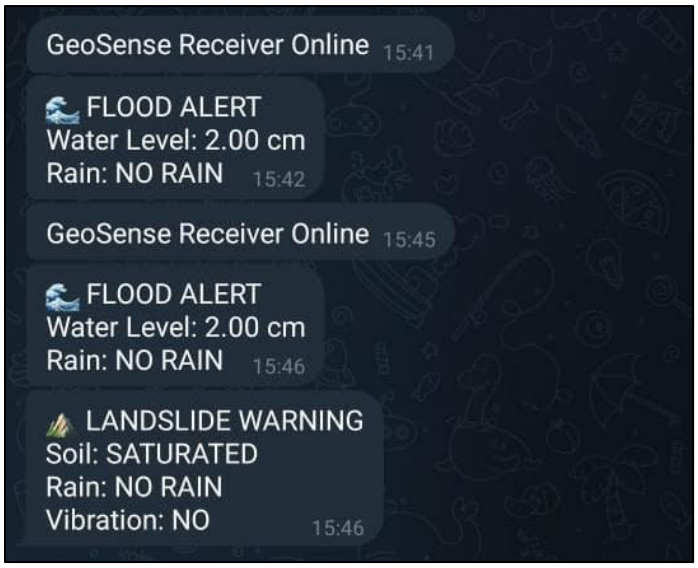

Figure 5. Telegram Notification.

When the sensor readings exceed the predefined threshold values, such as high soil moisture, heavy rainfall, rising water levels, or detected ground vibration, the ESP32 processes the data and triggers a notification. The system then sends an alert message through the Telegram bot to inform users about the detected risk. This notification allows users, authorities, or monitoring personnel to receive instant warnings directly on their smartphones, enabling them to take early precautionary actions. The use of Telegram is effective because it supports fast message delivery, easy integration with IoT systems, and remote monitoring without requiring a complex application.

3. Novelty and uniqueness

The novelty of this project lies in the integration of multiple environmental sensors with a smart monitoring and alert system to detect potential landslide and flood risks. The prototype combines several sensors, such as soil moisture, rain sensor, ultrasonic water level, vibration, and DHT11 sensors to monitor environmental conditions simultaneously. By analyzing multiple parameters together, the system can provide a more accurate assessment of environmental risks compared to systems that rely on only a single sensor. Another unique feature of this prototype is the use of LoRa communication and Telegram notifications for real-time tracking and alerts. LoRa allows long-range and low-power data transmission, making the system suitable for use in remote or rural areas. At the same time, the system sends automatic alerts through Telegram messages, allowing users or authorities to receive instant warnings on their smartphones when dangerous

conditions are identified. This mix of multi-sensor monitoring, long-range communication, and real-time mobile alerts makes the system a practical and efficient early warning solution.

4. Benefit to mankind

GeoSense directly adds to human safety and community resilience by giving timely early warnings for floods and landslides. Real-time monitoring allows local officials and residents to respond quickly, reducing the risk of injury, loss of life, and property damage. By providing actionable information through a user-friendly dashboard and automated alerts, GeoSense allows communities to take preemptive steps during hazardous conditions. Its low-cost design ensures accessibility for vulnerable and remote places, bridging the gap between technological resources and disaster-prone people. Ultimately, GeoSense improves disaster preparedness, supports informed decision-making, and mitigates the social and economic impacts of natural disasters, thereby improving total community safety and resilience.

5. Innovation and Entrepreneurial Impact

GeoSense supports innovation by applying IoT technology to address critical environmental challenges, integrating multiple sensors, long-range communication, and real-time dashboards in a single system. It encourages a culture of entrepreneurship by offering a scalable solution that can be adopted by local authorities, NGOs, and private companies for disaster management. The project promotes the use of technology and problem-solving skills within the community and school, inspiring students and professionals to create practical, impactful innovations. Its modular and low-cost design allows small-scale deployment with the potential for expansion into wider commercial applications.

6. Potential commercialization

GeoSense has strong potential for commercialization as an affordable IoT-based disaster monitoring kit for flood- and landslide-prone regions. Local authorities, municipalities, NGOs, and private disaster management companies could adopt the system for community safety and early warning services. The modular, low-cost design allows scalable deployment, making it feasible for both urban and remote areas. Additionally, GeoSense can be incorporated into smart city initiatives, environmental monitoring projects, and disaster preparedness programs. Its practical design, real-time functionality, and focus on community impact make it a commercially viable solution with social and economic value, creating opportunities for local entrepreneurs, small businesses, and tech startups to contribute to disaster resilience while generating sustainable revenue streams.

7. Acknowledgment

We want to express our sincere appreciation to all individuals and organizations who contributed to the successful completion of the GeoSense project. Our deepest gratitude goes to Puan Noor Aishah Zainiar, our project supervisor, for her invaluable guidance, continuous support, and expert advice throughout the development of this project. Special thanks are also given to all individuals and organizations who contributed resources, insights, and feedback during the project, which significantly enhanced the quality and functionality of the system. Finally, we acknowledge the support of our families and peers, whose motivation and encouragement have been essential to the successful completion of this project.

8. Researchers' Biography

Abdul Wahet bin Nurul Huda is a final-year student in the Diploma in Information Technology at Politeknik Sultan Idris Shah, Malaysia. Their research focuses on real-time flood monitoring and landslide detection as part of their final year project. This research was conducted under the supervision of Noor Aishah Zainiar.

Muhammad Dhani An bin Abdul Azim is a final-year student in the Diploma in Information Technology at Politeknik Sultan Idris Shah, Malaysia. Their research focuses on real-time flood monitoring and landslide detection as part of their final year project. This research was conducted under the supervision of Noor Aishah Zainiar.

Noor Aishah binti Zainiar is currently working as a Lecturer for Diploma in Information Technology (Networking System Track) in the Department of Information and Communication Technology of Sultan Idris Shah Polytechnic. Her interests include wireless network technologies and network security.

Farm-to-Pharmacy: Blue Petal Balm

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ABSTRACT

Blue Petal Balm is a plant-based skincare solution developed to address the increasing demands towards a safe, non-steroidal treatments for eczema, dry skins and mild irritations. Centered on a farm-to-pharmacy model, the balm is mainly derived from a butterfly pea flower offering a natural antioxidant such as anthocyanins to repair damaged skin and reduce inflammation. Unlike conventional treatments that may contain synthetic chemicals, steroids, or hazardous heavy metals like arsenic, the balm offers a gentle, non-greasy, and toxic-free alternative. Blue Petal Balm is specifically designed for long-term daily use, making it safe for toddlers and individuals with highly sensitive skin. By prioritizing ingredient transparency and sustainable practices, the product fills a significant market gap for affordable, locally sourced and dermatologically safe herbal remedies. Blue Petal Balm aims to promote holistic healing and healthy living in alignment with Sustainable Development Goals (SDG) 3 Good Health and Well-being. This innovation represents a shift toward ethical skincare that balances clinical effectiveness with environmental responsibility and community-based entrepreneurial growth.

Keywords: Butterfly pea flower, non-steroidal relief, farm-to-pharmacy, natural skincare, eczema

1. Product Description

Blue Petal Balm is a plant-based skincare solution specifically formulated to address common skin concerns such as eczema, chronic dryness, and mild irritations. Conventional treatments often rely on synthetic chemicals or corticosteroids, that only offer temporary relief use and may cause skin irritations to some users. The balm is developed with a butterfly pea flower as the primary active ingredients and meticulously blended with natural bases such as coconut oil, beeswax and Vitamin E, a natural antioxidant that prevents the oil from becoming rancid while protecting the skin from oxidative stress **(Figure 1)**. The innovated Blue Petal Balm is non-steroidal and free from artificial fragrances. It features a light, silky texture designed for rapid absorption, ensuring it does not leave a greasy residue on the skin. While the butterfly pea flower offers a wealthy of antioxidants and anti-inflammatory properties, the balm itself maintains a natural appearance rather than a blue hue, catering to consumers who prefer simple, clean aesthetics product. The balm is packaged in a compact, portable packaging **(Figure 2)**, that allows users to manage skin healthy anytime and anywhere, making it an ideal choice for the daily maintenance of the skin's natural barrier.

2. Step-by-steps on producing the Blue Petal Balm and final-product.

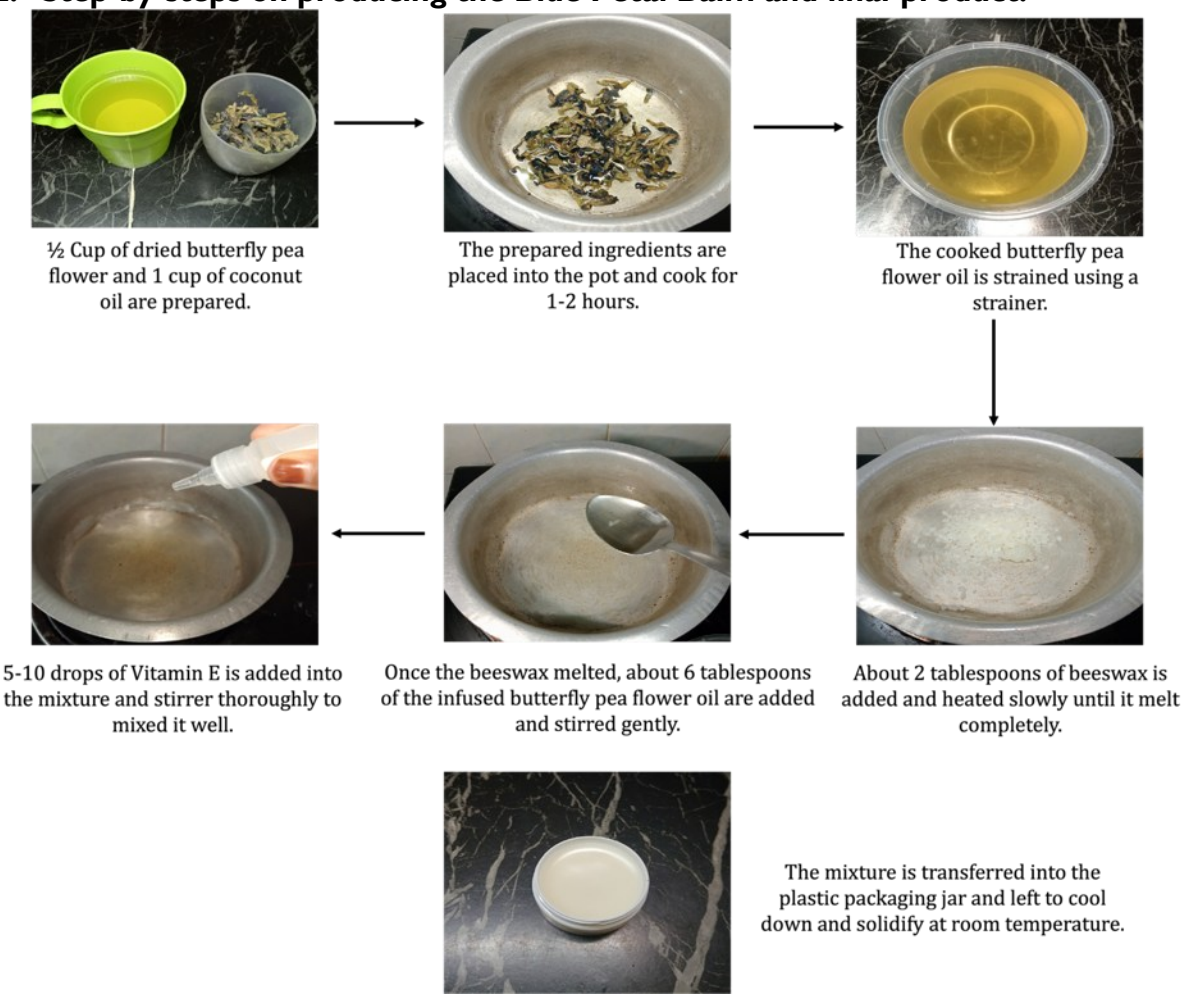

Figure 1. Flowchart for the Blue Petal Balm production.

Figure 2. Final product of Blue Petal Balm, packaged in plastic cosmetic jars.

3. Novelty and uniqueness

The novelty of Blue Petal Balm lies in its utilization of butterfly pea flower extract, rich in anthocyanins contents that provides a calming and cooling effect without the use of hazardous heavy metals or steroids. The balm bridges the gap by offering a dermatologically safe, non-steroidal alternative that avoids the risk of skin thinning or dependency. Its uniqueness is further defined by its "clean label" approach that offers complete ingredient transparency. Moreover, the balm is designated to be safe for all ages, including toddlers and individuals with highly sensitive skin. The balm serves a dual purpose as a symptomatic treatment for redness and itchiness and a long-term nourishing agent that improves skin texture over time.

4. Benefit to mankind

Blue Petal Balm provides notable health benefits by offering a safer, long-term alternative to conventional steroid creams, which are known to cause skin thinning and irritation with prolonged use. The balm also acts as a natural relief of the eczema inflammation and rashes, therefore, directly improves the daily quality life for sufferers. The butterfly pea flower-based balm supports SDG3 (Good Health and Well-being) by ensuring healthy lives and promoting well-being for all ages through its safe ingredients. By utilizing eco-friendly, plant-based ingredients, the product also encourages a sustainable lifestyle, reducing the environmental impact associated with synthetic chemical production.

5. Innovation and Entrepreneurial Impact

Blue Petal Balm bridging the gap between traditional herbal knowledge and modern dermatological needs, transforming the butterfly pea flower into a high-value farm-to-pharmacy product. This model creates vital entrepreneurial opportunities for local farmers by providing a stable, consistent demand for raw materials, turning a herbal plants into a source of regional economic growth. In addition, it helps empower the social enterprise community and strengthen the production of local pharmaceutical products in the market. The project proves that affordable, locally sourced natural balms can successfully compete with conventional pharmaceutical products while maintaining a commitment to environmental responsibility.

6. Potential commercialization

The commercialization potential of the Blue Petal Balm lies on the rising demand towards a plant-based and chemical-free skincare solution. The balm's affordability and focus on high-need demographics such as parents of toddlers and eczema suffering individuals may ensure a steady market entry point. Broadening the product line and a continuous improvement of its formulation based on client feedback may contribute for the future market growth. By positioning itself as a trustworthy, transparent, and eco-friend brand, Blue Petal Balm may be well-equipped to compete with conventional products and secure a reputable position in the sustainable skincare market. The business potential can maintain financial sustainability by diversifying its income through direct-to-consumer digital sales on TikTok and Instagram. Furthermore, partnerships with entities such as drugstores and pharmacies are instrumental in expanding the brand's market presence.

7. Acknowledgement

The authors express their sincere gratitude to Merah Mawar Eco Farm for the opportunity given in conducting the apprenticeship and development of the Blue Petal Balm. Appreciation was also extended to Ms. Grace Flavyeliz Sinong and Madam Nur Aziemah Jasni for their guidance and supervision throughout the project.

8. Researchers' Biography

Nur Batrisya Mohd Sabri is a student at the Universiti Teknologi MARA (UiTM) Sabah Branch, studying in Diploma in Agropreneurship (AT113). She has been actively involved in developing various innovations throughout her studies, including food products and service-related initiatives. Her role as the President of Planterspreneur Club has also provided valuable opportunities to engage in agropreneurship activities.

Flavyeliz Sinong is a lecturer and researcher at the Universiti Teknologi MARA (UiTM) Sabah Branch. With over 4 years of experience, she specializes in crop production, soil science, plant microbiology, agropreneurship and agro-based products. Her commitment and passionate has earned her many innovation awards locally and internationally in agro-based products and educational innovation. She also passionate on community engagement and global networking as well as continues to inspire the young generation with her dedication in research and innovation.

Nur Aziemah Jasni is a lecturer and researcher at the Universiti Teknologi MARA (UiTM) Sabah Branch, specializing in plantation management, agribusiness, and agropreneurship. With over 10 years of experience, she has achieved many innovation awards locally and internationally. In addition to her academic role, she is passionate about community engagement and agro-based innovation. She continues to inspire her students and colleagues with her dedication to research and teaching. Her commitment to academic excellence and her contributions to plantation management, agribusiness, and entrepreneurship have earned her recognition within the academic community, and her work continues to inspire the next generation of scholars.

GreenBoost a Zero-Sugar Moringa Superfood

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ABSTRACT

GreenBoost is a 100% organic, single-ingredient *Moringa* powder designed as a functional, caffeine-free alternative to matcha and sugary instant beverages. Driven by the rising prevalence of metabolic diseases linked to high-sugar diets, this innovation uses locally sourced *Moringa oleifera* leaves, processed through controlled dehydration, grinding, and fine sieving to preserve vital nutrients. GreenBoost offers a highly versatile wellness ingredient rich in antioxidants, vitamins, and plant-based proteins, suitable for lattes, smoothies, and baking. The product's uniqueness lies in its unadulterated, clean-label profile, specifically targeting health-conscious millennials, working professionals, and the wellness retail sector. Utilizing local agricultural partnerships supports sustainable farming and aligns with Sustainable Development Goal 3 (Good Health and Well-Being). According to the World Health Organization, global obesity has nearly tripled since 1975, underscoring the urgent need for zero-sugar, nutrient-dense beverage alternatives like GreenBoost. With a robust B2C and B2B model demonstrating a 100% profit margin, GreenBoost presents a highly scalable commercialization prospect in the rapidly expanding functional beverage market.

Keywords: *Moringa oleifera*, Functional Beverage, Superfood, Caffeine-Free, Sustainable Health

1. Product Description

GreenBoost is a premium, 100% organic *Moringa* leaf powder formulated to deliver an accessible, natural health solution for modern consumers. Unlike conventional powdered drinks laden with refined sugars and artificial additives, GreenBoost contains only one ingredient: finely processed *Moringa* leaves. The production involves sourcing fresh leaves from local eco-farms, meticulously separating them from stems, and drying them in a dehydrator to lock in essential vitamins, minerals, chlorophyll, and plant protein. The dried leaves are ground and sieved to produce a smooth, consistent texture that dissolves easily in liquids, leaving no grainy residue. Packaged in secure, moisture-resistant jars to ensure prolonged shelf life and freshness, the powder serves as a highly versatile nutritional boost. It serves as a soothing, caffeine-free alternative to matcha lattes and integrates seamlessly into smoothies, baked goods, and daily meals. The clean-label packaging transparently displays its nutritional profile and organic origins, appealing to consumers seeking straightforward, trustworthy wellness products.

2. Production process of GreenBoost and packaging for the market

Figure 1 illustrates the flowchart of the GreenBoost production process, which starts with the preparation of fresh *Moringa* leaves and proceeds through dehydration, grinding, sieving, packaging, and labelling. The figure provides a clear overview of the main processing stages involved in producing *Moringa* powder. **Figure 2** presents the final packaged GreenBoost *Moringa* powder product. The product is stored in a sealed container with an appropriate label.

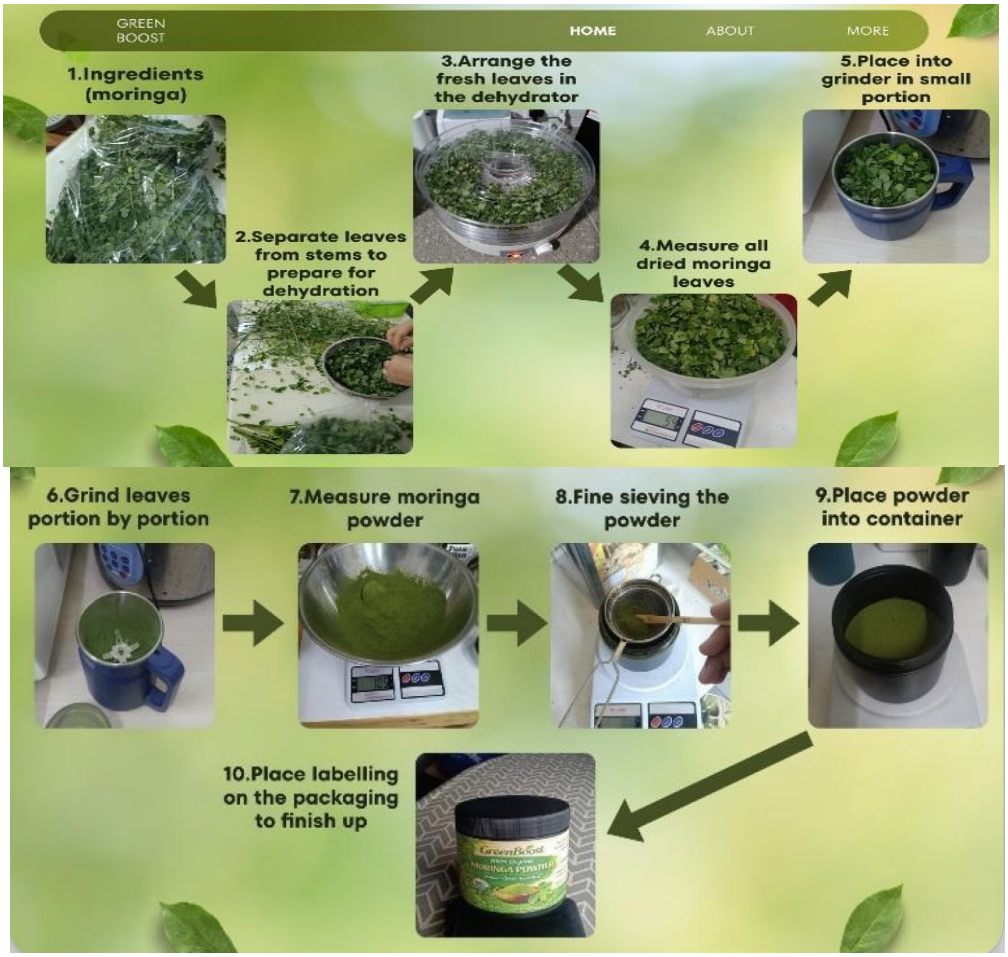

Figure 1. The flowchart of the production process of GreenBoost.

Figure 2. The final product of GreenBoost.

3. Novelty and uniqueness

The primary novelty of GreenBoost lies in its minimalist, single-ingredient formulation within a market saturated with hyper-processed, sugar-laden functional drinks. While many healthy beverage alternatives rely on complex formulations or imported ingredients like matcha, GreenBoost innovates by elevating locally cultivated *Moringa* into a premium, lifestyle-oriented cafe beverage ingredient. It clearly positions itself as a caffeine-free "new matcha," offering the sensory experience, versatility, and visual appeal of popular matcha drinks without the caffeine-induced sleep disruption or jitters. Furthermore, its rigorous fine-sieving production step specifically mitigates the coarse, grainy texture traditionally associated with herbal powders, vastly improving mouthfeel and mixability for commercial beverage applications. By bridging the gap between raw agricultural superfoods and modern, convenient lifestyle products, GreenBoost transforms a humble local crop into a sophisticated, multi-purpose ingredient suitable for direct-to-consumer daily use and high-end café integration.

4. Benefit to mankind

GreenBoost directly contributes to Sustainable Development Goal 3 (Good Health and Well-Being) by offering a nutrient-dense, natural alternative to sugary beverages. High consumption of sugar-sweetened drinks is a known catalyst for obesity and type 2 diabetes. The International Diabetes Federation reports that over 500 million adults live with diabetes globally, highlighting the critical need for dietary intervention. By providing a zero-sugar product packed with immune-strengthening vitamins, antioxidants, and protein, GreenBoost aids in fat metabolism, skin clarity, and overall wellness. Additionally, it supports agricultural sustainability by utilizing local farming resources, thereby reducing the carbon footprint associated with importing foreign wellness ingredients.

5. Innovation and Entrepreneurial Impact

GreenBoost champions a robust agropreneurial ecosystem by integrating local farming communities directly into the modern wellness economy. Through strategic partnerships with local cultivators like Kivatu Nature Farm and Urban Farmer KK, the venture stimulates local agricultural demand and empowers farmers with consistent revenue streams. Entrepreneurially, GreenBoost demonstrates a highly effective, low-barrier business model utilizing accessible processing technologies to achieve a scalable 100% profit margin. This project serves as a practical blueprint for aspiring agropreneurs, showcasing how raw, localized agricultural outputs can be value-added, branded, and commercialized into premium lifestyle products. By merging traditional agriculture with digital e-commerce and B2B cafe partnerships, GreenBoost fosters a dynamic culture of innovation and economic resilience within the agro-business sector.

6. Potential commercialization

GreenBoost possesses exceptional commercial viability, evidenced by its lucrative cost-pricing structure, achieving a 100% profit margin with a production cost of RM25.98 and a retail price of RM51.96 per unit. The commercialization strategy encompasses a hybrid omni-channel approach. Direct-to-consumer digital retail utilizes high-traffic platforms like TikTok Shop and Shopee. Crucially, the B2B wholesale model targets cafes (e.g., Zus Coffee), wellness stores, and fitness centers, embedding the product into established consumer habits. Additional revenue streams from subscription boxes, seasonal packaging, and branded accessories further maximize customer lifetime value. With imminent MESTI and Halal certifications to solidify consumer trust,

GreenBoost is strategically positioned to scale beyond local markets into the broader international functional beverage industry.

7. Acknowledgment

The author expresses heartfelt gratitude to Urban Farmer KK for their invaluable mentorship during the 20-week apprenticeship and project completion.

8. Researchers' Biography

Nabil Rayyan Shahnaz is a student at the Universiti Teknologi Mara (UiTM) Sabah Branch, studying in Diploma in Agropreneurship (AT113).

Ts. Dr. Rozlianah Fitri Said is a Senior Lecturer and dedicated researcher at Universiti Teknologi MARA (UiTM), Sabah Branch. With over 20 years of extensive experience, she specializes in the fields of crop protection, agricultural science and technology, plant-microbe interactions, agropreneurship, and student leadership and development. Her dedication to agricultural innovation has earned her numerous local and international awards. Passionate about community engagement, she connects academia with society and collaborates with industry, government, and academia to solve real-world challenges.

Nur Aziemah Jasni is a lecturer and researcher at the Universiti Teknologi MARA (UiTM) Sabah Branch, specializing in plantation management, agribusiness, and agropreneurship. With over 10 years of experience, she has achieved many innovation awards locally and internationally. In addition to her academic role, she is passionate about community engagement and agro-based innovation. She continues to inspire her students and colleagues with her dedication to research and teaching. Her commitment to academic excellence and her contributions to plantation management, agribusiness, and entrepreneurship have earned her recognition within the academic community, and her work continues to inspire the next generation of scholars.

The Autocart: Improving Shopping Efficiency Through a Smart Trolley Innovation

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ABSTRACT

The AutoCart is a smart trolley innovation proposed for a local supermarket in Dungun to address operational challenges in the retail shopping environment. Increasing customer traffic has created issues related to checkout congestion, service delays, and trolley management, which can affect customer satisfaction and operational performance. As a result, there is a need for a more efficient and customer-oriented shopping solution. The AutoCart system introduces smart retail innovation through a technology to support a smoother shopping process by allowing customers to manage item selection and payment through an integrated trolley system. This approach reduces dependency on conventional checkout counters while supporting better in-store flow and resource utilization. A survey conducted among customers at Dungun shows positive interest in smart shopping features, indicating readiness for technology-based retail solutions. Overall, the AutoCart has the potential to improve operational efficiency, enhance customer experience, and support the supermarket's transition towards a more modern and competitive retail operation.

Keywords: AutoCart, Smart Trolley, Retail Innovation, Operational Efficiency

1. Product Description

The AutoCart is a smart shopping trolley that was created to enhance supermarket operations and customer satisfaction. It has a cashless payment option, a real-time price display, and an item scanning system. Consumers don't need to visit a cashier counter because they can scan products while they shop, see the total cost instantly, and pay straight through the trolley. Supermarkets can control trolley usage and minimize loss or misplacement by using the AutoCart's tracking system. To guarantee safety and lower maintenance costs, the trolley is constructed from sturdy materials. By integrating these functions, AutoCart facilitates shorter lines, saves customers' time, and enhances the general efficiency of in-store operations. The purpose of this product is to facilitate more convenient shopping.

2. Diagrams

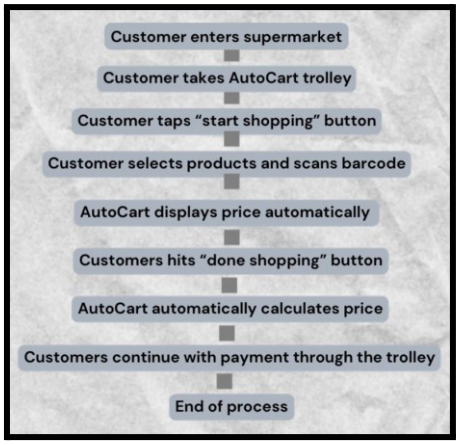

Figure 1 & 2: A display of AutoCart Trolley innovation & a flowchart of AutoCart usage.

Features of the AutoCart

The AutoCart includes built-in item barcode scanning, real-time price display, and a cashless payment system to reduce checkout congestion. A tracking system is also integrated to improve trolley management and prevent misplacement. In addition, the trolley is designed using durable materials to reduce maintenance costs and enhance user safety.

3. Analysis

A survey was conducted to study customers' satisfaction regarding shopping trolley usage particularly at a local supermarket in Dungun. **Figure 3** shows a total amount of 63.6% respondents have expressed the usage of shopping trolleys while shopping would be more convenient, while over 80% of respondents as shown in the **figure 4** agreed an innovation that would let customers pay 3 through a system implemented on a shopping trolley would improve their shopping experience. This indicates that there is a positive relationship between the surveys which supports the preliminary concept of AutoCart.

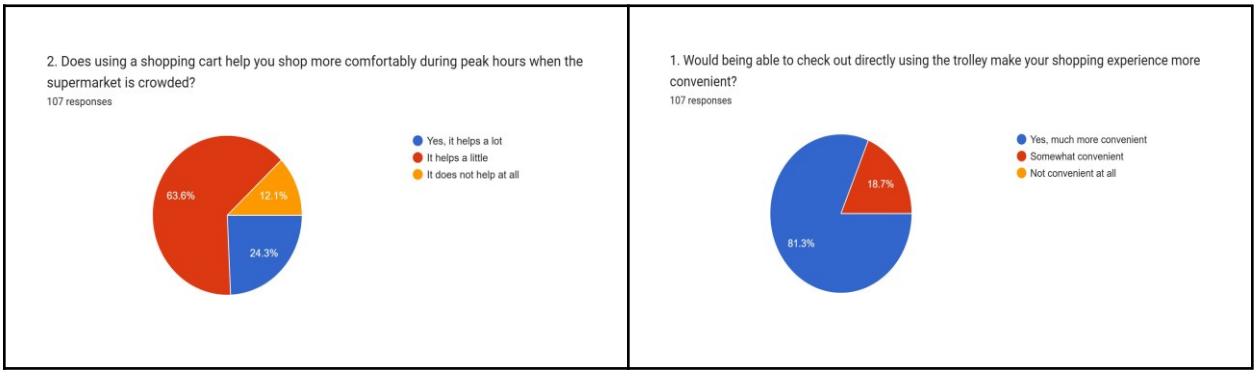

Figure 3 and Figure 4. Survey of customers' preferences on the usage of shopping trolleys & implementation of self-checkout system.

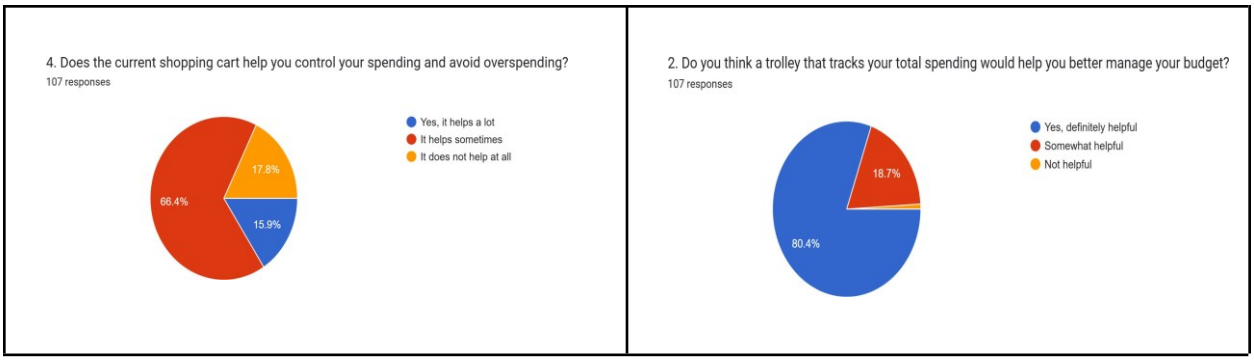

Figure 5 and Figure 6. Survey of customers' challenge against budget management & a survey on customers' opinion on the implementation of budget tracker.

Figure 5 signifies that most respondents partially approved of a certainty that the usage of shopping trolleys can help avoid overspending while shopping, with a total of 71 over 107 respondents expressing agreement. Meanwhile, **Figure 6** shows 86 over 107 respondents suggesting an interest in the application of a feature that could automate product's price scanning and supports budget tracking. As indicated by the positive responses of respondents, the initial concepts of AutoCart seem reasonable to be enhanced and introduced so it seems fitting to meet customers' expectations. By executing an innovation like AutoCart, the supermarket will be able to retain and attract new customers which will contribute to the business' long-term sustainability in the market.

4. Novelty and uniqueness

The AutoCart is unique because it combines several shopping features into a single trolley system. AutoCart, in contrast to conventional shopping trolleys, enables consumers to track their spending, scan products, and make payments in real time while they shop. This lessens the need for independent cashier counters or self-checkout devices. The integrated trolley tracking system, which aids supermarkets in better asset management, is another distinctive feature. A more seamless shopping experience is produced when smart technology and a real trolley are combined. Additionally, AutoCart's design prioritizes customer convenience by lowering wait times and improving budget control. AutoCart differs from traditional shopping solutions found in the majority of supermarkets thanks to its integrated approach.

5. Benefit to mankind

The AutoCart enhances everyday convenience and the overall shopping experience, which benefits humanity. Customers can shop more effectively and save time thanks to the reduction of lengthy checkout counter wait times. Better budget control is supported by the real-time price display, which enables consumers to keep an eye on their spending and make wiser purchases. AutoCart eases the burden of cashier duties for supermarket employees, freeing them up to concentrate on customer service and store management. Additionally, using cashless payment facilitates quicker and safer transactions. All things considered, AutoCart promotes the use of smart technology in daily life and contributes to the development of a more effective, well-organized, and user-friendly retail environment for the general public.

6. Innovation and entrepreneurial impact

By integrating smart technology into routine shopping activities, AutoCart can help decrease checkout traffic and the need for cashier employees during peak hours, it increases efficiency. Supermarkets are able to allocate workers more efficiently as a result. From an entrepreneurial standpoint, AutoCart creates chances for new business models like technology collaborations with retailers, maintenance services, and system licensing. Additionally, by encouraging supermarkets to use digital solutions, the innovation helps them maintain their competitiveness in the quickly evolving retail sector. AutoCart adds value for customers and businesses by enhancing operational performance and customer satisfaction.

7. Potential commercialization

Commercialization of the AutoCart is highly promising, particularly in large supermarkets and hypermarkets with high customer traffic. Retailers can use subscription-based, leasing, or direct purchase models to implement the system. Additionally, the technology can be tailored to the size of the store and its operational requirements. AutoCart can be gradually implemented, beginning with a few stores or during busy times. The system can be extended to additional locations as consumer acceptance increases. Data analytics services, software support, and system upgrades can all bring in extra profit. AutoCart has a strong market potential in the retail sector due to the growing demand for quicker and more convenient shopping experiences.

8. Acknowledgement

We would like to express our sincere appreciation to Madam Nur Dalila Adenan for her continuous guidance and support. Her advice and feedback were valuable in helping us improve our understanding of operations management concepts. We would also like to thank the local supermarket located in Dungun, and all survey respondents who took the time to share their opinions and experiences. Their cooperation provided useful insights that supported this study. Lastly, we appreciate the teamwork and cooperation among group members, which contributed to the successful completion of this project.

9. Researchers' Biography

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Muhammad Harris Nashriq bin Mohd Asri is a 2nd semester student at UiTM Terengganu Branch, Dungun Campus. Pursuing Bachelor of Operations Management (BA274) under the faculty of Business Management. Eager to learn, he continuously seeks opportunities to develop his knowledge and enhance his abilities. His commitment to learning and personal growth makes him a promising student in his field.

Madam Nur Dalila binti Adenan is a lecturer at UiTM Terengganu Branch, Dungun Campus. Known for her dedication to teaching, the lecturer creates a supportive learning environment and encourages active student participation. She is committed to helping students understand concepts clearly and apply them effectively.

Dragon Train

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ABSTRACT

This project presents Dragon Train, a 3D-printed dragon-shaped train model developed as an interactive physical learning tool that integrates creativity, technology, and hands-on engagement. The innovation was conceived in response to the increasing dependence of children on digital games, which has reduced their involvement in physical-based learning activities, as well as the limited opportunities for students in the 3D design field to apply digital design skills to real-world product fabrication. These challenges highlight the need for learning approaches that balance digital exposure with practical application. The Dragon Train was designed using 3D modeling software and fabricated through additive manufacturing techniques, allowing students to experience the full design-to-production workflow, including conceptualization, modeling, printing, assembly, and finishing. A key advantage of this innovation lies in the creative integration of an imaginative dragon form with functional train mechanics, resulting in a product that is both visually engaging and educational. Its modular structure supports hands-on learning, encourages problem-solving, and enhances creativity, logical thinking, and technical skills through physical interaction. From a socio-educational perspective, Dragon Train promotes active and balanced learning by combining digital technology with tactile experiences. In terms of commercialization, the product demonstrates strong potential as an educational kit and learning toy for schools, training institutions, and parents. The use of 3D printing enables cost-efficient, on-demand production and design customization, supporting scalability and adaptability to diverse market needs.

Keywords: 3D Printing, Educational Toy, Interactive Learning, Product Design, Dragon Train

1. Product Description

Dragon Train is a 3D-printed dragon-shaped train model developed as an interactive educational product that combines creativity, technology, and physical engagement. The product is designed to function as both a learning tool for children and a practical project platform for students in the 3D design and technology field. The product is created through a structured workflow involving concept development, 3D modeling, texturing, and additive manufacturing. Each component of the Dragon Train is designed modularly and printed separately using 3D printing technology before being assembled into a complete model. The external dragon form is integrated with essential train components such as the body and wheels, ensuring functionality while maintaining an imaginative appearance. Dragon Train

encourages hands-on interaction, allowing users to observe, touch, and explore a physical object rather than relying solely on digital interfaces. The modular design also supports customization in terms of size, color, and structural variation, making the product adaptable for different educational levels and user needs. Overall, Dragon Train serves as a practical example of how digital design can be transformed into a tangible product through modern manufacturing technology.

2. Flow Chart

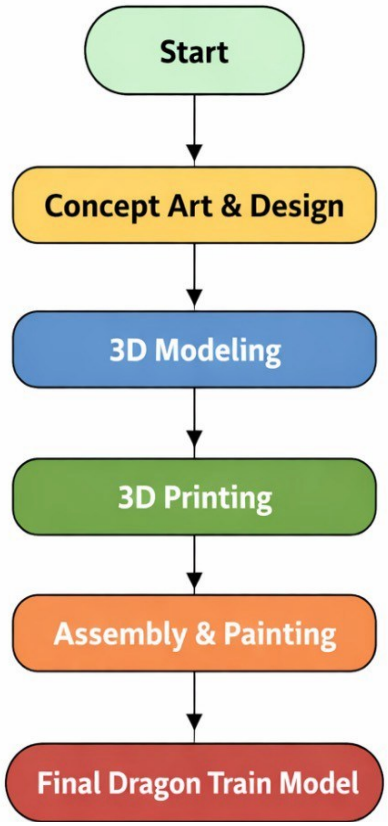


Figure 1. Flowchart of development process.

Figure 1 shows the flowchart illustrates the overall development process of the Dragon Train project from the initial stage to the final product. The process begins with the concept art and design phase, where initial ideas and visual concepts of the dragon-shaped train are developed. This stage focuses on defining the appearance, structure, and creative direction of the product. Next, the design proceeds to the 3D modeling stage, where the concept is transformed into a detailed digital model using 3D design software. This digital model serves as the blueprint for the physical product. The process then continues to the 3D printing stage, where the digital model is fabricated into physical components using additive manufacturing technology. After printing, the components undergo the assembly and painting stage, where

the parts are assembled into a complete model and finished with coloring to enhance visual appeal. The process concludes with the final Dragon Train model, which represents the completed product ready for use as an interactive educational tool.

3. Novelty and uniqueness

The Dragon Train represents a novel and innovative approach to educational tools by seamlessly integrating creativity, technology, and hands-on learning. Its uniqueness lies in the combination of an imaginative dragon design with fully functional train mechanics, producing a product that is visually captivating while promoting interactive, experiential learning. Unlike conventional educational toys, Dragon Train allows students to experience the complete 3D design-to-production workflow**,** including conceptualization, digital modeling, additive manufacturing, assembly, and finishing. This approach not only reinforces technical skills in 3D design and fabrication but also provides tangible, real-world applications of digital competencies, addressing the common gap between classroom learning and practical implementation. The modular and customizable structure of Dragon Train further enhances its educational value, encouraging critical thinking, problem-solving, and creative exploration. By physically manipulating components and experimenting with assembly, students actively engage in a multi-sensory learning **process** that balances digital exposure with tactile interaction a critical need in today's technology-driven environment. From a technological standpoint, the use of 3D printing allows on-demand production, design flexibility, and cost-efficiency, supporting iterative learning and enabling personalization for varying skill levels or educational objectives. Moreover, Dragon Train demonstrates strong commercial and societal potential. It can be adapted as an educational kit for schools, a learning toy for parents, or a hands-on training tool in institutions, bridging education, creativity, and entertainment. Its scalable design, combined with the ability to customize forms and functionality, positions it as a forward-thinking innovation that not only cultivates technical and cognitive skills but also nurtures imagination, logical reasoning, and collaborative learning. By integrating creative design, practical fabrication, and interactive education, Dragon Train exemplifies a holistic and unique approach to learning in the 21st century.

4. Benefit to mankind

The Dragon Train contributes to mankind by promoting balanced, hands-on learning that integrates creativity, technology, and practical skills. It addresses the growing concern of children becoming overly dependent on digital devices by providing an engaging physical learning experience that enhances cognitive development, critical thinking, and problem-solving abilities. By allowing students to experience the full design-to-production process, the project equips learners with real-world 3D design and fabrication skills, fostering innovation and technical competence from an early age. Beyond educational benefits, Dragon Train encourages imagination, creativity, and logical reasoning, nurturing well-rounded individuals capable of thinking critically and approaching challenges innovatively. Its modular, customizable design promotes collaborative learning and interactive play, strengthening social and communication skills while supporting STEM (Science, Technology, Engineering, Mathematics) education. Furthermore, the project demonstrates scalable and sustainable technology, offering a cost-efficient educational tool that can be widely adopted in schools, training institutions, and homes, ultimately contributing to a more skilled, creative, and tech-literate future generation.

5. Innovation and Entrepreneurial Impact

The Dragon Train represents a unique fusion of creativity, technology, and hands-on learning, making it a truly innovative educational tool. Its novelty lies in combining an imaginative dragon design with fully functional train mechanics, providing a product that is both visually captivating and educationally impactful. Unlike conventional learning toys, Dragon Train allows students to experience the entire 3D design-to-production workflow, including conceptualization, digital modeling, 3D printing, assembly, and finishing, thereby bridging the gap between digital skills and practical fabrication. Its modular and customizable structure encourages experimentation, problem-solving, and iterative learning, fostering creativity, logical reasoning, and technical skill development in a highly interactive format. From an entrepreneurial perspective, Dragon Train demonstrates strong commercial viability and scalability. The use of 3D printing technology enables cost-efficient, on-demand production and product personalization, making it adaptable for schools, training institutions, and home-based learning. Its versatility allows for expansion into educational kits, STEM learning tools, or creative playsets, targeting multiple market segments simultaneously. By integrating innovation with a sustainable and flexible business model, Dragon Train not only advances educational practices but also inspires opportunities for entrepreneurship in STEM-based learning products, promoting both economic growth and educational advancement.

6. Potential commercialization

The Dragon Train has strong potential as a commercial educational product due to its combination of creativity, interactivity, and STEM learning. Its modular, customizable design allows for easy scaling and adaptation to different age groups, skill levels, and educational objectives. The use of 3D printing enables cost-efficient, on-demand production, reducing inventory costs and allowing personalized designs for schools, training institutions, or individual buyers. Dragon Train can be marketed as an educational kit, STEM learning toy, or creative hands-on activity, appealing to parents, educators, and institutions seeking innovative learning tools. Its versatility and visual appeal enhance marketability, while its emphasis on problem-solving, creativity, and technical skills positions it as a premium educational product. With targeted marketing and partnerships with educational organizations, Dragon Train can establish a sustainable niche in the growing education entertainment and STEM toy market.

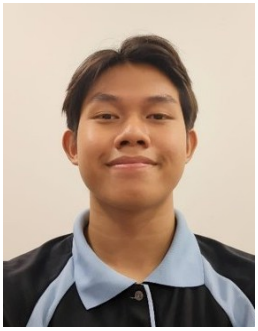
7. Acknowledgment

I would like to express my heartfelt gratitude to all those who have supported me throughout the development of the Dragon Train project. My deepest thanks go to Nur Wahida Binti Noordin for their expert guidance, valuable feedback, and constant encouragement during every stage of the project. I am also grateful to Aisy Danish for sharing their technical knowledge and assisting with the 3D modeling, printing, and assembly processes, which were essential to bringing this innovation to life. Finally, I sincerely thank Wan Rahadatul Aisya for their creative ideas, hands-on assistance, and collaborative efforts that greatly contributed to the success of this project. Their combined support and expertise have been invaluable in transforming Dragon Train from a concept into a tangible, innovative, and educational tool.

8. Researchers' Biography

Muhammad Zikry Fitri Bin Ahmad Ridhwan is a Kolej Vokasional Gombak's student specializing in Multimedia 3D Animation. He contributed to the Dragon Train project by developing abstract design elements and handling the 3D printing process, ensuring that the digital models were accurately transformed into physical prototypes. In addition, he took on the role of presenter, effectively communicating the project's concept, design process, and educational value.

Wan Rahadatul Aisya binti Wan Assad Qutubuldin is also Kolej Animation, with a strong passion for creativity and visual design. She was responsible for developing the concept art of the Dragon Train and bringing it to life through painting and finishing the final 3D-printed model. By combining artistic vision with practical skills, Wan Rahadatul Aisya ensured that the Dragon Train was not only functional but also visually engaging and appealing.



Muhammad Aisy Danish Bin Rozaidi is a Kolej Vokasional Gombak's student specializing in Multimedia 3D Animation, with a strong interest in digital design, modeling, and creative visualization. As the originator of the Dragon Train concept, he played a key role in transforming the idea into a tangible educational tool. He was responsible for conceptualizing, modeling, and texturing the dragon-shaped train, applying their 3D animation and design skills to create a visually engaging and functional product. Through this project, Aisy Danish demonstrated technical expertise, creativity, and the ability to integrate digital skills with practical fabrication, contributing significantly to the innovation, educational value, and overall success of the Dragon Train project.

Nur Wahida Binti Noordin is a lecturer at Kolej Vokasional Gombak, specializing in Multimedia 3D. She played a pivotal role in the Dragon Train project by introducing the train concept and providing essential resources, including the basic train model, battery, and 3D printing support. She also guided and mentored the team throughout the project, facilitating their participation in the competition and offering expert advice on design and fabrication. Her sponsorship, encouragement, and professional expertise enabled the students to transform their creative ideas into a tangible, innovative, and educational tool.

Inovasi Produk Lestari: Bekas Makanan Haiwan Interaktif Sebagai Cenderamata di Zoo Kemaman "Intellideer Box"

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ABSTRACT

Zoo Kemaman is one of the main tourism destinations on the East Coast of Malaysia, serving as a centre for recreation, education and wildlife conservation. However, its visitor attendance remains lower compared to other zoos due to limited interactive innovation and the use of non-environmentally friendly materials. To address this issue, the IntelliDeer Box was developed as an eco-friendly animal feeding container integrated with Quick Response (QR) Code, Near Field Communication (NFC) and Augmented Reality (AR) technologies. This innovation aims to replace single-use plastic containers while enhancing visitor engagement through interactive and educational features. The study employed the ADDIE model, which consists of analysis, design, development, implementation and evaluation phases. A total of 35 respondents comprising Zoo Kemaman visitors and staff participated in the survey. The instrument reliability recorded a Cronbach's Alpha value of 0.8, indicating acceptable reliability. Findings revealed high mean scores for the need for innovative design and the use of biodegradable materials in animal feeding containers. The use of eco-friendly materials in the IntelliDeer Box recorded the highest mean score. Overall, the IntelliDeer Box enhances interactive tourism experiences, promotes environmental sustainability and contributes positively to socio-environmental awareness. This innovation has strong potential for commercialization as an educational product and souvenir in zoos across Malaysia.

Keywords: *IntelliDeer Box, Eco-friendly innovation; Interactive tourism, Augmented Reality, Environmental sustainability*

Product Description

Product Overview

The IntelliDeer Box is an eco-friendly animal feeding container designed for use at Zoo Kemaman to enhance visitor interaction while supporting environmental sustainability. This product aims to replace single-use plastic feeding containers that contribute to environmental pollution within zoo environments.

Key Features

The IntelliDeer Box is integrated with interactive technologies including Quick Response (QR) Code, Near Field Communication (NFC) and Augmented Reality (AR).

These features allow visitors to access digital content such as animal information, fun facts, videos and interactive learning experiences using smart devices.

Materials and Design

The product is made from biodegradable and environmentally friendly materials to ensure safety for animals and reduce ecological impact. Its ergonomic and attractive design is suitable for users of all ages, making it user-friendly and engaging.

Functions and Advantages

Beyond serving as an animal feeding container, the IntelliDeer Box functions as an educational and interactive tourism tool. It enhances visitor experience, promotes environmental awareness and supports sustainable tourism practices, with strong potential for adoption in other zoos and conservation centres across Malaysia.

1. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc.

Figure 1. Prototype Visual / Diagram / Mockup.

Table 1. Cost and Pricing Determination.

Bahan	Kuantiti	Harga (RM)
Kertas biodiversiti	1 (helai)	2.50
Percetakan reka bentuk	1 (bekas)	10.00
Kos NFC	1 (tag)	1.65
Uncang	1 (unit)	00.47
Bidak	1 (unit)	8.00
Jumlah		22.62
Anggaran kos jualan		38.45

2. Novelty and uniqueness

The novelty of the IntelliDeer Box lies in its integrated approach that combines environmental sustainability, interactive technology, and experiential learning within a zoo setting. Unlike conventional animal feeding containers that rely heavily on single-use plastic and provide minimal educational value, IntelliDeer Box is developed using biodegradable ivory card material, which helps reduce plastic waste while supporting green tourism initiatives. This environmentally responsible design aligns with current efforts to promote sustainable practices in the tourism and conservation sectors. What makes this innovation unique is the incorporation of multiple interactive technologies—Quick Response (QR) Code, Near Field Communication (NFC), and Augmented Reality (AR)—within a simple animal feeding container. These technologies transform a basic feeding activity into an immersive and meaningful learning experience by enabling visitors to access educational videos, interactive quizzes, digital information, and three-dimensional virtual animal visuals through smart devices. In addition, IntelliDeer Box functions not only as a feeding container but also as an educational medium, promotional tool, and souvenir for visitors. This multifunctional design enhances visitor engagement, strengthens environmental awareness, and improves the overall zoo experience. The integration of smart technology with sustainable materials positions IntelliDeer Box as a distinctive innovation that effectively addresses environmental challenges while revitalizing visitor interest in zoological institutions.

3. Benefit to mankind

IntelliDeer Box provides significant benefits to mankind by promoting environmental awareness, education, and sustainable tourism practices. By replacing single-use plastic feeding containers with biodegradable materials, this innovation helps reduce environmental pollution while protecting animal habitats and supporting eco-friendly zoo management.
From an educational perspective, the interactive technologies embedded in IntelliDeer Box encourage experiential learning by allowing visitors—especially students, families, and young learners—to access digital content related to wildlife conservation, biodiversity, and environmental responsibility in an engaging and meaningful way.
Furthermore, the innovation enhances the overall visitor experience at zoological institutions by transforming traditional animal feeding activities into interactive and memorable.

4. Innovation and Entrepreneurial Impact

The IntelliDeer Box promotes innovation by demonstrating how traditional zoo facilities can be enhanced through the integration of sustainable materials and digital technology. The project encourages creative problem-solving by addressing environmental pollution and declining visitor engagement simultaneously through a single product innovation.
From an entrepreneurial perspective, IntelliDeer Box introduces a value-added product that creates new revenue opportunities for zoological institutions through its use as an animal feeding container and souvenir. It fosters an entrepreneurial mindset by highlighting opportunities in eco-innovation, digital tourism, and educational product development.
In addition, the project inspires institutions, students, and local communities to explore sustainable product design and technology-driven solutions within the tourism industry. By combining innovation with strong market potential, IntelliDeer Box supports socially responsible entrepreneurship and encourages the adoption of sustainable business practices.

5. Potential commercialization

IntelliDeer Box has strong commercialization potential due to its low production cost, use of readily available materials, and high market demand for eco-friendly and interactive tourism products. The product can be commercialized as an official animal feeding container and souvenir in Zoo Kemaman and expanded to other zoos, wildlife parks, recreational parks, and conservation centers across Malaysia. The integration of QR, NFC, and AR technology enhances its market value by offering digital content, promotional opportunities, and educational engagement. Support from tourism-related agencies such as MOTAC and local authorities further strengthens its commercialization prospects. With scalable production and customizable designs for different institutions and animal species, IntelliDeer Box has the potential to become a standardized sustainable product within the zoological and eco-tourism industry.

6. Acknowledgment

The authors would like to express their sincere appreciation to Zoo Kemaman for their cooperation and support throughout the implementation of this project. Special thanks are also extended to the respondents who participated in the study and provided valuable feedback. Gratitude is acknowledged to the lecturers and academic advisors for their guidance and constructive input, as well as to all parties who contributed directly or indirectly to the successful completion of the IntelliDeer Box innovation project.

7. Researchers' Biography

Madam Noor Jalilah Abdul Jalil is a Tourism and Hospitality lecturer at Politeknik Muadzam Shah, Pahang. She holds a Bachelor of Science (Hons) in Tourism Management from Universiti Teknologi MARA (UiTM) Puncak Alam, graduating with First Class Honours. With a strong foundation in both academic and industry experience, she is passionate about nurturing future professionals in the tourism and hospitality sector. Her expertise includes tourism management, hospitality operations, and experiential learning. She has been actively involved in teaching, supervising student projects, and supporting innovative initiatives related to tourism and hospitality education.

Shalomia A/P Annathuri is a diploma student in Tourism and Hospitality at Politeknik Muadzam Shah. She is currently involved in a research project under the supervision of Madam Noor Jalilah Abdul Jalil. Her academic interests include community-based tourism and visitor engagement, with an emphasis on developing projects that contribute positively to society. Through this project, she aims to enhance her research skills and gain practical experience in improving public awareness, visitor experience, or knowledge through creative projects.

AgriNano-MercuSense™: Agro-Derived Nano Rapid Mercury Screening Kit

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ABSTRACT
AgriNano-MercuSense™ is a rapid lateral flow screening kit developed to detect the potential presence of mercury (Hg^{2+}) in cosmetic products using agro-waste-derived silver nanoparticles (AgNPs). Mercury adulteration in whitening creams and unregulated cosmetic formulations remain a significant public health concern. Conventional confirmation techniques such as ICP-MS and AAS require expensive instrumentation and are inaccessible to most consumers and small-scale cosmetic entrepreneurs. This innovation utilizes green- synthesized AgNPs derived from pineapple (*Ananas comosus*), mangosteen (*Garcinia mangostana*), and mango (*Mangifera indica*) waste as a sustainable colorimetric sensing probe. Upon interaction with Hg^{2+} ions, nanoparticle aggregation and surface plasmon resonance alteration produces a visible optical signal at the detection zone. The kit provides preliminary screening results within 5–10 minutes without laboratory instrumentation. By integrating circular bioeconomy principles with nanotechnology-based sensing, AgriNano- MercuSense™ transforms agricultural waste into a functional public health screening solution. The innovation demonstrates a strong socio-economic impact through community awareness, SME product validation support, and scalable commercialization potential in cosmetic safety monitoring markets

Keywords: Agro-waste, Silver Nanoparticle, Mercury Detection, Cosmetic Safety, Green Nanotechnology

1. Product Description
AgriNano-MercuSense™ is a portable lateral flow cassette designed for rapid preliminary screening of mercury contamination in cosmetic formulations. The device features an integrated, burstable buffer blister or built-in buffer solutions. The sensing membrane contains immobilized plant-based silver nanoparticles synthesized through green reduction methods using pineapple peel, mangosteen rind, and mango peel extracts. These agro-waste materials serve as natural reducing and stabilizing agents during nanoparticle synthesis, promoting sustainable production. For testing, a small cosmetic sample is dabbed into the sample well. The user then presses the integrated buffer blister to release a pre-measured sterile buffer solution, initiating the lateral flow process without the need for manual dilutions. In the presence of Hg^{2+} ions, strong affinity interactions between mercury and the AgNP surface induce nanoparticle aggregation and localized surface plasmon resonance shifts This physicochemical interaction results in a visible color change at the test line, while the control line confirms procedural validity. Results are

interpreted visually within 5–10 minutes. The kit functions as a preliminary screening tool intended to indicate potential mercury presence. Positive results require confirmation by certified laboratory analysis. The product is designed for consumers, NGOs, and small cosmetic manufacturers seeking accessible early detection solutions.

2. Pictures and Schematic diagrams

In **Figure 1**, the structural layout of AgriNano-MercuSense™ lateral flow cassette is shown with highlights on the main components of the operation, including the integrated buffer blister (one-step activation), sample well (S), test line (T), and control line (C) on which to interpret the results visually. The schematic in **Figure 2** demonstrates the detection mechanism behind it, which starts with green synthesis of silver nanoparticles (AgNPs) with pineapple, mangosteen, and mango waste extracts used as a natural reducing agent. After synthesis, these AgNPs are put onto a cellulose membrane to create a stable sensing platform. As it is illustrated, the further addition of mercury (Hg2+) ions leads to a potent interaction between physicochemical elements, as the initially stable AgNPs are shifted to local aggregation, resulting in a detectable optical color change at the detection point.

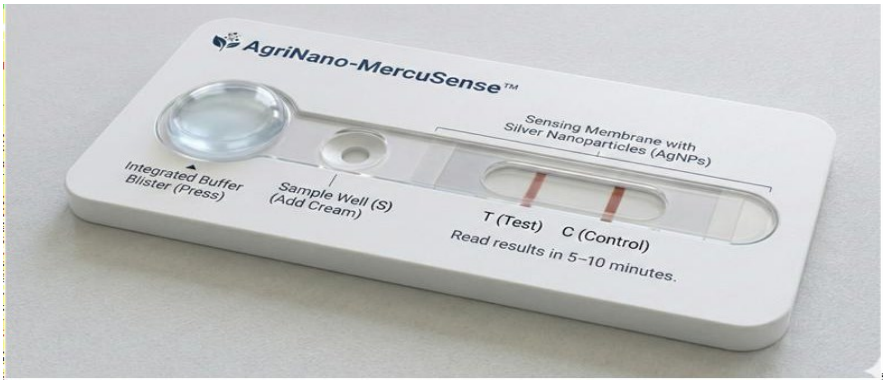

Figure 1. Structural configuration of AgriNano-MercuSense™ lateral flow cassette.

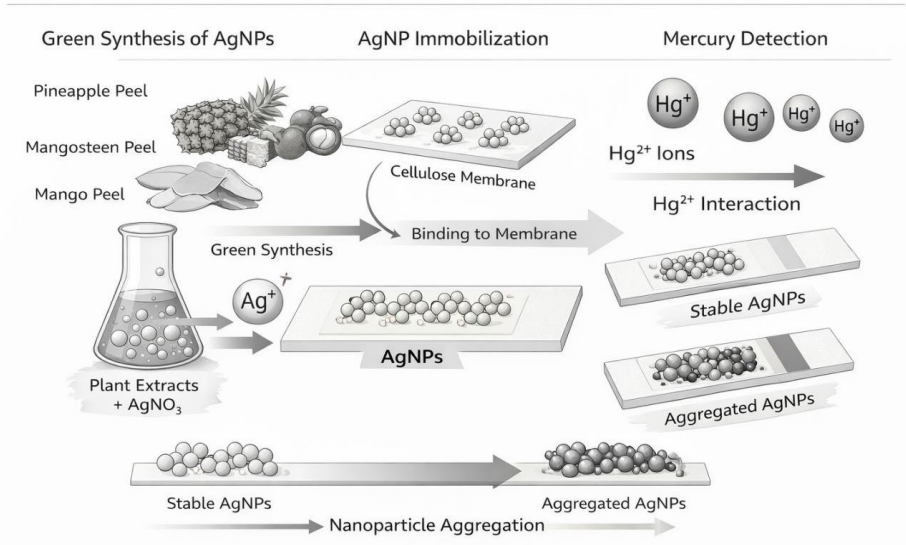

Figure 2. Schematic illustration of agro-waste silver nanoparticle synthesis and Hg^{2+}. interaction mechanism.

3. Novelty and uniqueness

AgriNano-MercuSense™ introduces a sustainable, nanotechnology-based heavy metal screening platform integrating agro-waste valorization with consumer safety. Unlike conventional mercury detection techniques requiring advanced laboratory instrumentation, this innovation employs plant-derived silver nanoparticles as an active colorimetric probe within a lateral flow format. The novelty lies in the dual integration of circular bioeconomy principles and nanomaterial-based sensing technology. Pineapple, mangosteen, and mango waste extracts are utilized as eco-friendly reducing and stabilizing agents, reducing chemical dependency and production costs. Furthermore, the project expands the functional application of plant-based AgNPs beyond antimicrobial research into heavy metal sensing for cosmetic safety. The portable lateral flow configuration enhances accessibility and usability for non-expert users while maintaining scientific validity through nanoparticle–metal interaction mechanisms. Importantly, this usability is boosted by the addition of an integrated, burstable buffer blister, which removes the extra steps of dealing with a buffer and making test dilutions manually, enabling a smooth one-step testing process. This combination of green synthesis, user-centric mechanical design, and nanomaterial sensing differentiates AgriNano-MercuSense™ from existing laboratory-based mercury detection solutions.

4. Benefit to mankind

Mercury exposure from cosmetic products can lead to severe neurological, renal, and dermatological health complications. AgriNano-MercuSense™ empowers communities by providing accessible preliminary screening capability prior to prolonged product use. The innovation supports consumer awareness, reduces potential toxic exposure risks, and promotes informed purchasing decisions. Small-scale cosmetic manufacturers benefit from early-stage raw material validation before regulatory testing. By converting agricultural waste into a functional nanotechnology-based safety device, the project contributes to environmental sustainability while addressing public health protection. The innovation bridges the gap between advanced laboratory detection and community- level preventive action.

5. Innovation and Entrepreneurial Impact

AgriNano-MercuSense™ promotes translational innovation by converting academic research in green nanotechnology into a market-ready safety solution. The project supports entrepreneurial culture by creating scalable opportunities for sustainable diagnostic kit production utilizing locally available agro-waste resources. It encourages interdisciplinary collaboration across nanotechnology, chemistry, product design, and commercialization sectors. The innovation aligns with circular economic strategies while opening pathways for spin-off ventures and licensing opportunities within cosmetic safety and consumer protection markets. By combining sustainability with public health applications, the project fosters applied research commercialization within institutional and community ecosystems.

6. Potential commercialization

The product has strong commercialization potential in regions with high prevalence of unregulated cosmetic products. Target markets include consumers, pharmacies, NGOs, cosmetic retailers, and small-scale manufacturers. Production costs are minimized through agro-waste-based nanoparticle synthesis. AgriNano-MercuSense™ can be positioned as an affordable

preliminary screening kit for mercury detection in cosmetic formulations. Future expansion may include multi-heavy metal detection capabilities. Intellectual property protection may be pursued for nanoparticle immobilization techniques and sensing configuration. Strategic collaboration with cosmetic safety agencies and distribution networks can enhance market penetration and international scalability.

7. Acknowledgment

The authors would like to thank the Faculty of Applied Sciences at Universiti Teknologi MARA (UiTM) Perlis Branch for their cooperation in completing this non-grant-funded study.

9. Researchers' Biography

Iman An Nuha Mohd Shamsuddin is a final-year undergraduate student pursuing a Bachelor of Science (Honours) in Biology at Universiti Teknologi MARA (UiTM) Perlis. Her academic background has provided her with comprehensive exposure to microbiology and plant biotechnology, with specialized interest in sustainable biotechnology and green nanotechnology. She has developed practical laboratory skills and a keen interest in exploring antibacterial activity, reflecting her dedication to finding innovative, eco-friendly solutions to modern biological challenges.

Nur Shaikha Asmawi is a final-year undergraduate student undertaking a Bachelor of Science (Honours) in Biology at Universiti Teknologi MARA (UiTM) Perlis under the Faculty of Applied Sciences. In her educational path, she has acquired a good background in microbiology, molecular biology, environmental biology, and biotechnology. Her academic studies and laboratory experience have provided her with practical experience in microbiology, synthesis of nanoparticles, biochar fabrication and physicochemical characterization including UV-Visible spectroscopy and Fourier Transform Infrared (FTIR) analysis. She is interested in sustainable biotechnology, green nanotechnology, and agro waste valorization, especially in the production of environmentally friendly antimicrobial materials.

Zainab Razali is a Senior Lecturer at Universiti Teknologi MARA (UiTM) Perlis, with over 13 years of teaching experience in biotechnology and plant sciences. Her research focuses on plant biotechnology, green nanotechnology, agro-waste valorization, and biohydrogen production. She has published peer-reviewed journals and conference proceedings

related to sustainable nanomaterials and renewable energy. She actively supervises innovation-based student projects and has served as a judge for innovation competitions at school, national, and international levels.

Roejhan Md Kawi is a researcher from the Faculty of Electrical Engineering & Technology, Universiti Malaysia Perlis (UniMAP), Pauh Putra Campus, Arau, Perlis, Malaysia. His expertise focuses on electrical engineering systems, sensor technology, and applied technological innovation. His research interests include embedded systems, smart sensing platforms, and technology integration for sustainable and community-oriented applications. He actively collaborates in interdisciplinary projects that bridge engineering solutions with real-world challenges, particularly in system development and functional device optimization

Posture and Sitting Behavior Monitor

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ABSTRACT
The rising prevalence of musculoskeletal disorders (MSDs) among office workers and students is largely attributed to prolonged sedentary behavior and poor spinal posture. While commercial posture correctors exist, they often lack real-time data tracking or are prohibitively expensive for the public. This project presents the design and development of a low-cost, IoT-based Posture Monitoring System intended to detect and correct spinal slouching in real-time. The system is built around the ESP32 microcontroller and the MPU6050 accelerometer/gyroscope sensor, which continuously measures the user's spinal inclination. A critical threshold is set at 75°; if the user's angle drops below this limit, the device triggers an immediate audiovisual alert via a buzzer and LED to prompt behavioral correction. Furthermore, the system integrates Internet of Things (IoT) capabilities, utilizing the Blynk mobile platform for live telemetry and Google Sheets for long-term historical data logging. Functional testing demonstrated that the device achieves a high angular accuracy with a deviation of only ±0.2° and a notification latency of less than 0.5 seconds. Experimental trials confirmed that the active feedback loop effectively reduced the duration of slouching events. The proposed system offers an affordable, data-driven solution for ergonomic health management, bridging the gap between passive wearable technology and active health intervention.

Keywords: Internet of Things (IoT), Posture Monitoring, ESP32, MPU6050, Musculoskeletal Disorders

1. Product Description
The Smart IoT Posture Monitor is an innovative wearable system engineered to combat the prevalence of musculoskeletal disorders caused by prolonged sedentary behaviour and poor spinal ergonomics. Built upon the powerful ESP32 microcontroller platform, this device seamlessly integrates a high-precision MPU6050 accelerometer and gyroscope to continuously monitor spinal inclination in real-time. Designed for unobtrusive wearability, the compact unit attaches comfortably to the user's upper back, utilizing a pre-calibrated threshold of 75° to distinguish between healthy posture and harmful slouching. Upon detecting a deviation beyond this safety limit, the system activates an immediate audiovisual feedback loop—comprising an active buzzer and a traffic-light LED indicator—to prompt instant behavioural correction. Beyond local alerts, the device leverages advanced IoT connectivity to transmit live telemetry to the Blynk mobile application and log long-term performance data to Google Sheets, providing users with a comprehensive digital health record. By combining active intervention with historical data analysis, the Smart IoT Posture Monitor serves as both a corrective tool and a preventative health

solution, offering an affordable, accessible, and data-driven approach to personal ergonomic management.

2. Methodology

The system architecture is illustrated in **Figure 1**. The core processing unit is the ESP32 microcontroller, which collects real-time inclination data from the MPU6050 accelerometer and time data from the DS3231 RTC. When the spinal tilt exceeds the threshold (75°), the ESP32 activates the local alarms (Buzzer and LED) and transmits the data via the Wi-Fi module to the Blynk IoT app and Google Sheets for remote monitoring.

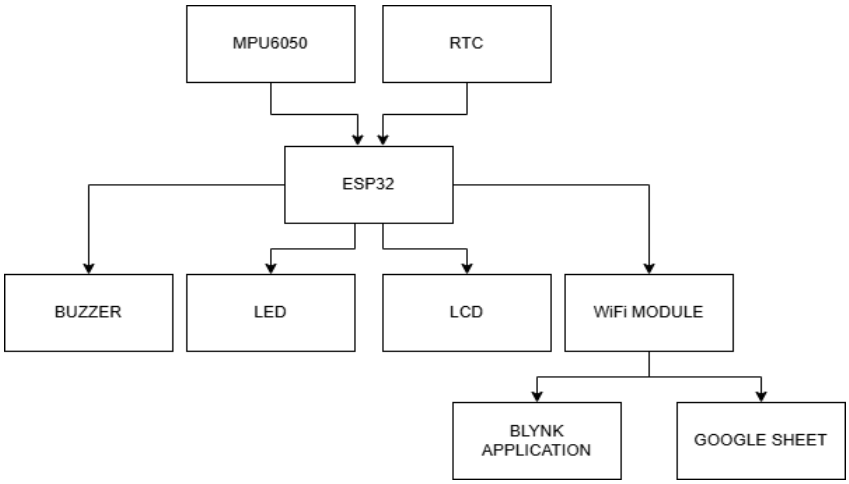

Figure 1. Block Diagram of Posture and Sitting Behavior Monitor.

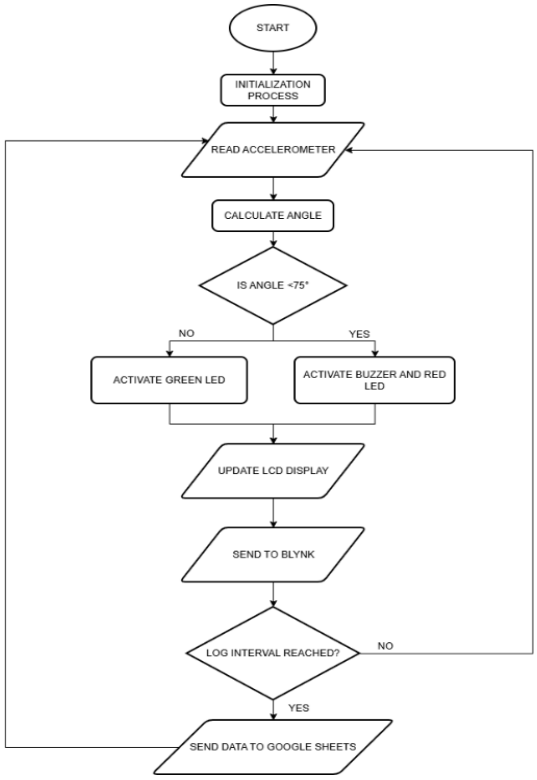

Figure 2. Flowchart of Posture and Sitting Behavior Monitor.

The control flow of the system is illustrated in **Figure 2**. After initialization, the program enters a continuous loop where it reads the accelerometer data and calculates the tilt angle. A decision logic checks if the angle is below 75°; if true, it activates the buzzer and Red LED. Simultaneously, data is sent to the Blynk app for real-time viewing, while a timer ensures data is logged to Google Sheets only at specific intervals to optimize bandwidth.

3. Novelty and uniqueness

The Smart IoT Posture Monitor distinguishes itself from conventional "passive" posture correctors by integrating real-time haptic feedback with advanced cloud-based analytics, a feature combination rarely found in affordable consumer health devices. Unlike standard market alternatives that merely vibrate without recording data, or high-end medical devices that require expensive subscriptions, this project introduces a novel, cost-effective architecture utilizing Google Apps Script to enable permanent, serverless historical data logging without recurring fees. The system's uniqueness is further defined by its "Dual-Feedback Loop," which provides immediate physical correction cues to the user via a buzzer while simultaneously transmitting live telemetry to the Blynk IoT dashboard for remote monitoring. This transforms the device from a simple corrective tool into a comprehensive, data-driven health ecosystem that makes professional-grade ergonomic tracking accessible to the public.

4. Benefit to mankind

The Smart IoT Posture Monitor offers a significant benefit to mankind by directly addressing the global rise in musculoskeletal disorders (MSDs) and chronic back pain associated with modern sedentary lifestyles. By democratizing access to preventative health technology, this system empowers students, office workers, and remote employees to take proactive control of their spinal health without the barrier of high medical costs. The device's ability to provide immediate corrective feedback fosters long- term behavioral changes, reducing the risk of permanent spinal curvature (kyphosis) and alleviating the burden on public healthcare systems caused by treatable orthopedic conditions. Furthermore, its open-source, affordable design makes ergonomic safety accessible to low-income communities and developing regions, ensuring that the fundamental right to physical well-being is not a luxury, but a widely available standard for anyone working in a digital environment.

5. Innovation and Entrepreneurial Impact

This project introduces significant innovation by transforming posture correction from a passive support system into an active, data-driven IoT solution. Unlike traditional braces, this device utilizes the MPU6050 sensor and ESP32 microcontroller to provide immediate biofeedback (< 0.5s latency) while simultaneously logging long-term behavioral data to the cloud via Google Sheets. This integration of real-time correction with historical tracking allows users to monitor their spinal health progress over time. Entrepreneurially, the system is designed with cost-effective components, making it a highly scalable product for the growing ergonomic market. It presents a viable commercial solution for corporate wellness programs and educational institutions aiming to reduce healthcare costs associated with Musculoskeletal Disorders (MSDs). By empowering individuals to proactively manage their spinal health, the project fosters a culture of preventative healthcare and technological adoption in daily life.

6. Potential commercialization

The Smart IoT Posture Monitor holds substantial commercial viability driven by the rapidly expanding global market for digital health wearables and the increasing awareness of ergonomic wellness in corporate and educational sectors. With a low production cost of approximately RM 104, the device offers a competitive pricing strategy that significantly undercuts existing market alternatives, which often range from RM 500 to RM 1,000, effectively removing the financial barrier to entry for mass adoption. The product appeals to diverse consumer segments, including remote workers, students, and parents monitoring their children's spinal health—while also presenting a scalable B2B opportunity for corporate wellness programs seeking cost-effective solutions to reduce employee healthcare costs associated with chronic back pain. Furthermore, the modular design allows for rapid manufacturing and future expansion into subscription-based premium analytics, ensuring a sustainable and profitable business model.

7. Acknowledgment

First and foremost, I would like to thank my supervisor, Dr Siti Aminah binti Nordin, for their invaluable guidance, support and encouragement throughout the duration of this project. Their expertise and insightful feedback have been essential in shaping the direction and outcome of the project. I would also like to thank my lecturers and friends from the Faculty of Electrical Engineering for providing the knowledge and resources necessary to complete the project. Lastly, a heartfelt thank you goes to my family for their unwavering support, motivation and patience, especially during challenging moments. Their presence has been a constant source of strength throughout this journey.

8. Researchers' Biography

Muhammad Azri Muhamad Adlan is a final-year student at the Centre for Electrical Engineering Studies, Universiti Teknologi MARA (UiTM), Pasir Gudang Campus. His research focuses on embedded systems, wearable technology, and Internet of Things (IoT) solutions for healthcare. This project, the Smart Posture and Sitting Behavior Monitor, was developed as his Final Year Project to address musculoskeletal health risks using the ESP32 microcontroller and real-time cloud data logging. He aims to innovate accessible tech solutions for daily ergonomic challenges.

Ts. Dr. Siti Aminah Nordin is a distinguished senior lecturer currently affiliated with UiTM Campus Pasir Gudang. She earned both her master's and Ph.D. degrees in Electrical Engineering from UiTM Shah Alam in 2014 and 2022, respectively, showcasing her commitment to academic excellence. With a specialized focus in the realm of Electrical Engineering, her research interests are notably centered around microwave filters, antennas, and electromagnetic wave area. She can be contacted email: sitia181@uitm.edu.my.

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Chicken Farm Monitoring IoT System

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ABSTRACT

Poultry farming in rural areas often relies on manual monitoring of water and feed supplies, which requires significant time, labor, and physical effort. This project presents a Chicken Farm Monitoring IoT System designed to assist farmers in monitoring poultry farm resources remotely and automatically. The system utilizes ESP32 microcontrollers and LoRa communication technology to enable long-range wireless data transmission between two devices without requiring internet infrastructure. Ultrasonic sensors measure the percentage levels of water and feed in the storage containers, and the data are transmitted to a monitoring unit for real-time display through OLED and LCD screens. The system also incorporates an automatic water refill mechanism using a water pump and a servo-controlled feed dispenser to maintain sufficient resources for poultry. Additionally, farm conditions such as temperature and humidity can be monitored using environmental sensors. The proposed system reduces the need for manual inspection and provides farmers with continuous monitoring capability even in remote areas with limited connectivity. This innovation offers a low-cost, energy-efficient, and practical solution for improving farm management, supporting sustainable agriculture, and enhancing productivity for rural poultry farmers. The system also demonstrates potential for future commercialization as an affordable smart farming solution.

Keywords: IoT farming, poultry monitoring, LoRa communication, smart agriculture, ESP32

1. Product Description

The Chicken Farm Monitoring IoT System is designed to automate the monitoring and management of poultry farm resources such as water supply and feed availability. The system consists of two main devices: a farm unit (Device 1) located at the chicken coop and a monitoring unit (Device 2) located at the farmer's house. The farm unit uses an ESP32 microcontroller integrated with LoRa communication to collect sensor data and transmit it to the monitoring device. Ultrasonic sensors measure the water level and feed level in storage containers and convert the readings into percentage values. When the water level drops below a defined threshold, the system automatically activates a water pump through a relay to refill the water tank. A servo motor controls the opening and closing of the feed container to distribute feed automatically. The monitoring unit receives the transmitted data through LoRa communication and displays real-time information on OLED and LCD screens, including water percentage, feed percentage, temperature, and humidity. Alerts such as buzzer notifications are triggered when resource levels become critically low. The system also supports optional data monitoring through

a smartphone using a cloud database platform. Overall, this system provides farmers with continuous monitoring and automated farm resource management, reducing labor and improving poultry welfare.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

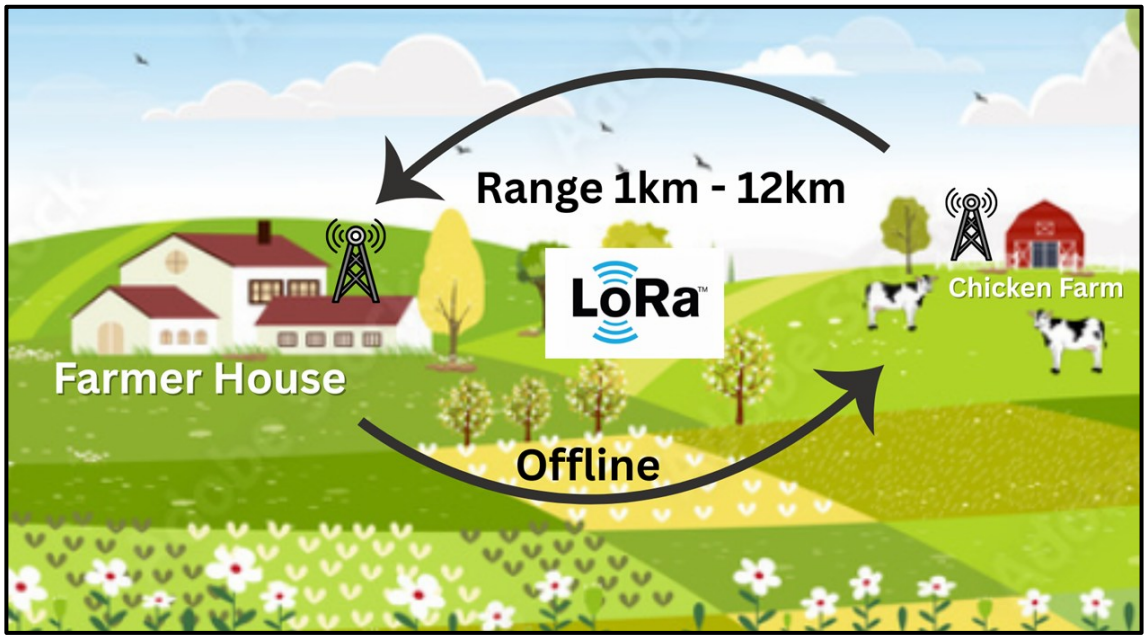
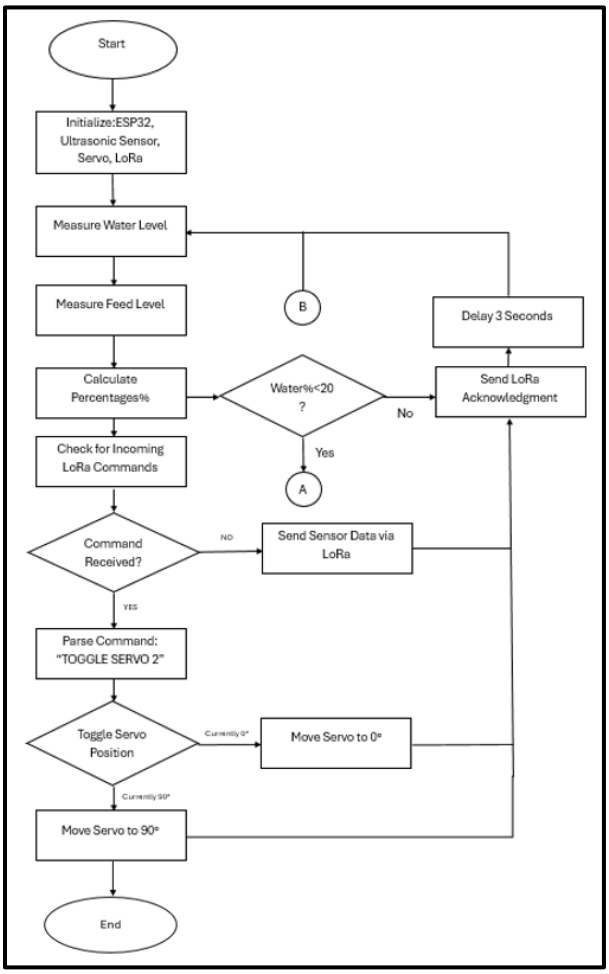


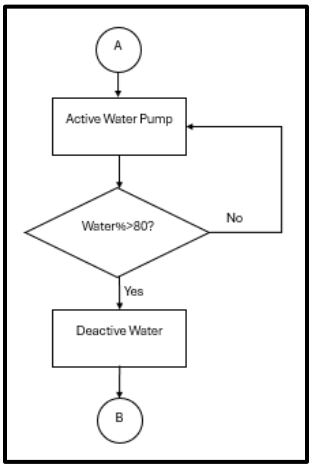
Figure 1. Overall Concept of Chicken Farm Monitoring IoT System.

Figure 1 illustrates the overall concept of the system, which consists of two main units: Device 1 placed at the chicken coop for sensing and automation, and Device 2 located at the farmer's monitoring station. Both devices communicate through LoRa wireless technology, allowing long-range data transmission without requiring internet connectivity. **Figure 2** shows the operational flow chart of Device 1. In **Figure 2(a)**, the overall system process is presented, where sensor data such as water level, feed level, temperature, and humidity are collected and processed by the microcontroller before being transmitted to the monitoring unit. **Figure 2(b)** focuses on the automatic water refill mechanism, where the system activates a water pump through a relay whenever the detected water level falls below a predefined threshold. **Figure 3** presents the operational flow chart of Device 2, which receives the transmitted data from Device 1 and displays the information for the user through visual indicators and alerts. **Figure 4** shows the overall prototype of the developed system, demonstrating the integration of sensors, microcontrollers, LoRa modules, and control components within the hardware structure. **Figures 5** and **Figure 6** illustrate the positioning of Device 1 and Device 2 together with the placement of the LoRa antennas to ensure stable wireless communication between the farm and the monitoring location.These figures show how the farm unit is installed near the poultry enclosure while the monitoring unit is placed at the farmer's house or control point. Finally, **Figure 7** presents the display interface of Device 2, where real-time information is shown to the user. **Figure 7(a)** displays environmental data such as temperature and humidity, while **Figure 7(b)** shows the percentage levels of food and water in the storage containers. Overall, these

figures provide a clear overview of the system architecture, operational process, physical implementation, and monitoring interface that enable efficient and automated poultry farm management.



(a)



(b)

Figure 2. Project progress flow chart (Device 1 System) for
(a) overall and
(b)when water pump is activated

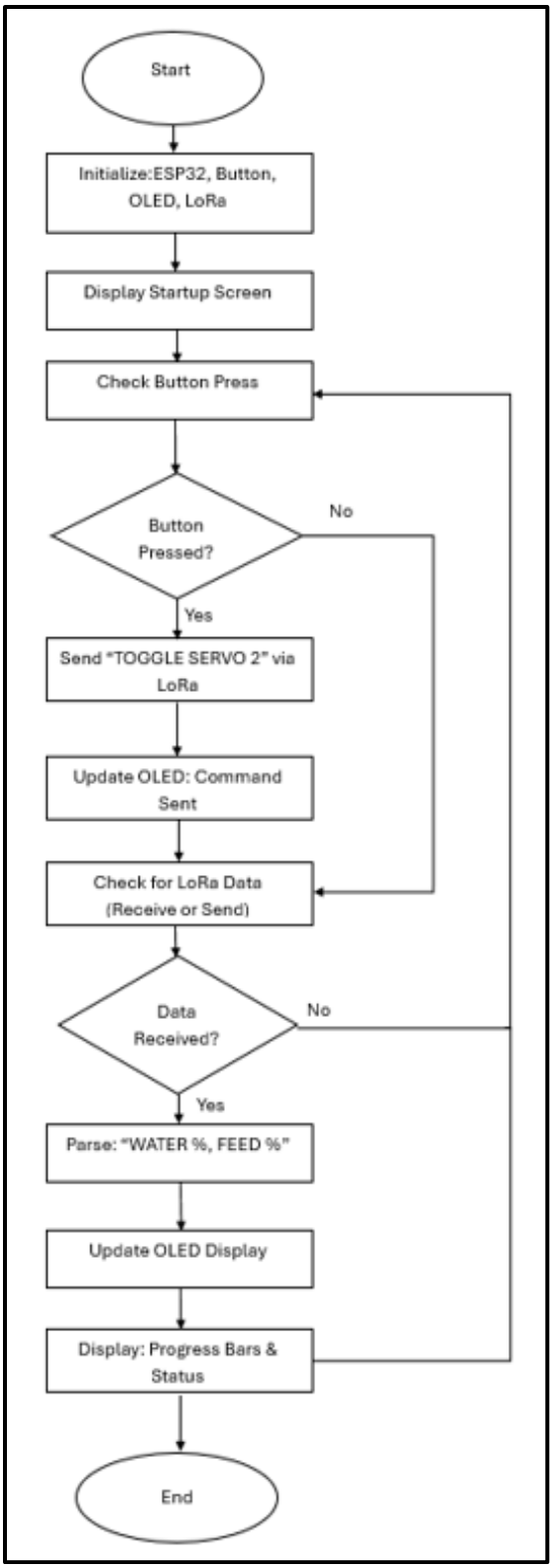


Figure 3. Project progress flow chart (Device 2 System).

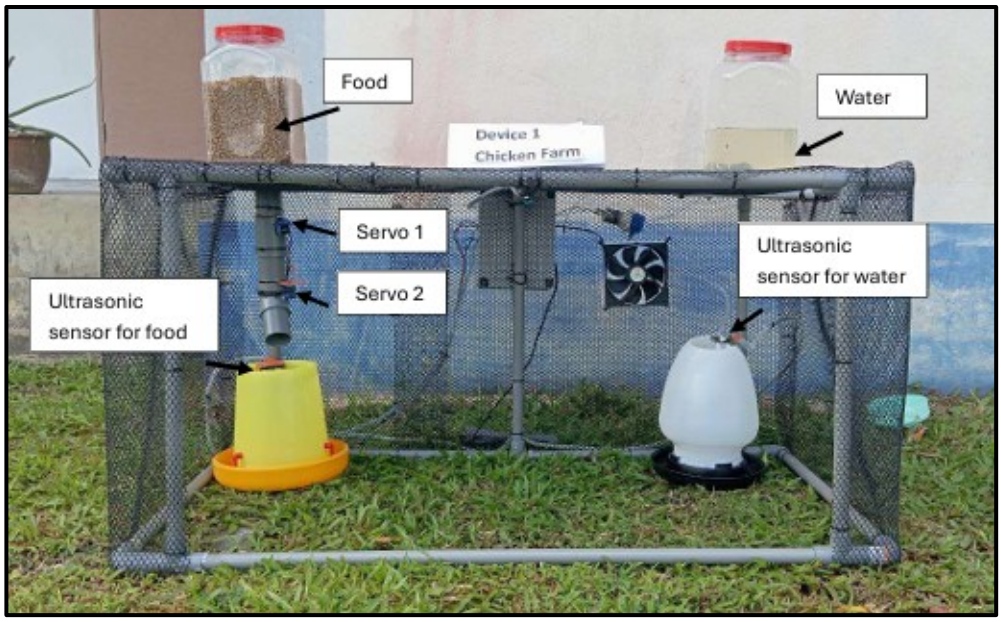


Figure 4. Overall Prototype of Chicken Farm Monitoring IoT System.

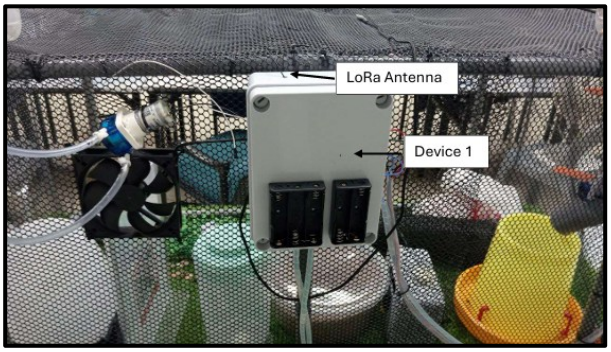


Figure 5. Device 1 Positioning with LoRA Antenna Location.

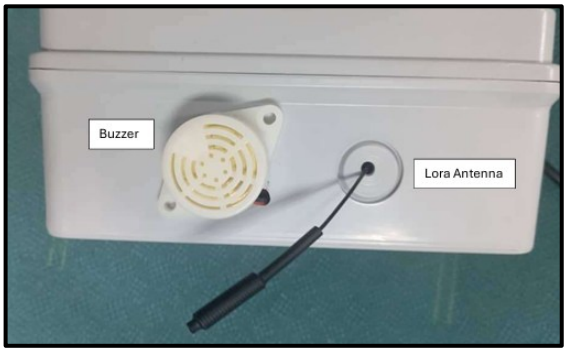
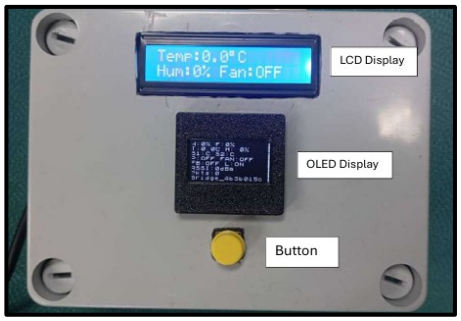


Figure 6. Device 2 Positioning with LoRA Antenna Location.



(a)

(b)

Figure 7. Display of Device 2 of (a) Temperature and Humidity, and (b) Food and Water Percentage.

3. Novelty and uniqueness

The novelty of this project lies in the integration of LoRa long-range communication with automated poultry resource management in a low-cost IoT architecture specifically designed for rural farming environments. Unlike conventional smart farming systems that rely heavily on WiFi or internet connectivity, the proposed system operates effectively in offline environments, making it highly suitable for remote agricultural areas with limited infrastructure. Another unique aspect is the dual-device architecture, consisting of a farm monitoring unit and a remote monitoring station that communicate through LoRa technology. This design enables long-distance data transmission while maintaining low power consumption and stable communication performance. The system also integrates multiple automation features, including automatic water refill control using ultrasonic sensing and relay-controlled water pumps, as well as servo-based feed dispensing mechanisms. These features help ensure consistent resource availability for poultry without requiring continuous human intervention. Additionally, the system provides real-time monitoring through multiple display interfaces, including OLED and LCD screens, as well as optional cloud storage for data tracking. This combination of long-range communication, automation, and real-time monitoring creates a practical and scalable smart farming solution tailored for rural poultry operations.

4. Benefit to mankind

This project provides significant benefits to rural farmers by simplifying the daily monitoring of poultry farms. The automated monitoring system reduces the need for manual inspection of water and feed supplies, saving time and physical effort for farmers. By ensuring consistent availability of water and feed, the system contributes to improved poultry health and productivity. The technology also promotes the adoption of smart agriculture practices, particularly in rural communities where access to advanced farming technologies is often limited. The system enables farmers to monitor farm conditions remotely, improving farm management efficiency and reducing operational risks. Furthermore, the project demonstrates how affordable microcontroller and communication technologies can be applied to solve practical agricultural challenges. The implementation of this system can support sustainable farming practices, increase farm productivity, and improve the overall livelihood of rural farming communities.

5. Innovation and Entrepreneurial Impact

The proposed chicken farm monitoring system encourages innovation by integrating IoT technologies with practical agricultural applications. The project demonstrates how emerging technologies such as ESP32 microcontrollers, wireless communication, and sensor-based automation can be combined to create cost-effective smart farming solutions. From an entrepreneurial perspective, the system has strong potential to inspire technology-driven agricultural startups focused on developing affordable farm automation tools.
The modular design of the system allows further development into a commercial smart farming platform that can support various livestock monitoring applications. The project also contributes to the development of technology-based solutions for rural communities, encouraging students and innovators to explore new opportunities in AgriTech entrepreneurship. With further product refinement and commercialization strategies, the system could evolve into a marketable solution that supports digital transformation in the agriculture sector.

6. Potential commercialization

The Chicken Farm Monitoring IoT System demonstrates promising commercialization potential as a low-cost smart farming product targeted at poultry farmers in rural areas. The system uses affordable hardware components such as ESP32 microcontrollers, ultrasonic sensors, and LoRa modules, which makes the overall production cost relatively low compared to existing commercial farm monitoring solutions. With further product development, the system could be packaged as a plug-and-play monitoring kit for poultry farms. The product may include sensor modules, wireless communication units, and a monitoring interface that farmers can easily install without advanced technical knowledge. Future commercialization strategies may include integration with mobile applications, cloud-based data analytics, and large-scale farm management systems. The product could also be expanded to support other livestock farms such as goat, cattle, or aquaculture monitoring systems. By addressing the needs of small-scale farmers, the system has strong potential to become an accessible smart agriculture technology in developing regions.

7. Acknowledgment

Sincere appreciation goes to Universiti Teknologi MARA (UiTM), Sarawak Branch, for providing the facilities and academic environment that supported the development of this project. Appreciation is also extended to the staff and colleagues of the Faculty of Electrical Engineering for their guidance, encouragement, and valuable feedback throughout the development of the NOVA system.

8. Researchers' Biography

Mohamad Aliff Mohamad Redzuan is a Diploma student in Electrical Engineering (Electronics) at Universiti Teknologi MARA (UiTM), Sarawak Branch. His interests include embedded systems and intelligent device development. He focuses on designing practical technological solutions that can contribute positively to society, particularly through innovative electronic systems and smart device applications.

Hadi Jumaat received the B. Eng. in engineering electronics, M.Sc. degree in electrical engineering, and PhD degree in electrical engineering from the Universiti Teknologi MARA (UiTM), Selangor, Malaysia in 2012, 2015, and 2025. He is currently a member of Antenna Research Center (ARC) in Universiti Teknologi MARA. Since 2015, he joined UiTM as a young lecturer. His research interests are in communication antenna design, biomedical antenna and electromagnetic wave propagation.

Muhd Firdaus Muhd Yusoff obtained his B. Eng. in Microelectronics and M.Eng. Computer and Microelectronics in electrical engineering from Universiti Teknologi Malaysia (UTM), Johor, Malaysia, in 2011 and 2015, respectively. He has been working as a lecturer at UiTM since 2015. His research interests include IC design and image processing applications

Nur Atiqah Abdul Rahman received a bachelor's degree in electrical engineering in 2011 and Master of Science in Electrical Engineering in 2014 from Universiti Teknologi MARA Malaysia. Currently she is working as a lecturer in Universiti Teknologi MARA Cawangan Sarawak and doing part time PhD in Electrical Engineering at Universiti Teknologi MARA Malaysia. Her current research interests are optimization techniques, distributed generation and Power System.

Water Pump Automation for Efficient Fish Pond Maintenance

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ABSTRACT
The Water Pump Automation for Efficient Fish Pond Maintenance is a localized hardware solution designed to automate water management and ensure liquid safety without the need for manual supervision. This project centers around the ESP32 microcontroller, which serves as the central processing unit to bridge multiple analog sensors with automated output controls. The system focuses on three essential parameters: pH level (chemical quality), turbidity (physical clarity), and water volume (quantity). By processing these inputs locally, the system can make immediate decisions to activate or deactivate a water pump. A key technical feature is the implementation of hysteresis logic, where the pump follows a specific activation cycle triggering at 50% capacity and deactivating only when the reservoir is empty to prevent motor wear and tear. For user interaction, the system utilizes a 16x2 I2C LCD as the primary data interface. This allows users to perform on-site checks of water health and system status at a glance. By focusing on a standalone architecture, the system ensures high reliability and stability, providing a fail-safe mechanism that protects the water pump from damage while ensuring that only water meeting the required quality standards is managed. Prototype development and testing have successfully operated the Water Pump Automation for Efficient Fish Pond Maintenance system.

Keywords: ESP32, Water Pump Automation, IoT, Fish Pond Maintenance

1. Product Description
The Water Pump Automation for Efficient Fish Pond Maintenance System is a comprehensive solution designed to modernize water management by integrating real-time sensing with automated hardware control. The system addresses critical challenges in water storage maintenance, such as the inefficiency of manual monitoring, the risk of pump damage due to dry-running, and the potential for undetected chemical or physical contamination. By utilizing the ESP32 microcontroller as its core processor, the system bridges the physical and digital worlds, leveraging built-in Wi-Fi to transmit vital environmental data specifically pH levels, turbidity, and water volume to a cloud-based interface. Functionally, the system operates on a dual-mode logic that provides both autonomy and flexibility. In Automatic Mode, a specialized hysteresis algorithm manages the water pump by monitoring specific level thresholds; the pump activates when the tank reaches a 50% capacity and remains operational until the reservoir is empty. This prevents "short-cycling" and ensures the motor operates in stable, efficient cycles. On-site monitoring is facilitated through a 16x2 I2C LCD, which provides a scannable local display of current water quality and system status. Simultaneously, the Blynk IoT platform serves as the remote monitoring hub, offering a graphical user interface (GUI) that visualizes data trends and system health from any location. By combining reliable hardware protection with sophisticated IoT integration, this

project provides a scalable and cost-effective approach to smart water management, ensuring that water remains safe for use while significantly reducing the need for constant physical supervision and manual intervention.

2. Method Flow Chart and Product Model

The hardware selection process was critical to ensuring the prototype could handle the continuous demands of an aquatic environment. At the center of the system is the ESP32 DevKit V1, which was chosen over traditional microcontrollers due to its superior clock speed and dual-core architecture, allowing it to process complex analog signals from multiple sensors simultaneously without latency. For chemical monitoring, the analog pH sensor utilizes a silver-chloride glass electrode to detect hydrogen ion activity; the methodology involved calibrating this sensor using standard buffer solutions to ensure the ESP32 accurately translates voltage into a pH scale of 0 to 14. To address physical water clarity, the turbidity sensor was integrated using an infrared transmitter and receiver pair. This component is essential for detecting suspended solids, such as uneaten fish feed or waste, which could otherwise lead to oxygen depletion if not managed by the automated pump. In addition to quality monitoring, the project utilizes an HC-SR04 ultrasonic sensor for precise water level tracking. Unlike mechanical float switches that can be jammed by algae or debris, this sensor uses high-frequency sound waves to provide non-contact distance measurements, ensuring high reliability and a longer lifespan. To make this data accessible to the user, a 16x2 LCD was incorporated using the I2C communication protocol. This choice was strategic, as the I2C interface requires only two data pins (SDA and SCL) from the ESP32, leaving more pins available for sensor expansion while providing a clear, real-time dashboard of the pond's status. Finally, the execution unit consists of a 5V Relay Module and a submersible water pump. The relay provides essential opto-isolation, protecting the sensitive ESP32 from the high-voltage spikes and electromagnetic interference generated by the pump's motor, thereby ensuring the overall stability and safety of the electronic system.

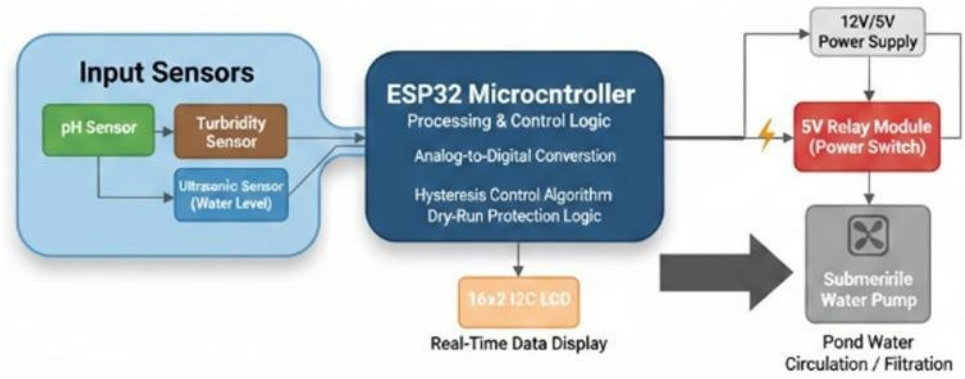


Figure 1. Block Diagram of the Water Pump Automation for Efficient Fish Pond Maintenance.

Based on **Figure 2**, The schematic diagram illustrates a fully automated control system centered around the ESP32 microcontroller, specifically engineered to monitor and manage pond environments with high precision. This setup is designed to replace manual supervision with an intelligent, data-driven process that maintains optimal living conditions for aquatic life. Each component in the circuit plays a specialized role in ensuring the system operates seamlessly. The

HC-SR04 ultrasonic sensor acts as the primary input for water level management; it continuously monitors the distance to the water surface and sends real-time data to the ESP32. When the water level reaches the programmed 50% threshold, the ESP32 processes this signal and triggers the Relay Module, which in turn activates the submersible water pump to begin the maintenance cycle.The system is further enhanced by integrated water quality sensors that provide a comprehensive view of the pond's health. The pH and turbidity sensors provide constant analog feedback, allowing the ESP32 to detect chemical imbalances or excessive waste buildup. To ensure user transparency, an I2C LCD display is connected to the ESP32 to provide live status updates, such as "PH LEVEL: 7.2", "WATER: 50%", or "PUMP: ACTIVE". This allows the fish farmer to observe the exact status of the ecosystem at a glance. Additionally, the system features a manual override capability, allowing the user to trigger the pump for testing or maintenance purposes, bypassing the automated sensors when necessary. To ensure hardware longevity, the schematic incorporates Dry-Run Protection and audible or visual alerts, providing a robust safety framework that prevents pump damage and ensures the fish stock remains in a stable, well-maintained environment.

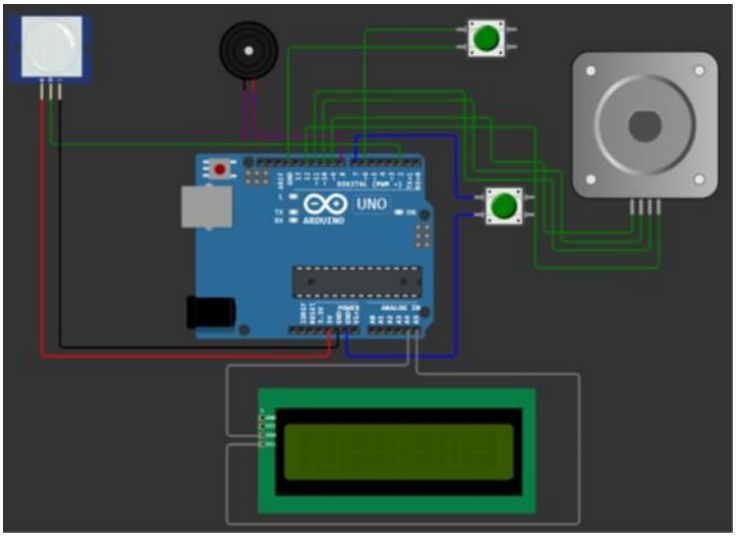
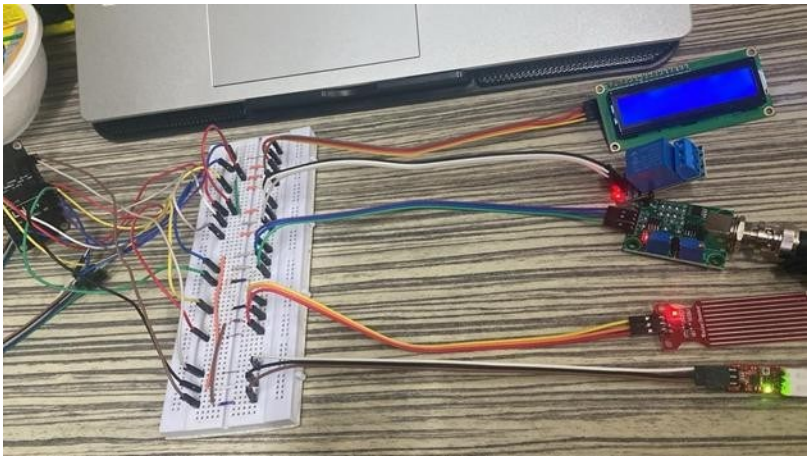


Figure 2. Schematic Diagram of Water Pump Automation For Efficient Fish Pond Maintenance.

Figure 3 (a) and **(b)** shows the successfully developed prototype of the Water Pump Automation For Efficient Fish Pond Maintenance system with the ESP32 as main controller where sensors as inputs; relay, pump and LCD screen as outputs. The results demonstration for the Water Pump Automation for Efficient Fish Pond Maintenance project confirms the successful integration of hardware and software into a fully autonomous system. During the evaluation phase, the ESP32 microcontroller demonstrated high stability in processing multi-sensor inputs, consistently updating the I2C LCD with accurate environmental data. The pH and turbidity sensors proved highly responsive, correctly identifying chemical imbalances and water clarity issues by triggering the water pump via the Relay Module within seconds of crossing the predefined safety thresholds. The use of Hysteresis logic was particularly effective during the demonstration, as it prevented the pump from rapid power cycling, while the Dry-Run Protection successfully deactivated the motor whenever water levels dropped below a critical point, ensuring the mechanical longevity of the system.

Furthermore, the physical prototype, housed in its acrylic enclosure, demonstrated its readiness for real-world deployment by maintaining structural integrity and electrical safety during active water circulation. The results showed that the system effectively automates the maintenance cycle, reducing the need for constant manual monitoring while ensuring the aquatic habitat remains within optimal biological parameters. By achieving a balance between precise sensing and reliable mechanical execution, the demonstration proved that the project is a viable solution for modern, efficient aquaculture, offering both water conservation and enhanced protection for livestock.



(a)

(b)

Figure 3. (a) The circuit connection testing on breadboard and **(b)** The fully functioned prototype of the syste.

3. Novelty and uniqueness

The development of the Water Pump Automation for Efficient Fish Pond Maintenance successfully demonstrates a robust solution for modernizing aquaculture through the use of an ESP32-based standalone system. By integrating a high-precision sensor suite consisting of pH, turbidity, and ultrasonic sensors, the project achieves a comprehensive monitoring framework that addresses both the physical and chemical health of the aquatic environment. The implementation of Advanced Hysteresis Logic serves as a critical engineering milestone, as it optimizes pump performance by establishing a defined "buffer zone" between 50% and 0% capacity, which prevents the mechanical fatigue and electrical surges associated with short-cycling. Furthermore, the inclusion of a localized 16x2 I2C LCD dashboard ensures that critical data is transparent and accessible on-site, effectively removing the need for constant manual inspection or complex network dependencies.

4. Benefit to mankind

The significance of this project lies in its ability to mitigate the dual risks of biological loss and hardware failure that frequently plague manual fish farming operations. By maintaining constant vigilance over water quality and levels, the system protects fish stocks from lethal environmental shifts while the built-in Dry-Run Protection safeguards the pumping hardware from burnout.

5. Innovation and Entrepreneurial Impact

The innovation of this project lies in its integration of real-time water quality monitoring, automated pump control, and hardware protection into a compact ESP32-based system designed specifically for fish pond maintenance. Unlike conventional manual monitoring methods, this system combines pH, turbidity, and water level sensors with hysteresis-based pump automation to provide a smarter and more reliable maintenance process. The inclusion of dry-run protection further enhances product durability by reducing the risk of pump damage, making the system practical for long-term use in small and medium-scale aquaculture operations. From an entrepreneurial perspective, the product has strong commercialization potential because it addresses a clear need among fish farmers: reducing manual labour, preventing fish loss, and improving water management efficiency. Its relatively low-cost components, scalable design, and suitability for local aquaculture environments make it a viable product for rural entrepreneurs, small fish farms, and educational institutions. With further refinement, such as mobile application integration, data logging, and solar-powered operation, the system could be developed into a marketable smart aquaculture solution that supports sustainable food production and modern farming practices.

6. Potential commercialization

The proposed Water Pump Automation for Efficient Fish Pond Maintenance system holds significant potential for commercialization within the agriculture and food security sector. By partnering with Kementerian Pertanian dan Keterjaminan Makanan who is managing the Aquaculture Licensing: Managing licenses and permits for fish and aquatic animal farming, Research: Conducted through the Fisheries Research Institute to enhance productivity, and Conservation: Protecting marine parks and fishery resources. road installation and safety in Malaysia.

7. Acknowledgment

Authors wish to acknowledge the support provided by the Electrical Engineering Studies, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, Masai, Malaysia in terms of financial, consultations and facilities.

8. Researchers' Biography

Muhammad Arif Aiman Joha is currently pursuing a Diploma in Electrical Engineering (Electronic) at the UiTM Pasir Gudang Campus. He has demonstrated outstanding performance in both academic and extracurricular activities, having earned a place on the Dean's List for two consecutive semesters. Apart of his expert skills in electronic project, he is also talented and has been involved in numerous faculty program.

9. Researchers' Biography

Muhammad Ammar Zufar Mohd Ramli is currently pursuing a Diploma in Electrical Engineering (Electronic) at the UiTM Pasir Gudang Campus. He has demonstrated outstanding performance in both academic and extracurricular activities, having earned a place on the Dean's List for two consecutive semesters. Apart of his expert skills in electronic project, he is also talented and has been involved in numerous faculty program.

Dr. Nor Affida M. Zin is a Senior Lecturer at UiTM Pasir Gudang Campus. She holds a Ph.D in Advanced Optical Networking, focusing on deterministic and time-sensitive services in Passive Optical Network. She has authored numerous high-impact journal articles and conference papers on PON technology. She is actively collaborating with academia and industry to enhance PON frameworks and developments in Malaysia.

Nur Asfahani Ismail has been serving as a lecturer at UiTM Pasir Gudang since 2014. She obtained her PhD in Optical Fibre Communication from Universiti Teknologi Malaysia (UTM) in 2025. Over the years, she has guided numerous students in their final year projects and earned recognition from the university for her contributions. Her research interests focus on IoT-based systems and machine learning.

SmartSolar Nursery System

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ABSTRACT
The SmartSolar Nursery System is an automated solution designed to enhance infant care through intelligent monitoring and renewable energy. Addressing the limitations of manual and energy-dependent cradles, this system utilizes an ESP32 microcontroller to process real-time data from sound, motion, and humidity sensors. Uniquely, it autonomously initiates soothing rocking mechanisms via a servo motor when crying is detected and activates cooling fans upon sensing high humidity, ensuring the baby's comfort without manual intervention. Additionally, the system features IoT integration, sending instant status alerts to a mobile application for remote supervision. Its primary advantage is sustainability, as harnessing solar energy, it eliminates reliance on the electrical grid and ensures functionality even during power outages. Socio-economically, this innovation reduces household electricity costs, while its eco-friendly design minimizes carbon footprints, offering a safe and sustainable alternative for modern parenting.

Keywords: smart cradle, IOT, solar energy, automated monitoring, infant care

1. Product Description
The SmartSolar Nursery System is an intelligent, eco-friendly infant care solution designed to modernize the traditional cradle. Powered entirely by renewable solar energy, it operates independently of the main electrical grid, ensuring continuous functionality even during power outages while significantly reducing household energy costs. At its core, the system utilizes an ESP32 microcontroller to process real-time data from a suite of integrated sensors. When sound or motion sensors detect the baby crying or stirring, the system automatically activates a soothing rocking mechanism driven by a precision servo motor. Simultaneously, environmental sensors monitor humidity and temperature and if conditions become uncomfortable, cooling fans are triggered automatically to restore a pleasant atmosphere. To keep parents connected, the system features Internet of Things (IoT) integration, sending instant status updates and alerts directly to a mobile application. This seamless blend of automation, renewable power, and remote connectivity provides a safe, sustainable environment for infants and offers unparalleled peace of mind to modern parents.

2. Block Diagram and Flow Charts
The SmartSolar Nursery System is designed with three primary stages consisting of input, processing, and output, all of which are supported by a renewable power source. The system continuously draws energy from a solar panel that charges a 12V battery via a charge controller, allowing for off-grid operation independent of the main electrical supply. In the input stage, a

network of sensors monitors the environment, including a sound sensor to detect crying, a PIR sensor to track motion, and a DHT11 sensor to measure temperature and humidity. These readings are transmitted to the ESP32 microcontroller, which serves as the processing core of the system. When the ESP32 analyzes the data and determines that specific comfort or safety thresholds have been crossed, it triggers the output stage devices such as a servo motor to initiate a rocking motion, a DC fan to regulate high humidity, and a buzzer for immediate local alerts. As illustrated in **Figure 1**, the block diagram presents the overall architecture of the SmartSolar Nursery System, highlighting the interaction between the solar power subsystem, sensor inputs, ESP32 processing unit, and output control devices. The diagram provides a clear visualization of how environmental data flows through the system and how automated responses are executed to maintain a safe and comfortable nursery environment. Additionally, the microcontroller utilizes its built-in Wi-Fi to integrate with the Blynk IoT platform to send real-time notifications and status updates directly to the parents' mobile application for comprehensive remote monitoring.

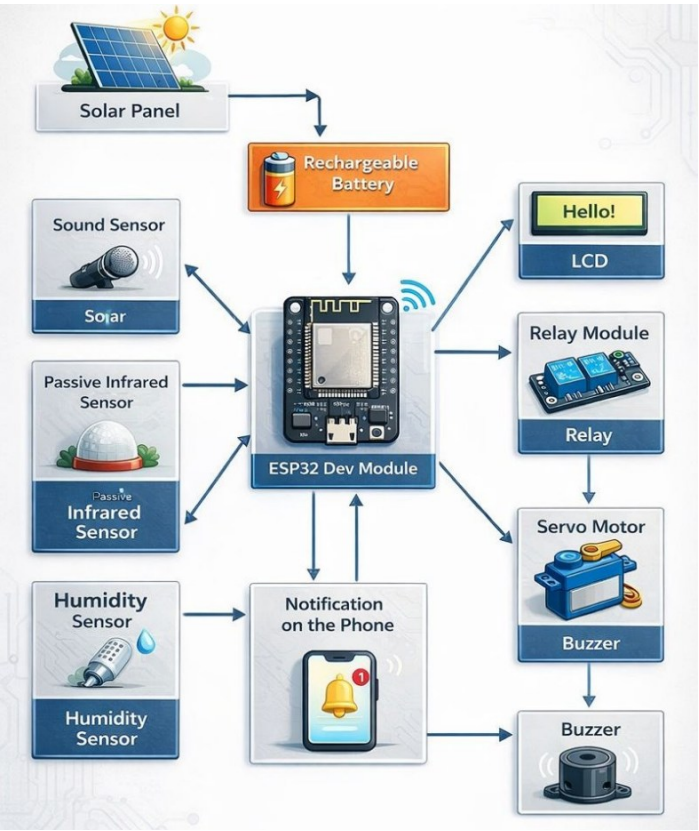

Figure 1. Block Diagram of SmartSolar Nursery System.

Figure 2 illustrates the operational flow of the SmartSolar Nursery System from power initialization to automated response. The process begins when the solar panel charges the battery, which subsequently powers the entire system. The system then continuously monitors the nursery environment using multiple sensors. The sound sensor first detects whether the baby is crying; if crying is detected, the buzzer is activated, a notification is sent to the parent's mobile device, and the baby cradle automatically begins rocking to soothe the baby.

The system also checks movement using the PIR sensor to determine whether there is activity in the cradle. If movement is detected, the system continues monitoring while keeping the alert mechanism active when necessary. In addition, the DHT11 sensor evaluates the humidity level inside the cradle. If high humidity is detected, a notification is sent to the parents, and the DC fan is automatically activated to improve air circulation and maintain a comfortable environment. If all monitored conditions remain within safe limits, the system maintains normal operation and the process ends until the next monitoring cycle.

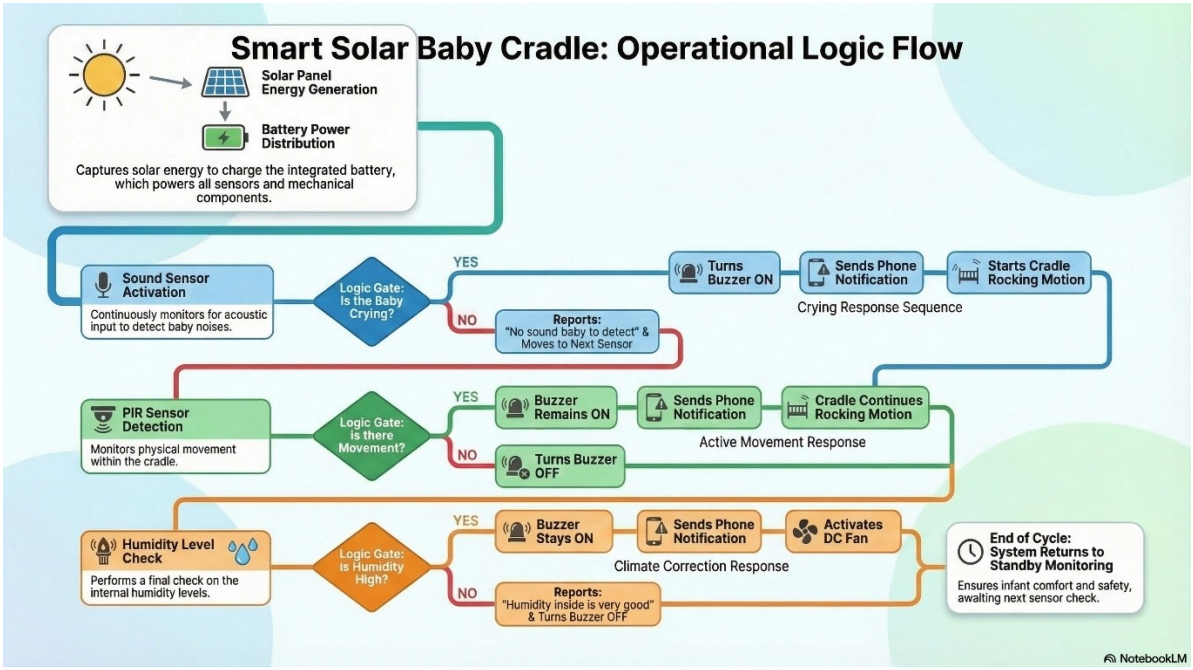

Figure 2. Operational Flow of SmartSolar Nursery System.

The schematic diagram illustrates in **Figure 3** shows the complete electronic circuit of the SmartSolar Nursery System, with the ESP32 microcontroller functioning as the central brain that coordinates all operations. The circuit begins with the power supply section, where a solar panel is connected to a charge controller and battery. This setup regulates the voltage to ensure a stable, renewable energy source that keeps the system running independently of the main electrical grid. The ESP32 is then wired to a suite of input sensors, specifically for sound, motion, and temperature, which continuously feed real-time data into the microcontroller to monitor the baby's condition.

In response to these sensor signals, the schematic shows how the ESP32 connects to the output devices to take action. When the brain detects crying or high heat, it sends electrical signals to a servo motor to rock the cradle and triggers a relay module to switch on the cooling fan. A buzzer is also included in the circuit for immediate audio alerts. This hardware design effectively links the physical sensors and motors with the microcontroller's logic, enabling the system to react automatically to the baby's needs while maintaining a connection to the mobile app for remote monitoring.

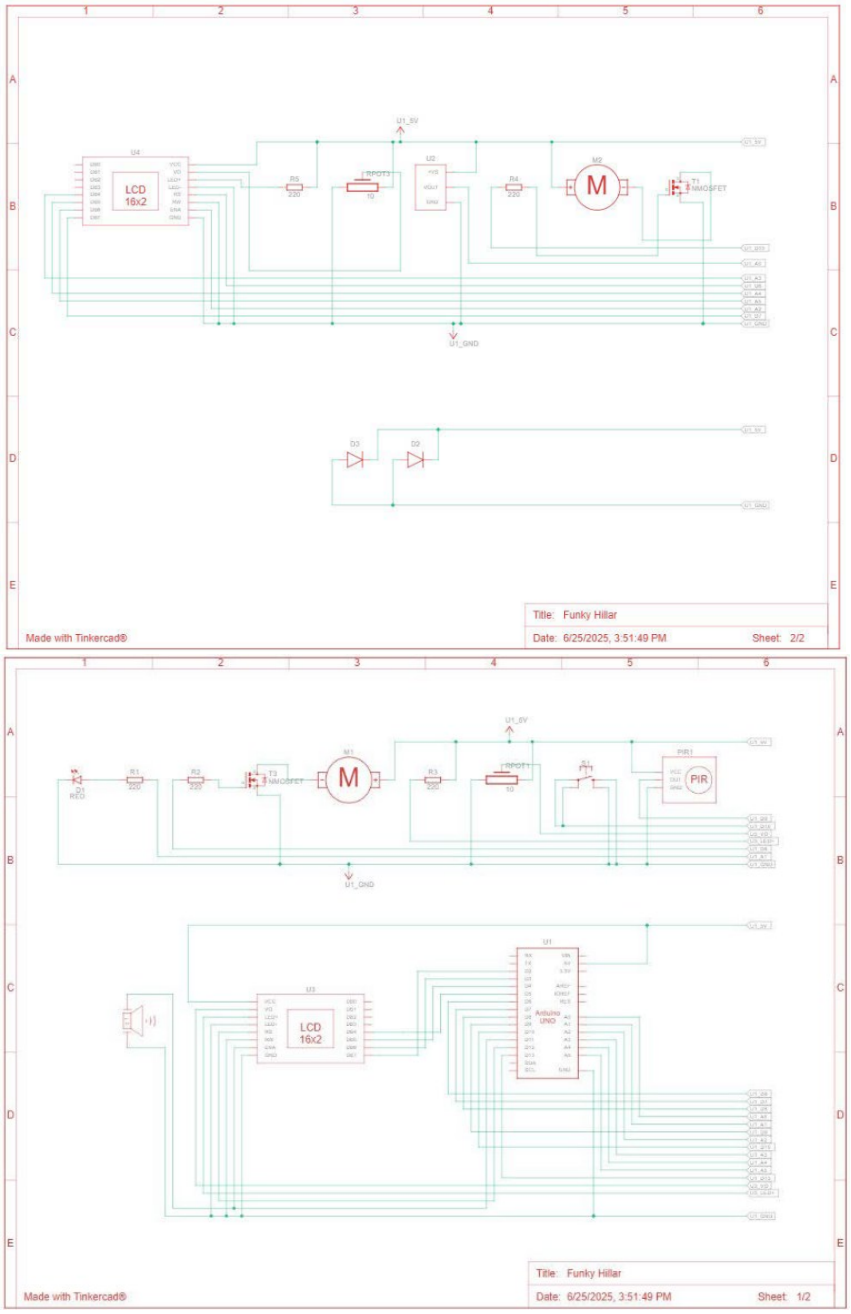

Figure 3. Schematic Diagram of SmartSolar Nursery System.

3. Novelty and uniqueness

The SmartSolar Nursery System distinguishes itself through the seamless integration of renewable energy and IoT-driven automation, addressing the limitations of conventional electric-dependent cradles. Unlike standard automated cradles that rely solely on grid electricity, this system incorporates a dedicated solar charging unit, ensuring uninterrupted operation during power outages and promoting energy independence. Its uniqueness lies in its multi-sensory responsive intelligence: an ESP32 microcontroller processes real-time data from sound, motion, and humidity sensors to autonomously trigger specific actions, such as rocking the cradle to soothe a crying

baby or activating cooling fans to regulate environmental comfort without parent intervention. Furthermore, the integration with the Blynk mobile application offers a novel layer of connectivity, allowing parents to monitor their infant's status and receive instant alerts from anywhere. This combination of eco-friendly power, autonomous care logic, and remote connectivity creates a comprehensive, self-sustaining nursery solution not currently found in the mainstream market.

4. Benefit to mankind

This innovation significantly improves the quality of life for modern parents and infants by merging convenience with sustainability. For parents, it reduces the physical and mental burden of constant monitoring, the automated soothing and cooling features ensure they can rest or attend to other tasks with peace of mind, knowing the system will respond immediately to the baby's distress. For infants, it guarantees a consistently comfortable and safe sleeping environment, protecting them from heat stress and discomfort. Broader societal benefits include the promotion of green technology. By reducing reliance on household electricity, the system lowers energy costs for families and contributes to environmental conservation efforts, fostering a shift towards more sustainable domestic living practices.

5. Innovation and Entrepreneurial Impact

The SmartSolar Nursery System serves as a tangible example of Green IoT, demonstrating how renewable energy can be effectively applied to everyday consumer electronics. By successfully merging solar technology with smart home automation, this project inspires a culture of eco-innovation within the engineering community, encouraging peers and institutions to rethink traditional appliances with sustainable designs. It promotes entrepreneurship by validating a market gap for off-grid smart furniture, signaling to local startups that there is demand for resilient, energy-efficient home solutions. Furthermore, the project's modular design, utilizing accessible components like the ESP32 and standard sensors, encourages a maker culture. It demonstrates that high-impact, commercial-grade solutions can be developed rapidly and cost-effectively, thereby lowering the barrier to entry for aspiring student-entrepreneurs.

6. Potential commercialization

This product holds strong commercial potential in the growing Smart Home and Baby Tech markets, particularly appealing to eco-conscious millennials and tech-savvy parents seeking convenience. Its solar-powered functionality gives it a unique competitive edge in regions with unstable power grids or high electricity tariffs, positioning it as a resilient appliance for developing markets. The system uses cost-effective, readily available components, allowing for a healthy profit margin even at a competitive retail price point. Future commercialization strategies could include a tiered model offering premium app features, such as sleep pattern analytics, or licensing the solar-integration module to existing furniture manufacturers. This approach creates multiple revenue streams while addressing the global demand for sustainable consumer goods.

7. Acknowledgment

Gratitude is extended to all those who contributed to the development and success of the SmartSolar Nursery System project. Special thanks to all team members for their collaboration in building and testing the system. Appreciation is also given to UiTM Pasir Gudang for providing the necessary resources and equipment to complete the project.

8. Researchers' Biography

Muhammad Amir Firdaus Bin Mohamad Akashah is a final-year Diploma student in Electrical Engineering (Power) at Universiti Teknologi MARA (UiTM), Pasir Gudang Campus. Currently in his final academic semester, he will proceed to industrial training in the upcoming term. He has developed strong technical competencies through active involvement in academic and project-based work, particularly in renewable energy systems, Arduino-based applications, and electrical circuit design. His hands-on experience in solar energy and microcontroller systems has strengthened his skills in system design, analysis, and implementation.

Ts. Wan Suhaifiza W Ibrahim received a Bachelor of Electrical (Hons) Engineering and Master of Electrical Engineering (Power) from Universiti Teknologi Malaysia in 2009 and 2011, respectively. She is currently serving as Senior Lecturer at Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, in Electrical Engineering Studies, specifically in Power Department. Her research interests are renewable energy, high voltage technology and online teaching and learning. She can be contacted at email: wsuhaifiza@uitm.edu.my.

Siti Aliyah Mohd Saleh obtained her Bachelor of Electrical (Hons) Engineering from UTM in 2009 and a Master in Engineering (Applied Science) from Tokai University, Japan in 2012. She is currently serving as a lecturer at Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, in Electrical Engineering Studies in the Power Department. Her main research interests are high voltage and power systems. She can be contacted at email: aliyah385@uitm.edu.my

Infinity Flash Light: A Handheld Thermoelectric Torch Powered by Human Body Heat

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ABSTRACT
This paper features the design, manufacture and experimental confirmation of a handheld thermoelectric torch called Infinity Flash Light, which can run its activities being powered by human body heat as its energies. The machine makes use of the thermoelectric Peltier modules (TEC1-12706) to transform the temperature difference between the ambient air and human skin into electrical energy. The average skin temperature of 36.5 o C and an ambient of about 31 ° C yields a useful thermal gradient of 5.5 o C, resulting in an open circuit voltage of approximately 64 mV/module. Since the voltage is extremely low, a self-oscillating unipolar DC-DC boost converter (ELC-UVB040) is used to boost the produced voltage to one that can be useful to drive a low-power LED. The output can be improved by adding two Peltier modules in series. Test output power of about 2.8 mW with a conversion efficiency of 41.7% is also exhibited by experimental assessment. The Infinity Flash Light will be battery-independent and provide a long-lasting and cost-effective, non-maintenance lighting system to be used in cases of emergency, off-grid, or disaster response. The simplicity of the system, its portability and environmental-friendly operation allow the system to serve as a viable alternative in the context of the environment where the traditional sources of power lack.

Keywords: Thermoelectric Energy, Body Heat Harvesting, Peltier Module, DC-DC Boost Converter, Sustainable Lighting.

1. Product Description
The Infinity Flash Light is a miniaturized flashlight that is easily held in a hand and enables the production of light based on the amount of heat a human body has without using batteries and other external power sources. This system works on the thermoelectric effect which is a voltage generated by a temperature difference across a Peltier module. The heat dissipated through the skin is exchanged to one side of the TEC1-12706 modules when gripped by the user, and exchanged to the other when the device is not handled (or touched), resulting in a thermal gradient. The DC low level voltage thus generated is not enough to drive an LED directly, thus a self-oscillating unipolar DC-DC boost converter is incorporated to boost the voltage to a practical level. The increased production generates a high efficiency LED, which gives constant brightness provided that the temperature gradient has not been exceeded. The flashlight is light, user friendly and does not need batteries, so it can be used in case of emergencies, in remote fieldwork, as well as in sustainable living.

2. Schematic diagrams

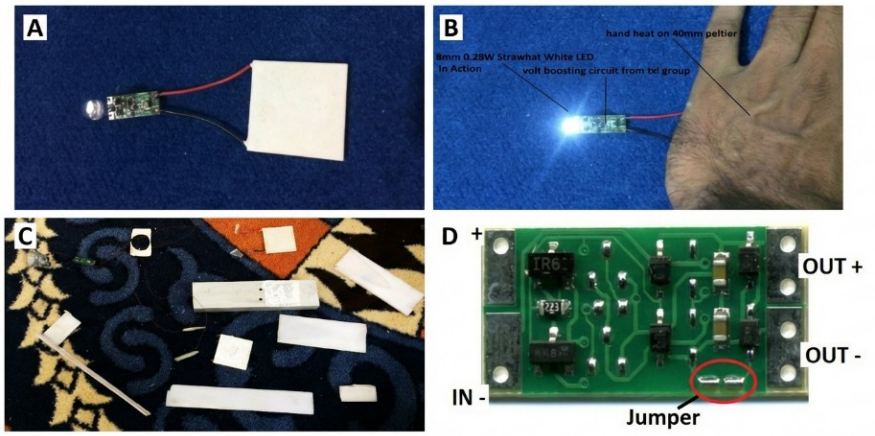

Figure 8 Thermoelectric generator circuit collage**.** This figure illustrates a circuit powered by body heat to light an LED, presenting the assembly, operational use, components, and voltage booster board across four panels.

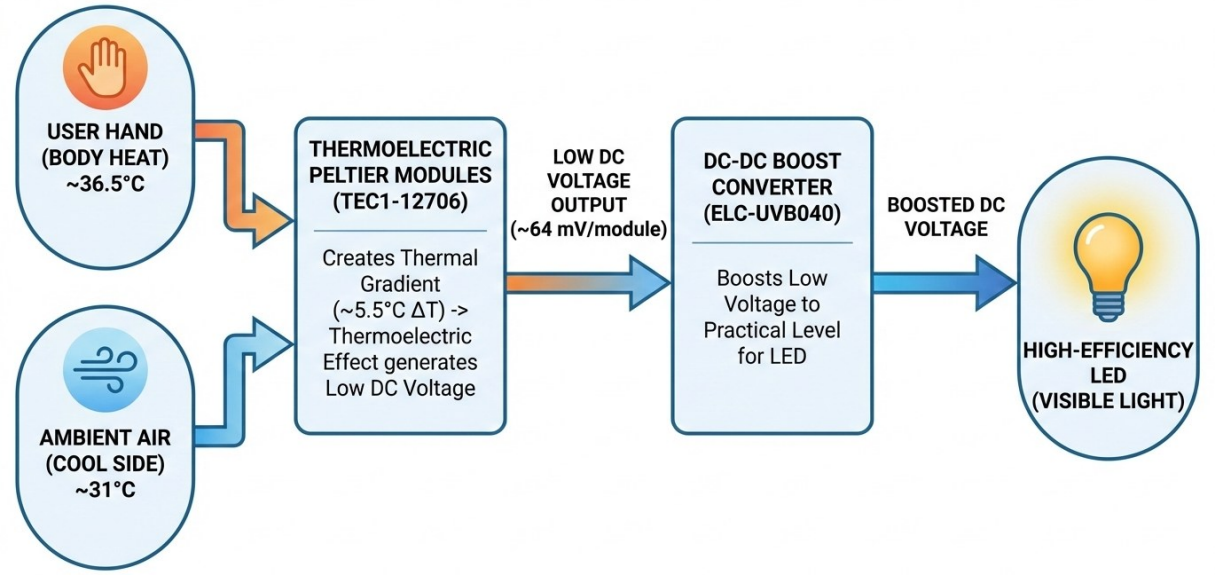

Figure 9 Infinity Flash Night: Working Principle

Table 4 Comparison Table

Device	Power Source	Output	Key Features	Limitations
Infinity Flash Light	Body heat (5.5°C ΔT, two modules)	1.2–10.0 V boosted, 2.8 mW, 41.7% efficiency	Handheld, aluminum housing, unipolar booster	Low brightness, contact-dependent
Hollow Flashlight (Makosinski)	Body heat (5°C ΔT, Peltier tiles)	Sufficient for LED	Battery-free, hollow design	Steady grip required, time to warm

Device	Power Source	Output	Key Features	Limitations
Body Heat Flashlight (Instructables)	Body heat (two TEC1-12703)	Via CJMCU-3108 booster	DIY, energy harvesting board	Limited to small LEDs, unoptimized
Lumen Eternal Flashlight	Body heat (Peltier-based)	Microwatts	Compact, crowdfunded	Dim output, short-duration use

3. Novelty and uniqueness

What makes the Infinity Flash Light so unique is the fact that it uses no batteries and no external power source and draws power solely through human body heat to constantly operate. This is a design that does not rely on movement, exposure to sunlight or stored energy except besides conventional hand-crank or solar-powered torches. A combination of a thermoelectric harvesting at ultra-low voltages with a self-oscillating DC-DC-booster permits lights to be practical off of modest thermal gradient variations. It is unique in its compact handheld shape and sustainable operation unlike other solutions in the market aimed at emergency lighting purposes. The system shows a different way of personal energy harvesting, that is, passive body heat is utilized to produce a dependable energy source that can be recycled.

4. Benefit to mankind

The Infinity Flash Light offers a sustainable compensation of lights in the community that has low access to electric power especially rural settings, disaster-prone places, and off-grid locations. It minimizes electronic waste, maintenance costs and environmental pollution since it does not require the use of batteries. The gadget supplements individual safety in the event of emergencies, power blackouts, and outdoor exercises. The simplicity of its operation makes it easy enough to access by everyone regardless of their age whereas its idea of renewable energy encourages the need to appreciate the existence of clean energy technologies and the need to conserve energy.

5. Innovation and Entrepreneurial Impact

The project will enhance innovation through showing how human-energy harvesting can work in practice in a product that is ready to use. It promotes thinking in an entrepreneurial manner as it takes a scientific law and remodels it into a market-able solution that offers solutions to a real-life problem. The Infinity Flash Light is capable of inciting the startups that deal with environmentally friendly personal devices, energy wears, and environmentally friendly emergency equipment. Its scalability layout enables additional advancement in thermoelectric wearables and smart survival gadgets.

6. Potential commercialization

The Infinity Flash Light has good commercialization opportunities in emergency preparedness kits, military and rescue emergency operations, outdoor adventure gear and in humanitarian disaster preparedness supplies. Thermoelectric modules and small boost converters are easily accessible and can be used to do mass production. Some of the variants of the products include wearable products, multi-led models, or products that are hybrid with solar energy. The battery free idea offers an element of distinct selling in the markets that prioritize sustainability.

7. Acknowledgment

Another aspect would be to give credit to the institution, their supervisors, and their partners in terms of support and help they gave throughout the entire process of developing this project.

8. Researchers' Biography

Muhammad Wasim, a researcher in Electronic Engineering, The Islamia University of Bahawalpur, Pakistan. He competed many projects about power generation and energy saving. A full size ceiling fan 56" powered by a cell phone battery. Cell phone battery charging system through walking for shoes with piezoelectric. Hydrogen fuel cell and hydrogen production from water with cheap way and running a bike through hydrogen. Cell phone charging system through radio signals coming from cell towers. A Smart watch where sound transfer from wrist to finger. The listener put finger on his ear to listen to the call. A water purifier and micro plastic remove the system from a muddy water. Charging free Magnesium based water battery system design from disaster and remote arias.

Muhammad Inam ul Haq an undergraduate researcher in Electronic Engineering, The Islamia University of Bahawalpur, Pakistan. He is a Double Gold Medalist and National Award Recipient of Pakistan, having received a Gold Medal from the Government of Pakistan (Medal No. GPK-GM-2025-017) and a Gold Medal from the Parliament of Pakistan (Medal No. PPK-GM-2025-042). I am also a National Award Recipient (National Award ID: NA-PK-EE-2025-311) in recognition of engineering innovation and research excellence. He is also an active member of the Center of Automation, Robotics, and Embedded Systems (CARE), where I engage in interdisciplinary research and applied engineering. My research interests include artificial intelligence, VLSI and IC design, FPGA-based acceleration, embedded and cyber-physical systems, and secure hardware–software co-design. In parallel, He is involved in research projects related to military and national security applications, with a focus on quantum intelligence and resilient cyber-physical infrastructures. My long-term goal is to develop secure, energy-efficient, and intelligent systems for next-generation computing, healthcare, and critical infrastructure.

Muhammad Rashid is working as Research Assistant in the Department of Electrical Engineering, The Islamia University of Bahawalpur, Punjab, Pakistan since March, 2021 and also served as Instructor (Electrical) in Electrical department, Govt. College of Technology Bahawalpur, Pakistan from Dec 2016 to Feb 2019. He completed M.Sc (Electrical Power Engineering) from "The Islamia University of Bahawalpur", Punjab, Pakistan in 2020. He hold a B.Sc Degree in Electrical (Power) Engineering (2016) from The Islamia University of Bahawalpur, Punjab, Pakistan. One research article has been accepted in a HEC recognized

Journal and presented one article in a conference held at The Islamia University of Bahawalpur, Punjab, Pakistan in March 2021.

Zeeshan Ahmad Arfeen is an Assistant Professor in theDepartment of Electrical Engineering in “The Islamia University of Bahawalpur," Pakistan. He doctorate from University Technology Malaysia (UTM) Skudai Johor Bahru, Johor, Malaysia. He is a senior member of the IEEE organization NJ. USA, member of IEEE Power and Energy Society (PES), life member IEEE Pakistan, and member of “The Institution of Engineers Pakistan” (IEP). Further, he is also a life member of the Pakistan Engineering Council. Arfeen is an Author/Coauthor of 50+ high indexed Journals with several conferences and book chapters and a distinguished potential reviewer of hundred International Conferences Proceedings and hundred International Journals. He was awarded a Partial doctoral scholarship from the Higher Education Commission (HEC) Pakistan. Arfeen also got an International doctoral fellowship (IDF) and UTM Young Scholarship Grant from the University of Technology Malaysia (UTM). His paper was the most downloaded in 2019 and 2020 and two of papers Wiley's and MDPI publisher's top 10 cited papers in 2020 and top downloaded.

Agro Ferti Tech

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ABSTRACT
Agro Ferti Tech is an IoT-based automated soil fertilization system developed to enhance fertilizer efficiency and support sustainable agriculture, particularly for small-scale and off-grid farming environments. Conventional fertilizer application relies heavily on manual observation and fixed schedules, often resulting in nutrient waste, inconsistent soil conditions, and reduced crop productivity. Agro Ferti Tech addresses these challenges by integrating real-time soil monitoring, automated fertilizer dispensing, and remote system control. The system continuously measures soil moisture, temperature, and pH using embedded sensors. Based on predefined thresholds, a microcontroller automatically activates a servo-controlled fertilizer dispensing mechanism, ensuring nutrients are delivered only when required. Real-time data and system status are transmitted to a mobile application via the Blynk IoT platform, enabling remote monitoring and manual intervention when necessary. A custom-designed power supply converter provides a stable 5V output, allowing reliable operation in remote or off-grid locations. Agro Ferti Tech offers a cost-effective, modular, and energy-efficient precision farming solution. Its implementation reduces fertilizer wastage, minimizes labor dependency, and promotes healthier crop growth, making it suitable for commercialization in modern smart agriculture markets.

Keywords: IoT Agriculture, Automated Fertilization, Soil Monitoring, Custom Power Supply, Precision Farming

1. Product Description
Agro Ferti Tech is a compact smart agriculture system designed to automate soil fertilization using real-time environmental sensing and IoT connectivity. The system is built around an ESP32 microcontroller integrated with soil moisture, temperature, and pH sensors to continuously assess soil conditions. When abnormal conditions are detected, the system automatically activates a servo motor to dispense fertilizer or water as required. A mobile interface developed using the Blynk IoT platform allows users to monitor soil conditions, receive alerts, and manually control fertilizer or water dispensing. LED indicators provide immediate on-site visual feedback for normal and abnormal soil conditions.A key feature of Agro Ferti Tech is its custom power supply converter, which converts AC input into a stable 5V DC output using a buck converter and filtering circuit. This ensures consistent and reliable system operation even in areas with unstable or off-grid power supply. The system is designed to be affordable, scalable, and easy to deploy, making it suitable for home farming, community agriculture projects, educational use, and small-scale commercial farming applications.

2. The Agro Ferti Tech Prototype

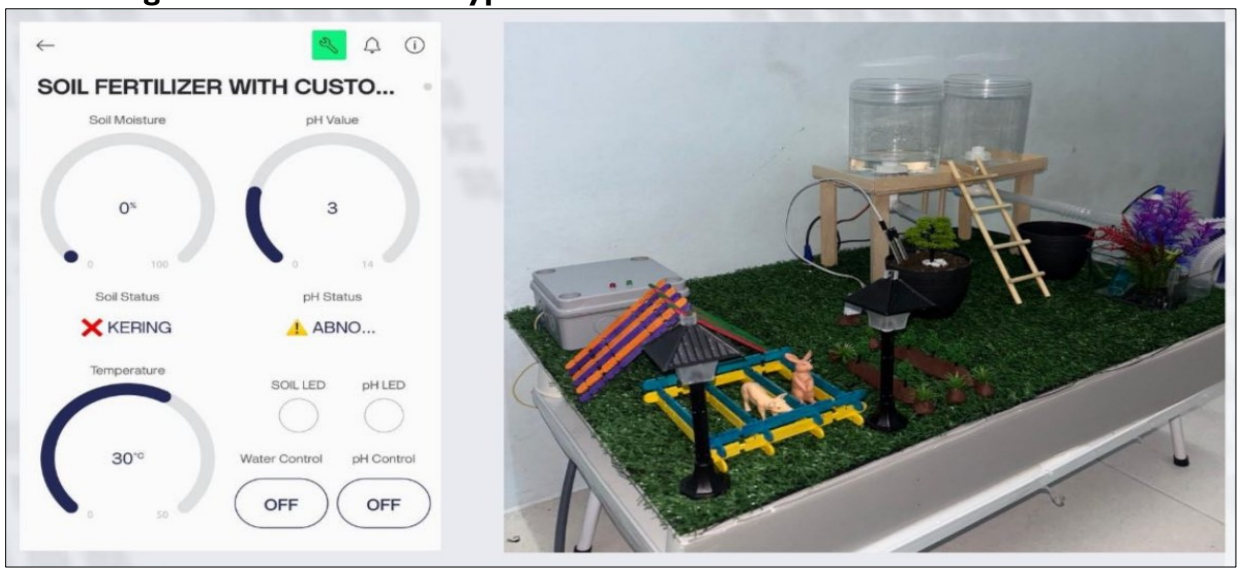

Figure 1. The Agro Ferti Tech prototype with IoT interphase.

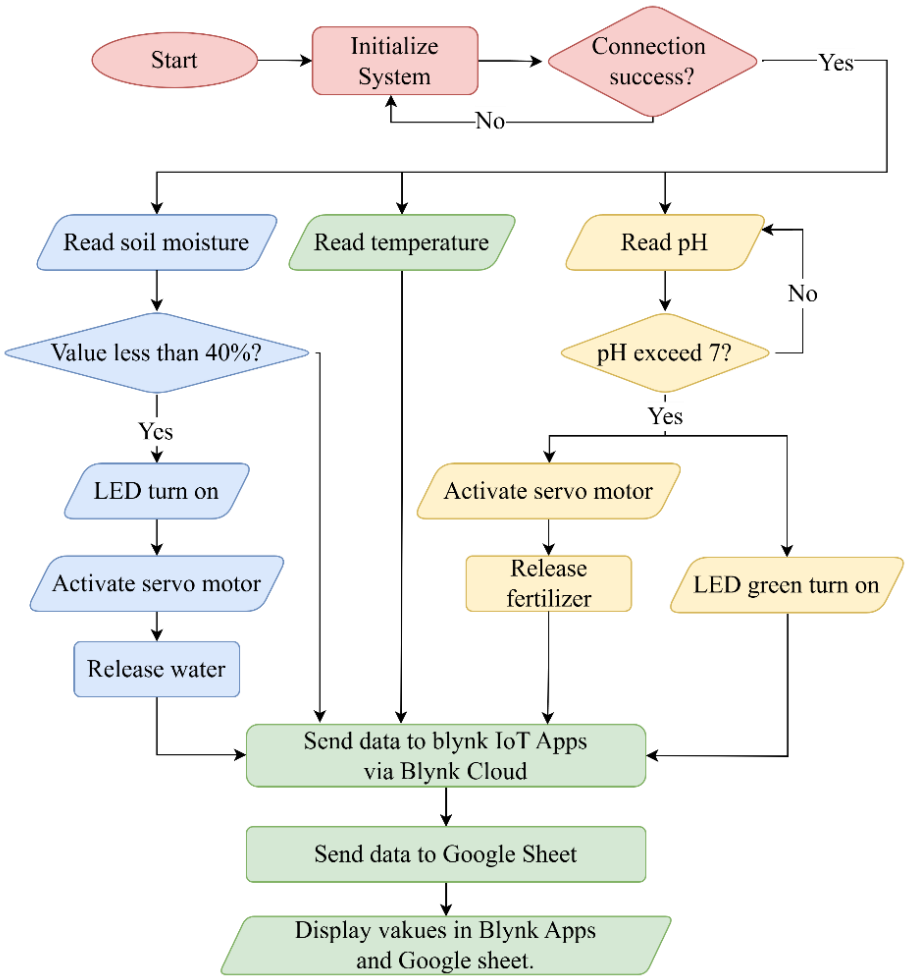

Figure 2. The Agro Ferti Tech operational flow chart.

The physical prototype integrated with an IoT interface is illustrated in **Figure 1**. The system consists of soil moisture, temperature, and pH sensors connected to an ESP32 microcontroller. A servo-driven dispensing mechanism releases water or fertilizer when abnormal soil conditions are detected. Real-time data is transmitted to the Blynk IoT application, where users can monitor soil status, view alerts, and manually control operations. LED indicators provide on-site visual feedback. The compact structure demonstrates a modular and scalable smart farming design suitable for small-scale applications The operational flow chart of Agro Ferti Tech is presented in **Figure 2**. The system initializes and checks connection status before reading soil parameters. If moisture falls below 40%, the system activates the servo motor to release water. If pH exceeds threshold levels, fertilizer is dispensed. Sensor data is then sent to the Blynk Cloud and recorded in Google Sheets for monitoring and analysis. This closed-loop process ensures automated, real-time precision fertilization.

3. Novelty and uniqueness

Agro Ferti Tech introduces a practical and fully automated soil fertilization solution that directly links real-time soil monitoring with mechanical fertilizer dispensing. Unlike many existing IoT-based agricultural systems that focus primarily on data visualization or fertilizer recommendations, Agro Ferti Tech converts sensor data into immediate physical action through an automated dispensing mechanism. The inclusion of a custom power supply converter enhances system reliability and enables autonomous operation in off-grid or low-infrastructure farming environments. This design eliminates dependence on existing irrigation systems or cloud-heavy infrastructures commonly required by smart agriculture technologies. Additionally, Agro Ferti Tech features a modular and low-cost design that allows customization according to crop type, soil conditions, and farm scale. Its affordability and simplicity make advanced precision farming technology accessible to small-scale farmers, a segment often underserved by commercial agri-tech solutions. The integration of automation, IoT connectivity, and independent power management distinguishes Agro Ferti Tech as a unique and field-ready smart farming product.

4. Benefit to mankind

Agro Ferti Tech contributes to sustainable agriculture by optimizing fertilizer usage and reducing environmental pollution caused by over-fertilization. By delivering nutrients only when needed, the system helps preserve soil quality, reduce chemical runoff, and promote healthier crop growth. The system reduces farmers' reliance on manual labor, improving efficiency and allowing better farm management. Its suitability for off-grid and rural environments empowers small-scale farmers with access to smart farming technology, enhancing food security and agricultural productivity. Agro Ferti Tech aligns with the United Nations Sustainable Development Goals, particularly SDG 2 (Zero Hunger) and SDG 12 (Responsible Consumption and Production), by supporting efficient and responsible agricultural practices.

5. Innovation and Entrepreneurial Impact

Agro Ferti Tech promotes innovation by transforming an academic prototype into a practical, market-oriented smart agriculture solution. The project demonstrates how IoT technology, automation, and power electronics can be integrated into a low-cost system that addresses real agricultural challenges. The product encourages an entrepreneurial mindset among students and innovators by highlighting commercialization opportunities in the agri-technology sector. Its modular architecture allows future expansion, including solar power integration, data analytics,

and AI-based nutrient optimization. Agro Ferti Tech has the potential to stimulate local innovation ecosystems by supporting startups, agricultural entrepreneurs, and community-based enterprises focused on sustainable farming solutions.

6. Potential commercialization

Agro Ferti Tech has strong commercialization potential as an affordable smart fertilization system for small-scale farmers, urban agriculture, educational institutions, and agri-training centers. The product can be offered as a plug-and-play hardware kit or customized solutions based on farm size and crop requirements. Potential revenue streams include hardware sales, system customization, maintenance services, and future subscription-based monitoring platforms. Strategic collaborations with agricultural agencies, cooperatives, and rural development programs can accelerate adoption. With scalable manufacturing and optional renewable energy integration, Agro Ferti Tech is well positioned for local and regional smart agriculture markets.

7. Acknowledgment

The authors thank Universiti Teknologi MARA Johor Branch, Pasir Gudang, for the facilities and academic support.

8. Researchers' Biography

Muhammad Aydil Mustaqim is a Diploma student in Electrical Engineering at Universiti Teknologi MARA (UiTM), Pasir Gudang Campus. He has a strong interest in innovation and smart technology, particularly in the integration of IoT-based systems and automation. Through hands-on project development, he continues to strengthen his technical skills in embedded systems and power electronics. His enthusiasm for learning and problem-solving reflects a strong commitment to professional growth and excellence in engineering.

Aznilinda Zainuddin obtained both her bachelor's degree and master's degree in electrical engineering from Universiti Teknologi MARA (UiTM), Shah Alam, Malaysia. Her research activities are centred on engineering education, inventive problem-solving, and space weather. Currently, she is a PhD student, and her research focuses on the development of prediction models for geomagnetically induced current.

Dr. Yusliza Jamalut is a Malaysian civil servant specializing in technology management and digital transformation. She holds a PhD in Management focused on IoT adoption in agriculture among agro-based MSMEs in Malaysia. Her research interests include IoT adoption, smart agriculture, MSME innovation, technology policy, and organizational change. She currently serves at the Ministry of Economy, contributing to national development planning specifically services industry, while actively publishing and engaging with academia, industry, and government nationwide.

Munirah Onn completed her PhD at the Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia (UTM), and is a Senior Lecturer at Universiti Teknologi MARA (UiTM). She holds a Bachelor of Science from UiTM and a Master of Science from UTM. Her achievements include UiTM's Best Degree Student, Best Thesis Writing, Vice-Chancellor Awards, and UTM's Best Master Programme Student award. She also has four years of industry experience as a Production Engineer, Research Officer, and Executive Chemist.

Deepfake Facial Image Forensics via Vision Transformer: A Transfer Learning Framework Leveraging Curated Multi-Source Datasets for Authentic and Synthetic Image Classification

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ABSTRACT

The proliferation of deepfake technology presents substantial challenges to digital media authenticity and cybersecurity infrastructure. This project presents a Vision Transformer- based detection system for identifying manipulated facial images. The approach utilizes transfer learning through fine-tuning a pre-trained ViT-base-patch16-224 model on a carefully curated dataset of 12,137 facial images, comprising 6,070 authentic and 6,067 synthetic samples. The dataset integrates images from established repositories (CelebA, FFHQ, FaceForensics++, Celeb-DF, DFDC) along with 600 self-collected images to enhance real-world applicability. The methodology incorporates comprehensive data quality assessment, systematic preprocessing with ImageNet normalization, strategic augmentation techniques, and rigorous stratified partitioning. Training employed the AdamW optimizer with carefully tuned hyperparameters over 8 epochs. The system achieved 99.01% test accuracy with balanced precision and recall across both classes, correctly classifying 1,202 of 1,214 test images. The results validate Vision Transformers as an effective architecture for image-based deepfake detection, with applications in digital forensics, content moderation, and cybersecurity.

Keywords: Deepfake detection, Vision Transformer, digital forensics, deep learning, image authentication

1. Product Description

This deepfake detection system addresses the growing challenge of synthetic media in digital environments. The system employs Vision Transformer architecture to distinguish authentic facial images from manipulated ones with 99.01% accuracy. Key features include balanced performance across both authentic and synthetic classes, rapid training convergence through transfer learning, and minimal misclassification rate. The system processes standard facial images through a systematic pipeline involving normalization, augmentation, and patch-based analysis using self-attention mechanisms. This enables detection of subtle manipulation artifacts that may not be visible to human observers. The

solution is suitable for deployment in digital forensics laboratories, social media platforms, biometric authentication systems, and law enforcement agencies. Applications extend to evidence verification, content moderation, identity validation, and security threat assessment. The complete implementation provides a reproducible framework for researchers and practitioners working to combat the spread of manipulated media.

2. Methodology and System Architecture

The system employs a Vision Transformer architecture (ViT-base-patch16-224) pre- trained on ImageNet and adapted for binary classification of facial images. The methodology encompasses several integrated stages. First, dataset curation involved collecting 12,137 images from multiple sources to ensure representation of various generation techniques and imaging conditions. This included both professional photography and smartphone captures to reflect real-world diversity. Second, thorough data quality assessment verified file integrity and identified resolution characteristics, with outliers below 200 pixels excluded from training to maintain spatial information quality. Third, preprocessing normalized all images to 224×224-pixel resolution with RGB standardization and ImageNet statistics normalization to match the pre-training distribution. Fourth, data augmentation applied random horizontal flipping, rotation within ±15 degrees, and color jittering to improve model robustness. Fifth, stratified partitioning allocated 70% for training, 20% for validation, and 10% for testing while maintaining class balance. Sixth, model training utilized AdamW optimization with a learning rate of 2×10^{-5}, weight decay of 0.01, batch size of 32, and gradient clipping to prevent instability. Training proceeded for 8 epochs with early stopping based on validation performance.

```
Dataset path: E:\Project_Dataset
Model/plots will be saved to: E:\final_training
Total images found: 12137 (Real: 6070, Fake: 6067)
Train: 8495, Validation: 2428, Test: 1214
Some weights of ViTForImageClassification were not initialized from the model checkpoint at google/vit-base-patch16-224 and are newly initialized because
a the shapes did not match:
- classifier.bias: found shape torch.Size([1000]) in the checkpoint and torch.Size([2]) in the model instantiated
- classifier.weight: found shape torch.Size([1000, 768]) in the checkpoint and torch.Size([2, 768]) in the model instantiated
You should probably TRAIN this model on a down-stream task to be able to use it for predictions and inference.
Model loaded: google/vit-base-patch16-224
Resuming training from checkpoint: E:\final_training\vit-deepfake-final\checkpoint-531
 [4248/4248 18:32:48, Epoch 8/8]
```

Epoch	Training Loss	Validation Loss	Accuracy	Precision	Recall	F1
2	0.071700	0.071473	0.972817	0.972943	0.972817	0.972815
3	0.049200	0.102520	0.969522	0.970523	0.969522	0.969506
4	0.020900	0.065665	0.981486	0.981469	0.981486	0.981486
5	0.016000	0.071890	0.980643	0.980698	0.980643	0.980642
6	0.000400	0.082781	0.983937	0.983977	0.983937	0.983937
7	0.001200	0.057256	0.985585	0.985593	0.985585	0.985585
8	0.001500	0.059226	0.985997	0.986009	0.985997	0.985997

```
Training completed.
Evaluating on test dataset...
{'eval_loss': 0.05043603922357559, 'eval_accuracy': 0.9901153212520593, 'eval_precision': 0.9901206421582597, 'eval_recall': 0.9901153212520593, 'eval_
f1': 0.9901152044241794, 'eval_runtime': 413.8503, 'eval_samples_per_second': 2.933, 'eval_steps_per_second': 0.367, 'epoch': 8.0}
```

Figure 1. Training performance metrics across 8 epochs showing convergence behavior.

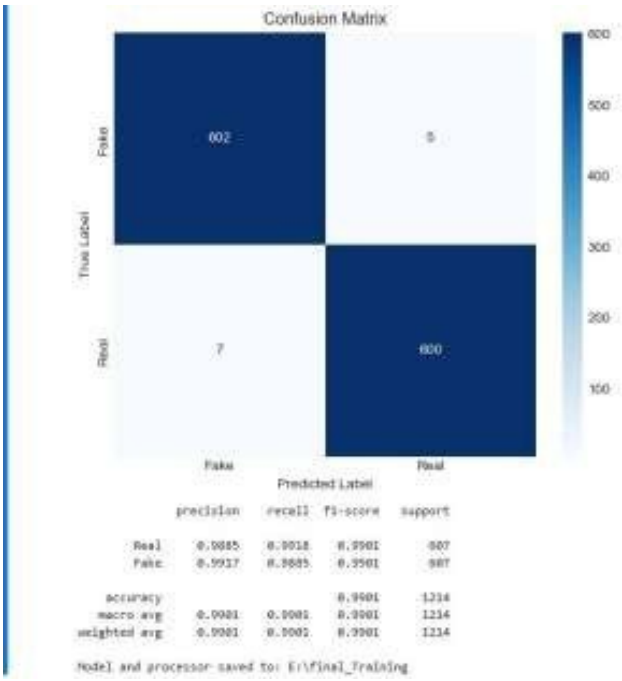

Figure 2. Confusion matrix demonstrating classification performance on test set.

3. Experimental Results

The model achieved 99.01% accuracy on the test set of 1,214 images. Performance analysis revealed 602 correctly identified synthetic images (true positives), 600 correctly identified authentic images (true negatives), 5 false positives, and 7 false negatives. This corresponds to precision values of 0.9885 for authentic and 0.9917 for synthetic images, with recall values of 0.9918 and 0.9885 respectively. The F1-scores of 0.9901 for both classes demonstrate balanced performance without systematic bias. Training convergence occurred rapidly, with training loss decreasing from 0.0717 at epoch 2 to 0.0010 at epoch 8, while validation loss stabilized around 0.05-0.06. The limited gap between training and validation metrics suggests effective generalization rather than overfitting. Analysis of misclassified images revealed that false positives typically involved authentic images with heavy beautification filters or extreme lighting conditions, while false negatives predominantly consisted of high-quality synthetic images generated using advanced diffusion models.

4. Novelty and Uniqueness

This work presents several distinctive contributions to deepfake detection research. First, it demonstrates the effective application of Vision Transformer architecture for facial manipulation detection, leveraging global self-attention mechanisms to identify subtle inconsistencies across spatially distant image regions. Unlike conventional approaches that rely primarily on local feature extraction, the transformer-based approach models long-range dependencies that may manifest in manipulation artifacts. Second, the dataset construction strategy combines established benchmark data with self-collected real-world images, addressing the temporal validity gap often present in deepfake detection research. The inclusion of 600 smartphone-captured images and contemporary synthetic samples ensures exposure to realistic imaging conditions and current generation techniques. Third, the methodology emphasizes transparency and reproducibility

through comprehensive documentation of data quality assessment, preprocessing steps, and training procedures. This facilitates independent verification and enables other researchers to build upon the work. The combination of high detection accuracy, balanced class performance, and reproducible implementation distinguishes this system from existing approaches.

5. Benefit to Mankind

The deepfake detection system addresses critical challenges in maintaining digital media integrity and protecting individuals from identity manipulation. By providing reliable identification of synthetic facial images, the system supports law enforcement investigations, protects public figures from malicious impersonation, and helps prevent the spread of misinformation. The technology contributes to maintaining trust in digital communications and protects vulnerable populations from exploitation through non- consensual synthetic media. Applications extend to verifying the authenticity of digital evidence in legal proceedings, screening uploaded content on social media platforms, and validating identity documents in security systems. The system's high accuracy and balanced performance ensure that legitimate content is not incorrectly flagged while maintaining effective detection of manipulated media.

6. Innovation and Entrepreneurial Impact

This project promotes innovation through the application of transformer-based architectures to digital forensics, demonstrating how advances in natural language processing can be effectively adapted for computer vision tasks in cybersecurity. The work contributes to building institutional capacity in artificial intelligence applications at The Islamia University of Bahawalpur, fostering technical expertise among students and researchers. The system's open-source approach and published dataset enable knowledge transfer within the academic community and industry practitioners. The methodology can serve as a foundation for commercial applications in content verification services, security consulting, and digital forensics tools. By addressing the practical challenges of deepfake detection with a reproducible and well-documented approach, the project encourages entrepreneurial ventures in the cybersecurity sector and supports the development of Pakistan's technology ecosystem.

7. Potential Commercialization

The detection system presents several commercialization pathways. First, it can be integrated as a software service for social media platforms and content-sharing websites requiring automated screening of uploaded images. Second, the technology can be licensed to digital forensics companies and law enforcement agencies for use in investigative workflows. Third, the system can form the basis of a standalone application for journalists and fact-checkers verifying the authenticity of visual content. Fourth, it can be incorporated into biometric authentication systems requiring liveness detection and anti-spoofing capabilities. The system's CPU-compatible design enables deployment without specialized hardware, reducing infrastructure costs for potential clients. The combination of high accuracy, interpretable results, and comprehensive documentation positions the system favorably for commercial adoption across multiple market segments.

8. Acknowledgment

The authors express gratitude to Dr. Asjad Amin for his guidance and supervision throughout this project. We acknowledge The Islamia University of Bahawalpur for providing the necessary resources and supportive academic environment. We thank the researchers and institutions who developed and shared the public datasets that contributed to this work, including the creators of CelebA, FFHQ, FaceForensics++, Celeb-DF, and DFDC datasets. We also appreciate the Kaggle community for maintaining accessible repositories of deepfake detection datasets.

9. Researchers' Biography

Ahmad Raza is a final-year B.S. Cyber Security and Digital Forensics student at The Islamia University of Bahawalpur, working under the supervision of Dr. Asjad Amin. He serves as Vice Chair of the IEEE EMBS Chapter at the university. He contributed to the design and implementation of the Vision Transformer-based deepfake detection system, including dataset curation, preprocessing pipeline development, and model fine-tuning. His research interests include deep learning, digital forensics, and AI-driven media authentication. Ahmad has a keen focus on applying transformer architectures to cybersecurity challenges and is committed to advancing reproducible methods in synthetic media detection.

Abdul Basit is a final-year B.S. Cyber Security and Digital Forensics student guided by Dr. Asjad Amin at The Islamia University of Bahawalpur. He played a central role in the exploratory data analysis, data augmentation strategies, and evaluation framework of the ViT-based deepfake forensics project. Abdul contributed to the systematic preprocessing pipeline and performance benchmarking against existing detection methods. His interests span machine learning, image forensics, and the development of robust detection systems capable of generalizing across diverse manipulation techniques.

Dr. Zeeshan Ahmad Arfeen is an Assistant Professor in the Department of Electrical Engineering at The Islamia University of Bahawalpur, Pakistan. He received his doctorate from University Technology Malaysia (UTM), Johor Bahru, Malaysia. He is a Senior Member of IEEE, member of IEEE Power and Energy Society (PES), life member of IEEE Pakistan, and member of The Institution of Engineers Pakistan (IEP). He is also a life member of the Pakistan Engineering Council. Dr. Arfeen has authored and co-authored over 50 publications in high-indexed journals along with numerous conference papers and book chapters. He serves as a reviewer for numerous international conferences and journals. His research was recognized with a Partial Doctoral Scholarship from the Higher Education Commission (HEC) Pakistan, an International Doctoral Fellowship (IDF), and UTM Young Scholarship Grant from the University of Technology

Malaysia. His publications have been among the most downloaded and cited papers in their respective domains, with papers recognized as top-cited by Wiley and MDPI publishers. His research interests include power systems, renewable energy, electrical engineering applications, and engineering.

Dr. Engr. Zain ul Abiden Akhtar is an Assistant Professor in the Department of Information and Communication Engineering, Faculty of Engineering, at The Islamia University of Bahawalpur, Pakistan. He has established a strong research profile with over 130 citations and an h-index of 7. His research interests span wireless sensing, image processing, and intelligent vehicles, with a focus on WiFi-based activity and gesture recognition systems for next-generation Internet of Vehicles. He has authored and co-authored over 18 publications in reputable international journals including Neurocomputing, Sensors, Applied Sciences, and IET Communications. His notable works include WiFi-based driver activity recognition, vehicle type identification, and face pose estimation using fine-grained signals. Dr. Akhtar has actively collaborated with researchers across institutions including Dalian University of Technology and Punjab Tianjin University of Technology, contributing to advances in intelligent transportation systems and wireless communication.

AI-Based Predictive Energy Demand and Load Optimization System

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ABSTRACT
The given project describes an AI-based predictive energy demand and load optimization system that will enhance energy efficiency, decrease peak loads, and minimize cost of operations in buildings and energy networks. As opposed to the traditional energy management systems which can only use real time or past data, the proposed system predicts future demand through intelligent prediction models and incorporates pre-emptive control strategies before situations get out of control. The system can be fully operated using only software, and there is no requirement of smart meters or additional sensors or infrastructure improvements, which makes it very appropriate in the context of already existing buildings and resource-limited conditions. It brings in a dynamic load prioritization system that categorizes the loads according to the estimated demand severity as essential operations cannot be affected, and non-essential loads can be rescheduled in the best manner. Web-based optimization by incorporating a multi-objective system will enable the system to optimize energy reduction, peak shaving, and cost minimization simultaneously in a balanced form. The offered solution will be scalable digital energy intelligence layer that could be expanded not only to individual buildings but also to large-scale smart grid settings. This innovation helps to ensure sustainable energy control, minimized carbon footprint, and enhanced economic performance and possesses a high potential of subsequent commercialization and integrating into a smart city.

Keywords: Artificial Intelligence, Energy Demand Prediction, Load Optimization, Peak Shaving, Smart Energy Management

1. Product Description
The AI-Based Predictive Energy Demand and Load Optimization System is an artificial intelligence-based software that would help to manage energy consumption intelligently through the ability to predict future patterns of energy demand. The system carries out a historical examination of energy usage data with historical contextual parameters to anticipate future load behavior and awareness of potential peaks. According to these forecasts, electrical loads are given a dynamic priority by the system and optimized scheduling plans are used to avoid spikes of energy and to ensure continuity of operations. Critical loads are maintained, and non-critical loads are relocated or rescheduled during times of low demand. The major benefit of the system is that it is not related with any other hardware, and it can easily be implemented in any existing infrastructure, without costly upgrades. The framework also includes a multi-objective optimization system that puts into consideration the energy efficiency, cost reduction and the system reliability. The solution will be deployed as a scalable digital energy intelligence layer that can be extended to a larger smart grid platform in the future, serving to scale small buildings all the way to a large energy network.

2. Schematic diagrams

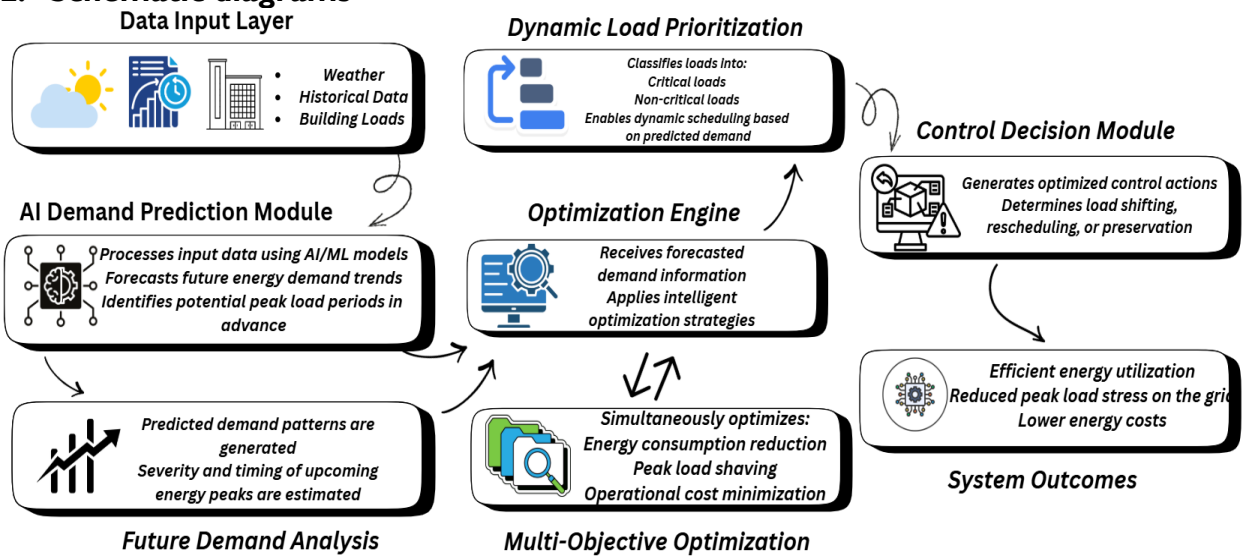

Figure 10 Overall Architecture of the AI-Based Predictive Energy Demand and Load Optimization System

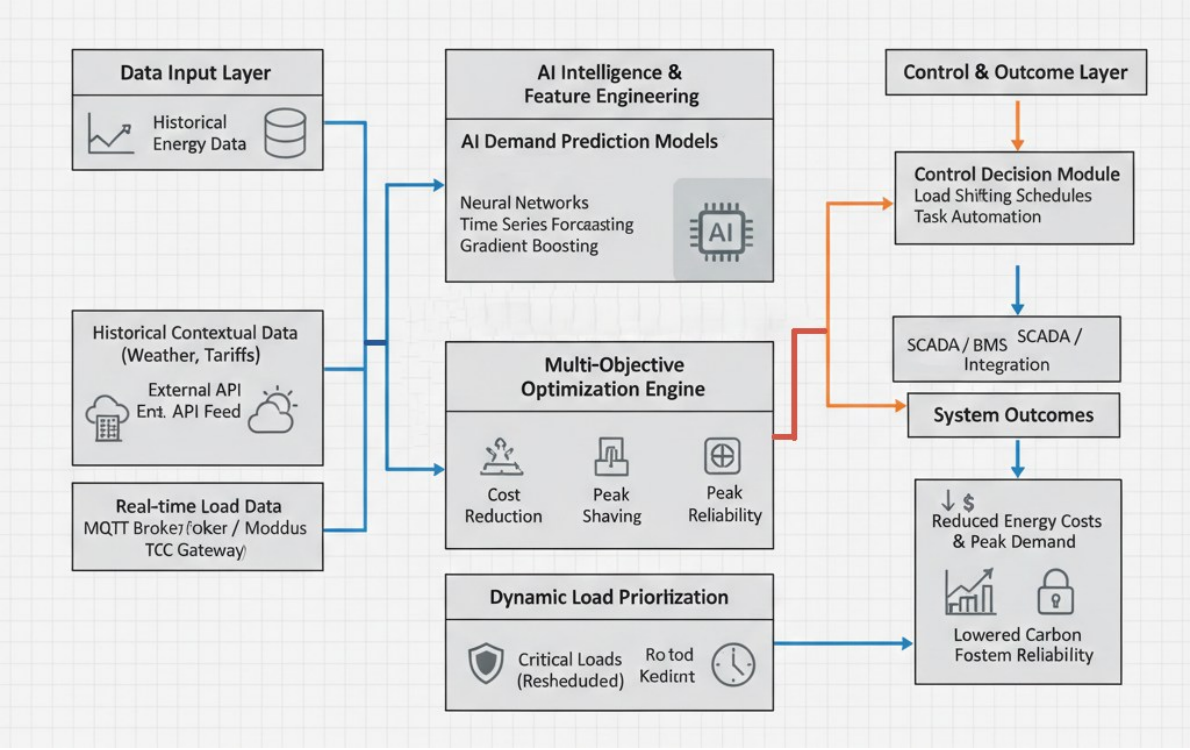

Figure 11 Section wise workflow of Load Optimization System

Table 5 Performance Evaluation Results on Custom Energy Consumption Dataset

Metric	Baseline Energy System	Rule-Based Load Control	Proposed AI-Based Predictive System
Average Daily Energy Consumption (kWh)	520	470	410
Peak Load Demand (kW)	92	78	61
Peak Load Reduction (%)	–	15.2%	33.7%
Energy Cost per Day (USD)	78.5	69.4	58.1
Cost Reduction (%)	–	11.6%	26.0%
Load Scheduling Efficiency (%)	65	78	92
Critical Load Interruption	Yes	Rare	No
System Response Type	Reactive	Semi-Reactive	Predictive (Future-Aware)

3. Novelty and uniqueness

This project is new in the sense that it will have a future conscious energy control mechanism where the management of energy is not reactive but rather proactive in decisions. The proposed solution is unique in the sense that it predicts the trend of energy consumption and optimistically controls loads in advance of the development of peak conditions as compared to traditional systems which only react to alterations in demand.

The third distinguishing feature is the software-only implementation of the system, and the fact that it does not rely on the smart meters, sensors, or hardware updates. This reduces considerably the deployment expenses, and also increases the flexibility of current buildings and emerging areas.

Also, the dynamic load prioritization logic is used because operational continuity is provided through smart protection of priority loads and the re-scheduling of non-essential loads. Multi-objective optimization used also makes the system stand out in a way that it balances the energy efficiency, peak shaving and cost reduction at the same time.

All these features combined would create a scalable digital layer of intelligence that has the potential to change with the future smart grid infrastructures.

4. Benefit to mankind

The offered system is useful in terms of supporting sustainable energy use as it may eliminate the instances of unnecessary consumption and avoid overload of the energy peaks. The solution will also help in making intelligent energy management available to more people including the developing regions by making them more energy efficient without necessarily having to upgrade their infrastructure.

The low peak demand reduces power grid pressure, reduces carbon emissions and promotes environmental sustainability. The savings of costs due to the optimized energy use are beneficial to households, business, and institutions. All in all, the system assists in aiming at energy security, economical performance, and environmental safeguards.

5. Innovation and Entrepreneurial Impact

The project is an innovative and represents AI base predictive intelligence to traditional energy management activities. It is software-based architecture and fosters quick adoption and experimentation without massive capital investments.

As an entrepreneur, the system creates a new business model of optimizing energy services, software use-based solutions, and intelligent buildings. It promotes the development of digital energy startups and tries to foster collaboration between industry, academia and smart city projects.

6. Potential commercialization

There is high commercialization potential of the system as a software which optimizes energy use on its own or as a built in module inside the specification of existing building management systems. It may be sold to commercial premises, schools, hospitals, and industries that would like to find an economical way of accessing energy.

Its scalability can be expanded to smart grid applications and energy analytics platform and AI-driven utility services. It is afforded by low deployment cost and high adaptability attractive to local and international markets.

7. Acknowledgment

Another aspect would be to give credit to the institution, their supervisors, and their partners in terms of support and help they gave throughout the entire process of developing this project.

8. Researchers' Biography

Muhammad Inam ul Haq an undergraduate researcher in Electronic Engineering, The Islamia University of Bahawalpur, Pakistan. He is a Double Gold Medalist and National Award Recipient of Pakistan, having received a Gold Medal from the Government of Pakistan (Medal No. GPK-GM-2025-017) and a Gold Medal from the Parliament of Pakistan (Medal No. PPK-GM-2025-042). I am also a National Award Recipient (National Award ID: NA-PK-EE-2025-311) in recognition of engineering innovation and research excellence. He is also an active member of the Center of Automation, Robotics, and Embedded Systems (CARE), where I engage in interdisciplinary research and applied engineering. My research interests include artificial intelligence, VLSI and IC design, FPGA-based acceleration, embedded and cyber-physical systems, and secure hardware–software co-design. In parallel, He is involved in research projects related to military and national security applications, with a focus on quantum intelligence and resilient cyber-physical infrastructures. My long-term goal is to develop secure, energy-efficient, and intelligent systems for next-generation computing, healthcare, and critical infrastructure.

Muhammad Wasim a researcher in Electronic Engineering, The Islamia University of Bahawalpur, Pakistan. He has competed many projects about power generation and energy saving. A full size ceiling fan 56" powered by a cell phone battery. Cell phone battery charging system through walking for shoes with piezoelectric. Hydrogen fuel cell and hydrogen production from water with cheap way and running a bike through hydrogen. Cell phone charging system through radio signals coming from cell towers. A Smart watch where sound transfer from wrist to finger. The listener put finger on his ear to listen to the call. A water purifier and micro plastic remove the system from a muddy water. Charging free Magnesium based water battery system design from disaster and remote arias.

Zeeshan Ahmad Arfeen is an Assistant Professor in theDepartment of Electrical Engineering in "The Islamia University of Bahawalpur," Pakistan. He doctorate from University Technology Malaysia (UTM) Skudai Johor Bahru, Johor, Malaysia. He is a senior member of the IEEE organization NJ. USA, member of IEEE Power and Energy Society (PES), life member IEEE Pakistan, and member of "The Institution of Engineers Pakistan" (IEP). Further, he is also a life member of the Pakistan Engineering Council. Arfeen is an Author/Coauthor of 50+ high indexed Journals with several conferences and book chapters and a distinguished potential reviewer of hundred International Conferences Proceedings and hundred International Journals. He was awarded a Partial doctoral scholarship from the Higher Education Commission (HEC) Pakistan. Arfeen also got an International doctoral fellowship (IDF) and UTM Young Scholarship Grant from the University of Technology Malaysia (UTM). His paper was the most downloaded in 2019 and 2020 and two of papers Wiley's and MDPI publisher's top 10 cited papers in 2020 and top downloaded.

Abdur Raheem received his Bachelor and Master in Electrical Engineering from University of Engineering & Technology (UET) Lahore, Pakistan. He held different research and teaching posts during his services in Pakistan. He received his Ph.D. degree from Universiti Teknologi Malaysia (UTM) where he has been involved in research of Optimization of pre-treatment techniques of anaerobic digestion of biomass. He published his papers in international reputed journals in the field of electrical engineering and renewable energy systems. His research interests include cost effective optimization of different combinations of wind turbines, bioenergy and PV arrays. Currently he is working as an Assistant Professor in Electrical Power Engineering Department, The Islamia University of Bahawalpur (IUB).

Automated Pet Feeding System with Sensor Monitoring and Activity Alerts

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ABSTRACT
This project introduces an autonomous pet dispenser system that automates food and water dispensing while providing real-time monitoring. The method was created to address difficulties such as uneven feeding schedules, inaccurate portion sizes, and the need for constant supervision, providing pet owners with a more dependable and convenient feeding solution. Using an ESP32 microcontroller with Wi-Fi connectivity, the system incorporates an ultrasonic sensor to detect water level, a load cell with HX711 to measure dispensed food weight, and a PIR sensor to detect pet presence. A camera streams live footage from the feeding area, and outputs such as a servo motor, water pump, and buzzer enable precise dispensing and timely alarms. An LCD displays feeding information, such as food weight, water level, pet activity, and the next feeding timer, which is then transferred to the cloud every minute for remote access. The system has several distinct features, including automated portion control, continuous monitoring, and IoT-based remote operation. The approach promotes healthy eating habits and reduces food waste, which has social and environmental benefits. Its functional design and use of low-cost components make it a great candidate for commercialisation in the smart pet-care sector.

Keywords: IoT and ESP 32

1. Product Description
In recent years, research on automatic pet feeding systems has remained relatively limited. Over the last two decades, only two major research have looked into wireless control systems designed exclusively for dogs. Despite this, previous research on automated pet feeders has resulted in a number of technical systems that incorporate scheduling functions, remote control capabilities, and monitoring features to assist with pet care. This review looks at and analyses similar systems to assess their strengths and weaknesses, with the goal of finding and avoiding common flaws in the construction of an improved automated pet feeding. The proposed autonomous pet dispenser system is designed around an ESP32 microcontroller with Wi-Fi connectivity, which serves as the core processing and communication unit. The design includes several sensors, such as an ultrasonic sensor for distance detection, a load cell linked with a HX711 amplifier for weight measurement, a PIR sensor for motion detection, and a camera for visual monitoring. The ESP32 processes data obtained from these sensors and activates a servo motor, water pump, and buzzer as needed. System status data is shown on an LCD screen and transmitted to the cloud via an IoT platform. The Blynk application also allows users to dispense food remotely, providing pets with a handy and effective feeding solution.

2. Automated Pet Feeding System

Figure 1 shows the automated pet feeder system's decision-making loop. The process begins with a check of the food's weight and water level. If the water level is less than 9 cm, the system pauses two minutes before reassessing. When the level remains insufficient, a notification is sent to the IoT platform and LCD, and the water pump is turned on until the level reaches 9 cm. Similarly, food dispensing is initiated when the meal weight is less than 12 g. The device notifies the user by IoT and LCD, engages the servo motor to refill food, and stops once the required weight has been reached.

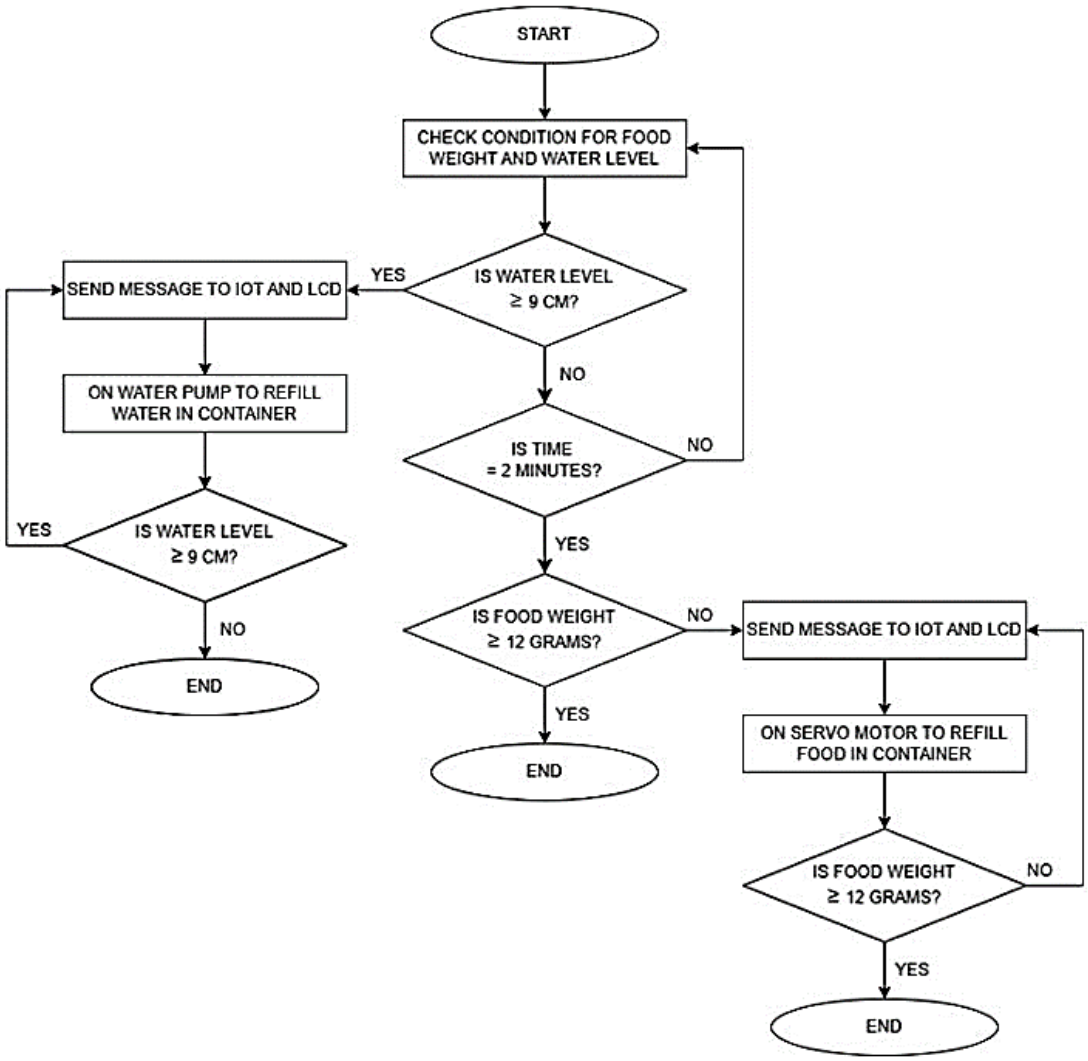

Figure 1. Flowchart of pet feeder.

Figures 2 and **3** shows the simulation result to test dispensing function using LCD display outputs during and after the food distribution procedure. **Figure 2** shows that food is currently being distributed and includes real-time readings such as water level, clock time, and pet presence status. This offers immediate input while the servo motor is operating. **Figure 3** depicts that once dispensing is complete, the message changes to "Food dispensed!" while the sensor data

remains updated. These displays show that the ESP32 evaluates inputs from the ultrasonic sensor, load cell, PIR sensor, and camera before clearly communicating system status to the user via the LCD interface.

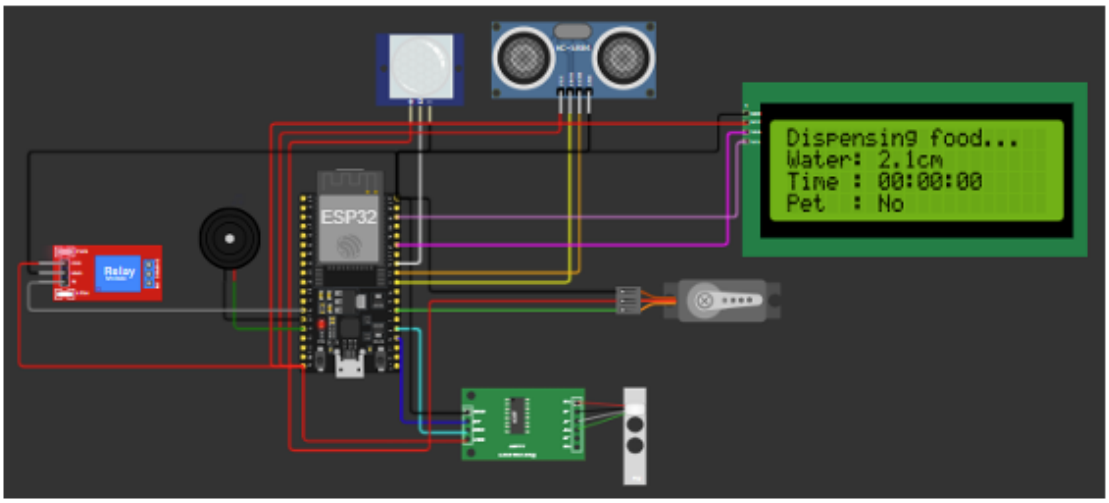

Figure 2. Output display while dispensing food.

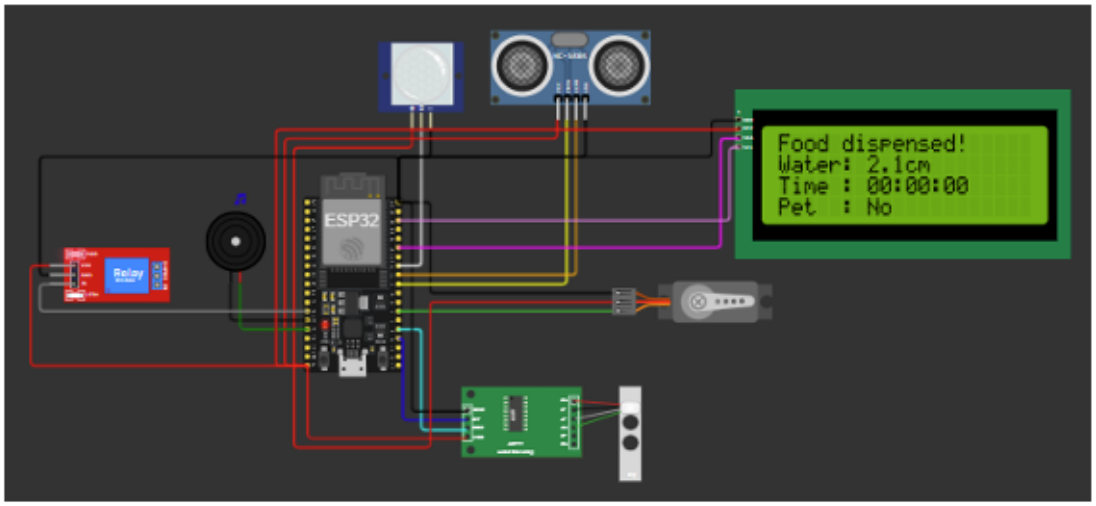

Figure 3. Output display after dispensing food.

Figures 4 and **5** show the sensor interaction in the system, as well as the finalised prototype. **Figure 4** illustrates the LCD output when the PIR sensor detects a pet near the feeder, displaying real-time data such as food weight, water level, time, and pet presence status ("Yes"). This demonstrates that the system is actively responding to adjacent motion. **Figure 5** shows the completed prototype, which includes integrated food and water containers, an LCD display, control electronics, and housing components. The design demonstrates all sensors, actuators, and the ESP32 microcontroller are combined to create a working, user-friendly automated feeding system.

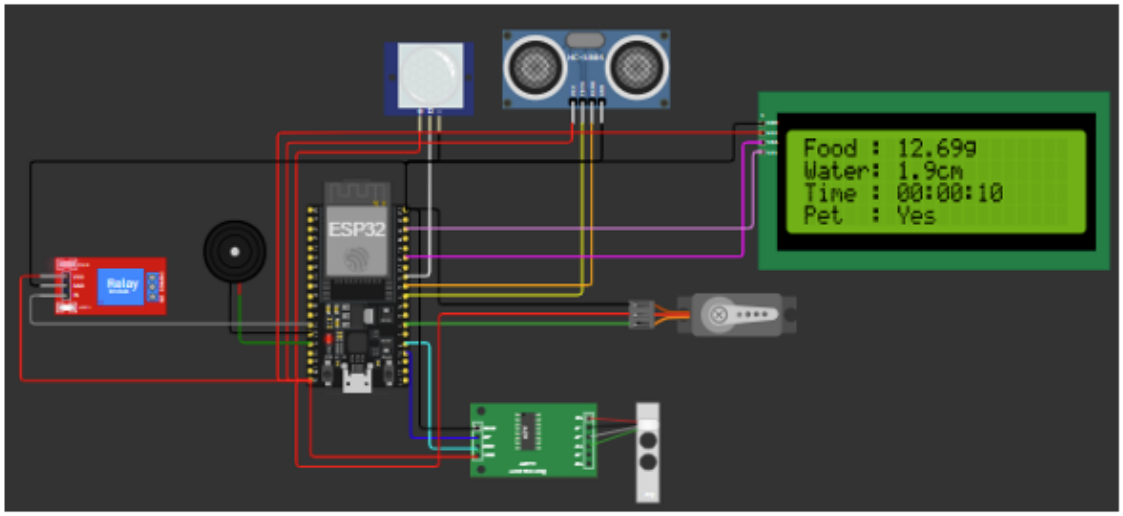

Figure 4. Output display when pet near the feeder.

Figure 5. Complete prototype.

The graphic depicts the IoT dashboard interface for an automated pet feeder system. The dashboard shows the device's status as online and allows access to controls and live sensor data. The user can engage food dispensing or water replenishing remotely by using two major switches: FOOD and WATER. Real-time readings are displayed beneath each switch: the WEIGHT gauge displays 17 grams of food identified in the tray, while the LEVEL gauge shows a water height of 7 cm. The interface also features time range options (live, hourly, daily, weekly, monthly, and yearly), allowing users to track trends in feeding behaviour over time.

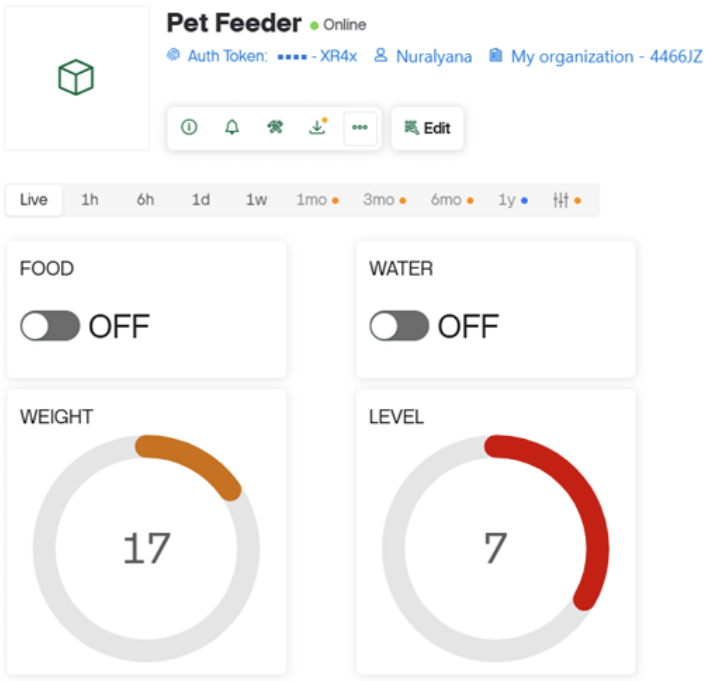

Figure 6. Remote Control of dispensing system.

3. Novelty and uniqueness

This project is unique in that it integrates automated feeding, water distribution, pet presence recognition, and live video monitoring into a single, low-cost IoT-based system built on the ESP32 platform. Unlike typical pet feeders, which essentially automate scheduled food release, this design includes a load cell for exact portion measuring, an ultrasonic sensor for monitoring and managing water levels, a PIR sensor for detecting pet activity, and a camera for real-time visual monitoring. The ESP32 controls all of these components, guaranteeing flawless data gathering and system responsiveness. The system is designed with dual-mode operation, which allows for both autonomous, sensor-driven decision-making and manual remote control via IoT apps, is a crucial differentiator. Users can override automatic activities as needed, enabling flexibility without sacrificing reliability. In addition, the system continuously logs operational and environmental data to the cloud, allowing for real-time notifications, historical analysis, and a better knowledge of pet behaviour. The suggested method goes beyond typical time-based feeders by integrating automation, sensing, remote connectivity, and data analytics to provide a more intelligent, responsive, and holistic approach to pet care. This level of integration distinguishes the technology from current automated feeding technologies.

4. Benefit to mankind

This approach serves society by improving animal care while lowering the everyday responsibilities of pet owners, particularly those with hectic schedules, the elderly, or frequent travellers. Consistent feeding, adequate hydration, and continual monitoring help minimise neglect, underfeeding, and overfeeding, fostering healthier pets and providing owners with better peace of mind. More broadly, the initiative demonstrates how affordable IoT technology can be used to create smart living solutions, fostering innovation in home automation and responsible

pet management. Its scalable architecture also allows for future applications in veterinary monitoring, animal shelters, and assistive care systems, indicating a high potential for widespread adoption.

5. Innovation and Entrepreneurial Impact

This project has significant commercialisation potential due to its practical functionality, modular design, and usage of low-cost IoT components, making it suitable for mass production at a cheap cost. The system appeals to budget-conscious owners and emerging markets by incorporating high-end feeder features such as portion control, remote monitoring, real-time notifications, and camera watching, as well as the ability to track a cat's food intake for early health diagnosis. Its flexible design allows for numerous product tiers, ranging from basic feeders to advanced smart-care models with cloud services. With additional development and safety compliance, the system might be sold through stores, e-commerce platforms, and smart-home ecosystems.

6. Potential commercialization

The primary target users for this system are working pet owners and individuals with disabilities, both of whom often face challenges in maintaining consistent feeding routines. For busy owners with lengthy work hours or frequent travel, the system provides consistent, planned feeding and monitoring without requiring constant physical presence. For disabled owners, automated functions like remote dispensing, real-time warnings, and health tracking significantly minimise the physical effort required for regular pet care. The system promotes independent, stress-free pet management by combining automation, IoT connectivity, and user-friendly controls, boosting owner convenience while assuring pets receive consistent feed and care.

7. Acknowledgment

This work was supported by the Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, Masai, Malaysia.

8. Researchers' Biography

Nuralyana Binti Omar Bahsir is a final year student in Electrical (Electronic) Engineering at the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM), Johor Branch, Pasir Gudang Campus, Malaysia. Her academic interests include embedded systems, Internet of Things (IoT) applications, control systems and power electronics. She is currently undertaking her final year project related to smart and automated systems, focusing on practical implementation and system integration. Her work reflects a strong interest in applying engineering knowledge to real-world problem solving.

Fatimah Khairiah Abd Hamid received the B.Eng. Degree in Electrical-Electronic from Universiti Teknologi Malaysia, in 2011. Meanwhile, she pursued her Master and PhD in Electrical Engineering in the same university in 2013 and 2016, respectively. She is currently a senior lecturer with the Faculty of Engineering, Universiti Teknologi Mara. Her research interests include modelling and simulation nanoscale transistor, radar and satellite system, sensor and IOT application.

Suhaili Binti Beeran Kutty is a Senior Lecturer at the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM), Johor Branch, Pasir Gudang Campus, Malaysia. She holds a PhD in Multimedia Computing from Universiti Putra Malaysia, a Master's degree in Computer Science from Universiti Teknologi Malaysia, and a Bachelor's degree in Information Technology (Hons) from Universiti Malaya. Her expertise includes image processing, artificial intelligence, Internet of Things (IoT), and application-based system design.

Smart Urban Farming and Irrigation System

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ABSTRACT
This project highlights the application of modern technology in engineering practice and its potential benefit to sustainable food security and environmental conservation . his mini project presents the development of a Smart Urban Farming and Irrigation System to address the inefficiency of manual watering and the need for precision agriculture in limited urban spaces. The system was developed using an Arduino Uno as the main microcontroller, with circuit simulation conducted in Wokwi, system layout designed using AutoCAD, and data analysis performed using Microsoft Excel. Soil moisture sensors continuously monitor real-time moisture levels, and when the value falls below a predefined threshold, the Arduino automatically activates a water pump to irrigate the crops until the desired level is reached. Simulation results show that the system successfully automates the irrigation process and maintains consistent soil moisture, indicating reliable system performance. From a socio-economic perspective, the system reduces labor dependency and operational costs while improving accessibility to smart farming technologies. In terms of socio-environmental impact, it supports water conservation and sustainable urban food production. The system also demonstrates strong commercialization potential as a low-cost, scalable solution for home gardens and small urban farms.

Keywords: Smart Irrigation, Urban Farming, Arduino Automation, Precision Agriculture, Water Conservation

1. Product Description
As global urbanization accelerates, the available land for traditional agriculture is rapidly decreasing, creating a critical need for innovative food production methods like precision agriculture to optimize resource usage [1]. However, urban farming currently faces significant challenges regarding inefficiency, as traditional manual irrigation methods often rely on estimation, leading to water wastage and inconsistent plant health due to a lack of real-time monitoring [4]. To address this, this mini project aims to design and validate a Smart Urban Farming and Irrigation System that automates water delivery based on soil moisture levels. The project focuses on the development of a small-scale prototype using an Arduino Uno microcontroller, with circuit functionality simulated in Wokwi, physical layout designed in AutoCAD, and performance data analyzed using Microsoft Excel. By integrating these modern engineering tools, the project seeks to validate a cost-effective solution that ensures optimal soil

hydration while adhering to sustainable practices, although the scope is limited to local automation without internet-based remote monitoring features.

2. System Diagram

Figure 1 shows the system diagram of soil irrigation systems. The soil irrigation system mostly will be used on a large scale for farming purposes. The purpose of the system is to provide plants with the right amount of water at the right time to make root growth at the same time to prevent the plant's root from being damaged. The soil irrigation system is significant toward the environment because it controls water usage and reduces water bills. Hence, to ensure it does not affect water supply and enhance food supply.

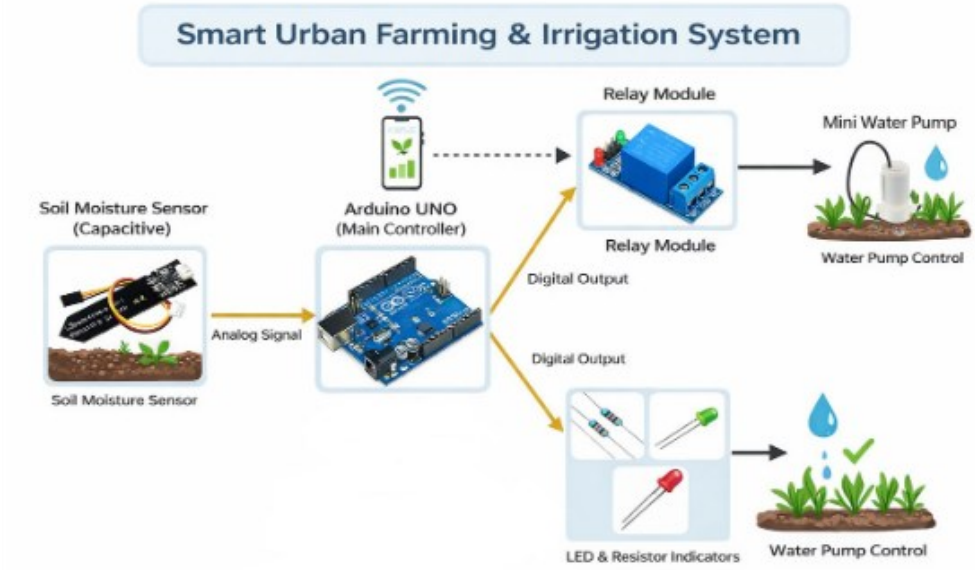

Figure 1. System Diagram.

Block Diagram

Figure 2 shows an input component that is a soil moisture sensor, relay module, Arduino UNO, water pump, and LED. This system monitors the amount of soil moisture whether it is dry soil or moist soil. A range of specified numbers to measure soil moisture has been set. If the moisture of the soil deviates from the specified range, the watering system will turn off or on. If the situation of the soil is dry, it will activate the irrigation system, pumping water for watering the plants. It needs Arduino UNO the microcontroller act as the main component in the system to reads and processed the input that come from soil moisture sensor and control the output components like LEDs to show whether the soil is dry or moist through programmed instructions by showing red or green light by using Arduino IDE software. Also, based on sensor reading by the Arduino UNO, it will send a signal to relay module to activate the water pump to on or off .

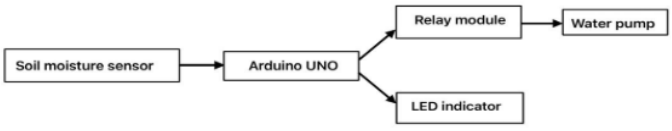

Figure 2. Block Diagram.

Schematic Diagram

Figure 3 shows a schematic diagram of soil irrigation systems. The soil moisture sensor is connected to the Arduino by connecting its VCC pin to the 5V pin of the Arduino, its GND pin to the Arduino GND, and its analog output (AO) pin to analog pin A0, which allows the Arduino to read the soil moisture value. LCD with I2C module is connected by wiring its VCC to the Arduino 5V, GND to GND, SDA to pin A4, and SCL to pin A5 on the Arduino Uno, enabling I2C communication for displaying soil status and sensor values. The red LED is connected to digital pin 6 through a 220-ohm resistor, with its cathode connected to GND, and it turns on when the soil is dry. The green LED is connected to digital pin 7 through a 220-ohm resistor, with its cathode connected to GND, and it lights up when the soil is wet. The buzzer is connected with its positive terminal to digital pin 8 and its negative terminal to GND, producing a beeping sound when the soil is dry. All components share a common ground to ensure proper operation of the circuit.

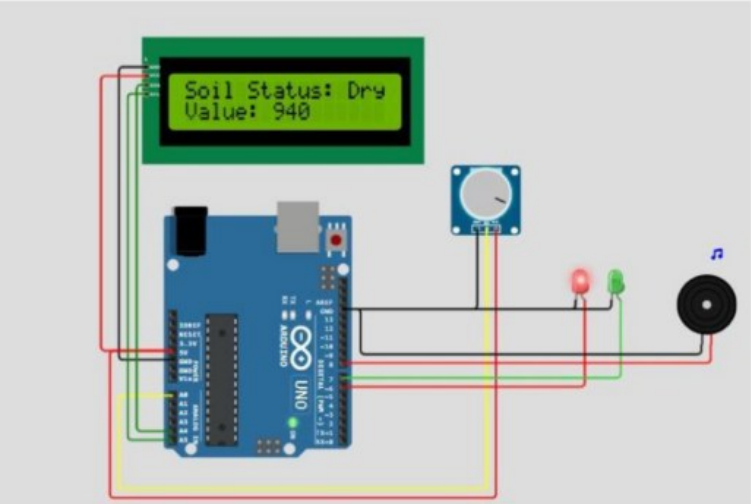

Figure 3 : Schematic Diagram

Flowchart Diagram

Figure 4 shows flow chart diagram of smart urban farming and irrigation system. The process will begin when the Arduino is powered on. Arduino sets up and defines the input and output (I/O) pins such as it designates the soil moisture sensor as an input while relay and LEDs as outputs. The systems will read soil moisture sensor input to process input from the sensor value against the threshold that is programmed. If the input from soil sensor measures below 450, Arduino will send signal to green LED to turn it on, but relay, water pump and red LED will off, signaling the plant is hydrate. Otherwise, if the sensor measures above 450, Arduino will send a signal to red LED to turn on, but relay, water pump and green LED will off, signaling a low water warning. The system will run continuously in a loop.

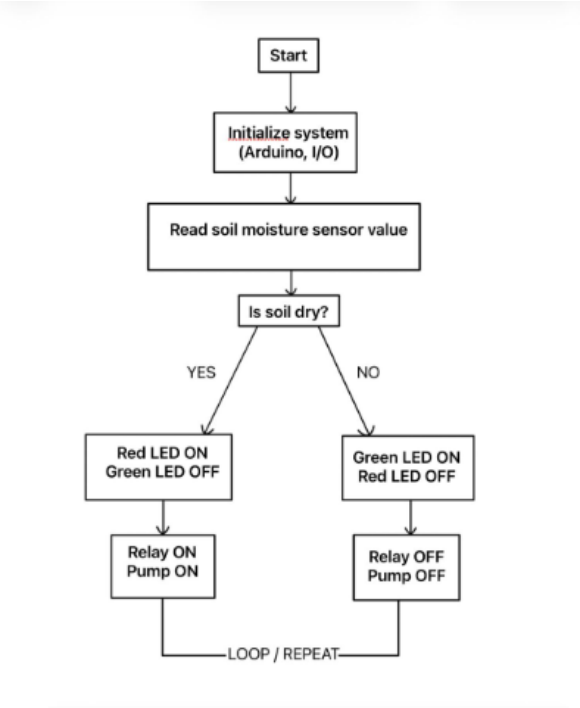

Figure 4 : Flowchart Diagarm

Wokwi Simulation

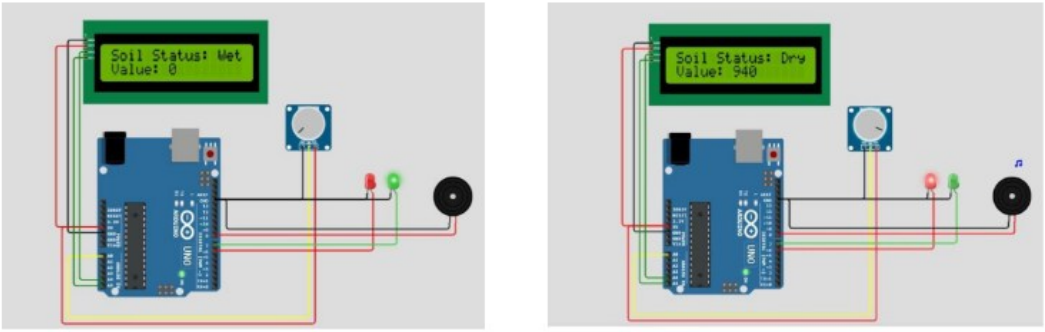

Figure 5. Condition of soil status (left) Below 450, (right) Above 450 .

Excel Data Record

Figure 6 shows data record of time soil sensor value, threshold, soil condition value, red LED, and green LED.

Data Soil Irrigation System					
Time	Soil Sensor Value	Threshold	Soil Condition Value	Red LED	Green LED
1	650	450	Dry	ON	OFF
2	620	450	Dry	ON	OFF
3	400	450	Wet	OFF	ON
4	380	450	Wet	OFF	ON
5	500	450	Dry	ON	OFF

Figure 6. Excel.

Result

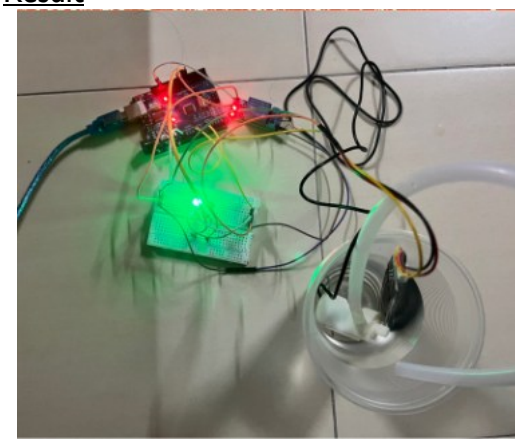

Figure 6. Wet Soil.

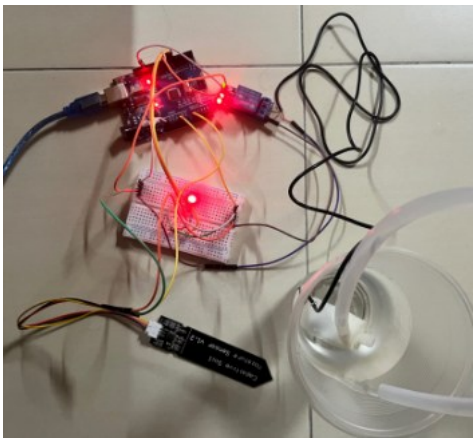

Figure 7. Dry Soil.

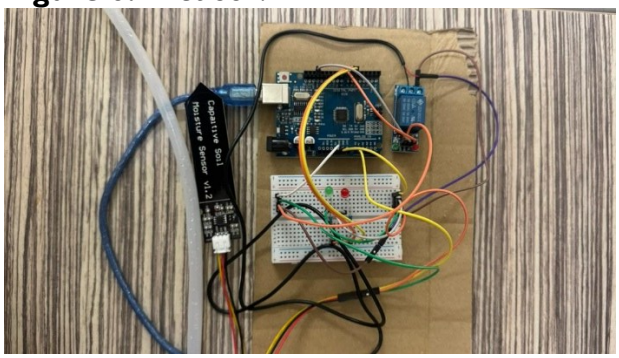

Figure 8. Hardware.

3. Novelty and uniqueness

Unlike traditional manual watering, this system utilizes a closed-up feedback mechanism via soil moisture sensor to ensure plants receive water only when necessary. The novelty lies in its precision driven approach to urban micro farming by integrating an Arduino based controller with real time sensor data. It eliminates human error and "over watering" syndrome common in small scale gardening. Its compact design is specifically optimized for high density urban environment (like balconies or indoor flats) where space is a premium and water conservation is critical.

4. Benefit to mankind

This project addresses the global challenge of water scarcity by reducing agricultural water waste through automated precision. For the modern urbanite, it lower the barrier to entry for "home-grown" food, promoting food security and mental well-being. By automating the most time-consuming part of gardening, it allow elderly individuals or busy professionals to maintain a sustainable food source. Furthermore, it encourages the greening of urban "concrete jungles", which helps in reducing the urban heat island effect and improving local air quality.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by transitioning traditional agriculture into Agri-Tech. It fosters an entrepreneurial culture by demonstrating that sophisticated automation can be achieved using

affordable, off the shelf components like Arduino Uno. Within an institutional setting, it serves as a prototypes for "Smart Campus" initiatives. By providing a low cost blueprint for automation, it empowers local community hobbyist to scale up their production, potentially turning home gardens into small-scale commercial ventures, thereby stimulating the local "green community".

6. Potential commercialization

This project has good potential to be sold because it solves a common problem for people living in apartments who are too busy to water their plants. Since the part we used like Arduino Uno and soil sensors are very affordable, we can sell this system at a low price that students and families can afford. We can sell it in two ways. First as a "DIY Kit" for students who want to learn about electronics and farming. Second, as a ready-to-use product for home balconies. We can make it look more professional by using a 3D-printed case to protect the wires. It is a simple, low-cost solution for anyone who wants to start a small "Smart Farm" at home.

7. Acknowledgment

We want to express our deepest gratitude to our supervisor and the faculty of the Electrical Engineering for their gratitude and for providing the laboratory facilities necessary to complete this project.

8. Researchers' Biography

Nurhelyshahana Ramadanina binti Aidil Fitri is a Semester 3 student in Electrical Engineering (Power) at Universiti Teknologi MARA (UiTM). She is currently developing her knowledge in electrical systems, power generation, and related engineering fundamentals. As a dedicated student, she is motivated to improve both her technical and practical skills through academic learning and hands-on experience. She is eager to gain new knowledge and grow as a future electrical engineer.

Nur Syafinaz Binti Mohammad currently pursuing her Diploma in Electrical Engineering at University teknologi MARA(UiTM). Her academic focus is on building a robust understanding of electrical principles and engineering design. She is disciplined student who thrives in collaborative environments and is committed to achieving excellence in both theoretical studies and practical applications within the engineering field,

Nur Faqihah Natasha binti Mohd Ridzuan is a Diploma student in Electrical Engineering (Power) at Universiti Teknologi Mara (UiTM). She is developing basic knowledge in electrical and power engineering through her studies and aims to further improve her skills and understanding throughout her diploma programmes.

Nor Diyana Md Sin is an Associate Professor in Electrical Engineering at Universiti Teknologi MARA (UiTM), Malaysia. Her research interests include sensor technology, metal oxide semiconductors, and nanotechnology, with a focus on research that contributes to academic advancement and broader societal impact.

FISHDA: An IoT-based Solar-Powered Automated Tilapia Feeding System with Real-Time Water Quality Monitoring

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ABSTRACT

This study presents FISHDA: An IoT-Based Solar-Powered Automated Tilapia Feeding System with Real-Time Water Quality Monitoring, a smart aquaculture innovation designed to improve feeding efficiency and water management in tilapia farming. The system was developed to address common challenges such as inconsistent manual feeding, unstable water conditions, and high electricity costs. FISHDA integrates solar energy, automated feed dispensing, and real-time monitoring of temperature, pH, dissolved oxygen, and turbidity using IoT-enabled sensors and a microcontroller-based platform. Its main features include programmable feeding schedules, remote data access through a mobile or web dashboard, SMS alerts for abnormal water parameters, and renewable energy operation for continuous performance. The system promotes accurate feeding, reduces labor dependency, minimizes feed waste, and helps prevent fish mortality caused by poor water quality. Socio-economically, FISHDA can increase farmers' productivity, lower operational expenses, and support sustainable aquaculture practices while reducing environmental impact. With its scalable and cost-efficient design, the project has strong commercialization potential for local fish farms, cooperatives, and aquaculture enterprises seeking modern, energy-efficient farming solutions.

Keywords: IoT, Solar-powered feeding system, Tilapia farming, Water quality monitoring, Automated aquaculture

1. Product Description

FISHDA is an IoT-based solar-powered automated tilapia feeding system with real-time water quality monitoring designed to improve efficiency and sustainability in aquaculture. The system integrates a solar panel, battery storage, ESP32 microcontroller, automated feeding mechanism, and water quality sensors for temperature, pH, dissolved oxygen, and turbidity. It automates feed dispensing based on programmed schedules while continuously collecting and transmitting water condition data to a mobile or web-based dashboard. Farmers can monitor feeding activity and pond status remotely and receive SMS alerts when parameters fall outside safe ranges. The product is designed to reduce labor dependency, prevent overfeeding, minimize feed waste, and maintain optimal pond conditions to support healthy fish growth. Its solar-powered feature ensures continuous operation even in areas with unstable electricity supply, lowering operational costs and promoting environmentally friendly practices.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc.

System Architectural Design

Figure 1. Simulated Prototype.

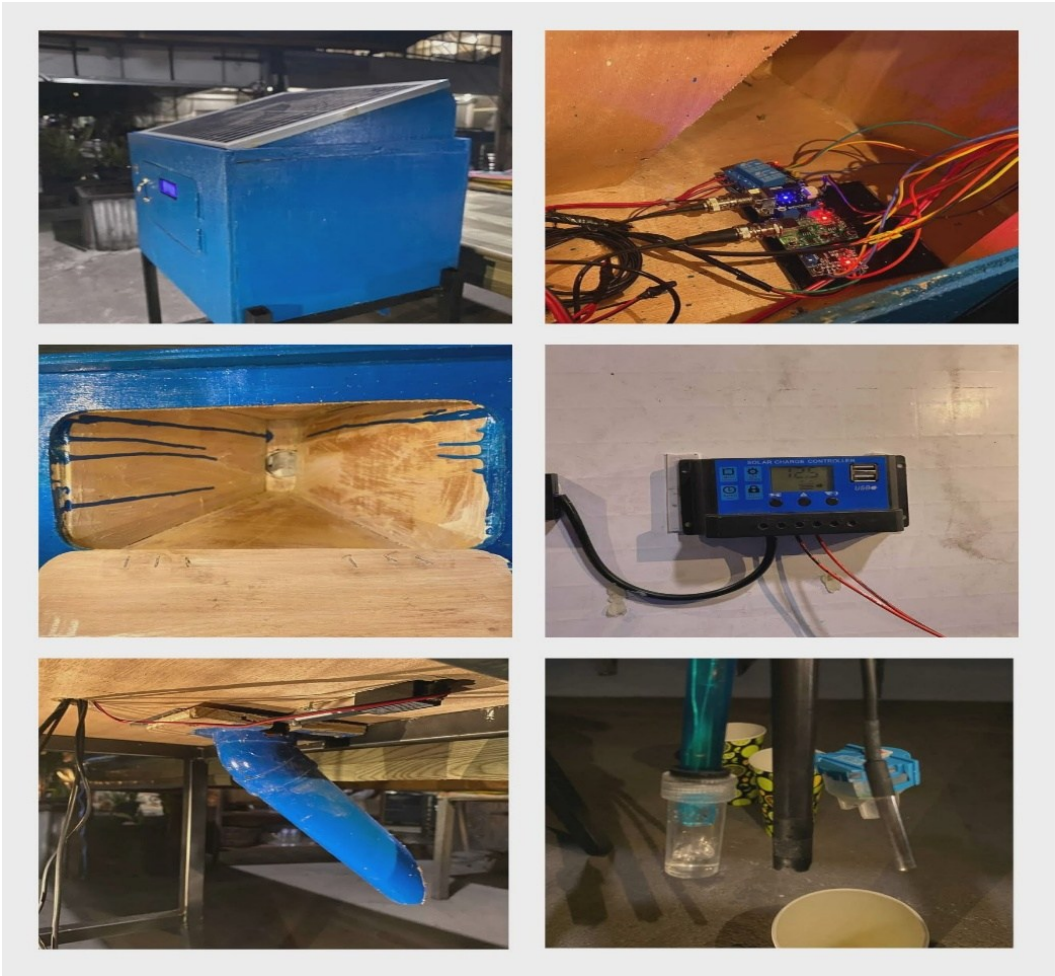

Figure 2. Actual Prototype.

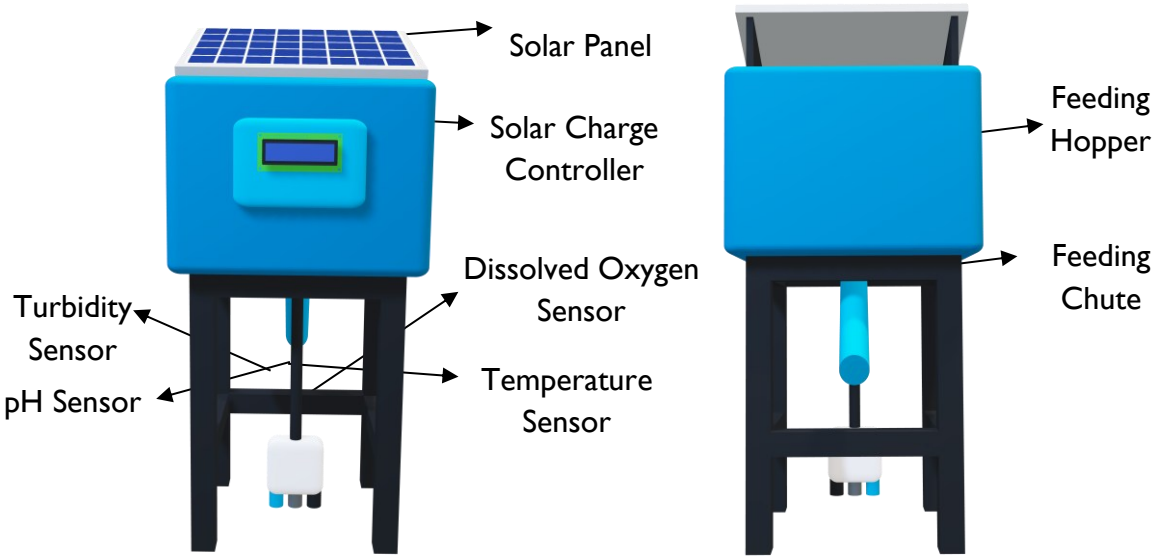

Figure 3. Project Anatomy.

The figure shows the Project Anatomy of the FISHDA: An IoT-Based Solar Powered Automated Tilapia Feeding System with Real-Time Water Quality Monitoring is designed to improve tilapia farming by combining automated feeding, renewable energy, and real-time water monitoring. The system uses a solar panel as its main power source, which collects sunlight and sends energy to a solar charge controller to regulate and supply stable power to the device. The structure also includes sensors placed near the water, such as a pH sensor to measure the acidity or alkalinity of the water, a dissolved oxygen sensor to monitor the oxygen level necessary for fish survival, and a temperature sensor to track water temperature for optimal fish growth. At the back portion of the system, the feed hopper serves as the storage container for tilapia feed, while the feeding chute releases the food into the water automatically at scheduled times. These components are supported by a sturdy frame that keeps the system elevated above the water. Through IoT integration, the system allows real-time monitoring of water quality, helping fish farmers ensure proper feeding and maintain a healthy environment for tilapia production. The circuit diagram of the system shows that the ESP32 microcontroller serves as the main control unit that connects and manages all sensors and electronic components. The system includes several sensors such as a temperature sensor, turbidity sensor, and pH sensor that collect real-time data about the water quality of the fish pond, which is essential for maintaining a healthy environment for tilapia. The gathered data is processed by the ESP32 and displayed on an LCD (Liquid Crystal Display), allowing users to easily monitor the current condition of the water. The circuit is powered by a battery connected to a buck converter that regulates the voltage to ensure stable power distribution to the components. A SIM800L module is integrated to enable IoT communication, allowing the system to send data and notifications remotely. In addition, a linear actuator is used to automate the feeding mechanism by releasing fish feed from the hopper at scheduled times, while a rain sensor detects weather conditions that may affect feeding or system operation. Together, these components work as an integrated system to automate fish feeding and continuously monitor water quality.

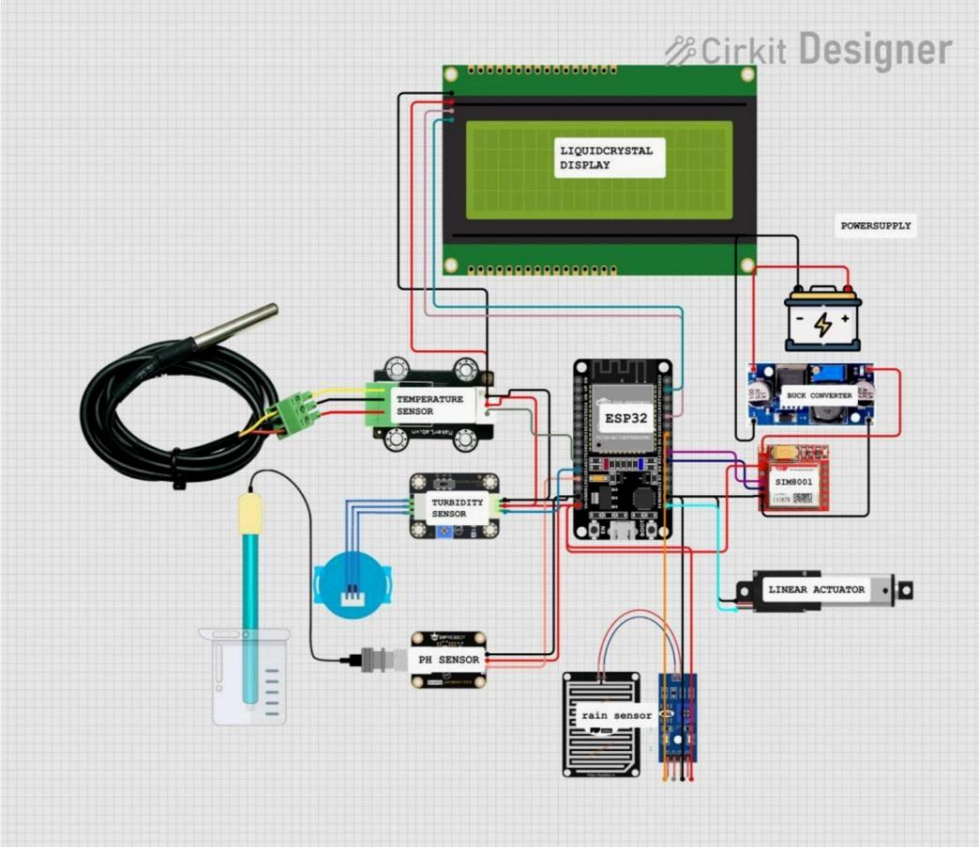

Figure 4. Circuit Diagram.

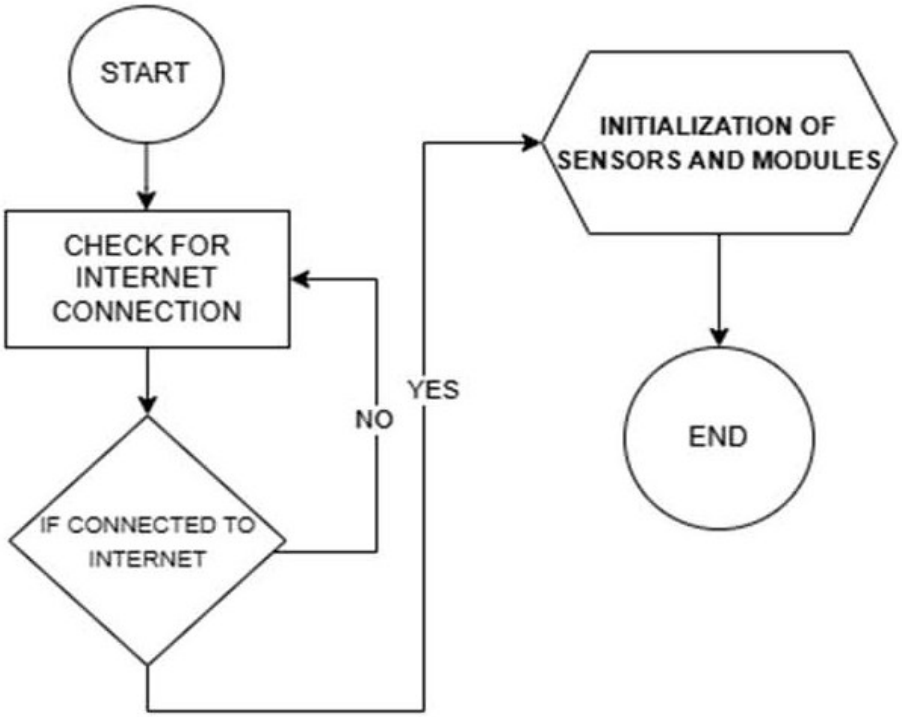

Figure 5. Schematic Diagram.

This schematic diagram shows the main operation of the automated tilapia feeding and alert system. The process starts by checking the sensor values and feeding schedules. The system continuously monitors the water quality parameters and compares them to the set threshold values. If a sensor value reaches the critical threshold, the system checks for SMS connection. It verifies whether the SIM800L module is connected. If connected, it sends an SMS alert to the registered recipient to inform them about the water condition. If not connected, it keeps checking until the connection is available. At the same time, the system checks if the current time matches the feeding schedule. If it is feeding time, the servo motor is activated to dispense fish feed. If not, the system continues monitoring. This ensures automatic feeding and real-time alert notifications.

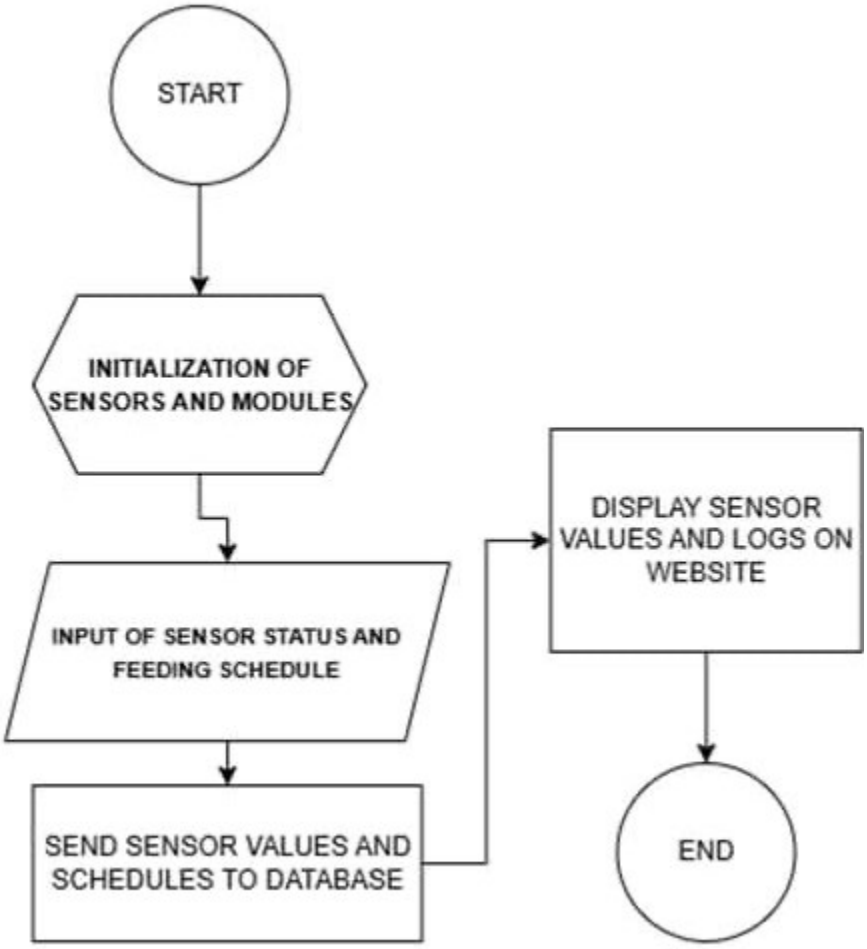

Figure 6. Schematic Diagram.

This diagram shows the internet connectivity and system setup process. The system starts by checking for an internet connection. If it is not connected, it continues checking until a stable connection is established. Once connected, the system proceeds to initialize all sensors and modules. This step ensures that the IoT components, sensors, and controllers are ready for operation. After successful initialization, the setup process ends and the system becomes ready for monitoring and feeding operations.

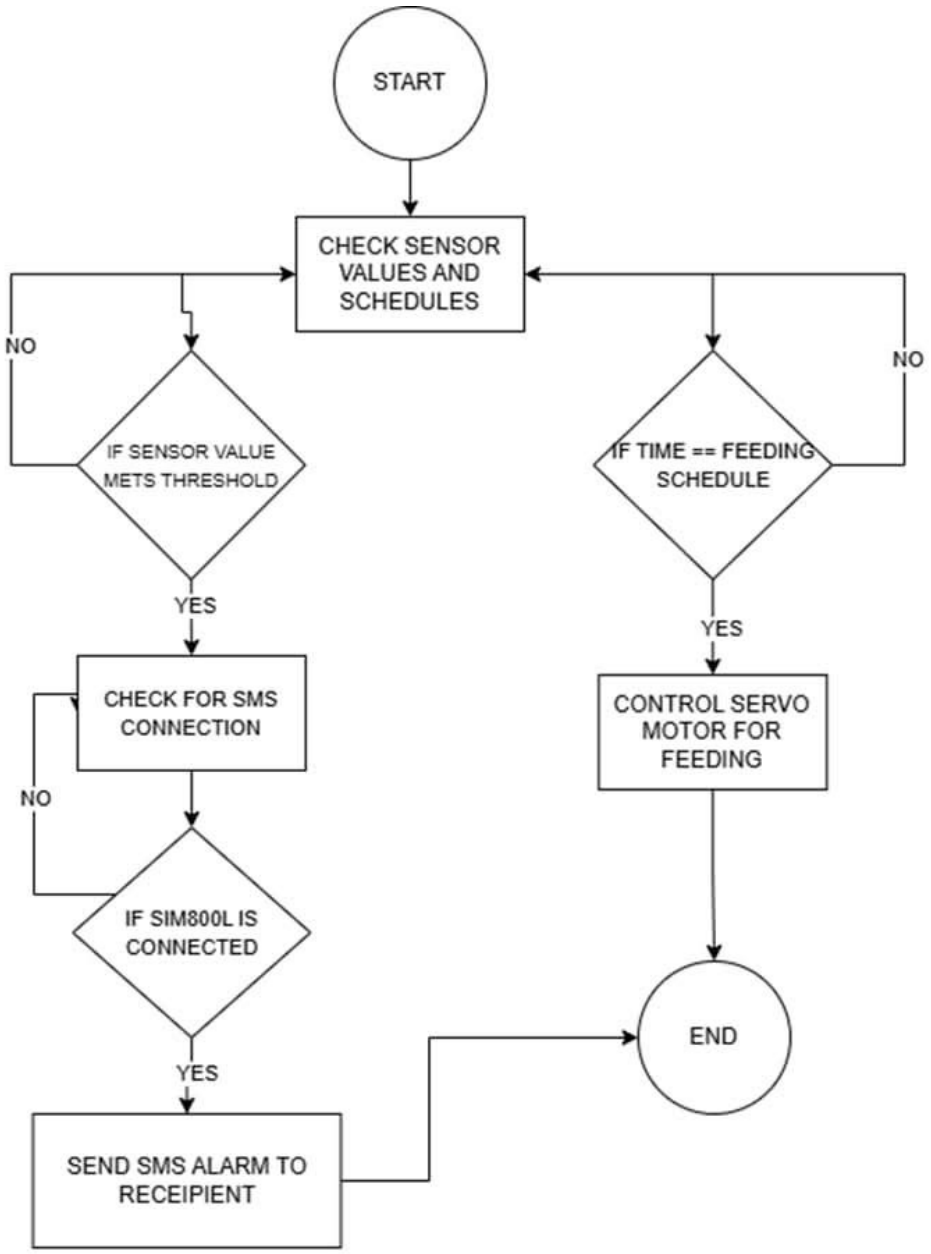

Figure 7. Schematic Diagram.

This schematic diagram explains the data management process. The system starts by initializing the sensors and modules. After initialization, it inputs the sensor status and feeding schedule into the system. The collected sensor values and schedule information are then sent to a database through the internet. Finally, the data is displayed on a website, where users can monitor water quality readings, feeding schedules, and system logs in real time. This process allows remote monitoring and ensures that fish farmers can easily track pond conditions anytime and anywhere.

Results and Discussion

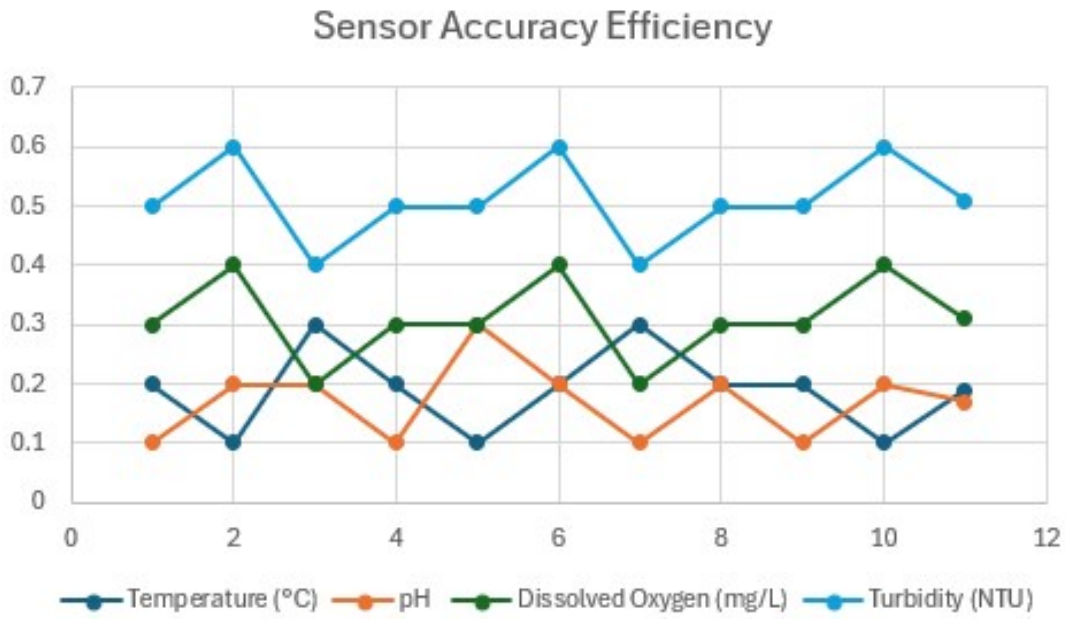

Figure 8. Sensor Accuracy Efficiency.

The figure shows the efficiency results of FISHDA's water quality sensors based on their variance from manual benchmark readings. The temperature sensor recorded the lowest average deviation at ±0.19°C, followed by the pH sensor with ±0.17, dissolved oxygen with ±0.31 mg/L, and turbidity with ±0.51 NTU. The computed grand mean variance of ±0.30 indicates that all sensors operated within acceptable limits of accuracy when compared to manual measurements. These results demonstrate that FISHDA's water quality monitoring sensors provide reliable and precise data, ensuring that farmers receive accurate real-time information for effective tilapia pond management.

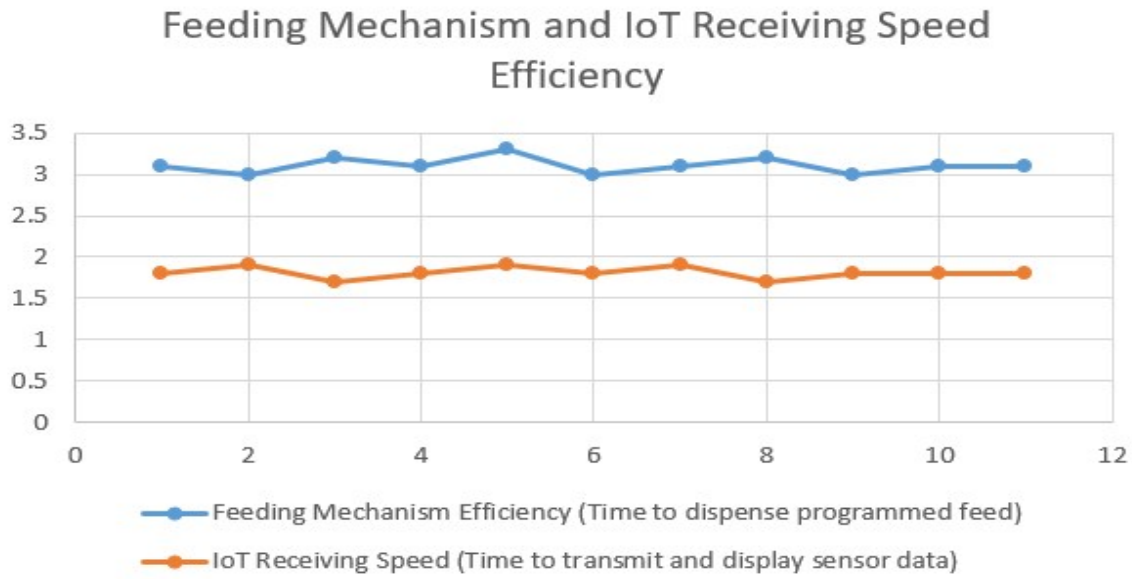

Figure 9. Feeding Mechanism and IoT Receiving Speed Efficiency.

The figure shows that the feeding mechanism averaged 3.1 seconds in dispensing feed while the IoT receiving speed averaged 1.8 seconds, both interpreted as highly efficient. This means the system delivers feed on time and updates sensor data almost instantly, ensuring smooth and reliable operation of FISHDA**.**

Table 1. Evaluation Result of FISHDA's Functionality .

Functionality	**WM**	**Interpretation**
The system will dispense fish feed automatically and consistently based on the programmed schedule.	3.25	Neutral
The system will monitor water quality parameters (temperature, pH, dissolved oxygen, turbidity) in real time.	4.3	Strongly Agree
The solar panel and battery system will supply reliable power for continuous operation.	3.5	Agree
The IoT platform will display feeding schedules and sensor readings on a mobile or web dashboard.	3.25	Neutral
The system will generate and store records of feeding activities and monitoring results.	4.5	Strongly Agree
TOTAL	3.76	Agree

This table shows that FISHDA's functionality gained a 3.76 weighted mean, interpreted as "Agree." This means the system can monitor water quality parameters (temperature, pH, dissolved oxygen, turbidity) in real time, reliably supply power through its solar panel and battery, and generate and store records of feeding and monitoring activities. However, some functions, such as automatic feed dispensing and dashboard display of schedules and sensor readings, received neutral responses, suggesting that these areas may need further enhancement for better performance.

Table 2. Evaluation Result for FISHDA's Accuracy.

Accuracy	**WM**	**Interpretation**
The automated feeder will dispense the correct quantity of fish feed at each interval.	3.75	Agree
The sensors (temperature, pH, dissolved oxygen, turbidity) will provide accurate readings compared with manual test results.	3.25	Neutral
The IoT dashboard will display precise feeding logs and sensor data without errors.	3.5	Agree
The solar system will provide consistent energy supply with minimal fluctuations.	4	Agree
The system will properly record, arrange, and update feeding and water quality data.	4	Agree
TOTAL	3.70	Agree

This shows that FISHDA's accuracy gained a 3.70 weighted mean, interpreted as "Agree." This indicates that the system can dispense the correct amount of feed at set intervals, consistently provide energy through its solar-powered feature, and properly record and update feeding and water quality data. The IoT dashboard also displays feeding logs and sensor information accurately. However, sensor readings such as temperature, pH, dissolved oxygen, and turbidity were rated neutral, suggesting the need for further refinement to ensure higher precision compared with manual testing.

Table 3. Evaluation Result for FISHDA's Acceptability .

Acceptability	**WM**	**Interpretation**
The system will display desired feeding and water quality information clearly.	3.5	Agree
The IoT dashboard will present texts, labels, and values that will be easy for farmers to read.	4	Agree
The system will display appropriate and updated data during usage.	4	Agree
The IoT platform will be accessible across different screen resolutions (desktop, tablet, and mobile).	4	Agree
The system will provide access to feeding and monitoring details through mobile devices for convenience.	3.75	Agree
TOTAL	3.85	Agree

Table 3. shows that FISHDA's acceptability gained a 3.85 weighted mean, interpreted as "Agree." This means the system is userfriendly, as it clearly displays feeding and water quality data, presents updated information, and is accessible across different devices such as desktops, tablets, and mobile phones. It also ensures that texts and labels are easy to read for farmers. Overall, the results suggest that FISHDA is acceptable for practical use, though continuous improvements can further enhance convenience and usability.

Table 4. Efficiency Result of Feeding Mechanism Efficiency .

Feed Quality (in grams)	**Feeding Mechanism Efficiency**										
	Automated Feeder – Total Time Lapsed (in seconds)										
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**Mean**
5g	2.1	2.0	2.2	2.3	2.1	2.2	2.0	2.1	2.3	2.1	2.14s
10g	3.9	4.0	4.1	4.0	3.8	4.2	4.1	4.0	3.9	4.1	4.01s
15g	5.8	5.9	6.0	5.7	5.9	6.1	6.0	5.8	5.9	6.0	5.91s
20g	**7.7**	7.8	7.9	7.8	7.6	7.9	8.0	7.7	7.8	7.9	7.81s
GRAND MEAN	**4.97s**										

Table 4. shows the efficiency results of the FISHDA system's automated feeding mechanism based on different feed quantities. The 5g feed release recorded an average time of 2.14 seconds, the 10g release averaged 4.01 seconds, the 15g release averaged 5.91 seconds, and the 20g release averaged 7.81 seconds, with a grand mean of 4.97 seconds. These findings indicate that the feeding mechanism dispenses feed consistently, with dispensing time increasing proportionally to the amount of feed. This demonstrates that the automated feeder operates efficiently and reliably in delivering the programmed feed quantities, ensuring timely and consistent feeding for tilapia farming. **Table 5**. shows the accuracy result of FISHDA's temperature sensor at varying water temperature levels. At 25°C, the sensor recorded an average response time of 1.60 seconds; at 27°C, the mean was 1.81 seconds; at 29°C, it was 1.91 seconds; and at 31°C, the mean response time reached 2.10 seconds. The results indicate that the response time of the temperature sensor slightly increases as the water temperature rises. Overall, the sensor demonstrated stable and reliable performance across the tested ranges, ensuring accurate and timely temperature readings necessary for effective pond monitoring in tilapia farming. The automation system employed several sensors, including a temperature sensor that was specifically responsible for detecting the temperature of the pool water. This sensor continuously monitored changes in the pond's thermal condition, which is crucial for maintaining an environment suitable for fish growth and development. The data gathered by the temperature sensor, along with that from the RTC and pH sensors, was processed by the NodeMCU ESP8266 microcontroller. Once processed, the

readings were transmitted and recorded into a Google spreadsheet, allowing real-time monitoring and analysis. This setup ensured that cultivators could track pond temperature accurately, detect unfavorable fluctuations, and maintain stable conditions that support optimal fish health. By integrating the temperature sensor into the automated feeding and water quality monitoring system, the study demonstrated how aquaculture farmers could not only regulate feeding schedules but also monitor and sustain proper pond temperature for improved fish survival and growth (Zuriati et al., 2022).

Table 5. Accuracy Result of Temperature Sensor.

Temperature Levels (°C)	**Analysis of Variance of Temperature Sensor**										
	TOTAL TIME LAPSED (in seconds)										
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**Mean**
25°C	1.6	1.7	1.5	1.6	1.7	1.5	1.6	1.7	1.6	1.5	1.60s
27°C	1.7	1.8	1.8	1.7	1.9	1.8	1.8	1.7	1.9	1.8	1.81s
29°C	1.9	2.0	1.8	1.9	2.0	1.9	1.9	2.0	1.8	1.9	1.91s
31°C	2.1	2.2	2.0	2.1	2.2	2.1	2.0	2.2	2.1	2.0	2.10

Since water temperature has a direct impact on fish metabolism, development, eating behavior, and survival, it is one of the characteristics that the gadget monitors. Severe temperature variations, frequently brought on by climate change, can stress fish and raise their mortality risk. Fish farmers can maintain the ideal temperature range required for optimum fish production thanks to the device's integration of a temperature sensor, which gives them real-time water condition monitoring. This enhances aquaculture management overall and lowers losses. To guarantee the precision and dependability of its results, the temperature sensor needs to be calibrated on a regular basis, just like the other sensors in the system (Babala et al., 2024). **Table 6**. shows that the pH sensor obtained mean response times ranging from 2.1 to 2.3 seconds, interpreted as accurate and consistent. This means the sensor can detect changes in water conditions quickly with only slight variations across pH levels, making it reliable for monitoring tilapia ponds. Aquaponics, aquaculture, and environmental water testing are just a few of the applications for the DFRobot Gravity Analogue pH Sensor, which is specifically made to measure the pH of the solution and reflect the acidity or alkalinity. This secondary generation pH meter pro sensor is an upgraded version of the pH meter pro V1, which greatly improves the precision and user experience. The onboard voltage regulator chip supports the wide voltage supply range of 3.3V to 5.5V (Mouser, 2025). The system monitors and maintains vital water quality parameters essential for fish growth, including potential hydrogen (pH) level, through the use of sensors integrated with Arduino and Raspberry Pi 3B+ via the LoRaWAN IoT Protocol. Among these, the DFRobot Gravity: Analog pH Sensor is utilized to measure the water's pH level accurately,

ensuring that it remains within the optimal range for aquaculture. Maintaining proper pH balance is critical, as fluctuations can stress or even kill fish in intensive aquaculture systems. The sensor, together with a motor that distributes sodium bicarbonate as a correcting device, enables realtime monitoring and automatic adjustment of the water's acidity or alkalinity, improving yield quality and reducing the risk of fish mortality (Tolentino, 2021).

Table 6. Accuracy Results of pH Sensor.

pH Levels	**Analysis of Variance of pH Sensor**										
	TOTAL TIME LAPSED (in seconds)										
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**Mean**
pH 6.5	2.1	2.3	2.0	2.2	2.1	2.4	2.0	2.2	2.3	2.1	2.2s
pH 7.0	2.0	2.1	1.9	2.2	2.1	2.0	2.1	1.9	2.2	2.0	2.1s
pH 7.5	2.2	2.3	2.1	2.4	2.3	2.1	2.2	2.3	2.1	2.2	2.2s
pH 8.0	2.3	2.4	2.2	2.5	2.3	2.4	2.2	2.3	2.4	2.3	2.3s

Table 7. Accuracy Results of Dissolved Oxygen Sensor.

DO Levels (mg/L)	Analysis of Variance of Dissolved Oxygen Sensor										
	TOTAL TIME LAPSED (in seconds)										
	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Mean
4.0 mg/L	2.1	2.2	2.0	2.3	2.1	2.2	2.1	2.3	2.2	2.1	2.16s
5.0 mg/L	3.1	3.0	3.2	3.3	3.1	3.2	3.0	3.1	3.2	3.1	3.13
6.0 mg/L	4.0	4.1	4.0	4.2	4.1	4.0	4.2	4.1	4.0	4.1	4.08
7.0 mg/L	5.0	4.9	5.1	5.0	5.1	5.0	5.1	5.0	5.0	5.1	5.03s

Table 7. shows the analysis of variance for FISHDA's dissolved oxygen (DO) sensor across different oxygen concentration levels. The results reveal that while response times varied slightly depending on DO levels, the differences remained consistent and within acceptable limits. This demonstrates that the DO sensor performs reliably in recording and transmitting readings, ensuring farmers can obtain timely and accurate water quality data for aquaculture management. The DFRobot Gravity: Analog Dissolved Oxygen Sensor is used to measure dissolved oxygen in water, an important parameter for assessing water quality. It uses a galvanic probe that requires no polarization time and is always ready for use. The probe's filling solution and membrane cap are replaceable, keeping maintenance costs low. The signal converter board is plug-and-play and operates at 3.3V–5V, making it compatible with popular microcontrollers such as ESP32, Raspberry Pi, and Arduino (Dfrobot, 2025).The Gravity: Analog Dissolved Oxygen Sensor is used to measure the dissolved oxygen in water, providing an indication of water quality. It is compatible with Arduino microcontrollers and widely applied in aquaculture, environmental monitoring, and other water quality applications. The sensor features a galvanic probe that requires no polarization time, with a replaceable filling solution and membrane cap for low maintenance. Its plug-and-play signal converter board allows easy integration into any control or detection system, enabling users to quickly build their own dissolved oxygen monitoring setup (Knowledge Research, 2021).

Table 8. Accuracy Results of Turbidity Sensor.

Turbidity Levels (NTU)	**Analysis of Variance of Turbidity Sensor**										
	TOTAL TIME LAPSED (in seconds)										
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**Mean**
5 NTU	2.0	2.1	2.0	2.1	2.2	2.0	2.1	2.0	2.1	2.0	2.06
10 NTU	2.2	2.3	2.1	2.2	2.3	2.2	2.2	2.3	2.1	2.2	2.21
15 NTU	2.4	2.5	2.3	2.4	2.5	2.4	2.5	2.3	2.4	2.5	2.42s
20 NTU	2.6	2.7	2.5	2.6	2.7	2.6	2.5	2.6	2.7	2.6	2.61

Table 8. shows the accuracy results of FISHDA's turbidity sensor across varying turbidity levels. At 5 NTU, the mean response time was 2.06 seconds; at 10 NTU, it was 2.21 seconds; at 15 NTU, it averaged 2.42 seconds; and at 20 NTU, the response time increased to 2.61 seconds. The results indicate that response times slightly increased as turbidity levels rose, but the values remained within acceptable limits. This demonstrates that the turbidity sensor operates with consistent accuracy and efficiency, allowing farmers to obtain timely and reliable water clarity measurements for effective tilapia pond management. The Arduino turbidity sensor detects water

quality by measuring turbidity levels. It works by detecting suspended particles in water through light transmittance and scattering, which vary with the amount of total suspended solids (TSS). As TSS increases, turbidity levels also rise. This sensor provides both analog and digital signal output modes, with an adjustable threshold in digital mode, allowing compatibility with different microcontrollers (Dfrobot, 2025). A water turbidity sensor is part of the Jade Smart 1.0 monitoring system, which measures the water purity in the fish breeding tank. During testing, location A's average turbidity reading was 3.3 NTU, whereas locations B and C recorded 9.8 and 9.9 NTU, respectively. Real-time water clarity monitoring is made possible by the turbidity sensor, which is crucial for preserving the ideal water quality for fish growth (Ghazali et al., 2023).

3. Novelty and uniqueness

FISHDA stands out as an innovative aquaculture solution due to its advanced and sustainable features. It uses solar energy to power the system, lowering operational costs while promoting environmental sustainability and reducing reliance on conventional electricity. This makes it ideal for small-scale and rural fish farming communities. This integrates automated feeding with real-time water quality monitoring in one system, eliminating the need for manual labor and separate monitoring equipment. This improves efficiency, reduces waste, and ensures optimal fish growth. The system is equipped with IoT sensors that track critical water parameters such as temperature, pH, dissolved oxygen, and ammonia levels, providing accurate and timely data to maintain a healthy aquatic environment. All monitoring data is accessible through a digital or mobile application, allowing farmers to track feeding schedules, water conditions, and system performance easily. Compared to traditional tilapia farming methods that rely heavily on manual feeding and periodic water checks, FISHDA offers a smart, unified, and efficient solution that enhances productivity, supports sustainability, and modernizes the aquaculture industry.

4. Benefit to mankind

The goal of this project is to provide small-scale fish farmers with an affordable, efficient, and easy-to-use system that improves tilapia farming, reduces labor, and ensures healthier fish.

- Fish Farmers. The system automates feeding and monitors water quality in real time. This results in healthier fish, more efficient operations, reduced labor, and increased productivity and profit.
- Vendors. A steady supply of high-quality tilapia ensures consistent product availability, safer food, and more reliable pricing.
- Consumers. Safer, fresh, and more affordable tilapia improves nutrition and provides a more satisfying food experience.

5. Innovation and Entrepreneurial Impact

The FISHDA: An IoT-Based Solar-Powered Automated Tilapia Feeding System with Real-Time Water Quality Monitoring contributes to a culture of entrepreneurship by providing small-scale fish farmers with affordable, high-tech solutions that increase productivity, improve fish health, and reduce operational costs. This project contributes to the following communities, institutions, and industries:

- Aquaculture and Fisheries Sector: Small-scale tilapia farmers, fish farms, and aquaculture cooperatives.
- Technology and Engineering: Innovators and engineers working in IoT, renewable energy, automation, and system integration.

- Environmental Sustainability: Communities and organizations promoting sustainable aquaculture practices and renewable energy solutions.
- Research and Development: Institutions involved in agricultural research, especially in the areas of smart farming and sustainable technologies.
- Local Government and NGOs: Organizations focused on rural development, agricultural modernization, and community empowerment in the fisheries sector.
- Educational Institutions: Universities and vocational training centers offering programs in aquaculture, engineering, environmental science, and technology-based farming solutions.

6. Potential commercialization

The FISHDA offers fish farmers a sustainable and cost-effective solution to traditional tilapia farming practices. By providing an automated feeding system powered by solar energy and integrated with real-time water quality monitoring, it helps farmers optimize fish growth, reduce labor, and prevent overfeeding, all while promoting environmental sustainability.The system is designed to be affordable, reducing the need for expensive manual labor and conventional equipment. Its durable and low-maintenance design ensures long-term usability, allowing farmers to consistently benefit from improved productivity and healthier fish. As a scalable solution, FISHDA has the potential for widespread adoption among small-scale and commercial fish farms, enhancing efficiency and competitiveness in the aquaculture industry. This makes it a viable product for commercialization, with opportunities for partnerships with aquaculture cooperatives, government agricultural programs, and private investors who aim to promote smart farming practices and sustainable aquaculture technologies.

7. Acknowledgement

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8. Researchers' Biography

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Shadrach Benjamin Varquez is a Senior High School student at Tupi National High School, enrolled in the Science, Technology, Engineering, and Mathematics strand. A consistent honor student, he exemplifies discipline, academic excellence, and strong time management. He effectively balances rigorous coursework with meaningful extracurricular involvement, reflecting dedication to personal and intellectual growth. In 2025, he represented the school in a National Robotics Competition in the Philippines, strengthening his skills in innovation, collaboration, and critical thinking. Driven and goal-oriented, Shadrach remains committed to advancing his abilities in science and technology while pursuing his aspirations with integrity and determination for future success.

Garage Security System with Flood Mitigation

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ABSTRACT
One of the most damaging natural events is flooding and because of this, the requirement for flood mitigation systems has gained critical importance due to escalating climate driven severe weather conditions. This thesis documents the design and demonstration of an automatic garage with security and flood mitigation system with Internet of Things (IoT). The system contains a keypad security system, water level sensor and an ESP-32 as a microcontroller that is used to transform the system into an Internet of Things (IoT). Additionally, a servomotor has been integrated as one of the system's outputs to open and close the garage door. An IoT-based flood mitigation system is implemented using a stepper motor- driven platform with a pulley mechanism. Platform elevation and water level data are acquired through sensors and transmitted to a Blynk interface, offering real-time monitoring and remote accessibility. By adding IoT in this system, the keypad security system can be accessed remotely (admin bypass) by using Blynk software. This project aimed to have a positive impact on the security of the garage and to mitigate flooding occurrence.

Keywords: Automatic garage, Flood mitigation, Internet of Things (IoT), Security Systems.

Product Description
The IoT-Based Automatic Garage Security and Flood Mitigation System is a smart solution developed to improve home safety and reduce the risk of flood damage, especially in areas prone to flood risk. The system is designed to work as part of a modern smart-home setup by combining automated security with real-time flood protection. It is built around an ESP32 microcontroller and includes a keypad access system, water level sensors, and motor-driven mechanisms for reliable operation. A servomotor is used to control the opening and closing of the garage door, while a stepper motor with a pulley mechanism raises the platform when rising water is detected. Through IoT integration, the system sends live data to a Blynk interface, allowing users to monitor conditions and control the system remotely, including an administrative bypass feature for emergency access. The main strength of this system is its ability to mitigate flood damage while maintaining strong security. By combining sensing, automation, and connectivity, it provides a practical way to protect vehicles and property from unauthorized access and flood damage.

2. Product prototype
Figure 1 and **Figure 2** show the block diagram and schematic diagram of the system**. Figure 3** depicts the flowchart operation of the system, while **Figure 4** shows the development of the prototype. **Figure 5** indicates the prototype result of the keypad security system, and **Figure 6**

shows the prototype result of the platform elevation system. **Figure 7** displays the prototype result of the admin bypass mode. **Figure 8** depicts the Blynk application display and notification water level sensor detects water. **Figure 9** depicts the Blynk application display of admin bypass mode for keypad security system.

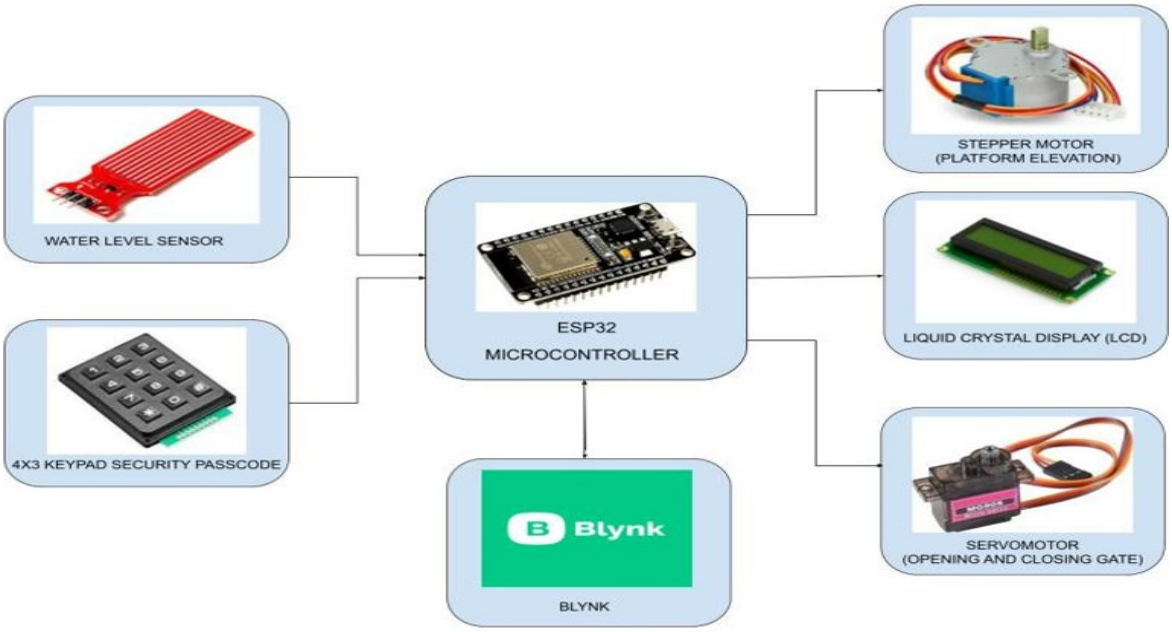

Figure 1. Block diagram of the Garage Security System with Flood Mitigation.

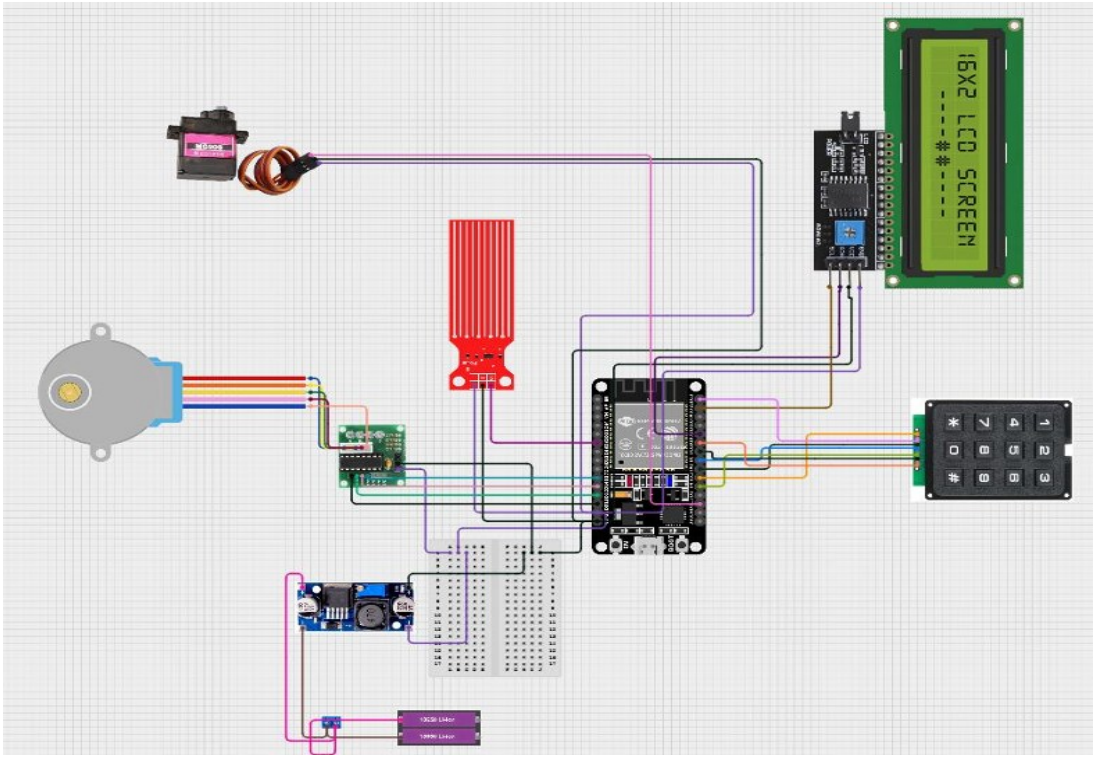

Figure 2. Schematic Diagram of the Garage Security System with Flood Mitigation.

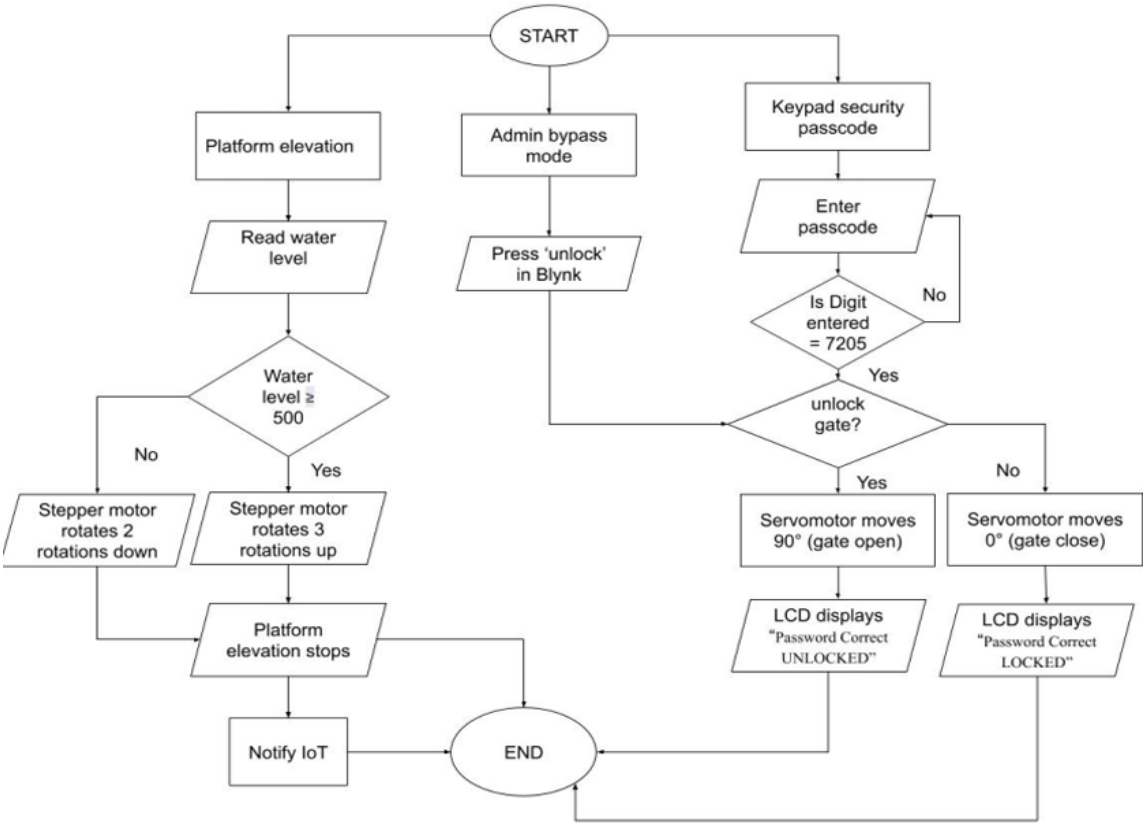

Figure 3. Flowchart of the of the Garage Security System with Flood Mitigation.

Figure 4. Prototype of the Garage Security System with Flood Mitigation.

Figure 5. Result of prototype of keypad security system of the Garage Security System with Flood Mitigation.

Figure 6. Result of prototype of platform elevation system of the Garage Security System with Flood Mitigation.

Figure 7. Result of prototype of admin bypass mode of the Garage Security System with Flood Mitigation.

(a) (b)

Figure 8. Mobile application interfaces of the Garage Security System with Flood Mitigation: (a) Platform elevation status (b) Blynk notification when water level sensor detects water.

Figure 9. Blynk application for admin bypass mode of the Garage Security System with Flood Mitigation.

3. Novelty and uniqueness

The uniqueness of this system lies in the combination of garage security and flood mitigation within a single IoT-based platform. While most garage systems focus only on access control, this project integrates a keypad security system with an automatic flood mitigation mechanism. Using an ESP32, the system enables real-time monitoring and remote control through a mobile application. A key feature is the stepper motor–driven platform that lifts the garage floor when rising water is detected. Instead of only sending alerts, the system takes direct action to reduce flood damage. The addition of a remote administrative bypass also improves flexibility during emergencies. This simple integration of security, automation, and flood response makes the system distinct from existing garage solutions.

4. Benefit to mankind

The Garage Security System with Flood mitigation offers essential benefits by improving home safety and disaster readiness. Its smart locking mechanism enhances security through controlled access and real-time monitoring, reducing risks of intrusion. The integrated water-level detection provides early flood warnings, enabling timely action to protect belongings and minimize damage. With its automated platform system, the design adds an extra layer of protection during rising water levels. Overall, this solution promotes a safer and more resilient living environment through efficient security control and proactive flood response.

5. Innovation and Entrepreneurial Impact

The Garage Security System with Flood Mitigation demonstrates innovation by combining access control, real-time flood detection, and automated response in a single smart security solution. The system integrates sensors, a microcontroller, and IoT connectivity to monitor water levels in the garage while also controlling access through automated locking mechanisms. When abnormal water levels are detected, the system can trigger alerts and activate protective actions, helping to reduce flood damage and improve overall safety. From an entrepreneurial perspective, this project has strong potential for residential and commercial applications such as landed houses, apartments, and parking garages in flood-prone areas. The system is cost-effective, scalable, and can be adapted to different building layouts with minimal changes. By improving security, providing early flood warnings, and reducing potential property damage, the system offers a practical solution that is suitable for commercialization in smart home and smart building security systems.

6. Potential commercialization

The Garage Security System with Flood Mitigation has strong commercialization potential because it addresses two major needs: home security and flood mitigation. Its smart locking features and IoT monitoring make it attractive for homeowners and small businesses looking for an affordable and reliable security solution. The built-in flood detection and automated mitigation system add significant value in flood-prone areas, helping protect vehicles and stored items. The system demonstrates significant potential for widespread adaptation in buildings and long-term impact in enhancing community safety and flood resilience.

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8. Researchers' Biography

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Zahari Abu Bakar is a senior lecturer in the the Faculty of Electrical Engineering, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus. He holds a Diploma in Electrical Engineering (Electronics) from UiTM Pulau Pinang, a Bachelor of Electrical Engineering (Hons), and an MSc in Telecommunication and Information Engineering from UiTM Shah Alam. His primary research interests include e-learning, IoT and machine learning.

Design of an Efficient Sun-Tracking Solar Charging System for Low-Power Devices

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ABSTRACT
This project proposes an improved solar energy harvesting system using a solar tracking mechanism to maximize sunlight absorption. The developed system employs an ESP32 microcontroller integrated with a temperature sensor, voltage sensor, and light-dependent resistor (LDR) as input parameters. The system outputs include LED indicators, an LCD display, and a servo motor that adjusts the orientation of the solar panel to track the sun's movement. In addition, Internet of Things (IoT) technology is incorporated to enable real-time monitoring and remote access to system information. Users can receive notifications and monitor the solar panel status even when they are not physically present at the installation site. Compared to conventional Arduino-based systems, the use of ESP32 enhances system performance by providing better connectivity, faster processing, and IoT capabilities. This project demonstrates a more efficient and user-friendly solar tracking solution, contributing to the advancement of renewable energy technologies in the energy sector.

Keywords: Internet of Things (IoT), Water Quality Monitoring, Aquaculture Technology

1. Product Description
The increasing demand for clean and sustainable energy has led to significant interest in solar energy technologies. Solar energy is one of the most abundant renewable energy sources available; however, the efficiency of conventional solar panel systems is limited due to their fixed installation position. Since the intensity of sunlight varies throughout the day, static solar panels are unable to consistently operate at maximum efficiency. To overcome this limitation, solar tracking systems have been introduced to optimize the orientation of solar panels toward the sun. This project presents the design and development of an IoT-based solar tracking and monitoring system using an ESP32 microcontroller for low power devices. The system consists of three main sections which are input control and processing unit and also output. The input includes Light Dependent Resistor (LDR), temperature sensor and voltage sensor. For output, servo Motor, LCD display, LED Indicators and energy storage system as **Figure 1**. When sunlight falls on the solar panel, electrical energy is generated and stored in the battery. The LDR continuously senses light intensity and sends data to the ESP32. Based on this data, the ESP32 controls the servo motor to align the panel with the sun. At the same time, the voltage and temperature sensors monitor system performance. All collected data are displayed locally on the LCD and transmitted to the IoT platform for remote access. This working principle is illustrated in **Figure 2**. In conclusion, this project can improve solar energy harvesting efficiency by dynamically adjusting the panel orientation and enabling real-time performance monitoring. The

integration of ESP32 and IoT technology enhances system intelligence, connectivity, and user convenience. This project demonstrates a practical and scalable solution for modern renewable energy applications and contributes to the advancement of smart energy systems. **Figure 3** presents the project result and findings.

2. Methodology

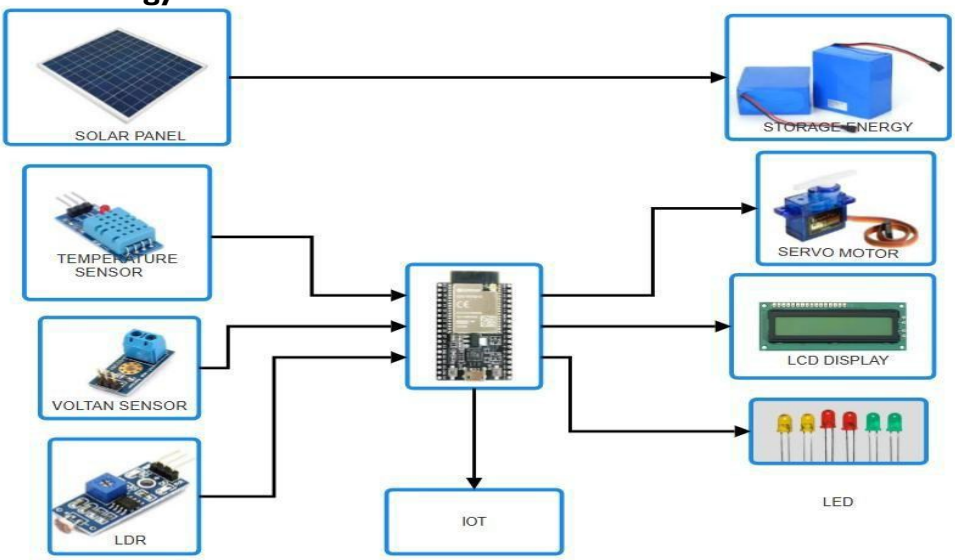

Figure 1. Block diagram of the project.

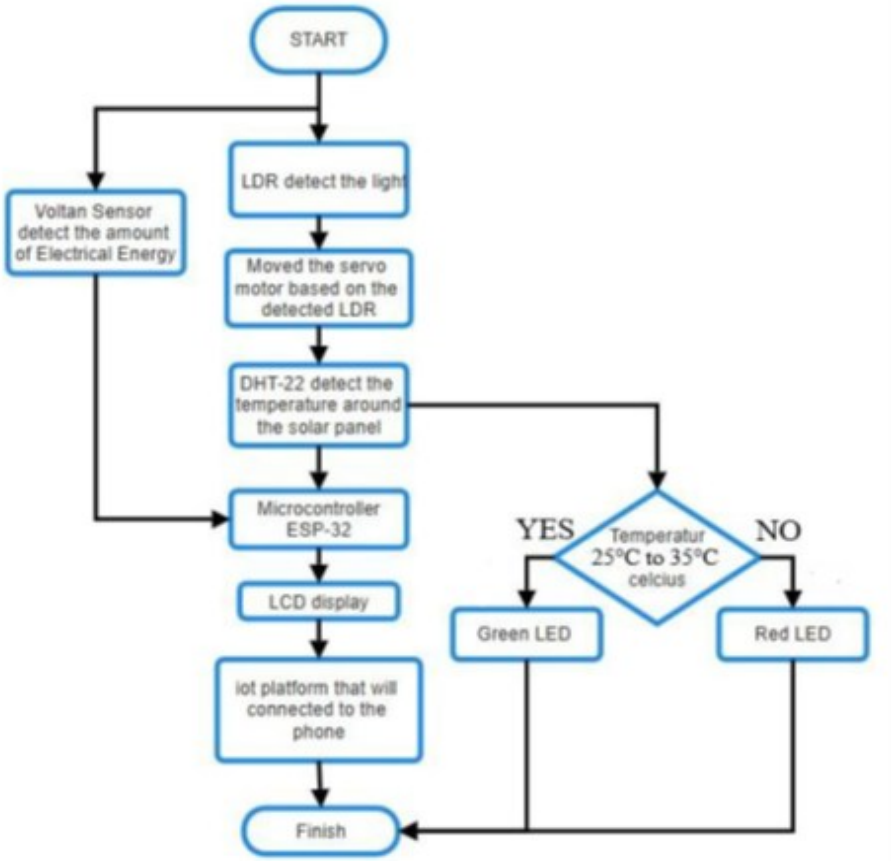

Figure 2. System operation flow chart.

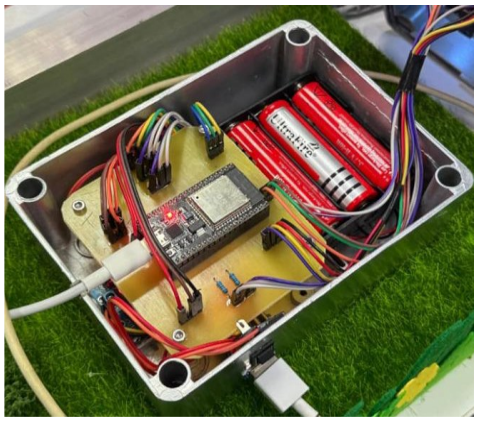

Figure 3(i). Wiring, connection and Installation

Figure 3(ii). Charging indicator with output application

Figure 3(iii). Prototype of the project

3. Novelty and uniqueness

The project lies in the integration of a solar tracking mechanism with IoT-enabled real-time monitoring using an ESP32 microcontroller. Unlike conventional static solar panels or Arduino-based trackers, this system combines multi-sensor inputs (temperature, voltage, and LDR) with remote accessibility and notification features. The use of ESP32 enhances system intelligence and connectivity, making the solution more efficient, modern, and user-oriented. Moreover, this project is highly effective as all system data and features are integrated through an IoT platform. The Blynk application is used for real-time monitoring, where parameters such as voltage and temperature are displayed directly on the app. This allows users to monitor the solar panel's performance remotely, even when they are located far from the installation site.

4. Benefit to mankind

This project contributes to mankind by promoting the use of renewable and clean solar energy, helping to reduce dependence on fossil fuels and mitigate the effects of global warming. The improved efficiency of solar panels leads to higher energy output, supporting sustainable energy generation. Remote monitoring also allows users to manage energy systems safely and conveniently, especially in rural, off-grid, or hard-to-access areas.

5. Innovation and Entrepreneurial Impact

The innovation of this project is the smart solar tracking system integrated with IoT technology. The system automatically adjusts the solar panel's position to follow sunlight while simultaneously providing real-time performance data to users. The combination of automated tracking, sensor-based decision-making, and wireless communication represents a smart energy management approach aligned with Industry 4.0 and smart energy concepts.In term of entrepreneurial impact, this project has strong entrepreneurial potential as it addresses the increasing demand for efficient and smart renewable energy solutions. The system can be developed into a commercial product or service for households, small businesses, agricultural farms, and educational institutions. Its modular design allows for customization, creating opportunities for start-ups, system integrators, and green technology entrepreneurs to enter the renewable energy market.

6. Potential commercialization

The project can be commercialized as a smart solar tracking kit, IoT-based solar monitoring system, or an upgrade module for existing solar panels. Potential customers include residential users, solar energy companies, smart home developers, and rural electrification programs. With further refinement, mass production, and mobile application integration, the system can be marketed as a cost-effective and scalable renewable energy solution.

7. Acknowledgment

The authors would like to acknowledge faculty of Electrical engineering, Universiti Teknologi MARA (UiTM), Johor Branch, Pasir Gudang Campus for technical support, consultation and facilities provided throughout the development of this project.

8. Researchers' Biography

Mohamad Danial Hakim Raimi is currently pursuing a Diploma in Electrical Engineering (Power) at the UiTM Pasir Gudang Campus. He has demonstrated outstanding performance in both academic and extracurricular activities. He shows dedicated and has a good character.

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Automated Sushi Plate Recognition and Billing System

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ABSTRACT

In response to the growing demand for efficient, hygienic, and environmentally responsible solutions in the food service industry, this project introduces an Automated Sushi Plate Recognition and Billing System designed for modern sushi restaurants. The system employs a color sensor to identify plate colors, with each color representing a specific price category, enabling accurate plate counting and pricing. Once detected, the plates are guided by a servo motor into designated storage for systematic counting and data collection. A weight sensor then monitors the total load of the storage area and displays status notifications on the LCD and Blynk mobile application, indicating whether the storage is "Available" or "Storage Full" based on the measured weight. All collected data are processed by an ESP microcontroller and transmitted wirelessly to the billing software system. By automating plate tracking and billing processes, the system reduces manual errors, enhances hygiene, and supports smoother restaurant operations. Overall, this project offers a smart and user-friendly solution that improves operational efficiency, enhances customer experience, and promotes cleanliness and sustainability within the food service environment.

Keywords: Internet of Things (IoT), Sushi Plate Counting, Color Sensor, Automated Billing System

1. Product Description

The Automated Sushi Plate Recognition and Billing System is an IoT-based automated solution designed to assist sushi restaurants in accurately counting plates, identifying plate colors, monitoring storage capacity, and transmitting billing data wirelessly. The system utilizes an ESP32 microcontroller as the main processing unit, integrating a color sensor, servo motor, weight sensor, LCD display, and cloud-based monitoring via the Blynk platform. Plate colors are detected to represent different pricing categories, and the servo motor guides the plates into a storage bin after detection. Simultaneously, the weight sensor continuously monitors the bin capacity to determine whether it is available or full, providing real-time alerts to restaurant staff. All collected data are transmitted wirelessly to the cashier interface for billing and monitoring purposes, ensuring smooth operation, reduced manual workload, and improved overall restaurant efficiency.

2. Block Diagram, Flow Charts, and Schematic diagrams

The overall architecture of the system is illustrated in **Figure 1**. The system consists of several main components, including the ESP microcontroller, color sensor, servo motor, weight sensor, LCD, and Blynk mobile application. The color sensor detects the sushi plate's color to determine

its pricing category, while the servo motor directs the plate into the storage compartment for counting and monitoring.

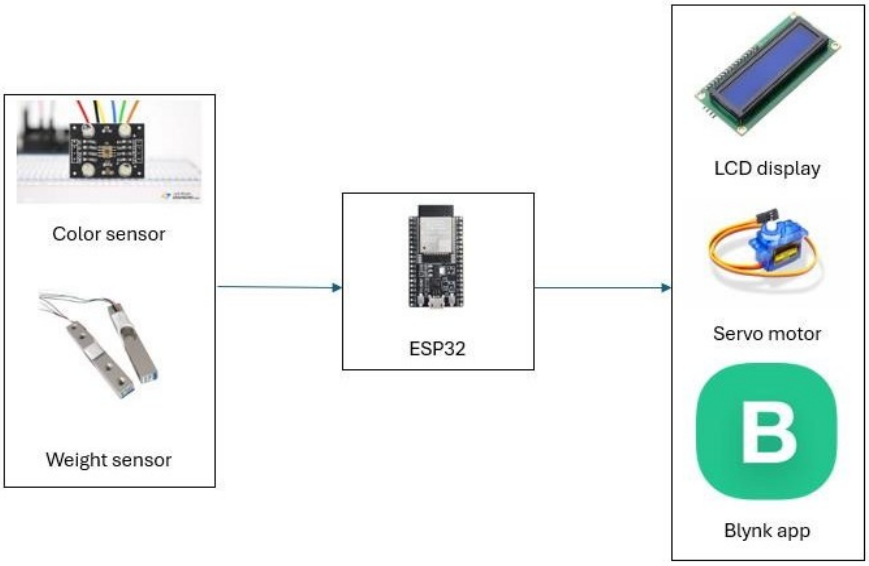


Figure 1. Block Diagram of the system.

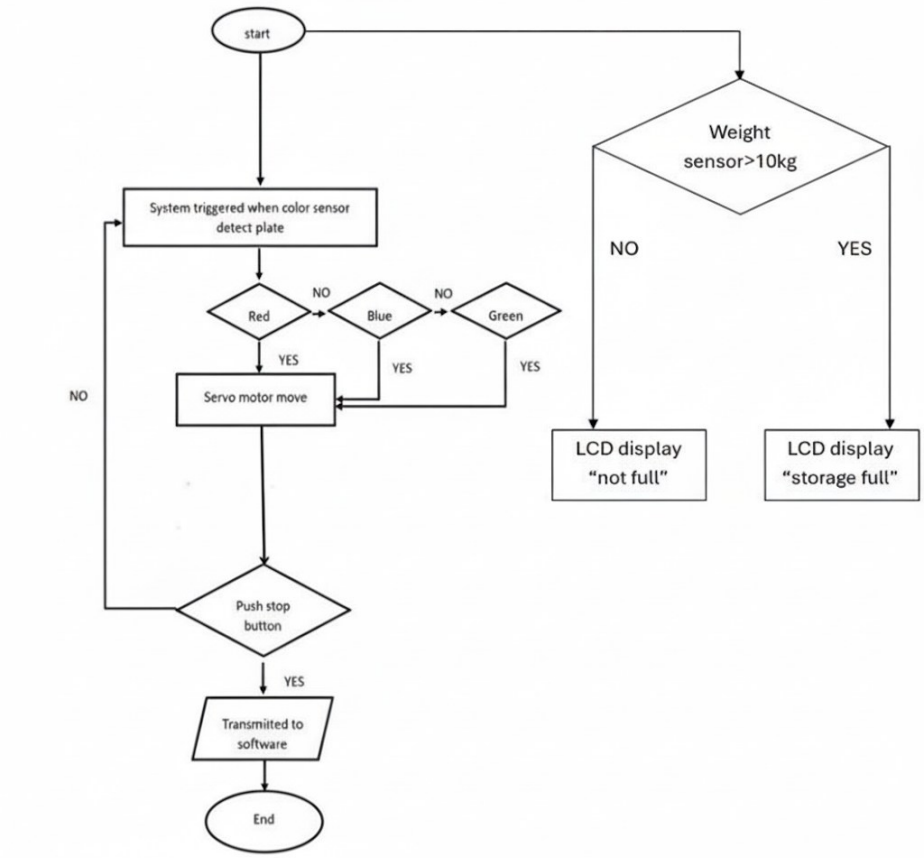
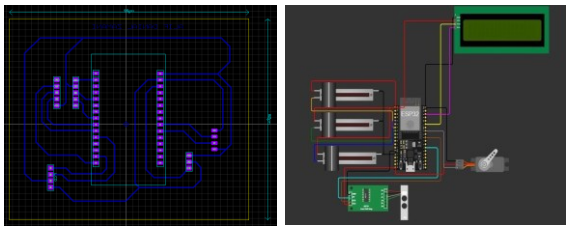


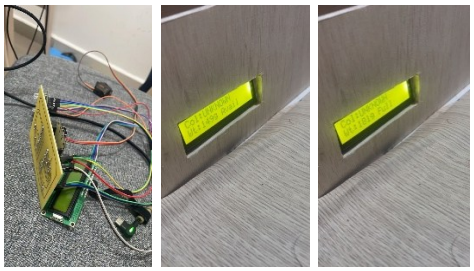
Figure 2. Flowchart of the system.

The operational process and hardware implementation of the proposed system are illustrated in **Figure 2** and **Figure 3**. **Figure 2** presents the system flowchart, which describes the sequence of operations starting from detecting the sushi plate using the color sensor, identifying the plate color category, and directing the plate using the servo motor to the appropriate storage section. The system then measures the accumulated weight of the plates using a weight sensor and updates the system status. Meanwhile, **Figure 3** shows the developed hardware prototype and testing results, including the PCB layout, assembled components, and the LCD display output during system operation. These results demonstrate that the system can detect plate colors and display the operational status effectively.



(a) PCB and schematic diagram design

(b) The actual developed hardware and PCB printed



(c) The testing of developed hardware

(d) The plot of data output saved in web apps

Figure 3. The system hardware testing and output display.

3. Novelty and uniqueness

The novelty of the Automated Sushi Plate Recognition and Billing System lies in its integration of color-based plate detection, automated plate handling, and real-time IoT-based billing within a single compact system. Unlike conventional plate counting methods that rely heavily on manual counting, this system automates the entire process, from detection to billing and storage monitoring. Another unique feature is the use of the ESP32 microcontroller with built-in Wi-Fi, enabling direct real-time data transmission without the need for additional communication modules. The inclusion of a weight sensor to monitor storage bin capacity further enhances operational safety and hygiene by ensuring timely plate disposal and uninterrupted restaurant workflow.

4. Benefit to mankind

This system provides significant benefits to restaurant operators by reducing billing errors, improving hygiene, and enhancing operational efficiency. Automated plate counting minimizes disputes caused by incorrect manual calculations and allows restaurant staff to focus on customer service rather than repetitive tasks. From a broader perspective, the system promotes the adoption of affordable IoT-based automation solutions among small and medium-sized businesses.

By improving service accuracy and cleanliness, the system contributes to higher customer satisfaction and supports a more organized and sustainable food service environment.

5. Innovation and Entrepreneurial Impact

The Automated Sushi Plate Recognition and Billing System demonstrates how simple IoT technologies can be transformed into a practical and commercially viable restaurant automation solution. The project reflects innovation through the integration of sensing, actuation, and wireless communication into a low-cost prototype suitable for real-world deployment. From an entrepreneurial standpoint, the system has strong potential as a scalable product for sushi restaurants and other plate-based dining concepts. The modular design allows future enhancements such as mobile app integration, cloud data analytics, or AI-assisted plate recognition, opening opportunities for product expansion and startup development in the food technology sector.

6. Potential commercialization

The system has strong potential for commercialization as an affordable and user-friendly automation tool for sushi restaurants. It can be marketed as a complete hardware-software package or offered through service-based models that include installation, calibration, and maintenance support. With the growing demand for smart restaurant technologies, this system addresses a clear market need for efficient, hygienic, and automated billing processes. In addition, the system can also be adapted for other restaurant concepts that use plate-based or item-based pricing, increasing its commercial reach and scalability.

7. Acknowledgment

The author would like to express sincere appreciation to the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM), Johor Branch, Pasir Gudang Campus, for the facilities and technical support provided throughout the development of this project. Special thanks are also extended to the project supervisor for guidance, encouragement, and valuable insights during the project completion.

8. Researchers' Biography

Muhammad Alif Danial bin Md Zamani is a Diploma student in Electrical Engineering (Power) at Universiti Teknologi MARA (UiTM), Johor Branch, Pasir Gudang Campus. His academic interests include embedded systems, Internet of Things (IoT), automation systems, and sensor-based applications for real-world problem solving. He has experience in developing microcontroller-based projects using ESP32, Arduino IDE, and simulation tools such as Wokwi and Proteus. His final year project focuses on the design and implementation of an IoT-based Automated Sushi Plate Recognition and Billing System, integrating color sensing, wireless data transmission, and automated monitoring to improve restaurant operational efficiency.

Siti Aliyah binti Mohd Saleh obtained her Bachelor of Electrical (Hons) Engineering from UTM and Master in Engineering (Applied Science) from Tokai University, Japan. Currently, she serves as a lecturer at UiTM Cawangan Johor Kampus Pasir Gudang in Power Department. Her main research interests are high voltage and power system.

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Smart Sugar Detection Using Refractometer: Technology for Healthier Living

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ABSTRACT
Excessive sugar consumption is a critical public health issue strongly associated with obesity, type 2 diabetes, and other lifestyle-related non-communicable diseases. Despite mandatory nutrition labeling, many consumers remain unaware of the true sugar content in beverages and liquid foods due to complex formats, hidden sugars, or difficulty interpreting serving sizes. This project proposes a smart, user-friendly sugar detection system based on refractometer technology utilizing the Brix scale to estimate sugar concentration through refractive index measurement. The innovation advances beyond conventional industrial use by adapting a scientifically established instrument into an accessible health-awareness tool for schools, households, small-scale food producers, and community health programs. The system enables rapid, real-time estimation of sugar content, translating technical measurements into intuitive health guidance that supports informed dietary decisions and strengthens nutrition literacy. By transforming a validated food science principle into an integrated preventive health and educational platform, the project bridges analytical chemistry, behavioral intervention, and public health practice. Socio-economically, it promotes preventive healthcare, empowers consumers with actionable data, and contributes to long-term reduction of lifestyle-related disease burden and healthcare costs. Commercially, the product demonstrates scalable potential across health education kits, SME food quality monitoring, agriculture, and consumer wellness markets, positioning it as a practical, data-driven solution for sustainable preventive healthcare.

Keywords: Sugar, refractometer, Brix, health awareness, health education

1. Product Description
The proposed product is a handheld refractometer as illustrated in **Figure 1**, designed to measure sugar concentration in liquid samples such as juices, soft drinks, and fruit extracts. The device operates by analyzing how light bends when passing through a liquid, converting this refraction into a readable Brix value. Users only need to place a few drops of liquid onto

the prism surface to obtain instant results. The refractometer is portable, easy to operate, and does not require advanced technical knowledge. This makes it suitable for everyday users, educational institutions, and small food industries. The product provides a reliable alternative to nutrition labels by offering direct and accurate sugar measurement.

Figure 12. A handheld refractometer.

2. Working Principle of Refractometer

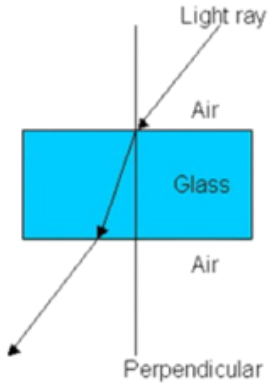

Figure 13. The refraction of light from air to glass to air.

The refractometer uses the principle of refraction of light. As shown in **Figure 2,** when the light moves from one medium to another, it changes speed and direction. This bending is called refraction. The refractometer converts the bending of light into a readable value. In the Brix refractometer, the value is converted into Brix which is the percentage of the sugar by weight in a solution. For example, 1 Brix means 1% or 1 g of sugar in 100 g liquid. In terms of teaspoon, 1 Brix is equivalent to one fourth (1/4) teaspoon of sugar.

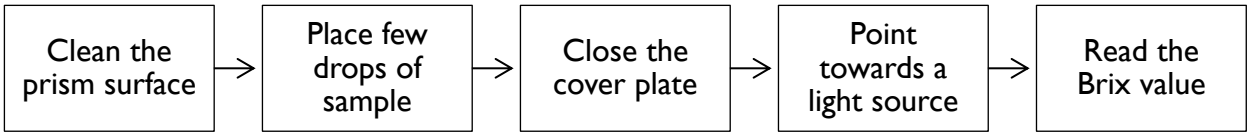

Figure 14. Step-by-step to measure sugar content using refractometer.

The basic procedure for determining sugar concentration using a refractometer is illustrated in **Figure 3**. A small drop of the liquid sample is first placed onto the prism surface of the refractometer. The cover plate is then closed to evenly distribute the sample across the prism. When the device is held toward a light source, the user can observe the boundary line between light and dark on the internal scale. This boundary indicates the **Brix value**, which represents the percentage of sugar by weight in the solution.

3. Novelty and uniqueness

The novelty of this device lies in translating a scientific measurement tool traditionally used in laboratories and industries into a user-friendly health monitoring solution. Unlike conventional sugar estimation methods that rely on nutritional labels or assumptions, this approach provides direct, real-time measurement of sugar content. The integration of health awareness with simple optical technology makes the project unique. Additionally, the refractometer's portability, accuracy, and ease of use distinguish it from existing dietary monitoring tools.

4. Benefit to mankind

The refractometer benefits individuals and society by empowering users to make informed dietary choices and reduce excessive sugar intake. It supports preventive healthcare by enabling early awareness of sugar consumption patterns. For communities, it promotes healthier lifestyles, reduces the risk of lifestyle diseases, and encourages nutritional education. In agriculture and food industries, it helps maintain product quality and safety. Overall, the innovation contributes to improved public health and sustainable food practices.

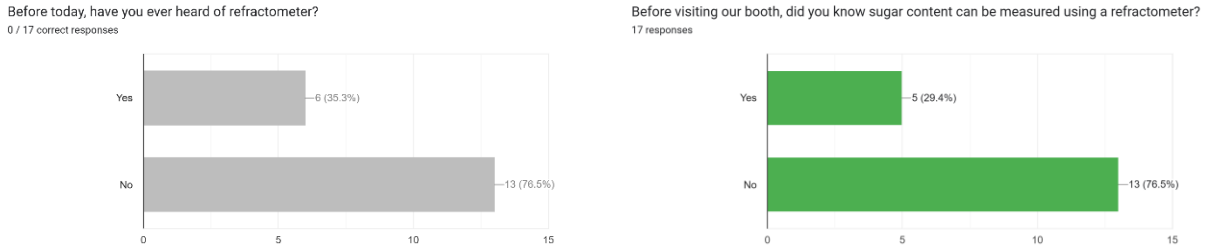

Figure 15. Community's awareness about refractometer before demonstration.

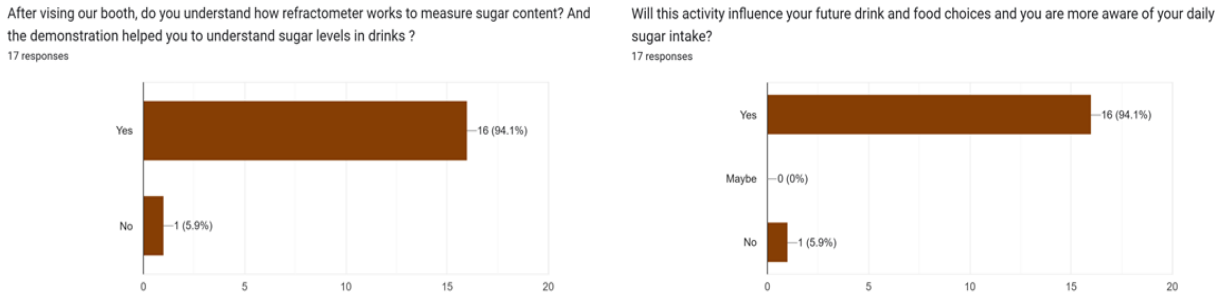

Figure 16. Community's awareness about refractometer after demonstration.

The figures above show some questionnaires given to visitors during Festival Sains, Teknologi, Inovasi, & Digital Negeri Sembilan (FESTID 2025). In **Figure 4**, the majority of the visitors (76.5%) are unfamiliar with the refractometer and its purposes. However, through demonstration during the festival, visitors gain insight on how the refractometer works to measure sugar content in drinks and increased awareness about recommended daily sugar intake and better drink and food choice for better health, as shown in **Figure 5**. Overall, the engagement at FESTID 2025 demonstrates that hands-on exposure to the refractometer effectively increases public awareness, fosters informed dietary decisions and strengthens community commitment toward healthier and more sustainable living.

5. Innovation and Entrepreneurial Impact

The refractometer, in a way, promotes innovation by demonstrating how existing scientific tools can be repurposed for new health-focused applications. It encourages entrepreneurial thinking by highlighting market opportunities in health monitoring devices, educational tools, and food quality assurance. The refractometer-based solution can inspire startups, student innovators, and small enterprises to develop affordable health technology products. This fosters a culture of innovation and entrepreneurship within academic institutions and the broader community.

6. Potential commercialization

The product has high commercialization potential due to its affordability, portability, and wide range of applications. Target markets include health-conscious consumers, schools, food and beverage manufacturers, farmers, and research institutions. The refractometer can be packaged as a consumer health gadget, an educational kit, or an industrial quality control tool. Future enhancements may include digital integration with mobile applications for data tracking and health monitoring.

7. Acknowledgment

The author would like to thank the organizing committee of the Festival Sains, Teknologi, Inovasi, & Digital Negeri Sembilan (FESTID 2025) for the opportunity given to us to share and educate the community about the importance and ideas of using this tool in helping to measure daily sugar intake.

8. Researchers' Biography

Abdul Alief Irfan Abdul Khalim Khapi obtained a Bachelor of Chemical Engineering (Hons.) in 2024 from Unversiti Teknologi MARA, Shah Alam. He pursues a MSc in Chemical Engineering in 2024 at Universiti Teknologi MARA. He currently works on research focusing on T1DM patients to control their blood glucose level by managing insulin injection dose. His research related to the simulation of glucose-insulin model, process control algorithms, and coding.

Aizad Farizi Mohd Sharoni is currently a postgraduate student in Chemical Engineering at Universiti Teknologi MARA, Shah Alam, specializing in advanced materials for wastewater treatment. He earned his B.Sc. in Chemical Engineering (Hons) from UiTM Shah Alam in 2024. His current research explores and emphasizes the modification of natural zeolites and microbead technologies using cationic surfactants for dye adsorption enhancement and removal. His academic interest includes adsorption technologies, advanced wastewater treatment, sciences, and sustainable materials utilization where it can contribute to low-cost solutions for

Assoc. Prof. Dr. Nuruliza Roslan is a cellular and molecular biologist whose work centers on lipid metabolism, immunometabolic regulation, and virus–host dynamics. She holds a PhD in Cancer Biology from the University of Sydney, with doctoral training in molecular oncology and cellular signaling. She is a Biochemistry Lecturer at the Faculty of Medicine and Health Sciences, Universiti Sains Islam Malaysia, where she teaches medical and health sciences students and leads translational research linking metabolic pathways to infection and chronic disease. Her current research interrogates lipid droplet remodeling, structural mechanisms in viral pathogenesis, and metabolic vulnerabilities relevant to diabetes, cancer, and obesity. In parallel, she develops research-driven STEM innovations and community-engaged scientific initiatives, aligning laboratory discovery with education, public health resilience, and national capacity building.

Dr. Nur Farhana Mohd Yusof is a Senior Lecturer and researcher in Process Systems Engineering, Universiti Teknologi MARA (UiTM) Johor Branch, Pasir Gudang Campus. Her research interests focus on artificial pancreas systems and diabetes-related technologies, integrating process control and system modeling to improve healthcare solutions. She is actively involved in STEM education programmes, promoting science and engineering awareness among students and young researchers. Dr. Farhana also collaborates with regional networks in South and East Asia and is engaged with the Neuro Climate Group, contributing to interdisciplinary research and innovation initiatives.

Solar-Powered IoT-Based Landslide Early Warning System for Remote and High-Risk Areas

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ABSTRACT

Landslides pose serious threats to human life and infrastructure, particularly in remote and high-rainfall regions where continuous monitoring and reliable power supply are limited. This project presents the design and development of a Solar Powered Landslide Early Warning System (S-LEWS) that integrates soil moisture and ground vibration sensing with Internet of Things (IoT) technology. The system is designed to detect early indicators of slope instability and provide timely alerts before landslide events occur. An ESP32 microcontroller processes real-time sensor data and categorizes risk levels into safe, warning and danger conditions. When hazardous conditions are detected, the system activates visual and audible alerts and transmits wireless notifications to users via a Telegram-based platform. A solar photovoltaic module with battery storage ensures continuous, energy-efficient operation without reliance on grid power. The proposed system offers a low-cost, autonomous, and sustainable solution suitable for deployment in rural and landslide-prone areas. Its modular design allows scalability and future integration with additional sensors and communication technologies. The system contributes to disaster risk reduction, enhances community safety, and demonstrates strong potential for commercialization in environmental monitoring and early warning applications.

Keywords: Landslide early warning; Solar power; ESP32; IoT monitoring, Battery Energy Storage

1. Product Description

The Solar Powered Landslide Early Warning System (S-LEWS) is an IoT-based safety device designed to monitor environmental parameters associated with landslide occurrence. The system uses a capacitive soil moisture sensor and a vibration sensor to detect ground saturation and subsurface movement. An ESP32 microcontroller serves as the core processing unit, enabling real-time data acquisition, decision-making, and wireless communication. Risk levels are classified into safe, warning, and danger states based on predefined threshold values. The system provides multi-level alerts through LEDs, a buzzer and instant Telegram notifications for remote monitoring. A solar photovoltaic panel combined with battery storage supplies sustainable power for continuous operation, making the system suitable for off-grid deployment. The prototype emphasizes low power consumption, affordability and ease of installation, offering a practical solution for landslide-prone communities, infrastructure monitoring and disaster management agencies.

2. System architecture

Figure 1 depicted the system architecture of the S-LEWS. The system integrates a soil moisture sensor and a vibration sensor to monitor gradual slope saturation and sudden ground movement, respectively. The ESP32 microcontroller function as the brain of S-LEWS that are continuously processed the sensor data and performs the signal normalization, comparison of threshold and risk classification by deploying a priority-based decision making algorithm. At any state of soil moisture level, vibration detection will immediately trigger a high-risk (DANGER) state. Visual indicators such as liquid crystal display (LCD) and LEDs as well as audible buzzer are installed for on-site warning. On the other hand, ESP32 communicates wirelessly with a smartphone via a Telegram-based IoT platform, enabling real-time notification.

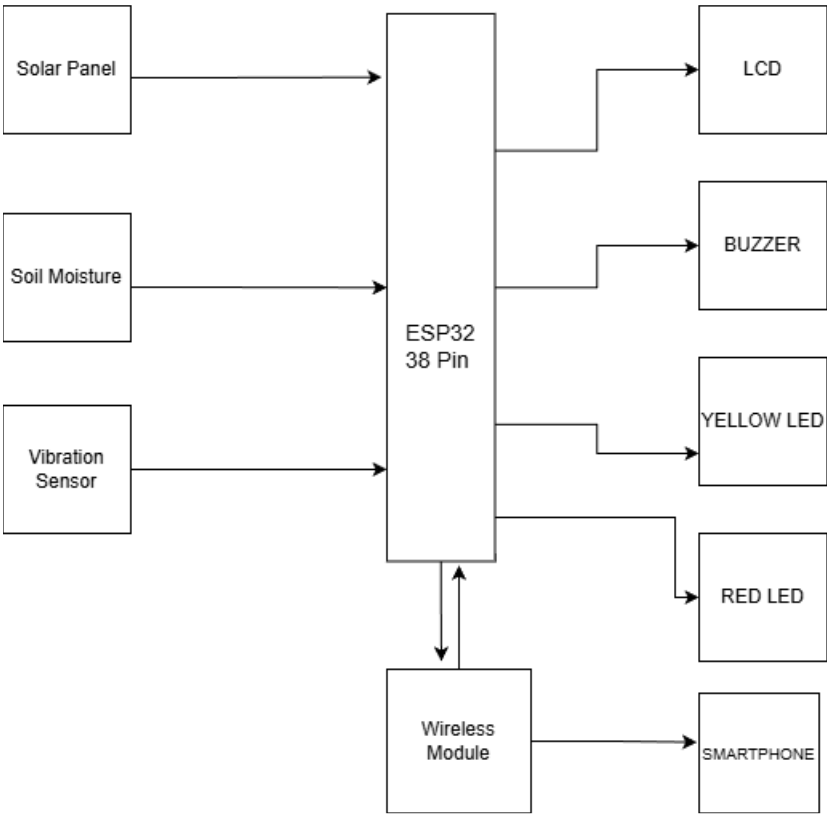

Figure 1. Block Diagram of the Solar Powered Landslide Early Warning System.

Figure 2 illustrates the operational sequence of the S-LEWS. The system begins with initializing the input data, wireless connection setup and continuous monitoring loop by ESP32. Soil moisture data are acquired in real time and the levels are evaluated based on the predefined thresholds classify as safe, warning and danger states. These states will activate corresponding visual and audible alerts. Concurrently, any detection of real time ground vibration will immediately trigger a danger alert regardless of soil moisture level. The system will restart the monitoring loop after the alert activation to ensure continuous real time operation. **Table 1** summarizes the alert logic for the S-LEWS. When soil moisture is low and no vibration is detected, the yellow LED lights up and the buzzer sounds once, indicating a low-risk condition. High soil moisture alone triggers the red LED and a continuous buzzer, signaling a potential

landslide hazard. Any detected vibration, regardless of moisture level, activates the red LED and continuous buzzer, representing an immediate high-risk situation.

This design prioritizes critical conditions, ensuring rapid alerts for both soil saturation and ground movement. The system effectively differentiates between warning and danger levels, enhancing early detection and safety measures.

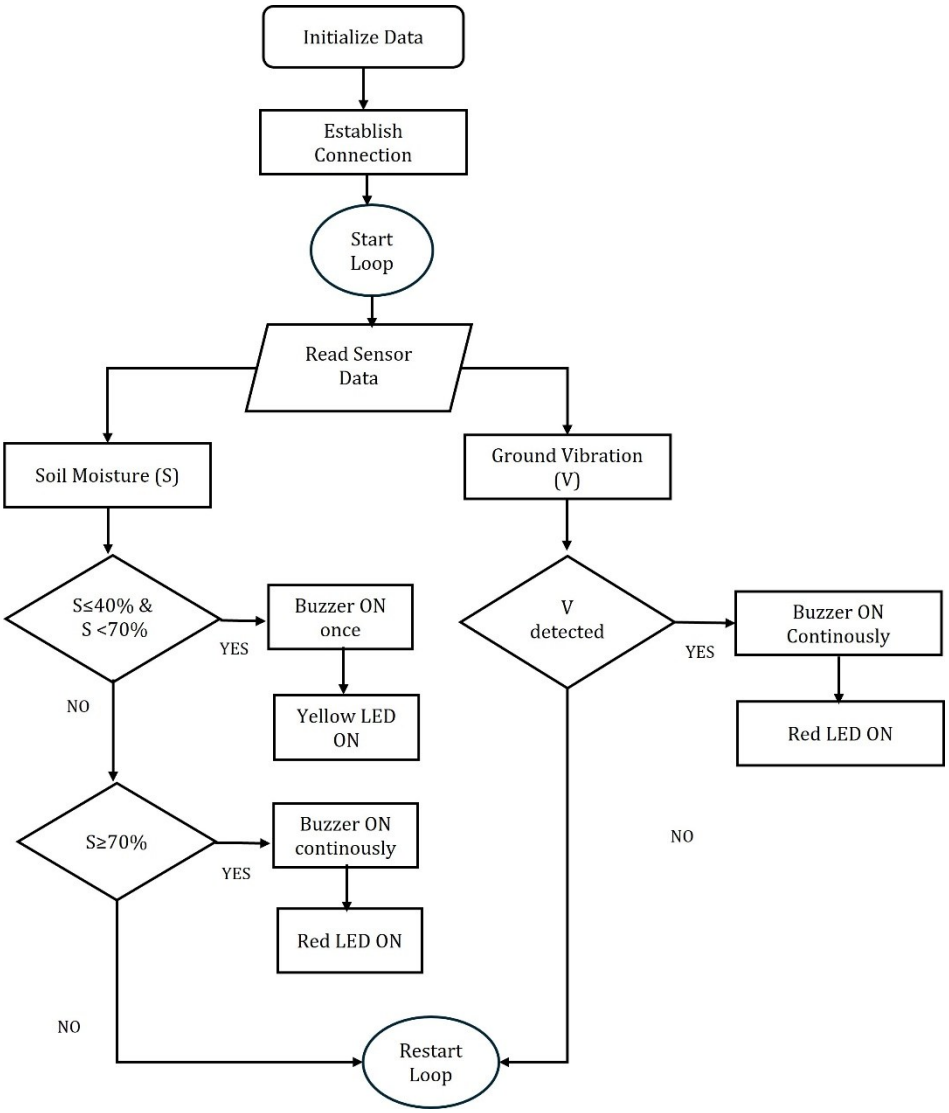

Figure 2. Flow Chart of the Solar Powered Landslide Early Warning System.

Table 1. Alert Response Based on Soil Moisture and Ground Vibration Conditions.

Soil Moisture (S)	Ground Vibration	LED Output	Buzzer Output
Low (< 40%)	No Vibration	Yellow	Once
High (≥ 70%)	No Vibration	Red	Continuously
Low (< 40%)	Vibration Detected	Red	Continuously
High (≥ 70%)	Vibration Detected	Red	Continuously

3. Novelty and uniqueness

The novelty of this project lies in the integration of dual-parameter sensing (soil moisture and vibration) with a solar-powered IoT platform for autonomous landslide monitoring. Unlike conventional systems that depend on grid power or focus on single indicators, this system combines renewable energy, real-time data processing, and instant wireless alerts in a compact and low-cost design. The use of ESP32 enables energy-efficient operation while supporting scalable IoT connectivity. The prioritization logic ensures that vibration detection immediately triggers high-risk alerts, enhancing reliability and response time. The system's modular architecture allows easy adaptation for additional sensors or communication technologies, making it suitable for diverse geographical conditions. This combination of sustainability, responsiveness, and affordability distinguishes the system from existing solutions.

4. Benefit to mankind

This project contributes directly to disaster risk reduction and public safety, particularly for communities living in landslide-prone and remote areas. By providing early warnings, the system enables timely evacuation and preventive action, potentially saving lives and reducing property damage. Its solar-powered operation ensures reliability even during extreme weather conditions when grid power may fail. The low-cost design allows wider adoption by local authorities, rural communities, and developing regions. Overall, the system supports safer living environments and promotes resilience against natural hazards.

5. Innovation and Entrepreneurial Impact

The project promotes innovation by transforming academic research into a market-ready engineering prototype addressing real-world environmental safety challenges. It fosters an entrepreneurial mindset through the development of a scalable, cost-effective product suitable for commercialization. The system encourages interdisciplinary innovation by combining renewable energy, embedded systems, and IoT technologies. It also provides opportunities for collaboration with disaster management agencies, infrastructure operators, and smart city initiatives, supporting a culture of applied innovation within academic and industrial ecosystems.

6. Potential commercialization

The system has strong commercialization potential as a standalone early warning device or as part of integrated disaster monitoring solutions. Target markets include government agencies, infrastructure operators, plantation and construction companies, and rural communities in landslide-prone regions. The low production cost and modular design enable scalable manufacturing and customization. Future enhancements such as cloud-based analytics, LoRa or GSM communication, and ruggedized enclosures can further increase market value. The product aligns sustainability goals and smart infrastructure initiatives, strengthening its commercial appeal.

7. Acknowledgment

The authors would like to acknowledge Faculty of Electrical Engineering, Universiti Teknologi MARA Johor Branch, Pasir Gudang Campus, for technical facilities and support throughout the development of this project.

8. Researchers' Biography

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IoT-Based Gas And Fire Safety System With Emergency Response

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ABSTRACT

The IoT-Based Gas and Fire Safety System with Emergency Response is an innovative safety solution designed to detect hazardous gas leaks and flames while providing early warnings and emergency guidance in residential, commercial, and industrial environments. It was designed to address the need for proactive, real-time hazard monitoring that enhances occupant safety and reduces property damage. This system is built around an ESP32 microcontroller and integrates multiple sensors for safety monitoring. The MQ-2 gas sensor detects combustible gases, the flame sensor sense fire, the PIR sensor monitors motion, and the HC-SR04 ultrasonic sensor assists with evacuation guidance. Gas levels detected by MQ-2 sensor are continuously monitored and categorized to trigger timely safety responses, while flame detection activates immediate visual, audible and IoT alerts. Unique features include automated ventilation to reduce toxic gas exposure, ultrasonic-guided evacuation, with buzzer volume adjusted according to proximity for effective warning. The system is low-cost, modular, and scalable design allows flexible deployment across different environments. By preventing accidents, protecting human life, and reducing health risks as well as material and energy losses, the system supports socio-economic and environmental sustainability. Its IoT integration supports smart living initiatives, energy-efficient buildings, future-ready solution, and commercially viable solution.

Keywords: IoT-based Safety System, Gas and Flame Detection, Emergency Evacuation Guidance, Smart and Sustainable Buildings, Proactive Hazard Monitoring

1. Product Description

The IoT-Based Gas and Fire Safety System with Emergency Response is a smart safety solution designed to detect hazardous conditions and enhance indoor safety in residential, commercial, and industrial environments. It employs an ESP32 microcontroller that integrates with multiple sensors: and MQ-2 gas sensor for detecting combustible gases such as LPG and methane, a flame sensor for early fire detection, a PIR motion sensor for human presence monitoring, and an HC-SR04 ultrasonic sensor for evacuation guidance. When dangerous gas levels or flames are detected, the system activates visual and audible alerts through LEDs, a buzzer, and a 20-by-4 I2C LCD display. An automatic cooling fan controlled via relay is also triggered to help ventilate harmful gases and smoke. The ultrasonic sensor assists occupants during emergencies by guiding them toward exits using sound-based proximity alerts, especially in low-visibility conditions. Additionally, the system is integrated with the Blynk IoT platform, enabling real-time monitoring, mobile notifications, and remote status updates. This product demonstrates a low-cost,

intelligent, and scalable approach to proactive safety monitoring and emergency response using modern IoT technology.

2. System Diagram, Operation, Outputs and Prototype

System Diagram

The system diagram of the IoT-Based Gas and Fire Safety System with Emergency Response, as illustrated in **Figure 1**, comprises a power supply, multi-sensor inputs, a microcontroller, local alert outputs, and IoT-based notification outputs, which together enable real-time hazard detection, emergency response, and remote monitoring.

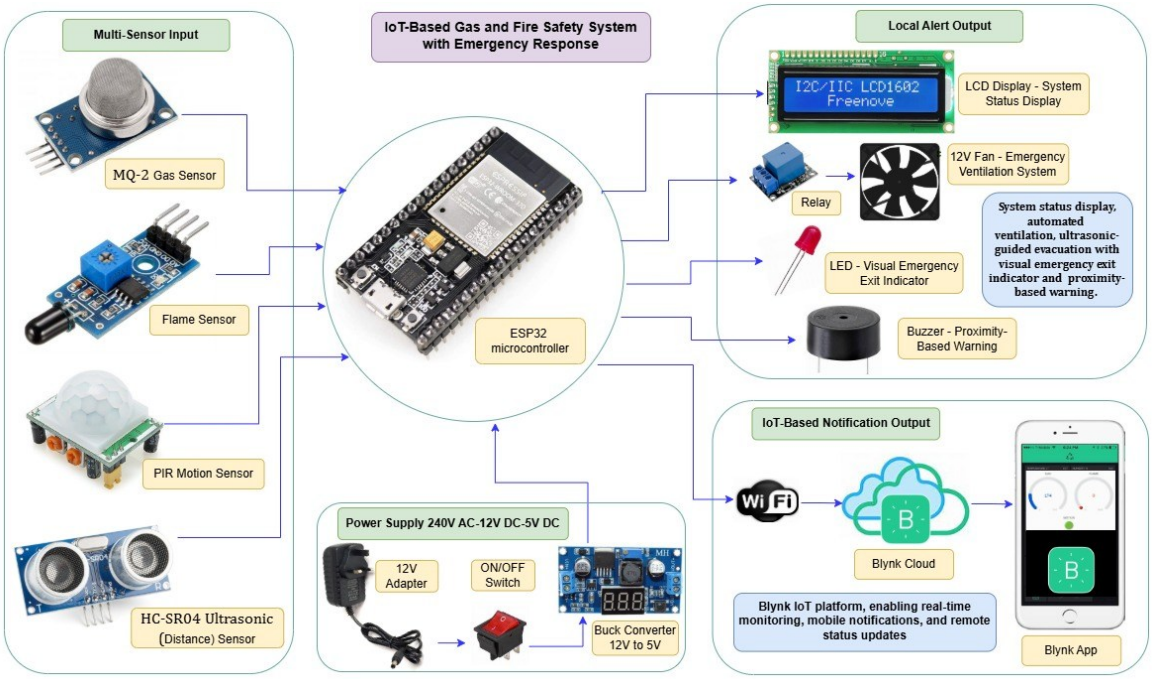


Figure 1. System Diagram of IoT-Based Gas and Fire Safety System with Emergency Response.

System Operation

The system operation is illustrated in the structured flowchart shown in **Figure 2**. It begins with the initialization of the ESP32 microcontroller, followed by establishing a Wi-Fi connection to activate Blynk IoT functionality. Once connected, the system continuously monitors environmental conditions through its multi-sensor array, the MQ-2 gas sensor and flame sensor. Gas levels are categorized for effective monitoring. Readings below 150 ppm indicate a clean and safe environment, 150–300 ppm represent low gas detection, 300–500 ppm indicate medium gas detection, and values above 500 ppm indicate high gas detection. All gas levels above 150 ppm and any flame detected trigger the system's safety responses. Upon gas or flame detection, the system checks the PIR motion sensor to determine human presence. If motion is detected, the local alert triggered with warning messages are displayed on the LCD, while the buzzer, red LED, and cooling fan are activated. After motion is detected, the HC-SR04 ultrasonic sensor identifies nearby individuals at emergency exits and activates guidance alerts when presence is detected. The sensor enables proximity-based alerts by adjusting the buzzer volume according to distance: distances below 30 cm trigger high-volume alerts, between 30 and 70 cm trigger medium-volume alerts, and distances above 70 cm result in low-volume alerts. The system uses the Blynk IoT platform to deliver real-time notifications and remote monitoring. When gas leaks or flames are

detected, instant alerts are sent to users through the Blynk mobile application, enabling quick awareness and response. The platform also displays live sensor data and system status including gas, flame and motion, supporting continuous monitoring and proactive safety management.

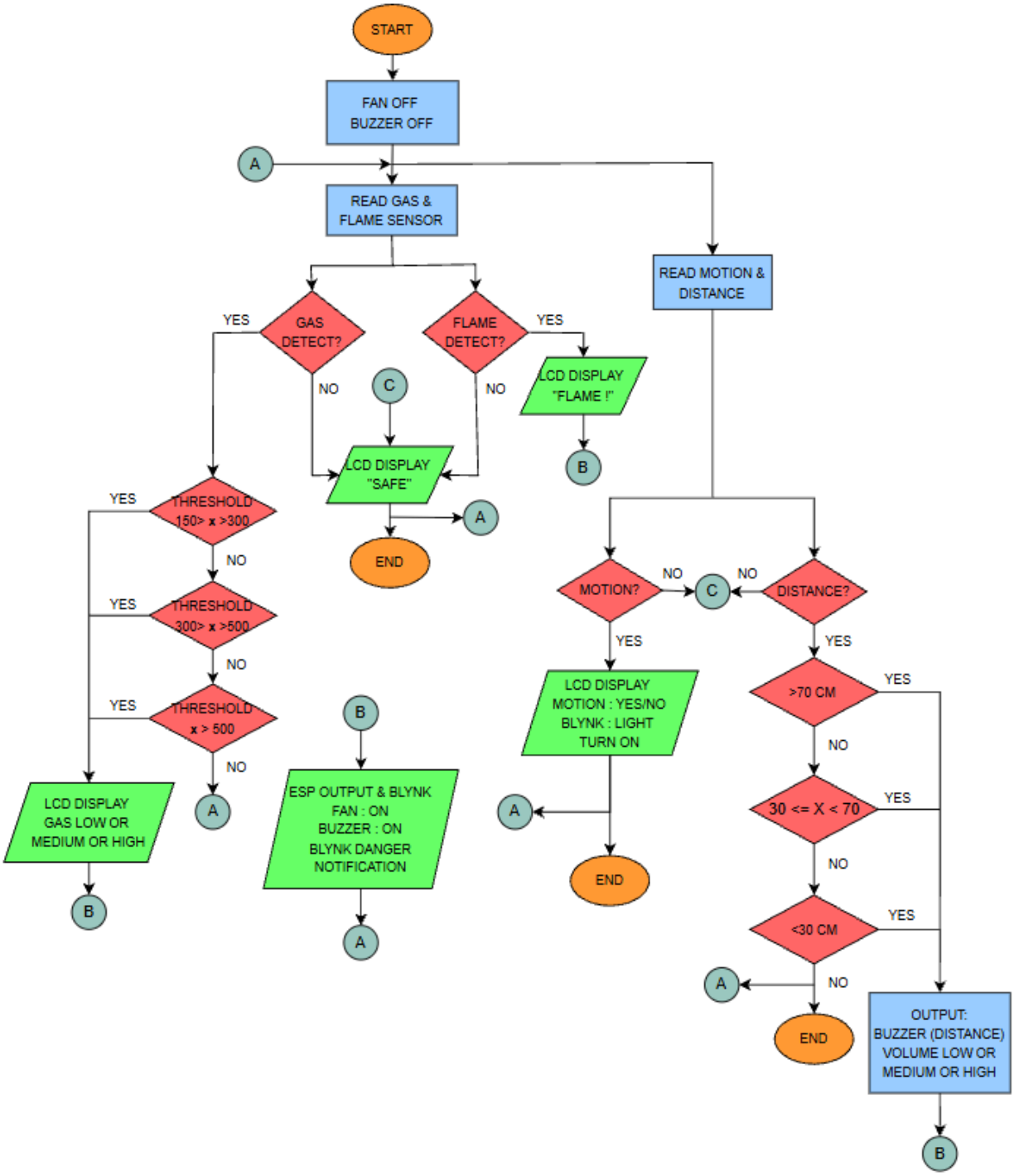


Figure 2. IoT-Based Gas and Fire Safety System with Emergency Response Operation Flowchart.

System Outputs

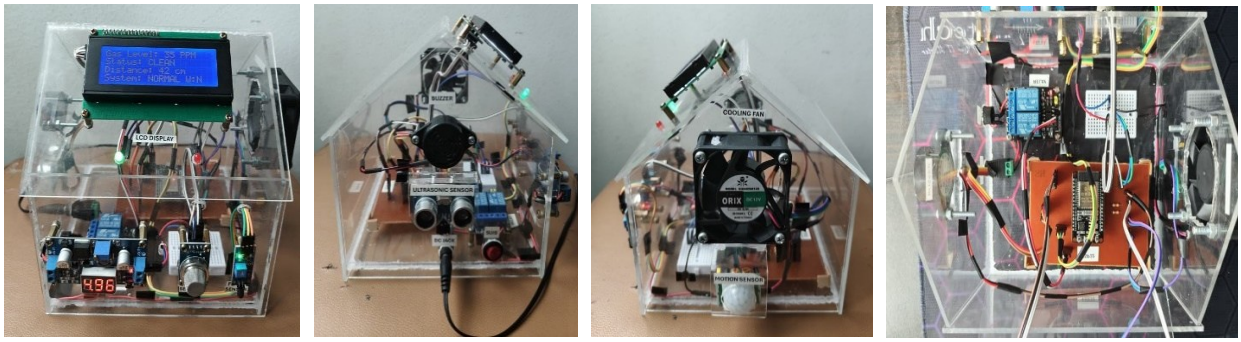
Figure 3 illustrates the local alert outputs alongside the Blynk app notifications and interfaces. When a flame or gas hazard is detected, the system simultaneously activates local alerts and sends notifications through the Blynk platform, while the user interface displays real-time monitoring indicators. Once all sensor readings return to safe levels, the system automatically resets and resumes normal monitoring, ensuring timely hazard detection and effective emergency response.

(a) (b) (c)

Figure 3. System Output and Blynk App User Interface (UI) (a) Local System LCD Status display; (b) Blynk Notifications; and (c) Blynk Monitoring Indicator – gas, flame and motion.

System Prototype

Figure 4 illustrates the prototype of the IoT-Based Gas and Fire Safety System with Emergency Response. The prototype demonstrates the system's modular design and practical feasibility, enabling easy implementation across residential, commercial, and industrial applications.



(a) (b) (c) (d)

Figure 4. Prototype views: (a) front, (b) right, (c) left, and (d) top.

3. Novelty and uniqueness

The novelty of the system lies in its smart integration of multiple sensing and response mechanisms within a unified IoT-based safety platform that extends beyond hazard detection to emergency guidance, occupant support, and effective emergency response solutions. Unlike conventional standalone gas or fire detectors, the system supports real-time data access and seamless integration with digital platforms, enabling proactive safety management. It simultaneously monitors gas leaks, flame presence, human occupancy, and spatial distance to facilitate context-aware hazard detection. The capability to activate automated ventilation and provide evacuation guidance represents an active mitigation approach rather than passive alerting. Furthermore, IoT-enabled real-time monitoring enhances situational awareness through remote supervision and instant notifications, clearly differentiating the system from existing safety devices. Its low-cost architecture and practical feasibility enhance accessibility while enabling seamless integration with smart home and smart building ecosystems. The unique combination of multi-sensor intelligence, IoT connectivity, automated hazard mitigation, and evacuation guidance clearly distinguishes the system from conventional safety devices, highlighting its novelty as an integrated, future-ready smart safety and emergency response solution.

4. Benefit to mankind

The system provides significant benefits to mankind by enhancing safety, sustainability, and overall quality of life through effective mitigation of gas leaks and fire hazards. Early detection enables timely warnings that help prevent accidents, injuries, loss of life, and property damage. The combination of real-time visual, audible, and mobile alerts with guided evacuation support improves emergency response and decision-making, particularly in low-visibility and high-risk situations. Automated ventilation reduces exposure to toxic gases and smoke, contributing to improved indoor air quality and better health outcomes. Ultrasonic-based evacuation guidance further assists occupants in locating safe exits, offering critical support to vulnerable groups such as children and the elderly. Its low-cost and scalable design makes advanced safety monitoring accessible across residential, commercial, and industrial settings. Integration with IoT platforms promotes proactive safety management, improved resource efficiency, and alignment with smart and sustainable living initiatives, fostering safer and more resilient communities.

5. Innovation and Entrepreneurial Impact

The IoT-Based Gas and Fire Safety System with Emergency Response promotes innovation by integrating multiple sensor detection, real-time data processing, and cloud-based IoT monitoring into a single intelligent safety solution. By combining gas, flame, motion, and distance sensing with automated responses and mobile notifications, the project demonstrates how affordable IoT technologies can be translated into practical, high-impact safety products. From an entrepreneurial perspective, the system offers strong market potential across residential, educational, commercial, and small-scale industrial sectors, particularly in cost-sensitive markets. Its modular and scalable design supports customization, future upgrades, and product diversification, encouraging startup development and technology-based entrepreneurship. Beyond commercial applications, the project fosters an innovative-driven culture within the community, institutions, and industry by addressing real-world safety challenges with applied engineering solutions, inspiring students, researchers, developers, and entrepreneurs to explore problem-solving, product innovation, and business opportunities in the growing smart safety and IoT industry.

6. Potential commercialization

The IoT-Based Gas and Fire Safety System with Emergency Response presents strong commercialization potential as a smart, cost-effective safety solution for residential, commercial, and industrial environments. Leveraging low-cost sensors, the ESP32 microcontroller, and IoT platforms such as Blynk, the system is scalable for mass production and accessible to cost-sensitive markets. ensures affordability and scalability for mass production. It can be deployed as a plug-and-play device or customized to meet the specific needs of homes, kindergartens, classrooms, laboratories, restaurants, and small factories. Key features including mobile notifications, modular sensor expansion, and cloud-based monitoring enhance its market appeal. With growing demand for smart building technologies and proactive safety solutions, this system offers a competitive alternative to conventional alarm systems. Its combination of affordability, adaptability, and IoT-enabled intelligence creates opportunities for startups, system integrators, and IoT-based safety service providers, positioning it as a commercially viable and high-impact solution in the emerging smart safety market.

7. Acknowledgment

The authors would like to express their sincere appreciation to Universiti Teknologi MARA, Cawangan Pulau Pinang, for the support and facilities that enabled the completion of this project.

8. Researchers' Biography

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SmartGrow: A Solar-Powered IoT-Based Vertical Hydroponic Monitoring and Control System

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ABSTRACT

SmartGrow: A Solar-Powered IoT-Based Vertical Hydroponic Monitoring and Control System addresses the growing challenges of urban agriculture, including limited land availability, high resource consumption, and reliance on manual farming practices. Traditional hydroponic systems, while efficient, often lack integrated automation, real-time remote monitoring, and sustainable energy sources, reducing their practicality for scalable deployment. This project aims to develop an intelligent vertical hydroponic system that integrates IoT, automation, and solar energy to enable real-time monitoring and control of key plant growth parameters, including pH level, Total Dissolved Solids (TDS), water level, and light intensity. Using an ESP32 microcontroller, SmartGrow supports both automatic and manual operation of nutrient pumps, water circulation, and grow lights through a web-based dashboard, with cloud-based data logging for performance analysis. The system findings demonstrate stable and reliable operation, effective nutrient and lighting regulation based on predefined thresholds, and a significant reduction in human intervention. By leveraging renewable solar energy, SmartGrow enhances energy efficiency and supports off-grid operation, making it suitable for urban, educational, and small-scale farming applications. Overall, SmartGrow offers a practical, scalable, and sustainable smart farming solution that promotes efficient food production and environmentally responsible agriculture.

Keywords: Vertical Hydroponics, Internet of Things (IoT), Solar-Powered System, Automated Monitoring and Control, Sustainable Urban Agriculture.

1. Product Description

SmartGrow is a solar-powered, IoT-based vertical hydroponic monitoring and control system designed to support sustainable, resilient urban agriculture in line with the United Nations Sustainable Development Goals (SDGs). The system addresses key challenges, such as limited farming space, inefficient resource use, and reliance on manual monitoring, by integrating smart sensing, automation, and renewable energy. SmartGrow continuously monitors critical plant growth parameters, including pH level, Total Dissolved Solids (TDS), water level, and light intensity, using an ESP32 microcontroller. Real-time data visualization, threshold configuration, and actuator control are provided through a web-based dashboard, enabling both automatic and manual operation of nutrient pumps, water circulation, and grow lights. Cloud-based data logging supports performance tracking and decision-making. Powered by solar energy, SmartGrow reduces reliance on conventional electricity and operational costs, contributing to SDG 7: Affordable and Clean Energy. The vertical, space-efficient design promotes SDG 11: Sustainable Cities and Communities, while automated nutrient and water management supports SDG 12:

Responsible Consumption and Production. By enabling efficient, localized food production, SmartGrow also contributes to SDG 2: Zero Hunger. Overall, SmartGrow offers a scalable, energy-efficient, and environmentally responsible smart farming solution for urban, educational, and small-scale agricultural applications.

2. Pictures

Figure 1 illustrates the SmartGrow prototype, a compact vertical hydroponic system designed for efficient plant cultivation in limited spaces. The structure consists of a cylindrical planting tower with multiple planting slots, a nutrient reservoir at the base, and a solar panel that provides renewable energy for sustainable and energy-efficient hydroponic farming. **Figure 2** presents the SmartGrow dashboard web server used for real-time monitoring and control of the hydroponic system. The interface displays important parameters, including TDS, water level, LDR, and pH readings. Users can also configure threshold values and manually operate the nutrient pump, water pump, and grow light. **Figure 3** shows the Google Sheet data logging interface that stores real-time operational data collected from the SmartGrow system. The spreadsheet records parameters such as timestamp, TDS value, water level, LDR reading, pH measurement, and device status. This feature enables continuous monitoring, systematic recording, and further analysis.

Figure 1. Prototype.

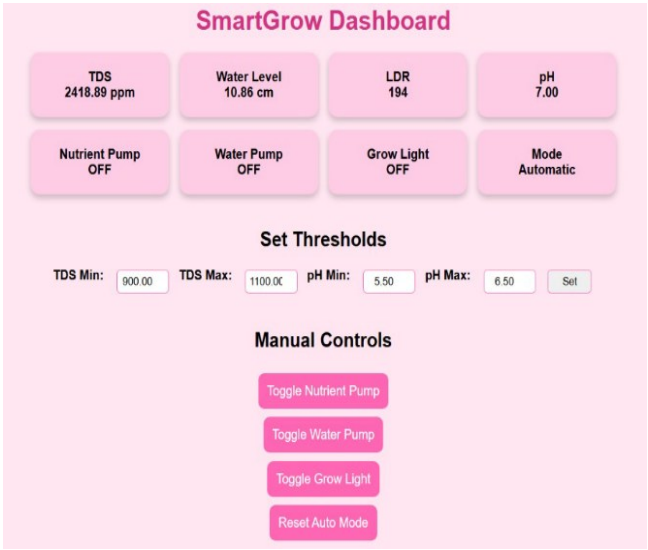

Figure 2. SmartGrow Dashboard Web Server.

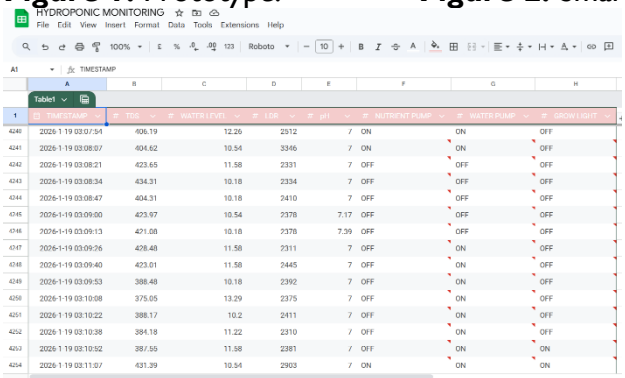

Figure 3. Google Sheet Data Logging.

3. Novelty and Uniqueness

SmartGrow introduces a novel integration of solar-powered vertical hydroponics with a dual-layer digital management system that combines a real-time Hydroponics Dashboard Web Server and cloud-based Google Sheets data logging. Unlike conventional hydroponic solutions that rely on isolated monitoring or mobile-only interfaces, SmartGrow delivers a unified, web-driven platform that enables live visualization, threshold configuration, and direct actuator control, while simultaneously capturing historical data for analysis and decision support. The Hydroponics Dashboard Web Server functions as an intelligent Human–Machine Interface (HMI), allowing users to monitor pH, TDS, water level, and light intensity in real time, configure automated control thresholds, and manually override system operations when required. This bidirectional control capability ensures system reliability, operational flexibility, and immediate response to changing plant conditions. In parallel, Google Sheets data logging provides an innovative yet accessible analytics layer by storing timestamped sensor data and actuator states in the cloud. This enables performance tracking, trend analysis, and scalability without the need for complex databases or proprietary software. By combining vertical space optimization, renewable solar energy, real-time web control, and transparent cloud-based data logging, SmartGrow offers a practical, scalable, and data-driven smart farming solution that clearly differentiates it from existing hydroponic systems.

4. Benefit to Mankind

SmartGrow delivers meaningful benefits to mankind by enabling sustainable, efficient, and accessible food production in urban and space-constrained environments. By combining vertical hydroponics with IoT automation and solar energy, the system supports continuous crop cultivation while significantly reducing water usage, energy consumption, and reliance on manual labor. This contributes directly to improved food security and resilience, particularly in densely populated or off-grid communities. The system empowers individuals, educational institutions, and small-scale farmers to monitor and manage plant growth remotely, ensuring consistent crop quality and minimizing losses from nutrient imbalances or improper lighting. Solar power integration reduces operational costs and environmental impact, promoting clean energy adoption and lowering carbon emissions. Beyond food production, SmartGrow serves as an educational and innovation platform that raises awareness of smart agriculture, renewable energy, and digital technologies. Overall, SmartGrow enhances quality of life by supporting sustainable agriculture, environmental conservation, and smarter resource management for present and future generations.

5. Innovation and Entrepreneurial Impact

SmartGrow promotes innovation by transforming conventional hydroponic farming into a smart, data-driven, and sustainable solution through the integration of IoT automation, renewable solar energy, and web-based control. The project demonstrates how emerging technologies can be translated into practical, real-world applications that address food security, resource efficiency, and urban farming challenges.From an entrepreneurial perspective, SmartGrow has strong commercialization potential as a modular, scalable, and cost-effective smart farming product. It can be adapted for home users, educational institutions, urban communities, and small- to medium-sized agricultural enterprises. The use of accessible platforms such as web dashboards and cloud-based data logging lowers technical barriers, encouraging adoption by non-experts and new entrepreneurs. Within institutions and communities, SmartGrow fosters a culture of

entrepreneurship by inspiring innovation-driven problem solving, hands-on technology development, and sustainable business thinking. The project serves as a foundation for startup development, technology transfer, and smart agriculture ventures, supporting innovation-led economic growth and digital transformation in the agricultural sector.

6. Potential Commercialization

SmartGrow has strong commercialization potential as a scalable, market-ready smart agriculture solution that addresses the growing demand for sustainable, space-efficient food production. The system can be packaged as a modular product, offering hardware kits, solar-powered upgrades, and subscription-based web monitoring services tailored for home users, educational institutions, urban communities, and small-scale farmers. Its flexible design allows customization based on user needs, enabling different pricing tiers for entry-level users and advanced users seeking automation and data analytics features. The integration of a web dashboard and cloud-based data logging enhances product value by supporting remote monitoring, predictive maintenance, and data-driven farming decisions. SmartGrow also presents opportunities for partnerships with agrotechnology companies, educational institutions, and government agencies promoting smart and sustainable agriculture. With rising interest in urban farming and clean energy solutions, SmartGrow is well-positioned for commercialization as a practical, affordable, and impactful smart-farming product across local and regional markets.

7. Acknowledgment

The project team extends its gratitude to the Faculty of Electrical Engineering, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, for their support in providing the resources necessary to bring this innovation to fruition.

8. Researchers' Biography

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Contactless IoT-Enabled Dustbin Featuring GPS and Waste-Level Monitoring

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ABSTRACT

The increase in population results in higher waste production, where the shortcomings of traditional waste management often lead to overflowing bins and sanitation problems in public spaces. This project presents an IoT-based smart dustbin created to enhance the efficiency and cleanliness of waste disposal. The system is built using an ESP32 microcontroller, integrated with motion detection for automatic lid operation, ultrasonic sensors for monitoring waste levels, and a GPS Neo M6 module for location tracking. Information is stored in Google Sheets for real-time monitoring, while a Telegram bot provides instant notifications once the bin reaches preset capacity limits. This design was developed to overcome the slow manual inspection process by enabling automated data logging and remote management. Through simulation, the system demonstrates consistent performance, including motion-triggered lid activation, precise measurement, and dependable alert transmission. The purpose of this project is to improve hygiene in public areas, reduce labour requirements, and ensure timely waste collection. The system's contribution extends to strengthening public health while optimizing municipal operations. With GPS integration, this IoT solution highlights strong commercial potential for smart city infrastructure, public amenities, and industrial waste management.

Keywords: GPS, IoT, Real-time monitoring, Smart Dustbin, Waste management

1. Product Description

The project incorporates a motion detection system along with waste-level monitoring in the dustbin, supported by GPS as an additional sensor to track variations in the type of waste disposed. The system records data into Google Sheets to calculate the average waste level. An ultrasonic sensor is employed to notify the system whenever the bin exceeds its weight capacity or surpasses the waste threshold. This smart dustbin is designed with a flexible system that can be upgraded periodically, though in this project it only provides data covering a span of three to four years. From a geographical perspective, it can be installed in industrial areas such as factories and large warehouses to optimize waste disposal. The improved dustbin stands as a representation of an innovative IoT-based solution for waste-level management. Its operation ensures that when the bin approaches maximum capacity, a text notification is automatically sent to the owner. This method offers an effective approach to waste management in smart cities, as efficient monitoring of garbage can elevate the standards of cleanliness and hygiene within the environment.

2. Flowchart and Block Diagram of The Project

The block diagram in **Figure 1** shows how a contactless dustbin system that integrates multiple components for efficient waste management. A motion sensor detects nearby movement and sends a signal to a servo motor, which automatically opens and closes the dustbin lid without any physical contact while the waste level sensor and weight sensor monitor the trash capacity. The system communicates wirelessly via Wi-Fi and sends notifications through Telegram. A microprocessor processes the sensor data, displaying information on an OLED screen and storing records in Excel for analysis. Additionally, an LED indicator provides visual feedback. This automated setup makes it more hygiene, reduces physical contact, and optimizes waste disposal by using real-time monitoring and notifications, making it more user-friendly.

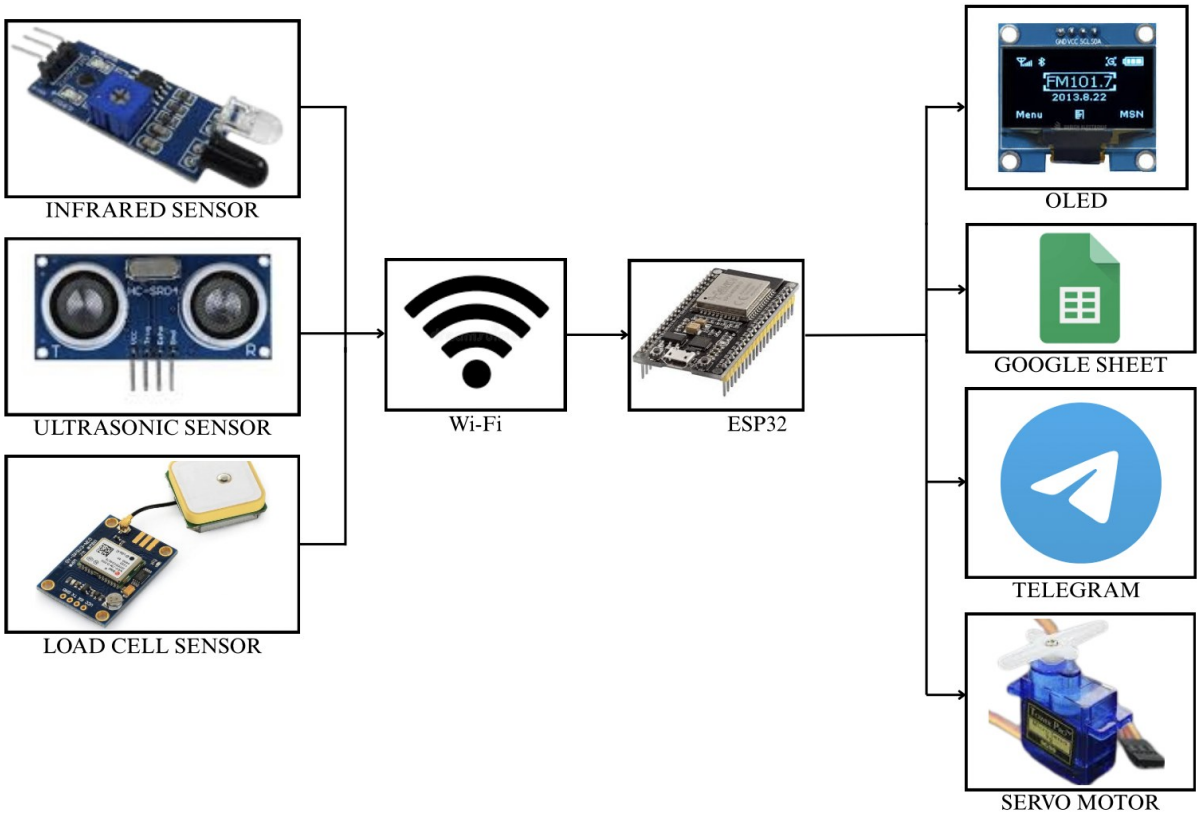

Figure 1. Block diagram of Contactless Dustbin with Motion Detection and Waste Level Monitoring.

The flowchart in **Figure 2** describes the operation of a contactless dustbin system. It begins by ensuring a Wi-Fi connection, followed by detecting the waste level and human presence. If human presence is detected, the lid opens. The waste level data is displayed on an OLED screen and sent to Google Sheets. If the bin is full, a message is sent to the telegram, the bin is cleaned, and the status is updated. If not, the process loops, creating an efficient and automated waste management system.

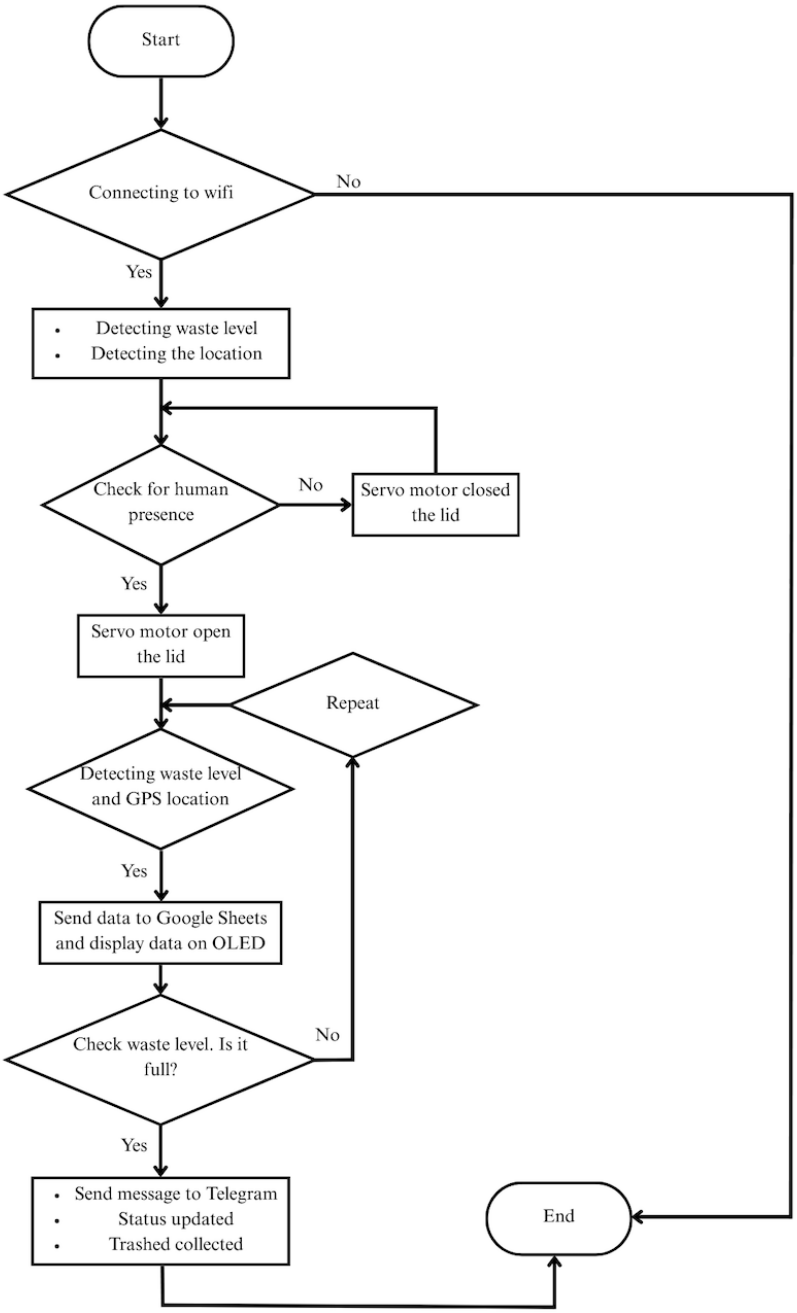

Figure 2. Flowchart of Contactless Dustbin with Motion Detection and Waste Level Monitoring.

3. Novelty and uniqueness

In terms of novelty and distinctiveness, this project focuses on the integration of multiple smart technologies into a unified IoT-based dustbin system. Unlike conventional bins or earlier smart prototypes that only track fill levels, this design incorporates motion detection for automated lid opening, ultrasonic sensing for waste-level measurement, and GPS tracking for location identification. Together, these features establish a comprehensive monitoring solution that enhances hygiene, reduces manual effort in opening the lid, and enables efficient waste collection. The uniqueness of the dustbin is further highlighted through real-time data recording in Google

Sheets and instant notifications via Telegram, ensuring prompt responses when bins approach maximum capacity. The system not only improves public cleanliness but also contributes to smart city frameworks by supporting route optimization and resource allocation. With scalability across industrial, rural, and urban applications, the design offers potential upgrades such as solar energy integration and cloud-based dashboards. This project ultimately delivers a sustainable and forward-looking solution for modern waste management practices.

4. Benefit to mankind

This project provides a few benefits to fulfil the society by improving public hygiene with environmental protection along the efficiency. When it comes through the automated lid opening, this system will minimize and avoid physical contact with the dustbin. With this alternative, it will reduce the spread of germs especially on your hands likely on the high-traffic areas such as hospitals, schools and public areas also streets. Furthermore, with built-in real-time monitoring of the waste levels, it helps from overflowing bins cases which are major sources of unpleasant odors and contamination. By enabling timely collection with the GPS location, it eliminates unnecessary trips and allows for more strategic scheduling routes. This will help to lower the fuel cost and consumption while do a contributing to environmental sustainability in a positive way. Finally, the project truly promotes a healthier, safer and will look more organized on the urban and rural area lifestyle while giving a realization to public to have a responsible waste management practice that benefits to all.

5. Innovation and Entrepreneurial Impact

The Enhanced Dustbin with Motion detection and Waste Level Monitoring demonstrate a strong innovation by doing an integration motion detection, ultrasonic waste-level monitoring, GPS tracking, IoT cloud storage and Telegram apps alert into one unified smart waste management system. This project is not like a conventional bin where it uses intelligent automation to enhance both usability and efficiency. By using ESP32 microcontroller that has wireless connectivity positions that the product as a modern IoT cloud solution suitable for smart city initiative in the future. On entrepreneurial perspective, the system offers a good strong market potential where it solves a good and growing problem such as inefficient waste of collection time and overflown bins. For the private cleaning contractors and the government on the shopping malls, universities and industrial sectors can significantly benefit from having these technologies. An entrepreneur can measure the product into multiple versions of solar powered model where it should have weather-resistant units or premium industrial units that creating diverse revenue streams. This project is in a good position where it's not only innovative but has a value in business opportunity.

6. Potential commercialization

The project system demonstrates strong commercial potential due to its scalability and applicability across diverse industries. As urban populations continue to grow, both local councils and private waste management companies must adopt more efficient technologies to optimize operations and reduce reliance on manual labor. This advanced dustbin provides several solutions, including a cost-effective approach through route optimization that lowers fuel consumption and guarantees timely collection. Additionally, it can be implemented in commercial environments such as shopping malls, airports, hotels, hospitals, and universities, where strict cleanliness and continuous monitoring are essential for potential users. In the context of smart city development,

this product aligns positively with government digitalization strategies, making it an attractive option for procurement.

7. Acknowledgment

I would like to express my deepest gratitude to my project supervisor for their invaluable guidance, support and valuable feedback throughout the development of this project. Her insights and encouragement really played a crucial role in shaping the outcome of my project. I am also sincerely thankful to my family for their constant support and motivation and to my faculty members who offered their assistance and shared their knowledge wherever possible. Their contributions really help in overcoming challenges and completing my project successfully.

8. Researchers' Biography

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Dr. Nur Asfahani Ismail has been serving as a lecturer at UiTM Pasir Gudang since 2014. She obtained her PhD in Optical Fibre Communication from Universiti Teknologi Malaysia (UTM) in 2025. Over the years, she has guided numerous students in their final year projects and earned recognition from the university for her contributions. Her research interests focus on IoT-based systems and machine learning.

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Nextgen Restroom: Smarter, Safer, Greener

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ABSTRACT
NextGen Restroom: Smarter, Safer, Greener is a project that aims to develop a smart restroom system with automated features to improve hygiene, safety, and energy efficiency. Traditional restrooms require frequent physical contact with surfaces and switches, which increases the risk of germ transmission and leads to unnecessary water and electricity consumption. To address these issues, the proposed system includes three main features. The first feature is an automatic hand-washing station using an IR sensor to detect hand presence, allowing water to flow automatically and promoting better hygiene while reducing water waste. The second feature is a motion-activated lighting and fan system controlled by an ultrasonic sensor, which turns the light and fan on when a person enters and off when the restroom is unoccupied, saving energy and reducing physical contact. The third feature is an emergency push button that allows users to alert security personnel during emergencies through smartphone notifications using Blynk software. All system operations are managed by an ESP32 microcontroller to ensure smooth and reliable performance. Overall, the system reduces surface contact, conserves water and electricity, enhances public safety, and has strong commercialization potential as a cost-effective solution for public facilities such as shopping malls, hospitals, and transportation hubs. The Nextgen Restroom is likely to give a positive impact to the economy and society by providing a safe restroom while optimizing the usage of electricity and water,

Keywords: Smart Restroom System, Sensor-Based Automation, Emergency Alert System.

1. Product Description
The proposed system is a smart automated restroom designed to improve user comfort, resource efficiency, and emergency response. It combines sensor-based automation to control lighting, ventilation, and water usage, along with an emergency push button that sends instant alerts to security personnel. An ultrasonic sensor is used to detect human presence inside the restroom. When a person enters, the sensor activates the LED lighting and DC fan to improve visibility and ventilation. These devices remain on while motion is detected and automatically turn off when the restroom is unoccupied, helping to save energy. An IR sensor is used at the sink to control a mini water pump, allowing water to flow automatically when a hand is detected and stop when no hand is present, reducing water waste and improving hygiene. A key feature of the system is the emergency push button installed inside the restroom. When pressed, an LED indicator turns on and alert messages is sent to the Blynk application, notifying security guards through their smartphones for immediate action. Once the situation is resolved, the button can be pressed again to reset the system. All operations are controlled by an ESP32 microcontroller, which manages inputs, outputs, and real-time communication through the Blynk platform.

2. Product prototype

Figure 1 and **Figure 2** show the block diagram and schematic diagram of the system. **Figure 3** depicts the flowchart operation of the system, while **Figure 4** shows the development of the prototype. **Figure 5** depicts the Blynk application display and notifications when the push button is pressed and the LED is ON. **Figure 6** shows the mobile application interface. **Figure 7**depicts the Blynk application display when the push button is pressed and the LED is OFF.

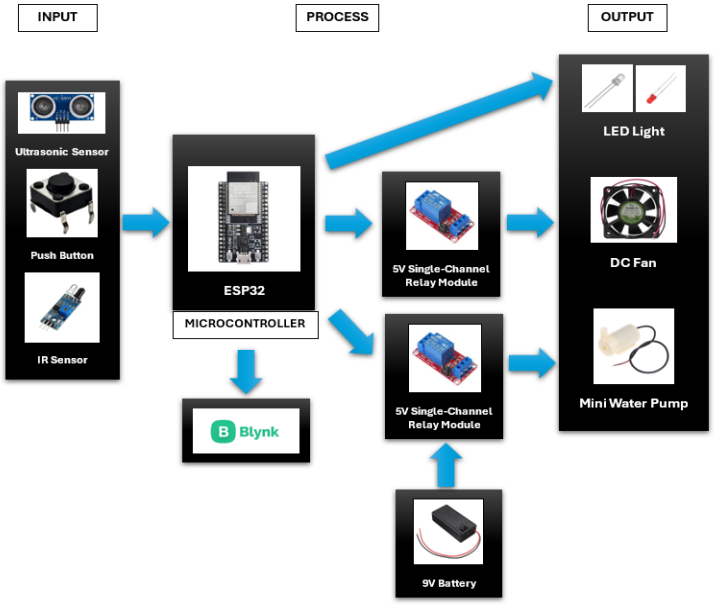


Figure 1. Block diagram of the Modern Restroom with Automation system and Emergency buttons.

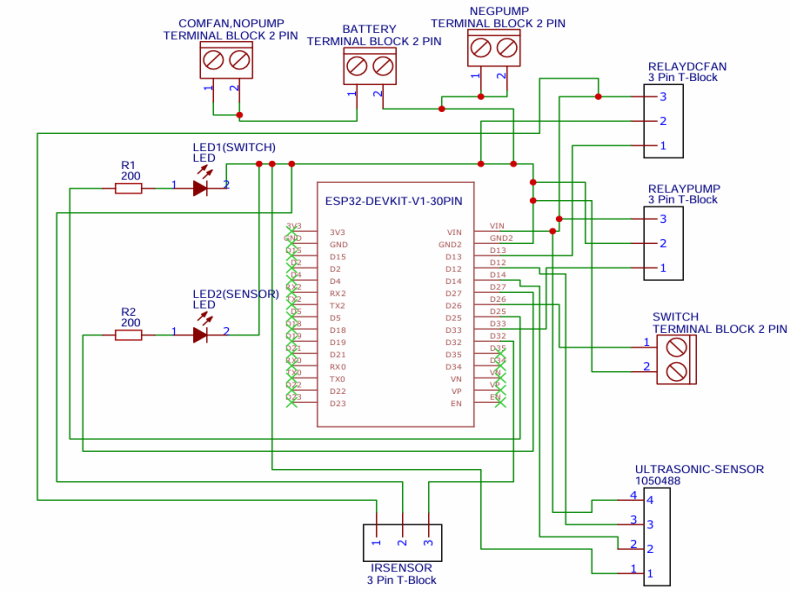


Figure 2. Schematic Diagram of the Modern Restroom with Automation system and Emergency buttons.

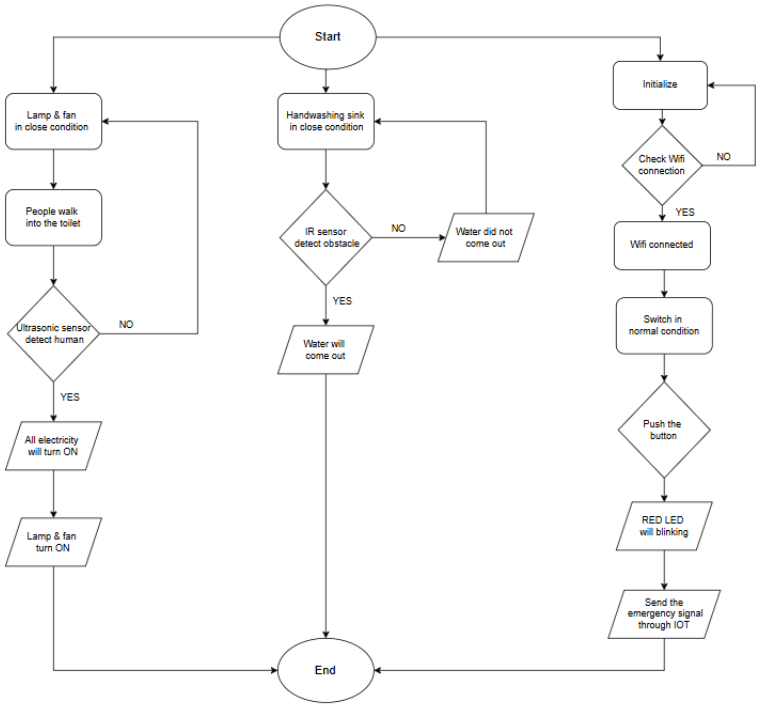


Figure 3. Flowchart of the of the Modern Restroom with Automation system and Emergency buttons.

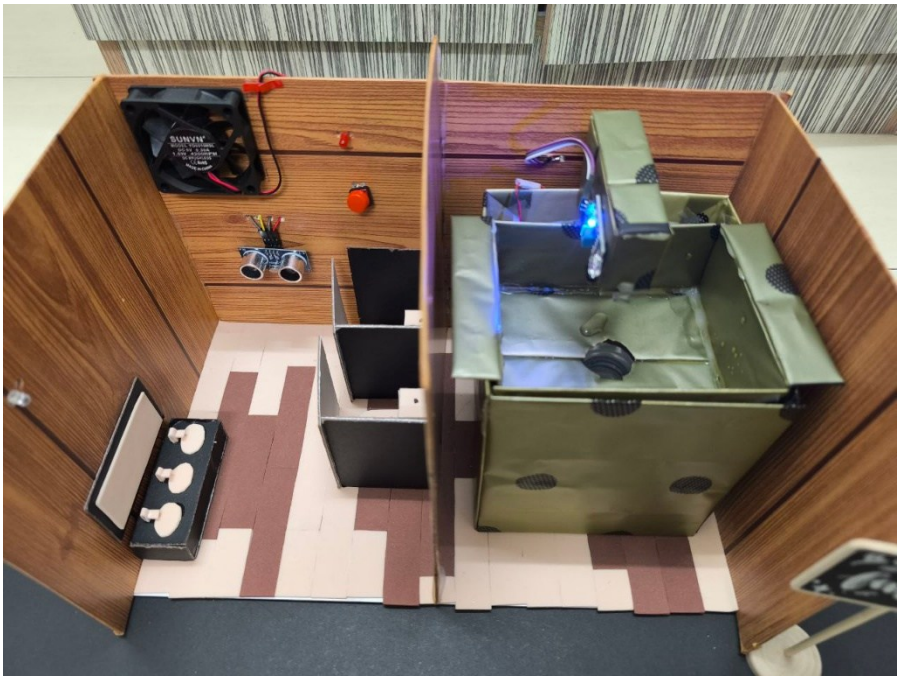


Figure 4. Prototype of the Modern Restroom with Automation system and Emergency buttons.

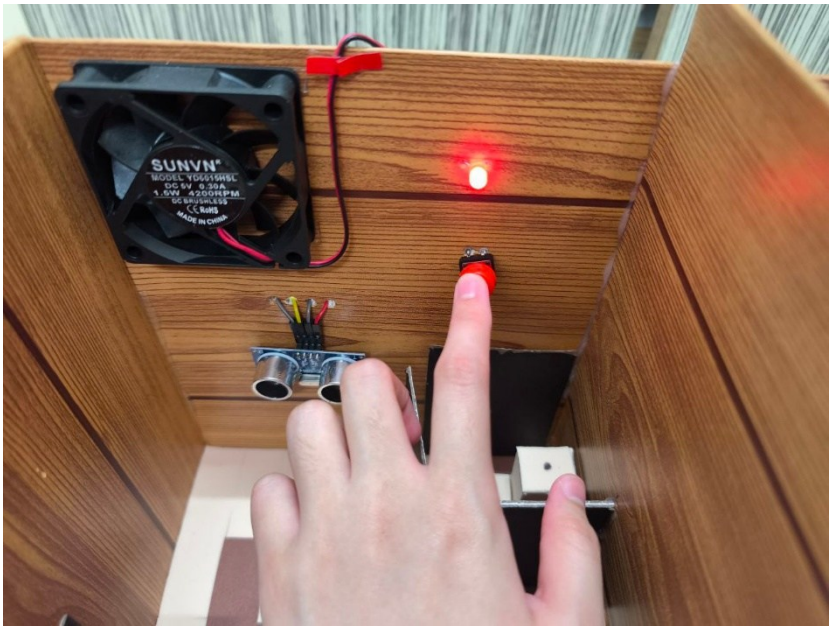
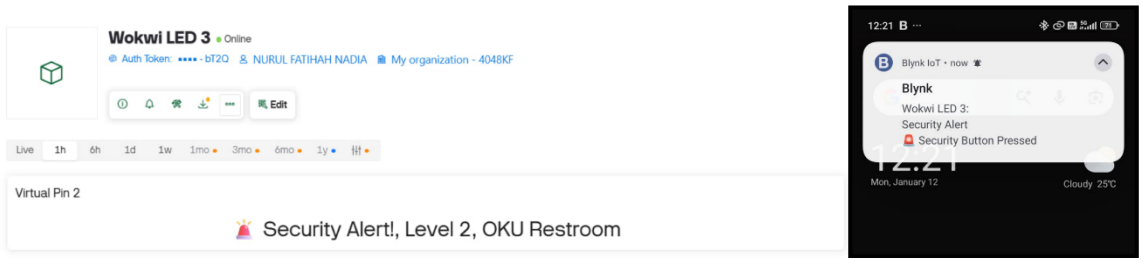


Figure 5. Result of prototype of Push Button when LED on of the Modern Restroom with Automation system and Emergency buttons.



(a) **(b)**

Figure 6. Mobile application interfaces of the Modern Restroom with Automation system and Emergency buttons: (a) Blynk application for push button when LED on (b) Blynk notification for push button when LED on.

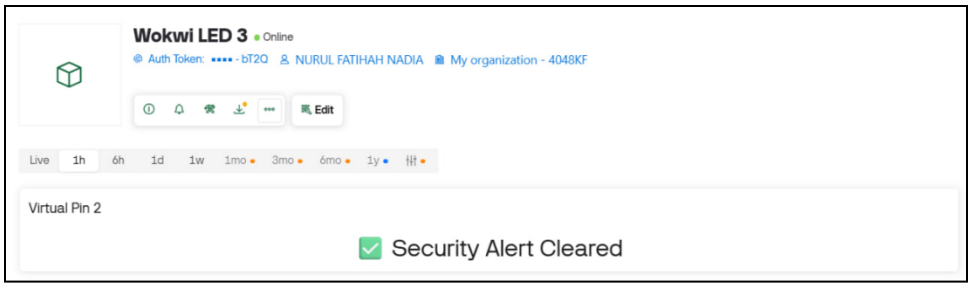


Figure 7. Blynk application for push button when LED off of the Modern Restroom with Automation system and Emergency buttons.

3. Novelty and uniqueness

The novelty and uniqueness of this project lie in the integration of automation and security systems within a public restroom environment. While automatic handwashing systems exist, they are mostly limited to modern restrooms in high-end shopping malls. In contrast, automation for

lighting and ventilation is still rarely implemented in public restrooms. More importantly, the emergency security system using a push button with real-time notification has not been applied in public restrooms. Based on a literature review of seven related studies, no system was found that combines an emergency alert system with automated lighting and ventilation. Therefore, this project is considered unique and rare, as it focuses not only on hygiene and automation but also strongly emphasizes user safety, which can bring a significant positive impact to public restroom design.

4. Benefit to mankind

The NextGen Restroom: Smarter, Safer, Greener system provides several benefits to society by improving safety, efficiency, and sustainability in public restrooms. The automated handwashing, lighting, and ventilation systems help reduce unnecessary use of electricity and water by operating only when needed. This leads to better energy management and lower resource consumption. In addition, the emergency security system enhances user safety by allowing restroom users to request help during critical situations such as injuries, medical emergencies, or dangerous incidents. The real-time alert ensures that security personnel receive notifications immediately and can respond quickly. Overall, the system makes public restrooms smarter, safer, and greener through the combination of automation, security, and energy efficiency.

5. Innovation and Entrepreneurial Impact

The NextGen Restroom project shows innovation by combining sensor-based automation and a real-time emergency alert system in one smart restroom solution. The system includes contactless handwashing, motion-activated lighting and ventilation, and smartphone alerts using the ESP32 and Blynk platform. These features help improve hygiene, safety, and energy efficiency. From an entrepreneurial view, this project has strong potential for use in public places such as shopping malls, hospitals, and offices. It is a cost-effective and scalable solution that can reduce operating costs, improve user experience, and support better safety management, making it suitable for commercialization in smart building applications.

6. Potential commercialization

The proposed system has strong potential for commercialization, particularly in public facilities such as shopping malls, hospitals, universities, airports, and public restrooms. The system uses affordable and widely available components such as IR sensors, ultrasonic sensors, push buttons, and the ESP32 microcontroller, making it cost-effective for large-scale deployment. The emergency alert feature adds high value, as safety is a major concern in public spaces. Furthermore, integration with mobile platforms like Blynk enables easy monitoring and real-time notification without complex infrastructure. With the increasing focus on smart cities and public safety, this system has good potential to be developed into a commercial smart restroom solution.

7. Acknowledgment

The author would like to acknowledge the Faculty of Electrical Engineering, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus for its support.

8. Researchers' Biography

Nurul Fatihah Nadia Mohd Khalil is a student of Diploma in Electrical Engineering (Electronic) program at the Faculty of Electrical Engineering, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus. She is a receiver of the Dean's award for 4 consecutive semesters and is currently on track to complete his studies in August 2026.

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GuardianNest: A Smart Monitoring System for Fire and Air Hazards

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ABSTRACT

GuardianNest is an integrated Internet of Things (IoT)–based system developed to enhance residential safety and improve energy efficiency. Powered by an ESP32 microcontroller, the system continuously monitors environmental hazards using an MQ-2 gas sensor and an infrared flame sensor, while energy usage is optimized through automated lighting control based on a light-dependent resistor (LDR). Upon detection of hazardous conditions, GuardianNest activates local alert mechanisms and delivers real-time notifications to users via the Blynk IoT platform and a Telegram bot. This multi-layered alert approach enables timely response and remote monitoring, even when the premises are unoccupied. By combining safety monitoring with energy-saving automation in a modular and scalable design, GuardianNest offers a practical, low-cost, and commercially viable smart home solution that supports safer and more sustainable living environments.

Keywords: IoT, ESP32, Home Safety, Energy Saving, Automation

1. Product Description

Residential fire, gas leakage, and energy wastage remain common issues due to the absence of continuous monitoring and automated control in many households. Conventional safety alarms often operate independently, lack remote notification capabilities, and do not address energy inefficiency. This project aims to develop GuardianNest, an integrated IoT-based smart home system that enhances residential safety and promotes energy efficiency. The objectives of the project are to detect gas and fire hazards in real time, provide immediate local and remote alerts, and automate lighting based on ambient conditions. By combining safety monitoring and energy-saving features in a single modular platform, GuardianNest offers a practical and scalable solution for modern smart living.

2. Methodology

Figure1 presents the functional block diagram of the GuardianNest safety system. The system architecture is divided into four main components: sensing, processing, local alert, and IoT communication. The sensing unit consists of an MQ-2 gas sensor, a DHT22 temperature and humidity sensor, and an IR flame sensor, which continuously monitors the environment for gas leakage, abnormal temperature changes, and fire presence. The collected sensor data is transmitted to the ESP32 microcontroller, which acts as the core processing unit of the system. The ESP32 processes the sensor inputs and executes predefined safety logic to detect hazardous conditions. When a risk is identified, the system activates local alert mechanisms, including a 16

× 2 LCD for real-time status display, a buzzer for audible warnings, and an LED indicator for visual alerts. To enable remote monitoring, the system connects to the internet via Wi-Fi. Alert notifications and system data are transmitted to the Blynk IoT platform and forwarded to the user through a Telegram bot, ensuring continuous safety monitoring even when the premises are unoccupied Furthermore, **Figure 2** illustrates the hardware development of the GuardianNest system, consisting of schematic and PCB designs. The schematic defines the electrical connections between the ESP32 microcontroller and all sensing and alert components, ensuring proper signal interfacing and power distribution. The PCB layout is designed based on the finalized schematic to provide a compact, organized, and reliable hardware implementation suitable for practical deploymen **Figure 3** illustrates the Internet of Things (IoT) interface of the GuardianNest system, integrating real-time monitoring via the Blynk application and remote alert notification through a Telegram bot. The ESP32 continuously evaluates gas, temperature, and flame sensor data and transmits the processed information to the Blynk dashboard for live visualization. When predefined safety thresholds are exceeded, the system automatically triggers instant alert messages via the Telegram bot, enabling rapid awareness and response. This dual IoT approach enhances system reliability by combining continuous remote monitoring with immediate emergency notification. **Figure 4** illustrates the completed prototype of the GuardianNest system. The final hardware implementation, shown in **Figure 4(a)**, integrates the ESP32 microcontroller and associated components on a custom PCB using a header-based modular design. This approach simplifies maintenance, testing, and future component replacement. **Figure 4(b)** presents the custom-designed enclosure, created using Tinkercad and fabricated via 3D printing. The casing provides physical protection for the electronics while ensuring proper exposure of sensors and clear visibility of the LCD display, supporting both functionality and practical deployment in a residential environment.

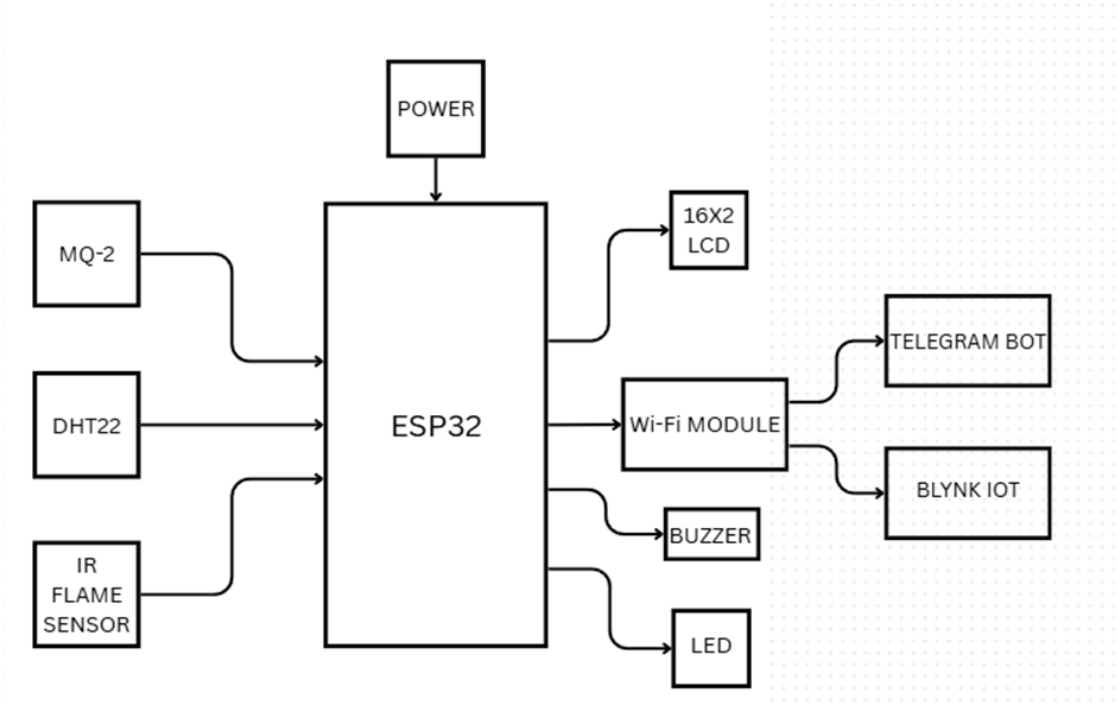
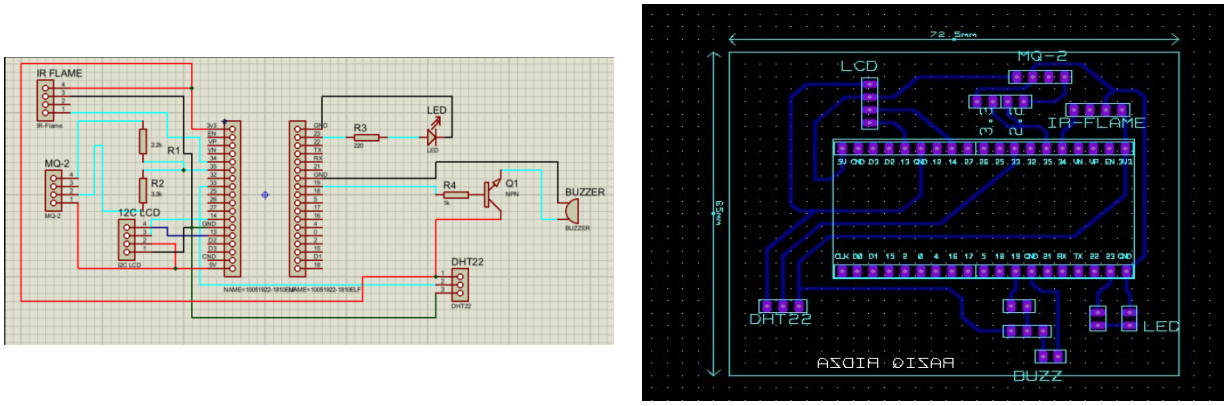
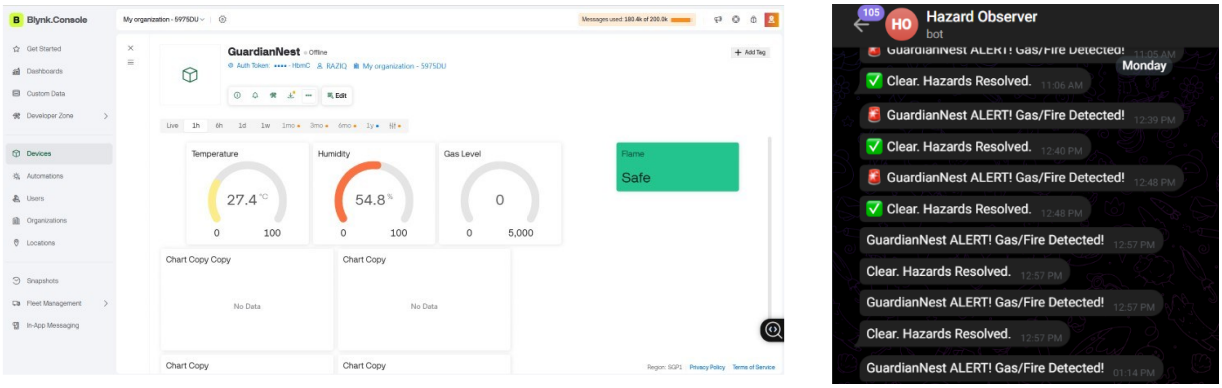


Figure 1. Block diagram of the GuardianNest system.



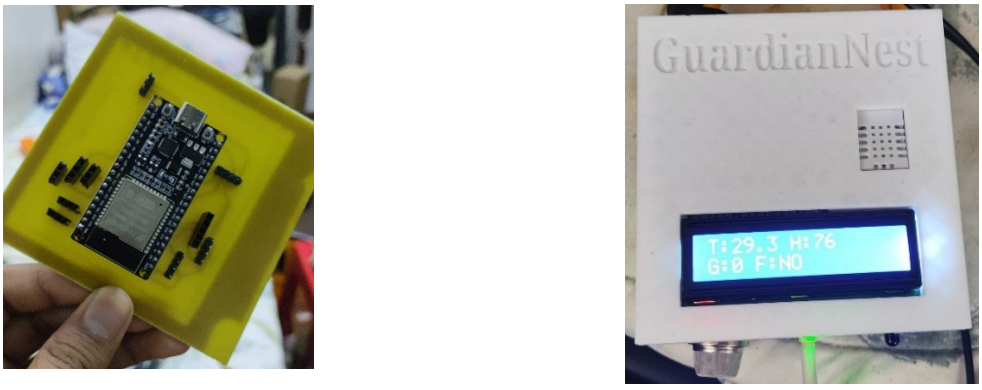
(a)Schematic Design (b) PCB Design

Figure 2. (a) Schematic design of the GuardianNest system developed using Proteus software. (b) Printed Circuit Board (PCB) layout design derived from the finalized schematic.



(a) Blynk Apps (b) Telegram Bot

Figure 3. (a) Real-time monitoring and control interface via the Blynk IoT application. (b) Telegram Bot Notification.



(a)The Hardware (b)The 3D-printed enclosure

Figure 4. (a) Final hardware implementation of the GuardianNest system with modular header-based PCB assembly. (b) 3D-printed enclosure of the GuardianNest system designed using Tinkercad.

3. Novelty and uniqueness

Unlike conventional safety alarm systems, GuardianNest features a modular, header-based PCB architecture that enables individual sensors or the microcontroller to be replaced without soldering. This design enhances maintainability and system longevity. The system's uniqueness is further strengthened by its triple-layered control strategy, which combines automated sensor-based detection, local manual alert mechanisms, and remote IoT-based monitoring and notification.

4. Benefit to mankind

GuardianNest enhances residential safety by reducing the risk of fire and gas-related accidents through continuous monitoring and real-time remote alerts. The system provides peace of mind to homeowners, particularly when the premises are unoccupied. In addition, the inclusion of automated lighting control supports energy-saving practices, helping to reduce electricity consumption and lower household utility costs.

5. Innovation and Entrepreneurial Impact

This project demonstrates how affordable, off-the-shelf electronic components can be transformed into a reliable and intelligent safety solution. GuardianNest promotes innovation by offering a scalable and adaptable system architecture that can be extended beyond residential use to commercial safety and industrial monitoring applications. The design supports entrepreneurial opportunities within the growing smart home and IoT-based safety markets.

6. Potential commercialization

With the increasing demand for cost-effective smart home security solutions, GuardianNest shows strong commercial potential. Its modular design minimizes maintenance and repair costs, making it appealing to budget-conscious consumers and property developers. The system can also be positioned as a "smart-ready" safety feature for residential developments, increasing its market value.

7. Acknowledgment

The authors would like to acknowledge the support and guidance provided by the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM), as well as all individuals who contributed to the development and testing of the GuardianNest system.

8. Researchers' Biography

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Dr. Noor Hafizah Khairul Anuar is a Senior Lecturer at the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM), Johor Branch. She received her Ph.D. in Electrical Engineering from Universiti Teknologi Malaysia (UTM) in 2025, with a research focus on sensor development, instrumentation, and deep learning.

Tengku Irfan Haiqal Bin Tengku Mohd Fuad completed his Sijil Pelajaran Malaysia (SPM) in 2018. He received his Diploma in Electronic Engineering (Communication) from Politeknik Kuala Terengganu in 2023. He is currently pursuing a Bachelor of Engineering Technology in Digitalization and Automation with Honours at Universiti Teknologi MARA (UiTM), Johor Branch, Pasir Gudang Campus. His interests focus on designing smart systems using 3D modeling and embedded electronics.

Nur Fatihah binti Hamdan completed the Sijil Pelajaran Malaysia (SPM) examination in 2020 also followed by pre-university studies at Matriculation College Negeri Sembilan from 2020 until 2022. Nur Fatihah binti Hamdan is currently pursuing a Bachelor of Engineering Technology in Digitalization and Automation with Honours at Universiti Teknologi MARA (UiTM), Johor Branch, Pasir Gudang Campus. Her interest is in machines learning.

AQUABACKUP: Emergency Backup System for Flood

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ABSTRACT

Flood disasters often introduce a life-threatening hazard, such as electrocution caused by rising water submerging live electrical outlets. AQUABACKUP is a smart safety system developed to eliminate this risk while providing emergency lighting during power disruption. The system employs water level sensors to continuously monitor flood conditions in real time. When water reaches a critical threshold, an ESP32 microcontroller processes the signal and activates a relay module to automatically disconnect the main household power supply. This rapid power isolation prevents electrical shock and reduces the likelihood of short circuits and fire incidents. Simultaneously, a high-intensity LED backup light is activated to maintain visibility, reducing panic and supporting safer evacuation. The system is integrated with the Blynk IoT mobile application, enabling homeowners to receive instant notifications and remotely monitor their property status. AQUABACKUP offers significant socio-economic and socio-environmental benefits by minimizing injury risks, lowering medical and property repair costs, and reducing infrastructure damage during floods. Its low-cost and accessible design makes it suitable for operation in flood-prone residential areas, particularly in regions affected by seasonal monsoons. With proper certification and industry collaboration, the system demonstrates strong commercialization potential as a practical and affordable household flood safety solution, enhancing community resilience and disaster preparedness

Keywords: Flood Detection, Emergency Backup System, IoT Monitoring, Automatic Power Cut-off, Disaster Safety.

1. Product Description

The AQUABACKUP is an advanced disaster management device engineered specifically for residential homes in flood-prone areas. It serves as an intelligent guardian that manages electrical risks without requiring human intervention. The core of the system is an ESP32 microcontroller that continuously reads data from strategically placed water level sensors. When these sensors detect that floodwaters have risen to a dangerous height, the system instantly activates a heavy-duty relay mechanism. This action completely isolates the home's electrical wiring from the main grid to prevent short circuits and fatal electrocution accidents. Beyond just safety, the device features a built-in emergency lighting system that automatically turns on when the main power is severed. This ensures that residents are never left in total darkness during a crisis. Additionally, the device is equipped with Wi-Fi capabilities to connect with the Blynk platform. This connectivity allows the system to transmit live updates directly to a smartphone app so users can see if their power is on or off and if the flood sensors have been triggered.

2. Block Diagram, Flow Charts and Schematic diagrams

Figure 1 illustrates the block diagram of the AQUABACKUP system, which is based on an ESP32 microcontroller. The system is powered by a solar panel connected to a charge controller and a 3.7 V battery, while a 7.4 V battery supplies power to the ESP32 as the main controller. The ESP32 receives input from water level, voltage, and current sensors to detect floods and ensure electrical safety. Based on these inputs, the system controls outputs such as an LCD, LED, buzzer, relay, and sends real-time notifications through the Blynk IoT platform. When floodwater reaches a critical level, the relay cuts off electricity and activates emergency lighting. The system operates independently and is safely installed at an elevated location.

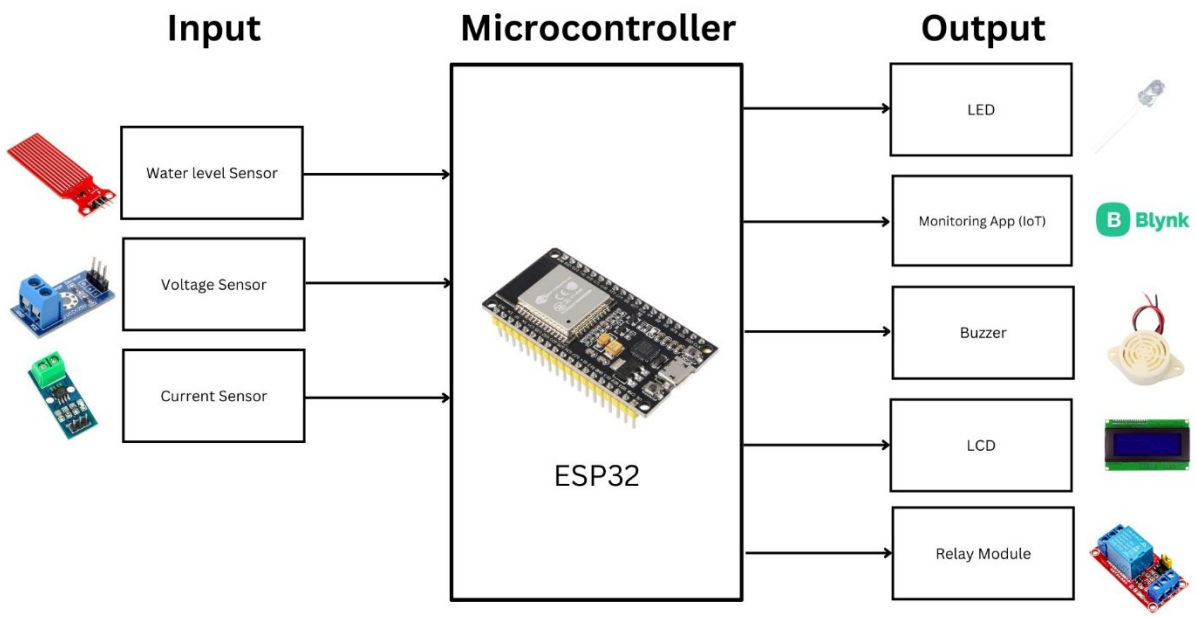

Figure 1. Block Diagram of the system.

Figure 2 presents the system flowchart, illustrating how the ESP32 processes sensor data and makes decisions based on water level and electrical conditions. The system starts by initializing all sensors and continuously monitors the water level. When the water level is low to medium (0–1800), normal monitoring continues. If a high-water level (≥1800) is detected, the ESP32 deactivates the relay to cut off electricity. Voltage and current sensors then verify that power has been fully disconnected for safety. The system subsequently activates emergency lighting, triggers visual and audible alerts, updates the LCD display, and sends real-time notifications via the Blynk IoT application. Monitoring continues until the water level returns to a safe level.

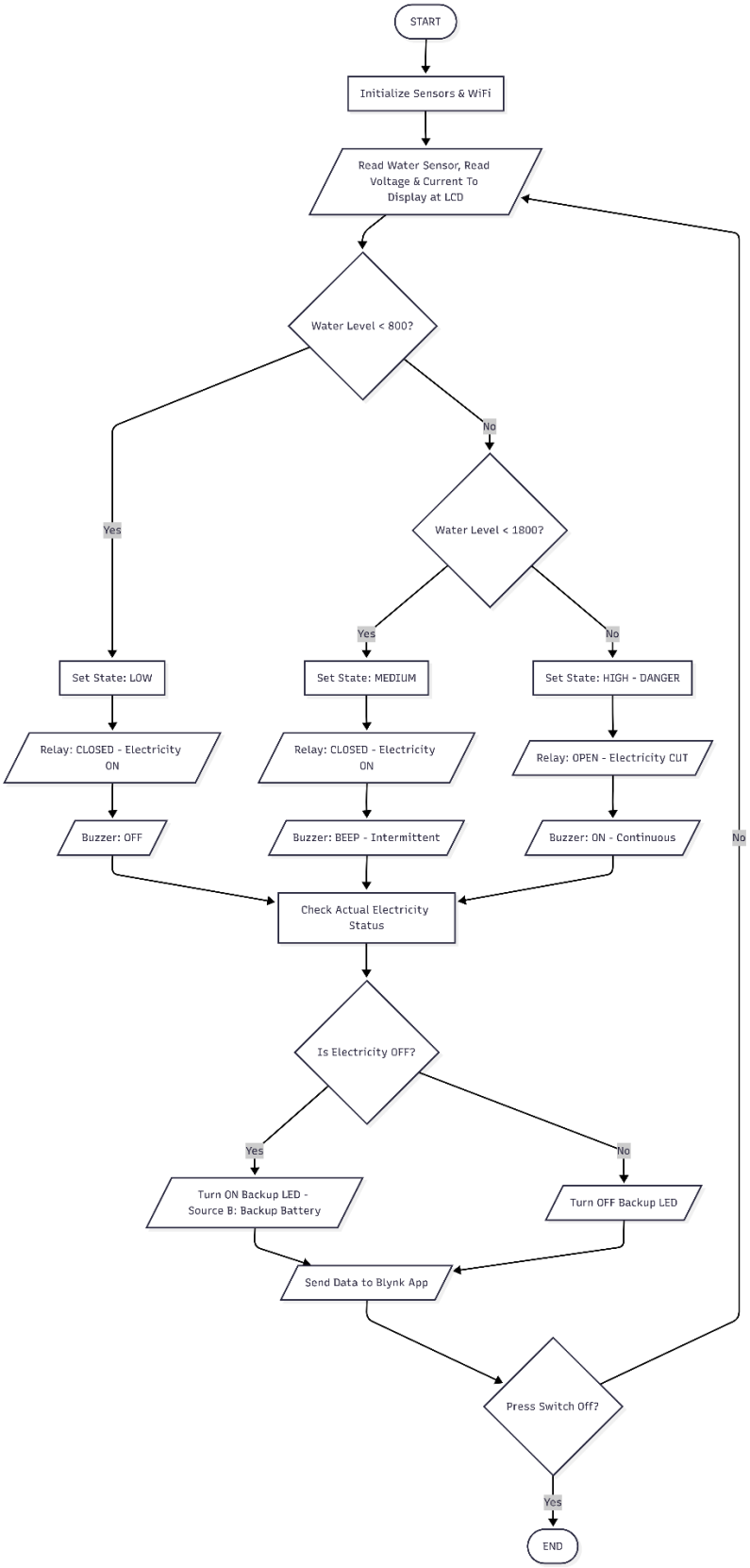

Figure 2. Model flow chart.

Figure 3 shows the schematic diagram of the AQUABACKUP system, highlighting the main components connected to the ESP32 microcontroller. An ultrasonic sensor is used to measure water level, while a relay module is included to cut off power during high flood levels. An LED and buzzer function as visual and audible emergency indicators, and a 20×4 I2C LCD displays water level, system status, and power condition. All components are connected via a breadboard for power distribution and signal wiring, enabling the system to detect floods, provide real-time updates, and respond automatically for safety.

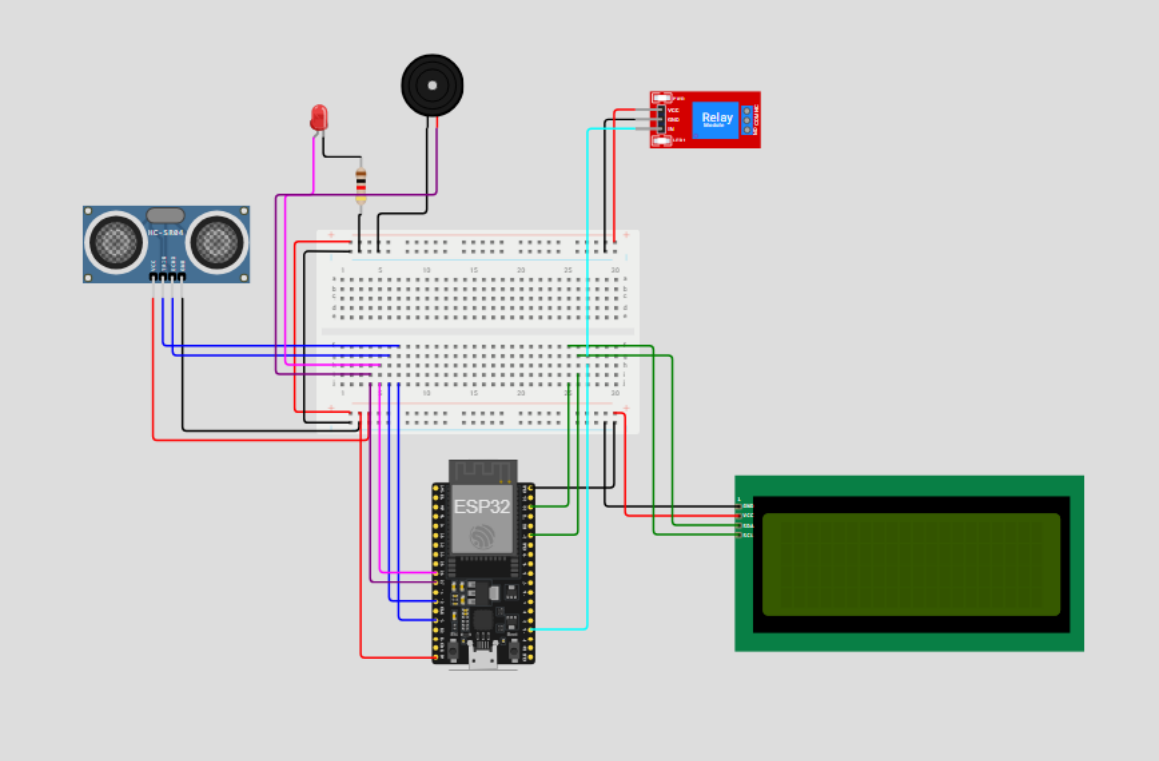

Figure 3. Schematic diagram.

3. Novelty and uniqueness

The primary novelty of AQUABACKUP is its ability to perform an active physical intervention rather than just providing a passive warning. Most existing flood alarm systems on the market only emit a sound or send a text message which puts the burden of action on the user who might panic or be away from home. AQUABACKUP is unique because it automatically disconnects the electricity supply the moment a threat is detected to ensure safety is guaranteed regardless of human reaction time. Another unique aspect is the dual-action response mechanism that pairs the power cut-off with the immediate activation of emergency lights. This feature addresses the two biggest fears during a flood which are the fear of electrocution and the fear of being trapped in the dark. This integration of active safety control with visual aid and remote IoT monitoring makes it a standalone life-saving solution that is far superior to standard water sensors.

4. Benefit to mankind

This project offers a profound benefit to society by directly addressing the life-threatening risks associated with floods. Electrocution is a major cause of death during water disasters and AQUABACKUP eliminates this danger by removing the human error factor from electrical safety. It protects vulnerable groups such as the elderly and children who may not know how to shut off the main power supply during an emergency. The automatic lighting feature also serves a community purpose by acting as a visual light for search and rescue teams. When an entire neighborhood is blacked out, a house with the AQUABACKUP light signals shows that there are likely people inside who need assistance. This helps rescue teams prioritize their efforts and saves valuable time. Ultimately, this system provides peace of mind and tangible protection for families living in high-risk zones.

5. Innovation and Entrepreneurial Impact

AQUABACKUP drives innovation by demonstrating how accessible components like the ESP32 can be engineered into a robust industrial-grade safety system. It shifts the industry's focus from building expensive proprietary systems to create affordable and adaptable solutions. This project encourages a culture of entrepreneurship by opening new market opportunities for local engineering firms to manufacture, install, and service these devices in their own communities. It empowers local technicians to become safety integrators who can upgrade standard homes into smart resilient shelters. Furthermore, the design allows for future upgrades such as adding more sensors or integrating with smart home. This fosters a continuous cycle of innovation where technology is constantly improved to better protect lives and property against an unpredictable climate.

6. Potential commercialization

The commercial potential for AQUABACKUP is extensive because of the increasing frequency of floods in Southeast Asia and globally. The primary target market includes homeowners in low-lying areas who desperately need affordable safety solutions. Real estate developers can also adopt this system as a value-added feature for new housing projects to market them as flood-resilient homes. There is also a significant opportunity to partner with insurance companies who could offer lower premiums to households that install this device since it mitigates the risk of fire and electrical damage. Additionally, the system can be pitched to government disaster management agencies for inclusion in subsidized safety programs for rural populations. With a low manufacturing cost and high social value, AQUABACKUP is positioned to be a profitable and scalable product in the disaster preparedness market.

7. Acknowledgments

I would like to express my sincere appreciation to my project supervisor, Ts. Shakira Azeehan Binti Azli, for her consistent support and expert advice throughout the duration of this research. Her technical insights were crucial in refining the safety mechanisms of the system. I also wish to thank the Faculty of Electrical Engineering at Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus for providing the essential laboratory facilities and equipment that made the development and testing of this prototype possible.

8. Researchers' Biography

Muhammad 'Afif Hazimi Bin Mohamad Rosidin is a dedicated electrical engineering student at Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus. He is currently completing his Diploma and has developed a strong passion for integrating Internet of Things technology with practical power systems. His research primarily focuses on creating automated solutions for disaster management to improve public safety. He aims to continue developing engineering innovations that solve real-world problems for vulnerable communities.

Ts. Shakira Azeehan Binti Azli obtained her Diploma in Electrical Engineering (Power) from UTM Kuala Lumpur, Bachelor of Engineering (Electrical) (Hons) and MSc. In Engineering (Electrical Power) from UTM Skudai. Currently, she serves as a lecturer at UiTM Cawangan Johor Kampus Pasir Gudang in Power Department. Her main research interests are power system and high voltage.

Dr. Nurul Nadia Mohammad is currently a lecturer under School of Electrical Engineering, College of Engineering, UiTM, Cawangan Johor. She received her PhD in Electrical Engineering from Universiti Teknologi MARA (UiTM) in October 2019. Her research interests include modelling and control system.

BIOTRON-CHAR: Utilizing Charcoal Waste as an Environmentally Friendly Biostimulant Medium

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ABSTRACT
Biotron-Char is an environmentally friendly biostimulant medium developed through the utilization of charcoal waste derived from agricultural and biomass residues. This product integrates biochar with beneficial microorganisms and natural organic compounds to enhance soil biological activity, improve nutrient availability, and stimulate plant growth sustainably. Biotron-Char is designed as a multifunctional soil amendment that supports soil rehabilitation, increases crop productivity, and reduces dependency on chemical fertilizers. The innovation addresses critical environmental issues such as waste accumulation, soil degradation, and low agricultural efficiency. Through a simple and scalable production process, Biotron-Char offers high potential for application in agriculture, plantations, and land restoration. This product contributes to sustainable agriculture practices by promoting circular economy principles and environmentally responsible innovation.

Keywords: Waste, Biostimulant, Environmental Innovation ,Soil Amendment, Sustainable Agriculture

1. Product Overview and Mechanism
Biotron Char is a biobased biostimulant medium formulated from recycled charcoal waste enriched with beneficial microbes and organic activators. The porous structure of charcoal acts as an effective carrier for microorganisms, enhancing microbial survival, colonization, and activity in the soil. This formulation improves soil physical properties such as porosity and water retention, while simultaneously enhancing chemical properties including nutrient availability and cation exchange capacity. Biotron Char functions as a slow-release medium that supports root development, stimulates microbial interactions in the rhizosphere, and increases plant resilience to environmental stress. The product is suitable for use in agricultural crops, plantation systems, horticulture, and land rehabilitation. Its environmentally friendly composition ensures long-term soil health improvement while reducing agricultural input costs. Biotron Char represents a practical solution to transform waste into value-added agricultural input.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc.
The schematic illustrates the functional mechanism of Biotron-Char when applied to soil. Charcoal waste-based biochar serves as a porous carrier medium that hosts beneficial microorganisms. The pores protect microbes from environmental stress while facilitating nutrient adsorption. Upon soil application, Biotron-Char enhances microbial colonization in the rhizosphere, improves water retention, increases nutrient availability, and stimulates root growth.

The interaction between biochar, microbes, and plant roots creates a biologically active soil environment that promotes sustainable plant development. Fig 1.

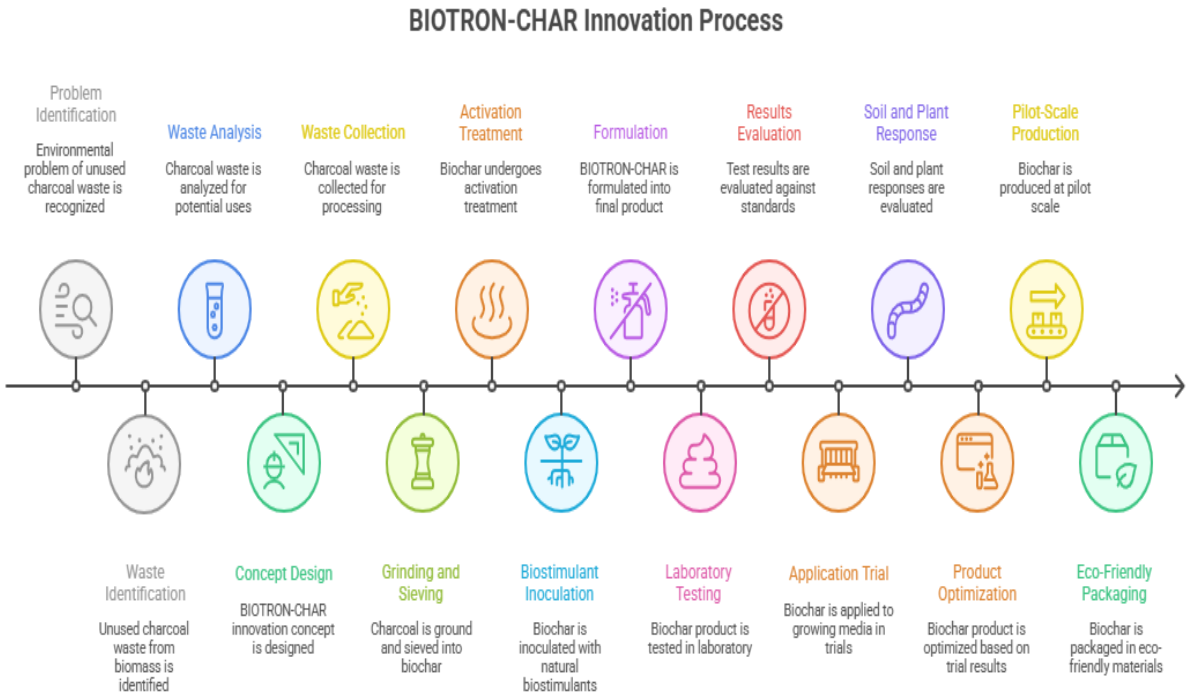

Figure 17. Flow Chart of BIOTRON-CHAR Production Process.

Figure 18. BIOTRON-CHAR Products.

3. Novelty and uniqueness

The novelty of Biotron Char lies in the integration of charcoal waste as a biostimulant carrier rather than merely a soil conditioner. Unlike conventional biochar products, Biotron Char is specifically engineered to function as a microbial habitat and biostimulation medium. This dual-function approach enhances soil biological activity while simultaneously addressing waste management issues. The product emphasizes circular economy principles by converting low-value waste into a high-performance agricultural inpu

4. Benefit to mankind

Biotron Char contributes to sustainable food production, environmental protection, and economic resilience. It improves soil fertility, increases crop productivity, reduces chemical fertilizer usage, and mitigates environmental pollution from charcoal waste. The product supports sustainable land management practices and promotes eco-friendly agriculture for current and future generations.

5. Innovation and Entrepreneurial Impact

Biotron-Char offers strong innovation and entrepreneurial potential due to its low-cost raw materials, scalable production process, and wide market applicability. The product opens opportunities for small and medium enterprises, community-based industries, and agribusiness startups. Its production can be localized, creating employment while supporting green entrepreneurship.

6. Potential commercialization

Biotron-Char has high commercialization potential in agricultural, plantation, and environmental rehabilitation markets. The product can be marketed as a soil enhancer, organic input, and sustainable biostimulant. Potential distribution channels include farmer cooperatives, agro-input retailers, and government-supported agricultural programs. Packaging variants can be developed to meet different user scales.

7. Acknowledgment

Gratitude to the Chancellor of Universitas Labuhanbatu, Head of the Agrotechnology Study Program, Faculty of Science and Technology, Universitas Labuhanbatu.

8. Researchers' Biography

Handoko Wibowo is an undergraduate student in the Agrotechnology Study Program at the University of Labuhanbatu. He has a strong interest in agriculture, particularly in horticultural crop development and sustainable farming systems. His experience in agriculture began during senior high school, where he was actively involved in farming practices. Additionally, he has experience in producing organic fertilizer and commercializing it on a small scale, demonstrating both practical agricultural skills and an entrepreneurial mindset. His interests focus on improving crop productivity through environmentally friendly and locally based agricultural innovations.

Daniel Amreza is an undergraduate student in the Agrotechnology Study Program at the University of Labuhanbatu who has strong dedication to the agricultural sector. His interest in agriculture has been evident since senior high school, with a focus on horticultural crop cultivation, particularly vegetable crops. In addition to cultivation activities, Daniel is actively involved in developing sustainable innovations, one of which is the utilization of vegetable waste to be processed into liquid organic fertilizer (LOF) as a solution for waste reduction and environmentally friendly agricultural practices.

Muhammad Fadel Aulia is an undergraduate student in the Agrotechnology Study Program at the University of Labuhanbatu. He is a graduate of SMK Ki Hajar Dewantara with an educational background in Computer and Network Engineering. His transition from the field of information technology to agrotechnology was driven by his interest in integrating digital solutions into the agricultural sector. His research focus includes the modernization of cultivation techniques and the utilization of information systems to improve agricultural efficiency. With a combination of technical and agronomic expertise, he is committed to advancing sustainable, data-driven agricultural technology innovations in Indonesia

Fitra Syawal Harahap, SP., M.Agr is a Lecturer and Head of the Agrotechnology Study Program, Faculty of Science and Technology, Universitas Labuhanbatu, specializing in Soil Fertility and Soil and Water Conservation as well as Land Suitability Evaluation. With more than 10 years of experience, he has pioneered the Land Suitability Matching method. His work bridges the academic and industrial worlds, with numerous high-impact publications and awards, including the Award in the Field of Agricultural and Plantation Studies, Especially Sustainable Oil Palm Plants.

HONEST-AI: A Validated Honesty Academic Integrity Index for Emerging Entrepreneurial Leaders in Secondary Schools

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ABSTRACT

The rapid integration of generative artificial intelligence (AI), particularly ChatGPT, into secondary school learning environments has enhanced innovation but raised serious concerns regarding academic integrity. Incidents of plagiarism, misrepresentation of authorship, and undisclosed AI assistance highlight the absence of a structured mechanism to measure students' honesty in AI-assisted academic tasks. As secondary school students are nurtured to become emerging entrepreneurial leaders, honesty must be cultivated as a foundational ethical competency alongside digital skills.To address this gap, the HONEST-AI Index was developed as a validated Honesty Academic Integrity Index grounded in the Academic Integrity Construct Assessment Instrument (ICAI). The index operationalizes honesty as a measurable entrepreneurial leadership competency through systematic construct development, expert validation, and pilot testing to ensure reliability and validity. Its uniqueness lies in transforming academic honesty from a compliance-based disciplinary issue into a preventive, value-driven profiling mechanism. The index enables early identification of integrity risk patterns and supports ethical AI governance in schools. HONEST-AI contributes to socio-economic development by strengthening integrity-driven human capital and promoting responsible digital citizenship. Institution-ready and scalable, the index demonstrates strong commercialization potential as a licensable assessment module adaptable across secondary education systems.

Keywords: academic integrity; Entrepreneurs-Leader, honesty index; ICAI; generative AI; ChatGPT.

1. Product Description

The HONEST-AI Index is a validated academic honesty measurement product designed to generate a standardized Honesty Academic Integrity Index for secondary school students in AI-assisted learning environments. Developed for emerging entrepreneurial leaders in secondary schools, the index measures honesty in the use of generative AI tools such as ChatGPT within academic tasks.Grounded in the Academic Integrity Construct Assessment Instrument (ICAI), HONEST-AI operationalizes honesty as a measurable entrepreneurial ethical competency. The product consists of a structured and empirically validated instrument developed through systematic construct operationalization, expert validation, and pilot testing to ensure reliability and validity. A standardized scoring framework converts student responses into quantifiable honesty index scores, enabling consistent and objective integrity profiling across individuals and groups.Unlike conventional plagiarism detection tools that focus on retrospective misconduct

identification, the HONEST-AI Index emphasizes preventive integrity cultivation through early profiling and data-informed educational intervention. Institution-ready and scalable, the validated index is adaptable for digital integration within school-based integrity governance systems and demonstrates strong potential as a licensable assessment module for broader educational adoption.

2. Flow Charts

The flowchart illustrates the structured development process of HONEST-AI across four key phases. Phase 1 (Foundation) establishes the theoretical basis by identifying the core academic integrity principles from the ICAI framework and defining honesty as the targeted construct**.** Phase 2 (Development) involves the systematic construction of instrument items, followed by expert validation and item refinement to ensure content relevance and conceptual alignment**.** Phase 3 (Validation) includes pilot testing within secondary school settings and reliability analysis to confirm internal consistency and measurement robustness. Finally, Phase 4 (Output) presents the finalized validated instrument, which generates a standardized Honesty Index for integrity profiling. This phased approach demonstrates a theory-driven, empirically tested, and institution-ready measurement development process.

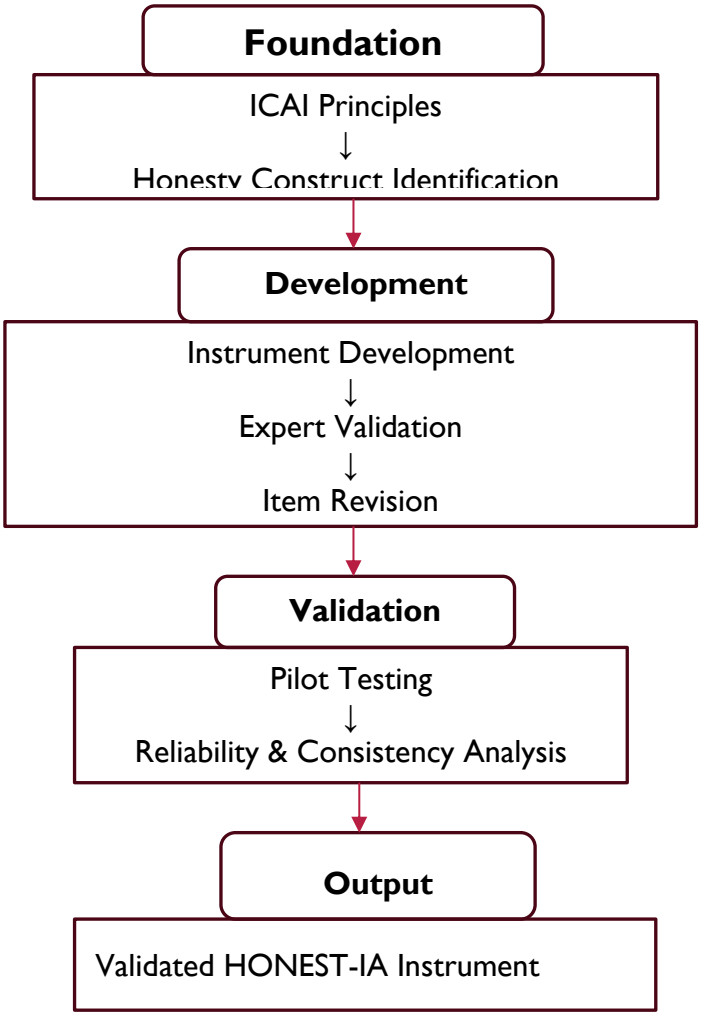

Figure 1. Flow Chart.

3. Novelty and uniqueness

The novelty of the HONEST-AI Index lies in redefining academic integrity assessment in secondary schools by positioning honesty as a measurable entrepreneurial leadership competency within AI-assisted learning environments. Unlike existing integrity tools that focus on retrospective plagiarism detection and are largely designed for higher education, HONEST-AI introduces a preventive, school-focused measurement approach tailored for emerging entrepreneurial leaders.This innovation addresses a critical gap where validated integrity instruments for adolescent learners remain limited. Grounded in the principles of the International Center for Academic Integrity (ICAI), HONEST-AI translates honesty into a developmentally appropriate and empirically validated index relevant to AI-integrated classrooms.Rather than functioning as a compliance-driven monitoring system, the index promotes value-based integrity cultivation. By generating a standardized Honesty Index, it enables proactive identification of integrity risk patterns and supports ethical AI governance at an early stage of entrepreneurial leadership development. This paradigm shift distinguishes HONEST-AI as a pioneering integrity solution for secondary education.

4. Benefit to mankind

The HONEST-AI Index benefits mankind by strengthening ethical foundations at the formative stage of secondary education, particularly among emerging entrepreneurial leaders in AI-assisted learning environments. As generative AI increasingly shapes academic practices, early cultivation of honesty is critical for developing responsible digital citizens. By providing a validated and structured honesty measurement index, HONEST-AI enables schools to proactively nurture integrity values rather than relying solely on punitive misconduct detection.At a broader level, the innovation supports the development of integrity-driven human capital capable of engaging ethically with emerging technologies. By promoting accountability, trust, and responsible AI usage, HONEST-AI contributes to long-term socio-economic sustainability. Its scalable implementation across secondary education systems fosters a culture of ethical leadership and responsible innovation, ensuring that future generations are not only technologically competent but also ethically grounded in an AI-driven world.

5. Innovation and Entrepreneurial Impact

The HONEST-AI Index drives innovation by transforming honesty into a validated and measurable academic indicator within secondary school AI-assisted learning environments. By converting ethical values into a standardized index, the innovation shifts schools from reactive misconduct detection to preventive, data-informed integrity governance. This approach strengthens responsible AI adoption, evidence-based decision-making, and continuous ethical development among emerging entrepreneurial leaders.Entrepreneurially, HONEST-AI positions academic integrity assessment as a scalable, value-added educational solution. The index has strong potential to be developed into licensable assessment modules or integrated institutional integrity profiling tools within AI-supported education systems. This creates opportunities for collaboration between educators, educational technology developers, and institutions while promoting sustainable innovation ecosystems.By aligning ethical education with scalable implementation, HONEST-AI supports responsible entrepreneurship and contributes to integrity-driven growth in the expanding AI-enabled education sector.

6. Potential commercialization

The HONEST-AI Index demonstrates strong commercialization potential as a validated academic honesty assessment solution tailored for secondary school AI-assisted learning environments. The product can be positioned as a licensable, school-based integrity assessment module that enables institutions to systematically measure and strengthen students' honesty as emerging entrepreneurial leaders.Its standardized scoring structure supports scalable implementation across schools, districts, and educational authorities, either as a standalone digital-ready assessment package or through integration with existing learning management systems. Strategic collaboration with educational technology providers and curriculum developers can further expand market reach.By addressing the growing global demand for ethical AI governance in education, HONEST-AI offers a sustainable and scalable solution that aligns value cultivation with measurable assessment, ensuring long-term commercial viability within the expanding AI-enabled education sector.

7. Acknowledgment

The authors would like to express their sincere appreciation to the academic experts who contributed to the validation of the instrument and to the secondary school students who participated in the pilot study. Their valuable feedback significantly strengthened the development and applicability of HONEST-IA. The authors also extend their heartfelt gratitude to the project supervisor for continuous guidance, scholarly insights, and constructive support throughout the development of this innovation. Appreciation is further extended to the supporting institution for providing the necessary resources and facilitation that enabled the successful implementation of this project.

8. Researchers' Biography

Rosidah binti Md Desa is a Master's student in Measurement and Evaluation at Universiti Kebangsaan Malaysia (UKM). Her research focuses on academic integrity among secondary school students in the era of artificial intelligence, particularly in AI-assisted learning and assessment contexts. She specializes in instrument development, construct validation, and educational measurement, with an emphasis on value-based assessment models grounded in integrity principles. Her work aims to develop empirically validated measurement tools that support ethical AI usage and sustainable academic practices within school environments.

Associate Professor Ts. Dr. Mohd Effendi @ Ewan Mohd Matore is a senior lecturer at Universiti Kebangsaan Malaysia (UKM) and Head of the University Research Group (KPU) in Educational Assessment. He specializes in educational measurement and evaluation, with expertise in psychometrics, instrument development, and quantitative research methodologies. His scholarly work focuses on construct validation, modern measurement models, and assessment design in educational settings. As a leading expert in measurement and evaluation, he has contributed extensively to research and innovation in assessment practices, supporting the development of valid and reliable educational measurement instruments.

LYRICALLY YOURS: An Interactive Song Analysis, Short Stories and ESL Activities Website

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ABSTRACT

Lyrically Yours is an interactive website developed to enhance English language learning through song lyrics. The platform transforms popular songs into structured learning materials by combining lyric analysis, storytelling, and ESL activities in one accessible digital environment. The project was designed in response to the need for more engaging and relatable learning methods, as many traditional ESL platforms rely heavily on grammar drills that may reduce learner motivation. By using music that reflects themes commonly experienced by young adults, the website encourages learners to explore the meaning, emotions, and language within song lyrics. The uniqueness of *Lyrically Yours* lies in its integration of simplified lyric analysis, short relatable stories inspired by the songs, and interactive ESL activities such as quizzes, vocabulary exercises, and grammar tasks. This combination promotes deeper comprehension, critical thinking, and emotional engagement in language learning. The platform benefits learners by making English learning more enjoyable, accessible, and meaningful while encouraging independent learning through digital tools. *Lyrically Yours* also demonstrates socio-educational value by promoting creative learning approaches that connect language education with popular culture. In terms of commercialization potential, the platform may expand through subscription features, digital learning partnerships, and social media promotion to reach wider audiences.

Keywords: Interactive website, music, ESL activities

1. Product Description

Lyrically Yours is an interactive English learning website that uses song lyrics as a creative and engaging way to help young adults improve their language skills. Designed especially for university students, the platform combines song analysis, short stories, ESL activities, and reflection questions to support vocabulary development, reading comprehension, and critical thinking. Each featured song explores real-life themes such as love, self-identity, ambition, emotional struggles, and personal growth, making learning more relatable and meaningful. Users can read lyric breakdowns, immerse themselves in story adaptations inspired by the songs, and participate in fun, interactive language games that strengthen grammar, spelling, and word usage. By connecting music with language learning, *Lyrically Yours* creates a motivating and emotionally engaging experience that goes beyond traditional study methods. The website aims to make English learning more enjoyable, expressive, and relevant to modern youth culture, encouraging learners to think deeply, reflect personally, and build confidence in using English.

2. Product Illustration

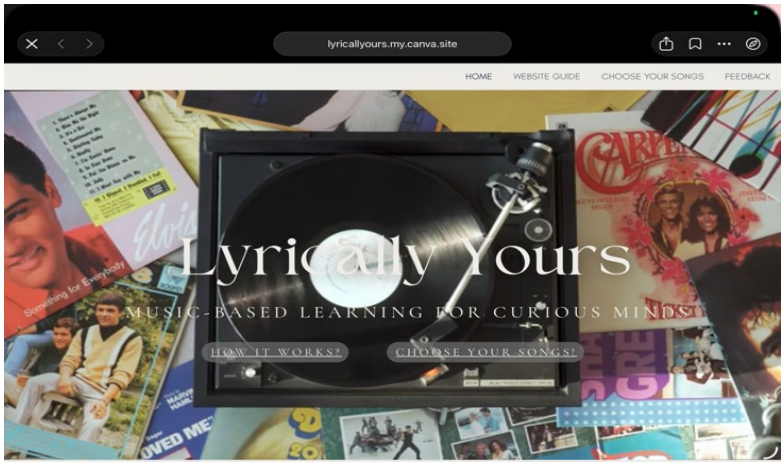

Figure 1. *Lyrically Yours* homepage that includes project introduction and author biography.

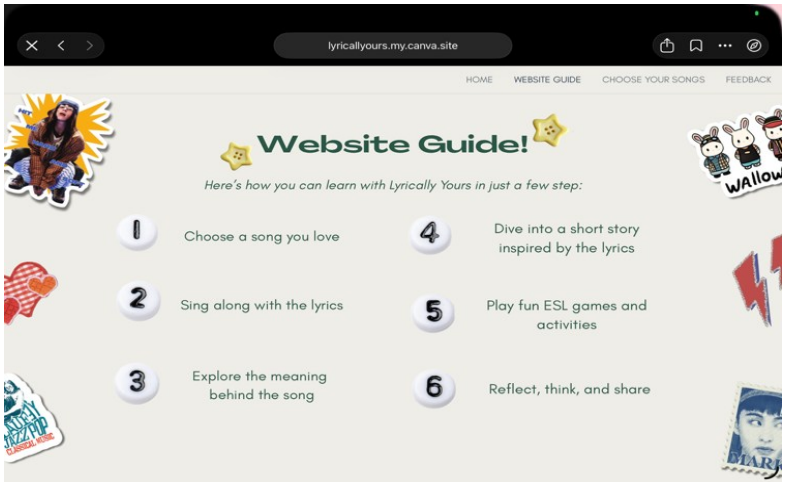

Figure 2. *Lyrically Yours* website guide/instructions.

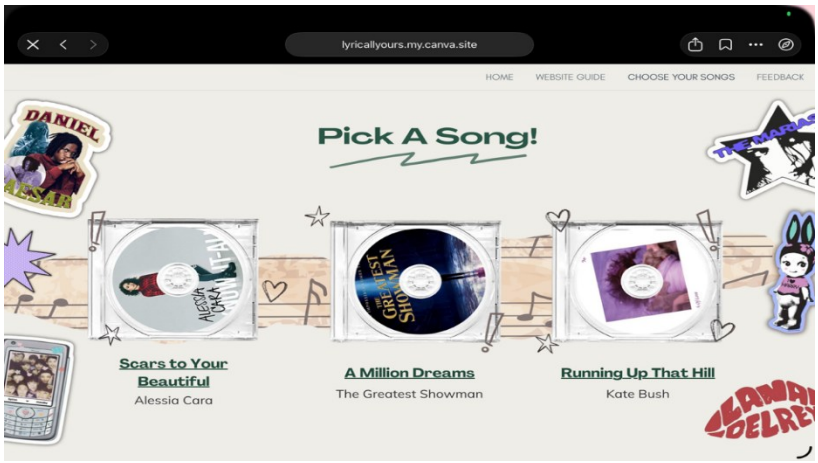

Figure 3. *Lyrically Yours* six song choice page to learn from.

Figure 4. *Lyrically Yours* paragraph-by-paragraph song analysis, short story and ESL activities choices.

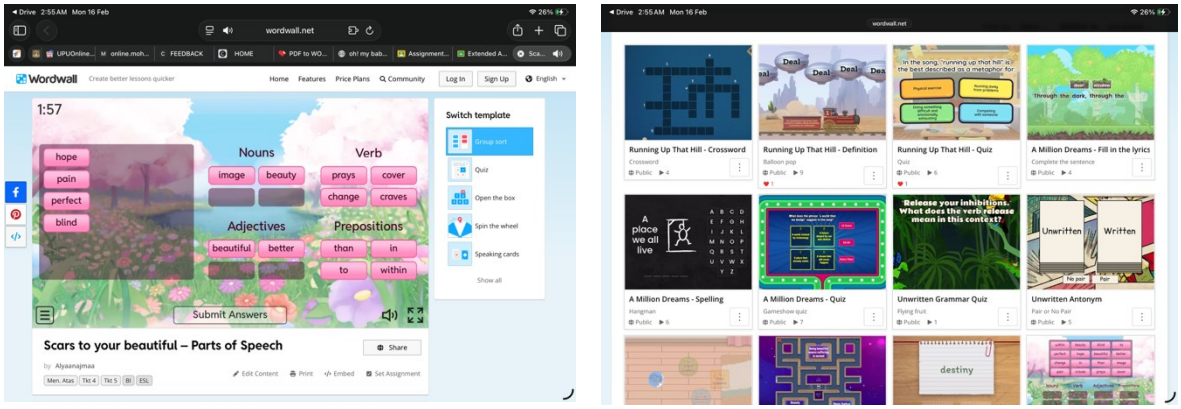

Figure 5. ESL activities examples that cover variety of English learning skills.

3. Novelty and uniqueness

The uniqueness of *Lyrically Yours* lies in its integration of music, storytelling, and ESL activities within a single digital platform. While existing ESL platforms may use songs, they often focus only on listening or vocabulary exercises. *Lyrically Yours* goes further by providing detailed lyric analysis, emotionally relatable short stories, and interactive language activities connected to the song themes. Another innovative feature is its emotional-based learning approach, which helps learners connect personally with the content. This emotional engagement improves motivation and deeper understanding. Additionally, the platform is fully digital, interactive, and accessible, making it suitable for modern learners who prefer flexible and engaging learning methods. Furthermore, *Lyrically Yours* emphasizes emotional relevance as a core learning strategy, which is often overlooked in traditional ESL platforms. The integration of reflection questions encourages learners to connect the song themes with their personal experiences, promoting deeper critical thinking and self-expression in English. In addition, its flexible structure allows continuous updates

with new songs based on current trends, ensuring long-term relevance. This adaptability strengthens its potential as both an innovative educational tool and a sustainable digital learning product.

4. Benefit to mankind

Lyrically Yours benefits students by providing an engaging alternative method for learning English. It helps improve vocabulary, comprehension, and critical thinking skills through meaningful and relatable content. The platform also increases motivation and confidence by using music that learners already enjoy. In addition, the website supports modern education by promoting digital learning and independent study. It can also benefit educators by serving as a supplementary learning resource. Overall, the platform contributes to improving English proficiency and learning engagement among young adults. In addition, *Lyrically Yours* supports independent and lifelong learning by providing an accessible platform that learners can use anytime and anywhere. It also encourages emotional awareness and self-reflection, which are important for mental well-being. This approach helps develop more confident, expressive, and motivated English users in modern digital society.

5. Innovation and Entrepreneurial Impact

Lyrically Yours promotes innovation by transforming familiar entertainment, music, into an interactive English learning experience that combines lyric analysis, storytelling, and gamified ESL activities within a single digital platform. This approach encourages creative thinking and demonstrates how educational content can be redesigned to match the interests and habits of modern learners. Within the institution, the project fosters an entrepreneurial mindset by showcasing how student ideas can evolve into scalable digital products with real market potential. It inspires other students to explore creative solutions, develop digital learning tools, and consider monetisation through subscriptions, collaborations, and merchandise. For the wider community and industry, *Lyrically Yours* highlights opportunities in edtech innovation, especially music-based learning. By integrating creativity, technology, and business potential, the project contributes to a culture that values innovation, self-initiative, and entrepreneurship among young creators and future educators globally and locally today and tomorrow's leaders in education sector now too as well.

6. Potential commercialization

Lyrically Yours has strong commercialization potential as a digital learning platform. Revenue can be generated through subscription plans that offer premium content such as additional song analyses, advanced activities, and personalized song requests. Since music keep evolving across generation, the website can remain relevant by keeping up with song choices and trends. The platform can also collaborate with educational institutions, ESL centres, and music-related brands to expand its reach. Additional income opportunities include selling digital products and merchandise. With continuous updates and marketing through social media platforms such as Instagram and TikTok, the website has strong potential to grow into a sustainable educational business.

7. Acknowledgment

Sincere appreciation is extended to the project supervisor, Miss Nurhamizah Ishak, for her guidance, support, and constructive feedback throughout the completion of this project. Appreciation is also conveyed to friends for their encouragement and assistance, as well as to parents for their continuous support and motivation. Finally, gratitude is expressed to all website users and respondents whose participation and feedback were invaluable in evaluating and enhancing *Lyrically Yours.*

8. Researchers' Biography

Nur Alya Najma Zahrul Nizam is a final-year student in English Professional Communication at Universiti Teknologi MARA Melaka. Her academic interests include digital communication, creative writing, and music-based learning. She is passionate about integrating creativity and education to develop engaging learning platforms. *Lyrically Yours* was developed as her Final Year Project to explore innovative approaches in English language learning through music and digital technology.

RAINSENTRY - A Smart Rain Detector System

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ABSTRACT
The unpredictability of weather patterns is a continuous problem for households, especially with the outdoor drying of laundry. Unexpected rain frequently leads to wet clothes, wasted time, and unnecessary stress for those unable to immediately retrieve their laundry. In solving outdoor weather risks, some individuals resort to drying laundry indoors. This significantly increases indoor humidity, fosters harmful mold growth and lead to long-term health problems. Thus, RainSentry - Smart Rain Detector System, a technology-driven solution develops which focuses on automated laundry protection. Built upon the user-friendly and dependable Arduino Uno R3 platform, the device incorporates an LM393 rain sensor and a servo motor mechanism to automatically retract the laundry rack upon rain detection. The system incorporates wireless connectivity (Bluetooth/Wi-Fi) to deliver real-time alarm alerts to the user's mobile device, ensuring awareness of weather changes regardless of location. The development phase emphasizes the utilization of economical, easily accessible electrical components to guarantee the product's cost-effectiveness for the mass market while preserving high reliability. Market analysis indicates a strong demand for affordable smart home solutions that solve specific, tangible pain points. The product provides substantial benefits by alleviating the burden of weather monitoring and the urgency of collecting laundry.

Keywords: Weather, Rain Detector, Laundry Protection, Cost-effectiveness, Affordable

1. Product Description
The system is built upon the following core technologies and components:

Microcontroller Unit (MCU): Arduino Uno R3

Arduino Uno R3 polls data from the rain sensor. When the sensor data exceeds a pre-defined threshold indicating rain, the Arduino executes the code to activate the servo motor and send a signal to the communication module. It is based on the ATmega328P microcontroller, operating at 5V

Environmental Sensing: LM393 Rain Sensor Module

When raindrops fall on the conductive tracks, water bridges the gaps, lowering the resistance and conducting electricity. LM393 comparator chip converts this analog resistance change into a digital signal (High/Low) that the Arduino can interpret as "Raining" or "Not Raining."

Actuation System: Servo Motor

Upon receiving a "Rain Detected" signal from the Arduino, the servo motor rotates to a specific angle of 90°. This rotational force is mechanically coupled to a pulley that automatically retracts the laundry rack from the open area into a sheltered zone such as under an awning or roof.

Connectivity and Alerts: Bluetooth Module

When rain is detected, the system transmits a data packet via Bluetooth to a user's paired smartphone application, triggering a notification.

2. Pictures/ Schematic diagrams/ Flow Charts/Screenshots/Graphs/Table and etc .

Conceptual Model of RainSentry

Figure 1. Conceptual Model of RainSentry.

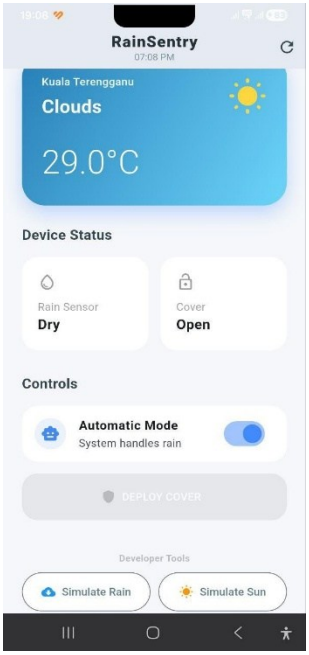

Figure 2. RainSentry Home Screen.

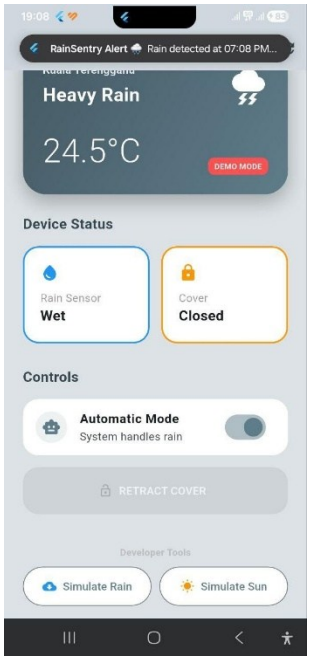

Figure 3. RainSentry Alert Interface.

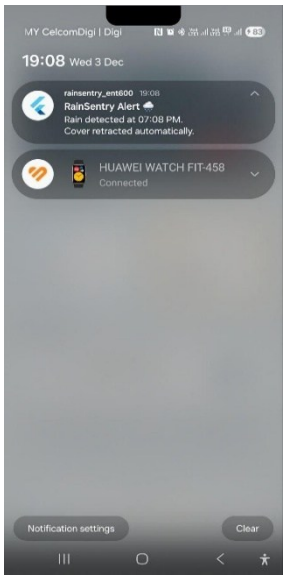

Figure 4. RainSentry Push Notification.

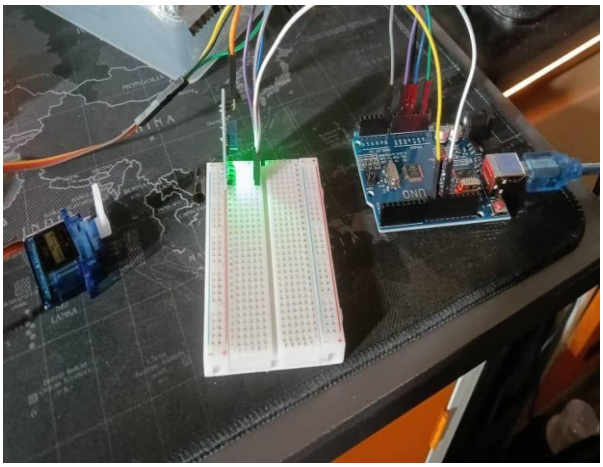

Figure 5. Circuit Assembly of RainSentry.

The conceptual model is shown in **Figure 1** above, which includes a house with a special outdoor drying area. In order to optimize exposure to rain and sunlight, respectively, the Rain Sensor (LM393) and Solar Panel are positioned strategically on the roof. In order to replicate the retraction movement, the servo motor is mechanically connected to the washing rack and integrated into the wall construction.

The Application's Home Screen

Figure 2 showed the application's home screen that gives a quick and easy summary of the current weather conditions. It displays live weather data (e.g., "Clouds, 29.0°C") fetched via API. Key status indicators show the "Rain Sensor" as Dry and the "Cover" as Open, confirming the system is in standby mode. The control features, particularly the "Automatic Mode" toggle and the "Manual Override" buttons. This design gives the user the option of direct human control or sensor-driven automation.

RainSentry Alert Interface

The critical alert interface is shown in **Figure 3**. When moisture is detected, the app visually transforms to alert the user. A prominent red banner displays "Laundry Has Been Retracted!" alongside a storm icon and real-time weather metrics (e.g., "18°C, Light Rain"). This provides immediate visual confirmation that the system has activated.

RainSentry Push Notification

The Push Notification features, as shown in **Figure 4**, are to ensure users are informed even when the app is closed; the system triggers a push notification. As shown in the figure, the user receives a "RainSentry Alert" on their lock screen stating: "Rain detected at [Time]. Cover retracted automatically."

Circuit Assembly of RainSentry

Figure 5 shows the Circuit Assembly of RainSentry. A breadboard was used to assemble and test the essential circuitry. The LM393 Rain Sensor, a Bluetooth Module, and the Servo Motor

are connected to the Arduino Uno R3 microprocessor in this configuration. The signal flow from the sensor to the microcontroller, which powers the actuator, is shown in the wiring.

RainSentry Physical Prototype

Figure 6. RainSentry Physical Prototype.

Figure 6 shows the RainSentry system's physical prototype. To show the demonstration of the mechanics, the components were attached to a scale model of a house. To achieve accurate detection and avoid water pooling, the rain sensor is installed on the slanted roof. A solar panel next to it serves as an example of a green energy source. A little washing rack is directly attached to the servo motor, which is installed on the side wall. The servo simulates the mechanical retraction of the clothing into a safe zone when the roof sensor detects water.

3. Novelty and uniqueness

RainSentry's design concept is "seamless integration."

i) Hardware Architecture & Engineering

Microcontroller

We selected the Arduino Uno R3 due to its robust I/O capabilities and extensive library support for sensor integration. It processes analog sensor data and executes the motor control logic.

Sensing Technology

Due to its great sensitivity, the LM393 Rain Sensor was used. It makes use of an impedance plate covered in nickel. Resistance decreases when water crosses the tracks, sending a logic high signal to the Arduino in milliseconds.

Actuation Mechanism

The MG996R or a comparable high-torque servo motor is used. A servo, in contrast to conventional DC motors, offers exact angular control (0° to 90°), which enables us to design precise "Open" and "Closed" positions for the protective cover.

ii) Software Architecture (Mobile Application)

API Integration

The app connects to the OpenWeatherMap API via HTTP requests. It parses JSON data to display real-time temperature, humidity, and weather forecasts, acting as a secondary verification layer for the user.

Notification Service
We implemented flutter_local_notifications to push urgent alerts ("Rain Detected! Cover Deployed") to the system tray, ensuring the user is notified even if the phone is locked.

4. Benefit to mankind

RainSentry provides the solution for these requirements with the automated laundry protection system that integrates rain detection, mechanical control, and wireless notification. The automated system includes a highly sensitive sensor that detects rainfall, making the laundry retract/protect instantly with the use of a servo motor. The user is also capable of receiving notifications instantaneously on a mobile device with the assistance of Bluetooth technology. RainSentry offers a smart home solution that is affordable for most households with the use of inexpensive electronics. It offers a "set-it-and-forget-it" experience that reduces the stress of erratic weather by functionally pairing with a mobile application that enables users to manually override the system and monitor weather status remotely.

5. Innovation and Entrepreneurial Impact

The RainSentry is an automated electromechanical solution designed to operate as a standalone protective unit for household laundry. The technology stack relies on a closed-loop control system where the rain are processed by a microcontroller to trigger a mechanical output and a digital alert, which is a user notification. RainSentry is a cutting-edge approach to managing household laundry that puts automation and weather protection first. It includes a mechanical retraction unit and a high-sensitivity moisture detection system that enable real-time environmental monitoring and automatically secure laundry without the need for human involvement. It incorporates solar power capabilities and an independent battery system to enable wireless operation on balconies or yards, all while keeping sustainability in mind. It offers a "set-it-and-forget-it" experience that reduces the stress of erratic weather by functionally pairing with a mobile application that enables users to manually override the system and monitor weather status remotely.

6. Potential commercialization

Smart devices already on the market, like smart dryers or automatic laundry systems, are quite costly and beyond the budget of people belonging to the mid-income class. There is a clear need for an affordable, automated solution that protects laundry outdoors, avoiding the health risks of indoor drying while providing the modern IoT connectivity users need to monitor their homes remotely. RainSentry presents an opportunity with low-cost modules like Arduino Uno R3, LM393 sensor, and a servo motor. It places the offering as a low-cost and high-value innovation. Based on survey, it indicates a strong demand for affordable smart home solutions that solve specific, tangible pain points. The product provides substantial benefits by alleviating the burden of weather monitoring and the urgency of collecting laundry.

7. Acknowledgment

The authors would like to thank UiTMKKT for supporting the researcher in conducting this project. Also thank you for the cooperation and commitment given by all members, lecturers and all parties involved in making this project success.

8. Researchers' Biography

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ERI-P 5.0 Framework: Entrepreneurial Resilience and Ethical AI Readiness in Primary Education

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ABSTRACT

In an increasingly competitive and AI-driven world, primary school learners are becoming early participants in digital platforms, artificial intelligence tools, and value-creation activities. However, structured school-based guidance that cultivates resilience, ethical digital judgment, and responsible AI engagement at this foundational stage remains limited.

The ERI-P 5.0 Framework addresses this gap by positioning primary education as the starting point for shaping a Future-Ready Digital Generation. Grounded in a human-centered philosophy aligned with Industry Revolution 5.0 (IR5.0), the framework integrates four key dimensions: Entrepreneurial Resilience, Ethical Digital Awareness, Adaptive Thinking, and Responsible AI Readiness. Operationalized through the ERI-P 5.0 Growth Pathway (Recognise–Engage–Create), the framework provides educators with a practical approach to nurture initiative, resilience, and ethical AI awareness through contextual learning activities and mini-projects within existing school environments. Beyond educational outcomes, ERI-P 5.0 contributes to long-term socio-economic development by nurturing resilient and value-creating young citizens while promoting responsible digital engagement that supports healthier digital communities. Its infrastructure-light and adaptable design also presents commercialization potential through scalable school adoption toolkits, teacher training modules, and structured digital-age readiness programs.

Keywords: primary education; entrepreneurial resilience; responsible AI readiness; ethical digital awareness; future-ready digital generation

1. Product Description

The ERI-P 5.0 Framework is a practical, school-based human-centered innovation designed to prepare primary learners for responsible participation in the digital and AI-driven economy. Rather than introducing complex technological systems, the framework provides a structured and implementable model that empowers teachers to cultivate entrepreneurial resilience and Responsible AI Readiness within everyday school contexts. At its conceptual core are four integrated dimensions; Entrepreneurial Resilience, Ethical Digital Awareness, Adaptive Thinking, and Responsible AI Readiness. These dimensions function as developmental pillars that guide learners in building initiative, ethical judgment, and adaptive capacity in digital environments. The framework is operationalized through the ERI-P 5.0 Growth Pathway, consisting of three progressive stages: Recognise, Engage, and Create. In the Recognise stage, students develop awareness of responsible digital behavior and foundational entrepreneurial thinking through guided discussions and scenario-based reflection. In the Engage stage, learners participate in

contextual mini-projects that strengthen resilience, initiative, and ethical decision-making. In the Create stage, students apply their competencies through collaborative initiatives that integrate value creation and responsible AI engagement. Designed to be infrastructure-light and adaptable, ERI-P 5.0 can be integrated into classroom instruction, project-based learning, and co-curricular activities without requiring specialized technological systems.

2. Flow Charts

The ERI-P 5.0 Implementation Flow begins with a Human-Centered IR5.0 Foundation, ensuring that technological engagement remains aligned with ethical values and societal well-being. Building upon this foundation, the four core dimensions which are Entrepreneurial Resilience, Ethical Digital Awareness, Adaptive Thinking, and Responsible AI Readiness that serve as structured conceptual pillars.

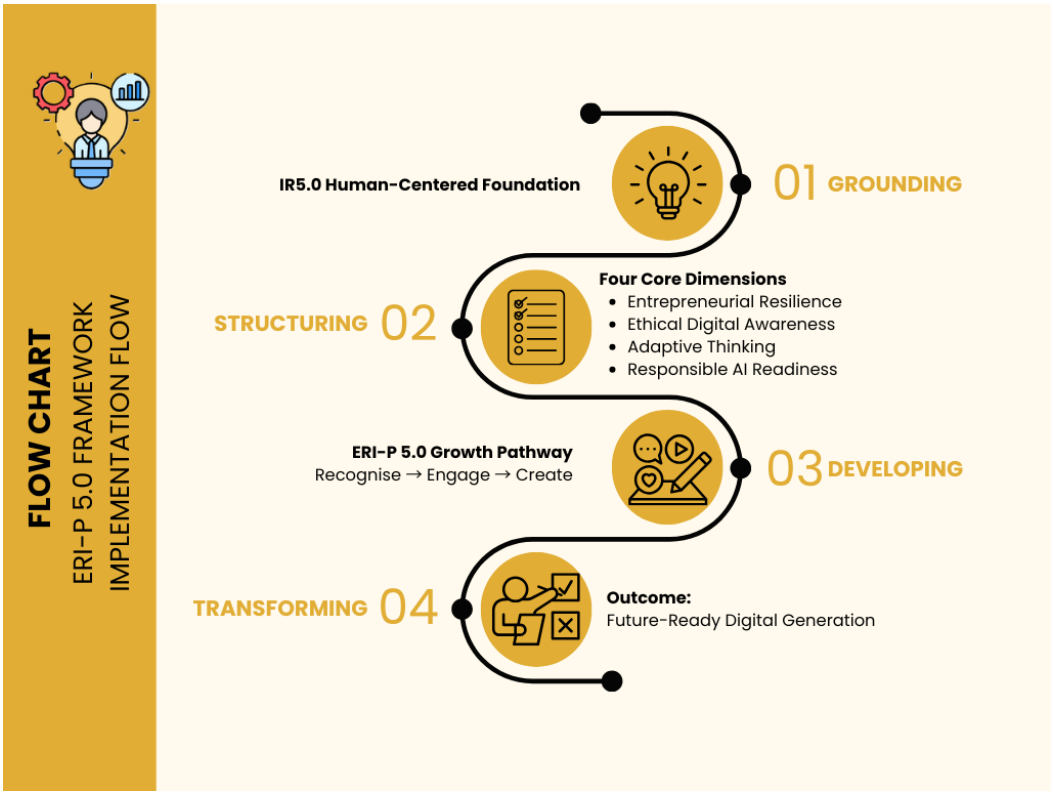

Figure 1. The Flow Chart of ERI-P 5.0 Framework.

These dimensions are then operationalized through the ERI-P 5.0 Growth Pathway (Recognise–Engage–Create), guiding students progressively from awareness to active value creation. The flow culminates in the formation of a Future-Ready Digital Generation equipped with resilience, ethical AI engagement capacity, adaptive problem-solving skills, and entrepreneurial initiative.

Figure 2. The ERI-P 5.0 Framework: Entrepreneurial Resilience and Ethical AI Readiness in Primary Education.

3. Novelty and uniqueness

The ERI-P 5.0 Framework distinguishes itself by addressing a critical yet underexplored intersection in primary education: the integration of entrepreneurial resilience and ethical AI readiness within a human-centered developmental structure. While existing educational initiatives often focus separately on digital literacy, entrepreneurship education, or AI awareness, ERI-P 5.0 uniquely consolidates these domains into a coherent and progressive school-based implementation model. Rather than treating ethical digital awareness as a disciplinary concern or entrepreneurial skills as a secondary enrichment component, the framework positions both as foundational competencies for future-ready digital generation formation. Another distinctive feature lies in its early intervention approach. Most digital ethics and AI-related frameworks target secondary or tertiary education levels. ERI-P 5.0 repositions primary education as the strategic starting point for cultivating responsible AI engagement, adaptive thinking, and value-based innovation. This proactive orientation shifts educational practice from reactive digital control to structured resilience-building and ethical formation. Furthermore, ERI-P 5.0 emphasizes feasibility over technological dependency. Unlike innovation models that rely on advanced platforms or costly infrastructure, this framework is designed to function within existing school ecosystems. Its structured Growth Pathway (Recognise–Engage–Create) provides a scalable developmental guide that can be implemented through classroom activities, project-based learning, and co-curricular integration without requiring additional digital systems. The novelty of ERI-P 5.0 therefore lies not in technological complexity, but in conceptual integration, early-stage positioning, and practical scalability. By merging entrepreneurial resilience with ethical AI

readiness at the primary level within a structured human-centered pathway, the framework offers a distinctive and sustainable contribution to future education transformation.

4. Benefit to mankind

The ERI-P 5.0 Framework contributes to societal advancement by addressing a foundational gap in early digital-age preparation. As children increasingly engage with artificial intelligence, digital platforms, and value-creation opportunities, the absence of structured ethical and resilience-based guidance at the primary level may result in reactive digital discipline rather than proactive human development. ERI-P 5.0 responds by positioning primary education as the strategic starting point for cultivating responsible, resilient, and future-ready citizens. At the individual level, the framework strengthens students' entrepreneurial initiative, adaptive problem-solving capacity, and ethical AI engagement. By embedding these competencies early, learners are equipped not merely to consume technology, but to participate responsibly and create value within digital ecosystems. At the school level, ERI-P 5.0 offers educators a structured yet practical model that can be integrated into existing teaching practices without significant infrastructure investment. This reduces implementation barriers and supports consistent value-based digital formation across diverse educational contexts. At the national level, the framework aligns with digital transformation agendas and human-centered development principles. By fostering entrepreneurial resilience and ethical AI readiness from an early age, ERI-P 5.0 contributes to long-term human capital strengthening, sustainable digital citizenship, and responsible innovation culture development. Ultimately, the societal impact of ERI-P 5.0 lies in its preventive and formative approach. Rather than addressing digital misconduct after it occurs, the framework proactively cultivates character, resilience, and ethical judgment before maladaptive patterns are formed. This forward-looking orientation supports the development of a generation capable of navigating technological advancement with integrity, adaptability, and social responsibility.

5. Innovation and Entrepreneurial Impact

The ERI-P 5.0 Framework represents an educational innovation that repositions primary education as the starting point for structured digital-age preparation. Rather than introducing isolated digital literacy or entrepreneurship components, the framework integrates resilience formation, ethical AI awareness, and value-based initiative into a coherent developmental structure suitable for young learners. Its innovative strength lies in redefining entrepreneurship at the primary level—not as early business exposure, but as the cultivation of initiative, responsible decision-making, and constructive problem-solving. ERI-P 5.0 emphasizes mindset development before market orientation, ensuring that children first develop resilience, ethical awareness, and adaptability prior to engaging more complex economic realities. Within school ecosystems, the framework encourages value-oriented contribution through contextual mini-projects and reflective digital practices. Students are guided to see challenges in their immediate environment as opportunities to improve, create, and collaborate responsibly. This approach nurtures early innovation habits rooted in social responsibility rather than competition alone. At the institutional level, ERI-P 5.0 introduces a structured yet flexible model that strengthens educator capacity to guide future digital readiness without dependence on advanced technological systems. The framework supports gradual, sustainable implementation within existing curricular and co-curricular structures, enabling schools to embed digital-age preparation as part of everyday learning culture. By integrating resilience, ethical AI readiness, and initiative-building at the foundational stage of education, ERI-P 5.0 contributes to cultivating a generation prepared

not only to participate in the digital economy, but to shape it responsibly. Its impact lies in strengthening long-term innovation capacity through character formation, adaptability, and guided value creation from an early age.

6. Potential commercialization

The ERI-P 5.0 Framework demonstrates strong commercialization potential as a scalable educational innovation aligned with national digital transformation and AI integration agendas. Positioned as a structured school-based readiness model, ERI-P 5.0 can be developed into a comprehensive implementation package tailored for primary education systems. The framework holds potential to be commercialized as a modular adoption toolkit comprising structured implementation guides, teacher training modules, readiness assessment rubrics, and developmental activity blueprints. These components may be offered as licensed school adoption packages, professional development programs, or institutional framework integration modules. At the national level, ERI-P 5.0 aligns with digital education reform initiatives and human capital strengthening strategies, making it suitable for collaboration with educational authorities, curriculum developers, and training institutions. Its infrastructure-light design enhances market feasibility, as it does not require high-cost technological systems, enabling broad adoption across urban and rural school contexts. In addition, the framework presents opportunities for digital expansion through future integration into online teacher training platforms or structured digital readiness dashboards. Such developments can enhance scalability while maintaining the framework's human-centered philosophy. By positioning entrepreneurial resilience and ethical AI readiness as measurable and structured developmental competencies, ERI-P 5.0 addresses a growing national demand for responsible AI engagement in early education. Its commercialization strength lies in its transferability, policy relevance, and adaptability across diverse primary school ecosystems. With structured branding and strategic partnerships, ERI-P 5.0 has the potential to evolve into a nationally recognized educational framework supporting sustainable digital-age preparation.

7. Acknowledgment

The author extends her sincere appreciation to her supervisor for the guidance, thoughtful insights, and continuous encouragement that contributed to the conceptual refinement and strengthening of this framework. The constructive feedback and professional mentorship provided have been instrumental in shaping the clarity and direction of the ERI-P 5.0 Framework. Appreciation is also extended to fellow educators and colleagues whose shared classroom experiences, reflections, and discussions have inspired the human-centered and practical orientation of this innovation. Their collective commitment to nurturing responsible and resilient learners has reinforced the relevance of developing structured digital-age preparation at the primary level. This innovation is driven by a shared aspiration to support the formation of resilient, ethical, and future-ready young generations capable of navigating evolving technological landscapes with integrity and purpose.

8. Researchers' Biography

Siti Nuur Rahmah binti Mahmood is a Full Research Master's student in Measurement and Evaluation at Universiti Kebangsaan Malaysia (UKM). Her research focuses on the entrepreneurship education and the implementation of entrepreneurship elements in primary schools. She specializes in entrepreneurship basic business values, attitudes, and skills from an early age, focusing on character building such as being powerful affective traits. Her work aims to develop empirically validated measurement tools that measure effectiveness of cross-curricular elements on entrepreneurship among primary school students.

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A Plug-and-Use Power-Based Safety System for Detecting Unattended Children in Vehicles

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ABSTRACT

Leaving children unattended in parked vehicles is a serious safety issue, especially in hot climates like Malaysia, where cabin temperatures can rise rapidly and cause heatstroke or suffocation. Existing safety systems are usually expensive and limited to newer vehicle models, making them inaccessible to many families. This project presents a plug-and-use power-based safety system designed to detect the presence of unattended children inside vehicles in a simple, affordable, and portable manner. The system uses an ESP32 microcontroller integrated with a PIR motion sensor, DHT22 temperature sensor, and MQ-2 gas sensor to monitor movement, temperature, and air quality inside the vehicle. When dangerous conditions are detected, the system activates a buzzer and LED while simultaneously sending real-time alerts to caregivers via the Telegram platform. Sensor data is also logged to Google Sheets for monitoring and analysis. The device is powered by a lithium-ion battery with a boost converter, ensuring continuous operation even when the vehicle engine is turned off. This system provides an effective and low-cost safety solution that can be installed in any vehicle without complex wiring. It has strong potential to reduce preventable child-related accidents and increase public awareness of vehicle safety.

Keywords: Child safety, vehicle safety system, unattended children, ESP32, IoT

1. Product Description

The Plug-and-Use Power-Based Safety System is a portable device designed to detect unattended children inside parked vehicles. The system is installed inside the vehicle cabin and powered by a rechargeable lithium-ion battery, allowing it to operate independently from the car's main electrical system. This ensures continuous monitoring even after the engine is switched off. The device uses multiple sensors to improve detection accuracy. A PIR sensor detects movement, indicating the presence of a child. A DHT22 sensor monitors temperature levels inside the vehicle, while an MQ-2 gas sensor detects changes in air quality that may indicate suffocation risks. When unsafe conditions are detected, the system activates a buzzer and LED as immediate alerts and sends real-time notifications to caregivers through Telegram. Sensor readings are also uploaded to Google Sheets for data logging. The system is designed to be user-friendly, affordable, and compatible with all vehicle types. It requires no professional installation and functions as a safety assistant to support caregivers in preventing dangerous situations involving unattended children.

2. Block Diagrams and Flow Charts

Figure 1 shows the proposed child safety system in centred around an ESP32 microcontroller, which receives input from a temperature sensor, PIR motion sensor, and MQ2 sensor. It is powered by the vehicle's power supply by battery (Lithium-Ion). When the unsafe conditions are detected, the system activates a buzzer and LEDs, and sends real-time alerts via Telegram platform. This diagram clearly shows how each component interacts to support the system's safety function. The system operation begins with the power-up sequence, where the ESP32 receives energy from the independent Li-ion battery supply. Upon startup, the microcontroller enters an initialization phase, systematically activating and calibrating all connected peripherals, including the PIR motion sensor, DHT22 temperature sensor, MQ-2 gas sensor, and communication modules. This critical stage ensures that the hardware is stabilized and the system is fully prepared to enter its continuous monitoring loop inside the vehicle cabin.

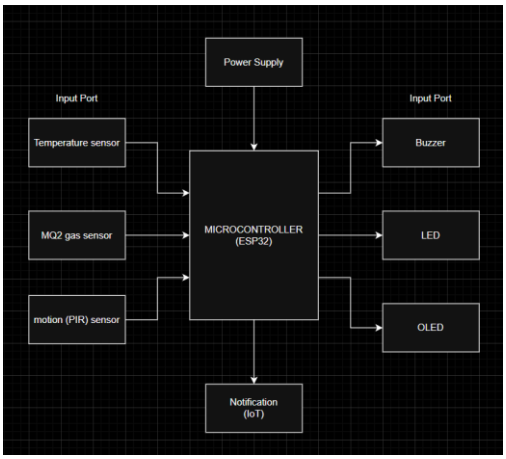

Figure 1. Block diagram of A Plug-and-Use Power-Based Safety System for Detecting Unattended Children in Vehicles.

Once the system is active, it follows a logical detection hierarchy to determine if a child is at risk. The process starts with the PIR sensor scanning for physical movement; if no motion is detected, the system remains in a passive standby state. However, if movement is confirmed, the ESP32 immediately evaluates environmental thresholds. It checks if the cabin temperature has exceeded a safe limit, such as 35°C, and monitors the MQ-2 sensor for high gas concentrations (e.g., above 500 ppm), which could indicate poor air quality or heavy respiration in a confined space. In the event that motion is detected alongside dangerous temperature or gas levels, the system transitions into an emergency state. It executes a multi-channel alert by sending a "SAFETY ALERT" notification to the caregiver via Telegram while simultaneously triggering the local buzzer and LED to attract the attention of bystanders.All real-time sensor data is uploaded to Google Sheets for logging and remote monitoring. The system continues this alert cycle until the sensors indicate that the child has been safely removed and the environment has returned to normal parameters, at which point the process resets or terminates. **Figure 2** illustrates hardware setup consisted of a small embedded system built for monitoring and display purposes. Looking from the top view, the main controller is an ESP-based microcontroller, which manages data processing and communication. It is connected to an OLED display that shows real-time readings, making the system user-friendly and easy to interpret. A custom PCB is included to organize connections and support additional components, while jumper wires link the display and controller. Power is

supplied through an external voltage regulator module, indicated by a red LED that confirms stable operation.

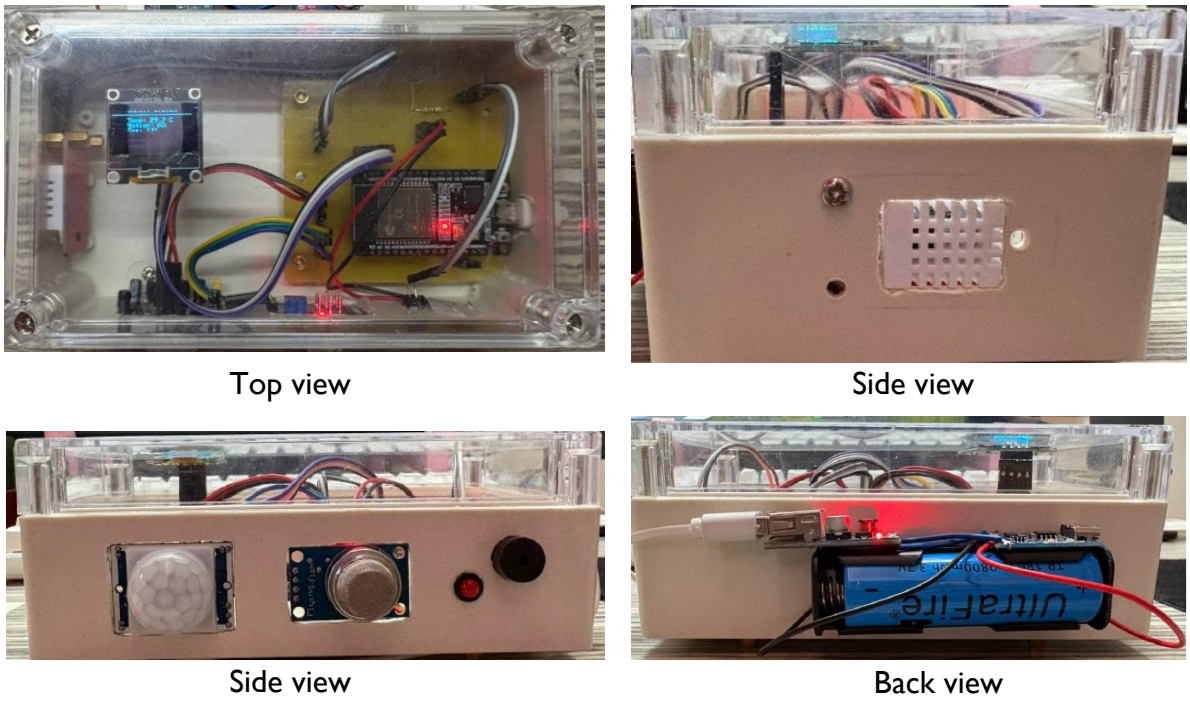

Figure 2. Top view of A Plug-and-Use Power-Based Safety System for Detecting Unattended Children in Vehicles.

Overall, the design is neat and practical, showing a clear integration of control, display, and power management, which makes it suitable for IoT or sensor-based applications. The side view shows a PIR sensor on the left to detect movement and a gas sensor in the center, likely from the MQ series, to measure air quality or detect harmful gases. A red push button is placed on the panel which can be used to reset the system or acknowledge alerts. Next to it is a buzzer that produces sound when danger is detected. Inside the casing, all components are connected with wires to the internal circuit. The design is simple and practical, suitable for safety applications like smart home systems or environmental monitoring. On the other side shows the temperature and humidity sensor mounted on the front panel. The sensor is likely a DHT11 or DHT22, used to measure environmental conditions. There are also two small circular openings which may be for a status LED or additional sensors. A screw is placed to secure the panel. The back view shows the power supply setup and circuit integration. A blue UltraFire lithium-ion battery is connected to a small circuit board with a USB port and a red LED indicator, confirming that the system is powered on. Several wires from the board lead into the transparent enclosure above, where the main components are housed. The entire setup is mounted on a white base, keeping the layout organized and stable. This view highlights how the device is powered and how the internal electronics are linked to the external power source, making it suitable for portable or embedded applications.

3. Novelty and uniqueness

The novelty of this project lies in its plug-and-use design combined with a multi-sensor detection approach. Unlike existing vehicle safety systems that are built into newer or luxury cars, this system is portable and can be used in any vehicle without modifying the car's internal electronics. This makes it highly accessible and cost-effective. Another unique feature is the integration of motion, temperature, and gas sensors into a single safety device. Instead of relying on only one parameter, the system uses multiple environmental indicators to reduce false alarms and improve detection reliability. The use of the ESP32 microcontroller enables seamless Internet of Things (IoT) connectivity, allowing real-time alerts to be sent through Telegram and data to be logged on Google Sheets. Additionally, the independent battery-powered system ensures that monitoring continues even when the vehicle is turned off, addressing a major limitation of many existing safety solutions. These combined features make the system practical, scalable, and suitable for real-world application.

4. Benefit to mankind

This project provides a direct benefit to society by addressing the growing issue of children being accidentally left in parked vehicles. By offering an affordable and easy-to-use safety device, the system helps prevent heatstroke, suffocation, and potentially fatal accidents involving children. It also raises awareness among caregivers about vehicle safety and the dangers of unattended children. The system supports responsible caregiving by acting as an additional safety layer rather than replacing human supervision. Its real-time alert capability ensures quick response during emergencies, potentially saving lives. Overall, this project contributes to public safety, family well-being, and the reduction of preventable tragedies.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by applying IoT technology and embedded systems to solve a real-world safety problem. It demonstrates how low-cost components can be transformed into a practical and market-ready safety product. The system encourages a problem-solving mindset among students and promotes hands-on engineering skills. From an entrepreneurial perspective, the device has strong potential for further development into a commercial product. Its simple installation, portability, and compatibility with all vehicle types make it attractive to a wide consumer market. The project supports the growth of innovation-driven solutions in automotive safety and smart technology sectors.

6. Potential commercialization

The proposed system has strong commercialization potential as an aftermarket vehicle safety product. It can be marketed to parents, childcare providers, and vehicle owners as an affordable child safety accessory. Its plug-and-use design allows mass production with minimal installation requirements, reducing overall manufacturing and user costs. Future commercial versions could include mobile applications, enhanced sensors, and compact casing designs to improve user experience. The system could be sold through online platforms, automotive accessory shops, or bundled with child safety products. With increasing awareness of child safety issues, this product has high market demand and scalability potential.

7. Acknowledgment

The author would like to express sincere gratitude to Dr. Siti Musliha Ajmal Binti Mokhtar for her guidance, support, and valuable feedback throughout the completion of this project. Appreciation is also extended to family, friends, lecturers, and Universiti Teknologi MARA for providing the facilities and encouragement necessary for the successful completion of this work.

8. Researchers' Biography

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GAIL-PaT: A Modular Curriculum Framework for Generative AI Literacy among Teachers

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ABSTRACT

The rapid proliferation of generative artificial intelligence (GenAI) in educational settings has created a critical gap where teachers are exposed to AI tools without structured guidance on how to evaluate, apply, or critically reflect on their pedagogical use. GAIL-PaT (Generative AI Literacy Pathway for Teachers) is a modular curriculum framework designed to bridge this gap by developing generative AI literacy as a professional competency rather than a technical skill. The framework comprises four sequentially scaffolded modules consisting of AI Fundamentals, Prompt-Centric Pedagogy, Evaluating Output Quality, and Ethical & Responsible AI Usage. Grounded in established principles of adult learning and cognitive scaffolding, GAIL-PaT is platform-independent, low-infrastructure, and adaptable across diverse educational contexts. The framework addresses the Malaysian educational landscape specifically by embedding cultural and ethical considerations relevant to national curriculum and data privacy requirements. Expected outcomes include enhanced teacher confidence, reduced AI misuse, and responsible classroom integration. GAIL-PaT offers high commercialisation potential through institutional licensing and certified professional development programmes, targeting over 400,000 educators nationwide via scalable digital resource packages for schools, universities, and corporate training providers.

Keywords: Generative AI, AI Literacy, Teacher Professional Development, Curriculum Framework, Sustainable Education

1. Product Description

GAIL-PaT is a structured, four-module curriculum framework developed to build generative AI literacy specifically among teachers. Unlike existing professional development approaches that focus primarily on tool proficiency, GAIL-PaT positions AI literacy as a pedagogically grounded professional competency. The framework is organised into four sequential modules that mirror how educators naturally build expertise, where foundational understanding precedes hands-on prompting, which then leads to critical evaluation and ethical application. This intentional sequencing ensures that teachers do not engage with GenAI tools superficially but instead develop deep and transferable competencies applicable across various subjects, levels, and educational contexts. GAIL-PaT does not require proprietary platforms, expensive subscriptions, or specialised infrastructure, making it immediately accessible to schools and institutions across Malaysia and beyond. It is designed for seamless delivery through existing Continuing Professional Development (CPD) structures, teacher education programmes at universities, or school-based

learning communities. The framework includes comprehensive facilitation guides, module outlines, and formative assessment checkpoints designed to be adapted by professional development coordinators without the need for extensive technical training.

2. Framework Diagram — The GAIL-PaT Modular Learning Path

The GAIL-PaT framework is organised into four sequential, scaffolded modules as illustrated in **Figure 1** below. Each module builds upon the competencies established in the preceding module, reflecting the pedagogical logic of progressive expertise development.

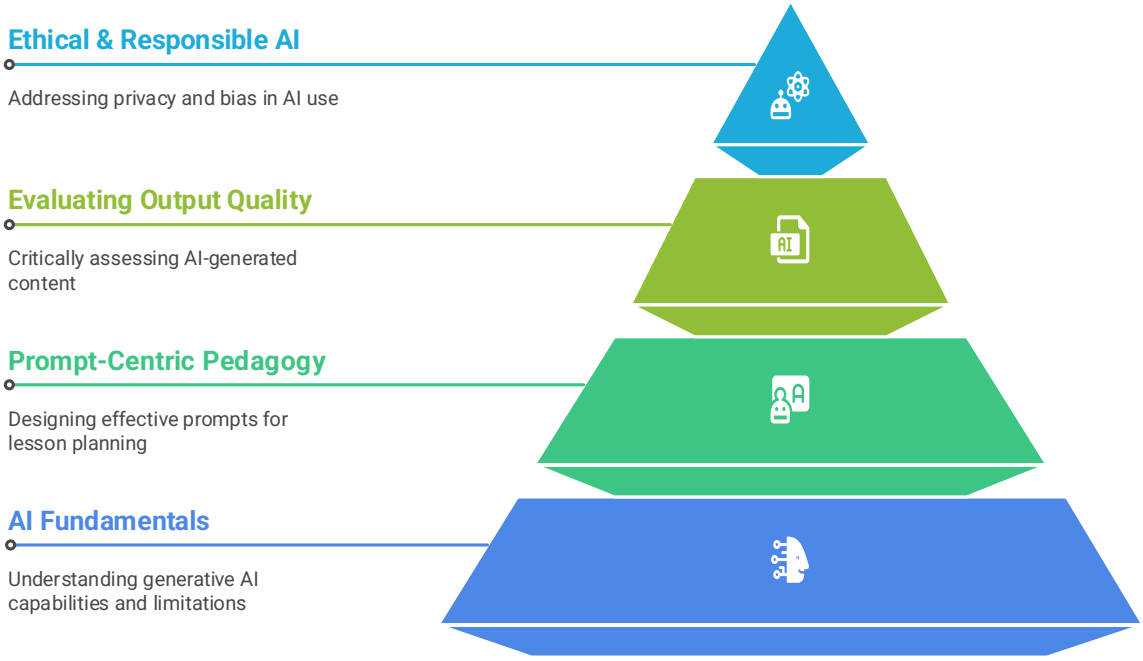

Figure 1. The GAIL-PaT Four-Module Sequential Learning Framework.

The pedagogical logic shown in **Figure 1** reflects a core principle: teachers must first understand what generative AI is and what it cannot do (Module 1) before applying it meaningfully through prompting (Module 2). Hands-on prompting experience then builds the contextual knowledge required to critically evaluate outputs (Module 3), which ultimately enables sound ethical decision-making in the classroom (Module 4). The framework is technically light but pedagogically strong, prioritising deep understanding over surface-level tool proficiency.

3. Novelty and Uniqueness

GAIL-PaT introduces several distinctive characteristics that set it apart from existing teacher professional development approaches in the AI domain. Firstly, it features a competency-first design as the first framework to position generative AI literacy explicitly as a structured professional competency rather than a technical tool skill. This approach reflects how educators naturally build durable expertise over time. Secondly, the framework employs a sequenced pedagogical architecture where the four-module structure follows established adult learning theory and cognitive scaffolding principles. This intentional design is often absent in current professional development practices. Furthermore, ethics are embedded throughout the entire

journey, culminating in a dedicated module that addresses Malaysian-specific cultural, legal, and data privacy considerations. As a platform-independent and equitable solution, GAIL-PaT requires no proprietary AI platforms or specialised hardware, ensuring accessibility across diverse and under-resourced school environments. Finally, it offers measurable progression by providing institutions with a clear and assessable pathway to track and report teacher AI literacy development, effectively filling a critical measurement gap in the industry.

4. Benefit to Mankind

GAIL-PaT delivers measurable benefits across multiple stakeholder levels. For teachers, the framework builds genuine confidence in evaluating and applying GenAI responsibly, effectively reducing the risk of uncritical over-reliance on AI-generated content. For students, educators trained through GAIL-PaT model critically informed AI use, which equips the next generation with ethical AI literacy as a foundational 21st-century competency. For educational institutions, the framework provides a scalable and implementable tool for measuring and reporting teacher AI readiness across CPD programmes and teacher education pipelines. At the national level, GAIL-PaT directly supports Malaysia's digital education agenda and AI strategy by building an educator workforce capable of guiding students sustainably through an AI-enhanced world. This contributes meaningfully to long-term human capital development and national competitiveness in the knowledge economy.

5. Innovation and Entrepreneurial Impact

GAIL-PaT promotes a culture of responsible innovation within educational institutions by equipping teachers as the primary agents of pedagogical change with the competencies needed to critically engage with emerging AI technologies rather than passively adopting them. By treating AI literacy as a structured and teachable professional skill, the framework encourages educators to become innovators in their own right through designing AI-augmented learning experiences, evaluating AI-assisted pedagogical strategies, and cultivating AI-critical thinking among students. From an entrepreneurial standpoint, GAIL-PaT creates a replicable and scalable professional development product with clear market demand. Its modular architecture enables rapid customisation for different institutional contexts ranging from national teacher training institutes to corporate upskilling programmes. This establishes a flexible entrepreneurial model that is highly adaptable to evolving market needs within the rapidly growing AI education sector.

6. Potential Commercialization

GAIL-PaT presents clear and substantial commercialisation potential across multiple markets. Primary targets include Malaysian public and private schools, Institutes of Teacher Education (IPGs), and universities seeking structured AI professional development programmes. The framework offers high commercialisation potential through institutional licensing and certified professional development programmes, targeting over 400,000 educators nationwide via scalable digital resource packages. Secondary markets encompass corporate training providers and HR departments requiring AI literacy upskilling for knowledge workers. Revenue streams include institutional licensing of the curriculum framework, facilitated certified professional development workshops, and packaged digital resource bundles comprising facilitator guides and assessment rubrics. Additionally, institutional subscription models can be offered for access to updated modules as the GenAI landscape evolves. This positions GAIL-PaT as a highly accessible, low-

cost, and scalable commercial product suitable for adoption from single-school to national policy-level implementation.

7. Acknowledgment

The authors gratefully acknowledge the support of the Faculty of Education, Universiti Kebangsaan Malaysia (UKM) in the development of this innovation. This work is part of an ongoing research programme on generative AI in education and teacher professional development.

8. Researchers' Biography

Mohammed Afandi Zainal holds a B.Ed in Primary Mathematics from the University of Hertfordshire, United Kingdom (2009) and an M.Ed in Measurement and Evaluation from Universiti Kebangsaan Malaysia (2021). He is currently a postgraduate student at Faculty of Education, Universiti Kebangsaan Malaysia, focusing on educational research. His research interests include education, leadership, innovative behaviors, teachers, artificial intelligence, and measurement & evaluation. He is actively involved in research projects focusing on the integration of AI in teaching and learning practices. He can be contacted at email: p148303@siswa.ukm.edu.my.

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Autonomous Cleaning Vacuum Robot With Real-Time Monitoring for Modern Living

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ABSTRACT

Sanitation and home security are increasingly vital in modern residential management. As manual cleaning becomes impractical for larger spaces, there is a growing demand for automated, efficient solutions. This project details the development of an autonomous cleaning robot designed to upgrade existing vacuum technology by integrating surveillance capabilities. Utilizing an ESP32 microcontroller and ultrasonic sensors for navigation, the device not only automates floor cleaning but also features a camera for live video streaming to user smartphones. The system's unique value proposition lies in its dual functionality of combining house cleaning with remote security monitoring. This innovation positively impacts the socio-economic landscape by reducing household labour while enhancing safety. Commercially, it targets the expanding smart home market by offering a multifunctional alternative to single-purpose devices. While the current prototype excludes automatic charging and has terrain limitations due to budgetary constraints, it successfully demonstrates the efficacy of integrating affordable IoT connectivity into domestic robotics.

Keywords: Internet of Things (IoT), Autonomous Robotics, Smart Home Security, ESP32 Microcontroller, Remote Monitoring.

1. Product Description

The Autonomous Cleaning Vacuum Robot With Real-Time Monitoring For Modern Living is an intelligent system designed to streamline home maintenance for the modern lifestyle. This autonomous device utilizes advanced sensors to navigate complex environments, effectively vacuuming floors while avoiding obstacles in real-time. Going beyond standard cleaning, the system offers robust IoT versatility. Users can override the autonomous mode via the Blynk mobile application for manual steering, while operational data is seamlessly logged to Google Sheets for performance tracking and analysis. Uniquely, the robot doubles as a mobile security unit. Equipped with an onboard camera, it streams live video directly to the user's smartphone. This surveillance capability is enhanced by a remotely triggered alarm system, which functions both as a locator if the device is misplaced and as an auditory deterrent for potential intruders. This innovative fusion of sanitation, smart data analytics, and security ensures efficiency and peace of mind in a single, compact package.

2. Methodology & Schematic Diagram

As illustrated in **Figure 1**, the schematic details the complete electronic architecture of the autonomous robot, centered around an ESP32 microcontroller as the primary processing unit. Power is managed via a battery array connected to dual LM2596 DC-DC buck converters, which regulate voltage levels to stable 12V and 5V outputs for the various subsystems. The system employs three HC-SR04 ultrasonic sensors (Front, Left, and Right) for comprehensive obstacle detection. Mobility is controlled by an L298N motor driver interfacing with two N20 DC motors, while the vacuum mechanism utilizes a BLDC motor actuated by a dedicated relay module. Additionally, the design integrates an ESP32-CAM for video streaming capabilities and a buzzer for auditory feedback, ensuring full functionality for both cleaning and security operations.

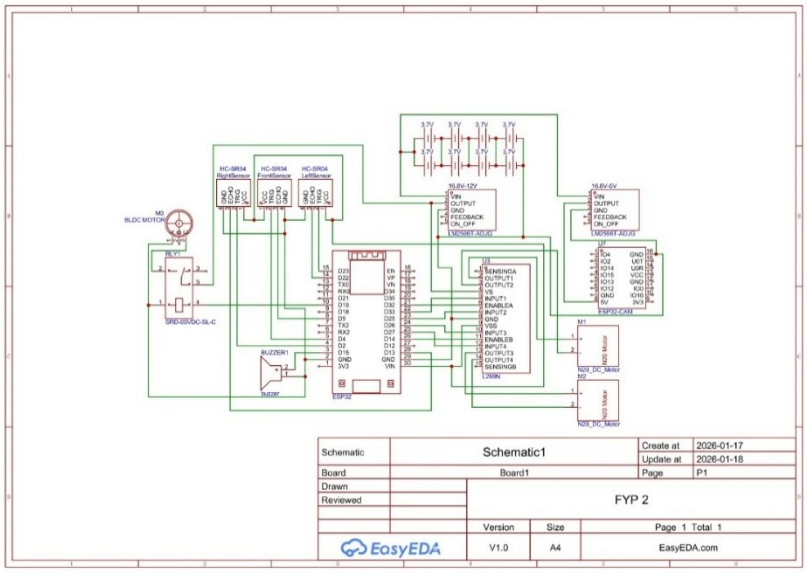

Figure 1. Schematic Diagram Of The Project.

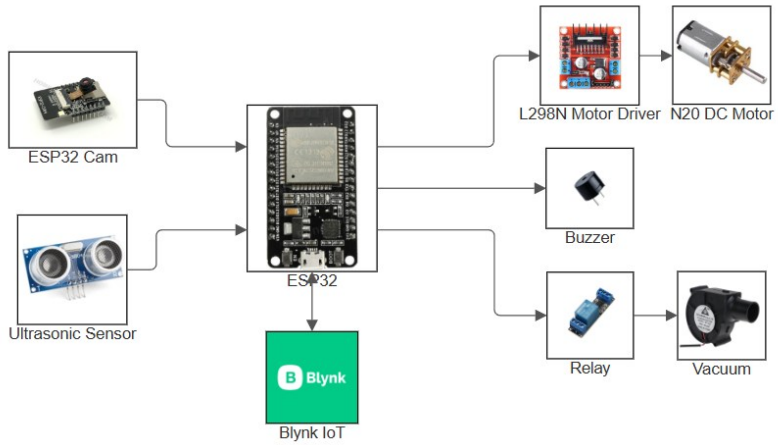

Figure 2. Block Diagram.

The high-level system architecture is presented in **Figure 2**. The design is centralized around the ESP32 microcontroller, which acts as the primary processing unit, orchestrating all data acquisition and control logic. Inputs are continuously derived from the HC-SR04 Ultrasonic

Sensors for precise distance measurement and obstacle avoidance, while the ESP32-CAM provides real-time visual surveillance capabilities. This sensory data is processed to intelligently manage the system's actuators: the L298N Motor Driver, which regulates the speed and direction of the N20 DC Motors for autonomous navigation, and a Relay module that triggers the high-power Vacuum component for cleaning. Power distribution is critical to this architecture, where the battery source is regulated via DC-DC converters to supply stable voltage to both the heavy-load motors and sensitive logic circuits. Additionally, a Buzzer is integrated for immediate audio status signaling, while the system leverages the ESP32's built-in Wi-Fi to communicate with the Blynk IoT interface, enabling seamless remote monitoring and manual contro As depicted in **Figure 3**, the process starts with Wi-Fi and Blynk initialization before entering a continuous loop that checks for manual mode. If inactive, the robot defaults to autonomous navigation, using ultrasonic sensors to avoid obstacles within 20cm or move forward to vacuum when the path is clear. Throughout both modes, the system continuously streams live video to the Blynk interface before the cycle repeats.

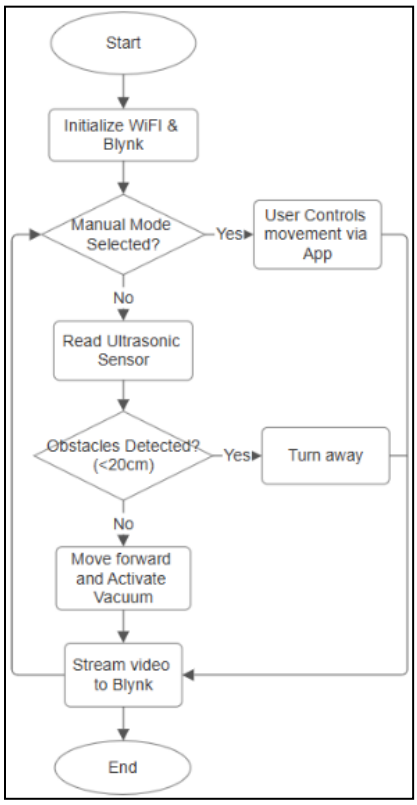

Figure 3. Flowchart Of The Project.

3. Novelty and uniqueness

The novelty of the Autonomous Cleaning Vacuum Robot With Real-Time Monitoring For Modern Living lies in its innovative convergence of autonomous sanitation and mobile surveillance. While conventional robotic vacuums are strictly limited to floor maintenance, this system differentiates itself by integrating an ESP32-CAM module and the Blynk IoT platform to provide real-time visual feedback. This architecture effectively transforms the device into a mobile security unit, offering dynamic monitoring capabilities superior to static, fixed-angle CCTV cameras. Furthermore, the system addresses the common limitation of "missed spots" in

autonomous navigation by offering a manual override feature, granting users precise remote control via their smartphone. This hybridization of cost-effective autonomous cleaning, manual steerability, and live security streaming establishes a unique two-in-one value proposition that significantly advances the functionality of traditional domestic robots.

4. Benefit to mankind

The Autonomous Cleaning Vacuum Robot With Real-Time Monitoring For Modern Living delivers tangible benefits to society by enhancing both domestic hygiene and household security. It significantly improves quality of life through the consistent removal of dust and allergens, thereby promoting better indoor air quality and respiratory health. For time-constrained individuals, the device alleviates the burden of daily chores via automation, allowing users to reclaim time and energy for high-priority activities. Regarding home safety, the system functions as a dynamic surveillance asset. Its mobile video streaming capabilities allow homeowners to proactively monitor their premises, acting as a deterrent against potential intrusions. Furthermore, the robot offers ergonomic advantages by reducing the physical strain associated with manual cleaning, particularly eliminating the need to move heavy furniture to access hard-to-reach areas.

5. Innovation and Entrepreneurial Impact

The Autonomous Cleaning Vacuum Robot With Real-Time Monitoring For Modern Living drives innovation by showcasing the seamless integration of autonomous robotics with IoT-based security. It challenges the convention that smart home devices must be single-purpose or prohibitively expensive by demonstrating how accessible components, such as the ESP32, can be engineered to solve complex, multi-faceted consumer problems. Culturally, the project fosters entrepreneurship by validating the pathway from academic prototyping to commercial product development. It encourages the community to identify specific market gaps, specifically the demand for affordable, multifunctional home assistant, addressing them with scalable technology. By proving that high-value consumer electronics can be developed within a modest budget, this initiative inspires fellow students and local developers to transition from theoretical learning to practical value creation, laying the groundwork for a new generation of hardware entrepreneurs.

6. Potential commercialization

The Autonomous Cleaning Vacuum Robot With Real-Time Monitoring For Modern Living holds significant commercial viability within the rapidly expanding smart home and IoT sectors. Its primary demographic encompasses working professionals and homeowners seeking time-efficient solutions that prioritize domestic security. Furthermore, the device presents a compelling use case for small-to-medium enterprises (SMEs) requiring cost-effective maintenance and after-hours surveillance. The product differentiates itself through value convergence; by integrating autonomous sanitation with mobile video surveillance, it offers a flexible, cost-efficient alternative to static CCTV infrastructure. Capitalizing on the surging demand for app-controlled IoT ecosystems, this robot is strategically positioned as a budget-friendly, multifunctional solution that eliminates the need for purchasing separate cleaning and security systems.

7. Acknowledgement

I would like to express my sincere gratitude to my supervisor, Norbaiti Binti Sidik, for her invaluable guidance, patience, and technical insight throughout the duration of this project. Her constructive feedback and constant encouragement played a pivotal role in the successful completion of the Autonomous Cleaning Vacuum Robot With Real-Time Monitoring For Modern Living. Finally, I extend my deepest appreciation to my family and peers for their unwavering support, motivation, and understanding during this academic journey.

8. Researchers' Biography

Muhammad Faiz Adzeem Bin Mohd Fadly is a dedicated Final Year Student in the Diploma of Electrical Engineering (Electronics) program at UiTM Cawangan Johor Kampus Pasir Gudang. With a strong technical foundation in the Internet of Things (IoT), robotics, and automation, he has demonstrated consistent academic excellence, securing a place on the Dean's List for four consecutive semesters. His innovative approach to problem-solving was recently recognized with a prestigious IEEE Award for his Final Year Project, the "State Of The Art Multipurpose Robot Cleaner." Driven by a passion for integrating hardware with smart technology, he aspires to contribute to the engineering field by developing accessible automation solutions that enhance modern living standards.

Mrs Norbaiti Binti Sidik received her first formal education at government primary school, Sekolah Kebangsaan Batu Lima in Sik Kedah. The second foundation, her academic journey was laid at Arabic high school established as Maktab Mahmud Alor Setar, Kedah Darul Aman. Her studies continued at Universiti Kebangsaan Malaysia in Bandar Baru Bangi Selangor right after completed 1 year Science Matriculation Certificate at Science Matriculation Centre, Ipoh Perak Darul Ridzuan. She graduated her Bachelor Engineering Degree in Electrical, Electronics and System within 3 years from Universiti Kebangsaan Malaysia, Bandar Baru Bangi Selangor Darul Ehsan and she further developed her academic and professional skills by obtaining Master Engineering Degree in Communication and Computer also from the same university in 2002. She is very committed, passionate and dedicated in education line who is now a senior lecturer and having experienced more than 15 years in teaching & learning and lecturing at Electrical Engineering Studies, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, Johor Darul Takzim.

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Smart Home with Electrical Current Monitoring based on Internet of Things

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ABSTRACT
The rapid development of Internet of Things (IoT) technology has enabled the creation of smart home systems that improve convenience, safety, and energy efficiency. This paper presents the design and implementation of a smart home system with electrical current monitoring. The proposed system allows users to control household appliances such as lamps, fans, and an automatic gate through voice commands using Google Assistant integrated with the Bylink platform. In addition, electrical current monitoring information is continuously displayed to provide real-time feedback on electricity usage. An ESP8266/ESP32 microcontroller is used as the main controller, integrating WiFi communication, relay modules, current monitoring sensors, and an I2C-based LCD display. Ex perimental results show that the system operates reliably, provides responsive control, and improves user awareness of electrical energy usage.

Keywords: Smart Home, Internet of Things, Electrical Current Monitoring, Google Assistant, ESP8266, ESP32

1. Product Description
The Smart Home with Electrical Current Monitoring is an IoT-based prototype developed to efficiently control and monitor household electrical systems. This product integrates home automation, real-time electrical current monitoring, and voice-based control into a single unified platform. The system is built using an ESP8266/ESP32 microcontroller as the main controller, connected to relay modules, electrical current sensors, a stepper motor, and an I2C-based LCD display. The system enables users to remotely control electrical devices, such as lighting and household appliances, using voice commands through Google Assistant via the SinricPro cloud platform. In addition to device control, the electrical current monitoring function operates continuously while the system is active, providing real-time data on electricity usage. This information is displayed on the LCD in the form of running text, allowing users to easily observe power consumption patterns and identify abnormal current conditions that may indicate electrical overloads or inefficiencies. Furthermore, the prototype supports automated gate control using a stepper motor, improving residential security and user convenience. The system is designed to maintain stable operation through reliable WiFi connectivity and efficient power management. Overall, this smart home prototype provides a practical and cost-effective solution for home automation while enhancing energy awareness, electrical safety, and user comfort.

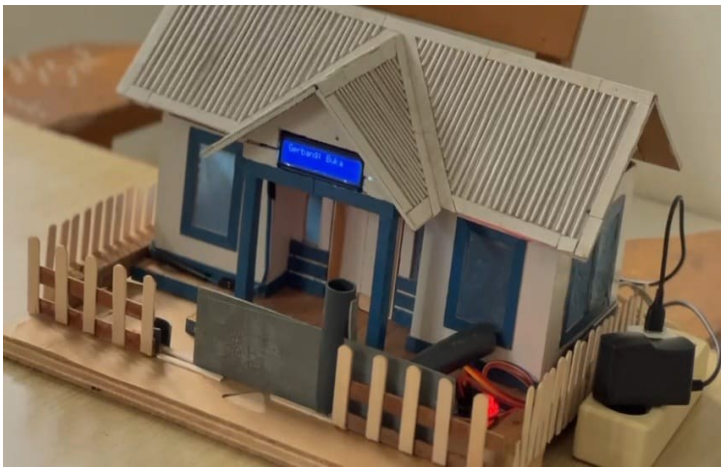

Figure 1. Project View.

2. System Overview And Aplication Interface

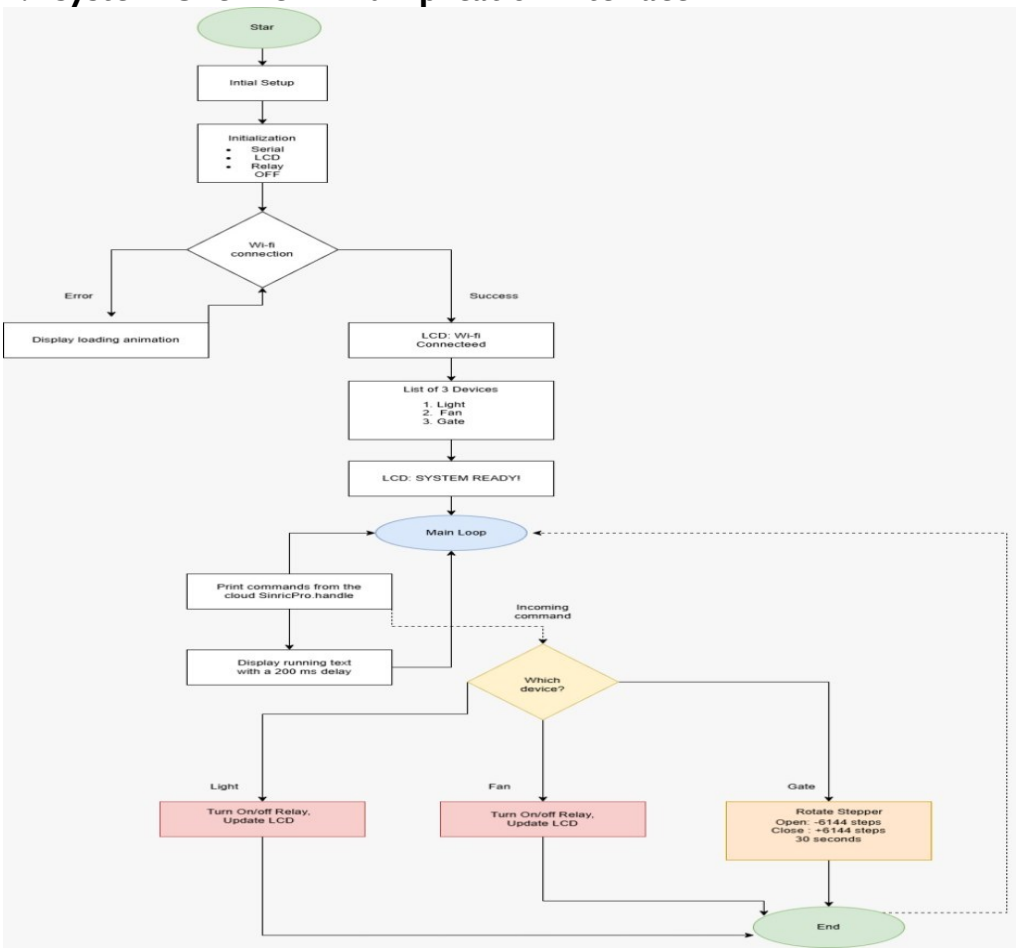

Figure 2. Flow Chart of Smart Home with Electrical Current Monitoring based on Internet of Things.

The flowchart illustrates the operational workflow of the **Smart Home system with electricity current monitoring**, starting from system initialization to device control based on cloud commands.The process begins at the **Start** stage, followed by the **Initial Setup**, where the system prepares the hardware and software environment. During the **Initialization** phase, several components are activated, including the **serial communication**, **LCD display**, and **relay modules**, with all relays initially set to the **OFF** state to ensure safety.

Next, the system attempts to establish a **Wi-Fi connection**. This step is crucial as the system relies on cloud-based communication. If the Wi-Fi connection fails, the system displays a **loading animation** on the LCD and continuously retries the connection. Once the Wi-Fi connection is successful, the LCD displays a confirmation message indicating that the device is connected to the network.

After a successful connection, the system displays a **list of three controllable devices** on the LCD:

1. Light
2. Fan
3. Gate

When all components are ready, the LCD shows the message **"SYSTEM READY!"**, indicating that the system has entered operational mode. The program then proceeds to the **Main Loop**, which runs continuously.Inside the main loop, the system listens for **incoming commands from the cloud platform (SinricPro)**. Any received command is printed and processed by the system handler. At the same time, the LCD displays a **running text animation** with a delay of 200 milliseconds to provide real-time feedback to the user.When a command is received, the system determines **which device** is being addressed. Based on this decision:

9. If the command is for the **Light**, the corresponding relay is turned **ON or OFF**, and the LCD is updated accordingly.
10. If the command is for the **Fan**, the relay is similarly controlled, and the LCD reflects the current status.
11. If the command is for the **Gate**, a **stepper motor** is activated. The motor rotates **-6144 steps to open** the gate and **+6144 steps to close** it, with a **30-second delay** between operations.

After executing the command, the system returns to the **Main Loop**, allowing it to continuously monitor and respond to new commands in real time. The process continues until the system is stopped, reaching the **End** state.

The image shows the **electricity monitoring dashboard** of the *Smart Home* project, which is designed to monitor real-time electrical parameters and energy consumption. This dashboard provides users with a comprehensive overview of household electricity usage in an intuitive and visual format.At the top of the dashboard, the system displays the **electric current usage** through a circular gauge. The current power consumptiosn is shown as **5.8 watts**, indicating the real-time electrical load being used by connected devices. This visualization helps users quickly understand their instantaneous power usage.On the right side of the interface, several key electrical parameters are presented numerically. The **voltage** is measured at **214 volts**, while the **current (ampere)** value is **0.05 A**, representing the flow of electric current through the system. Additionally, the **energy consumption** is shown as **0.03 kWh**, which reflects the total electrical energy used over a certain period.

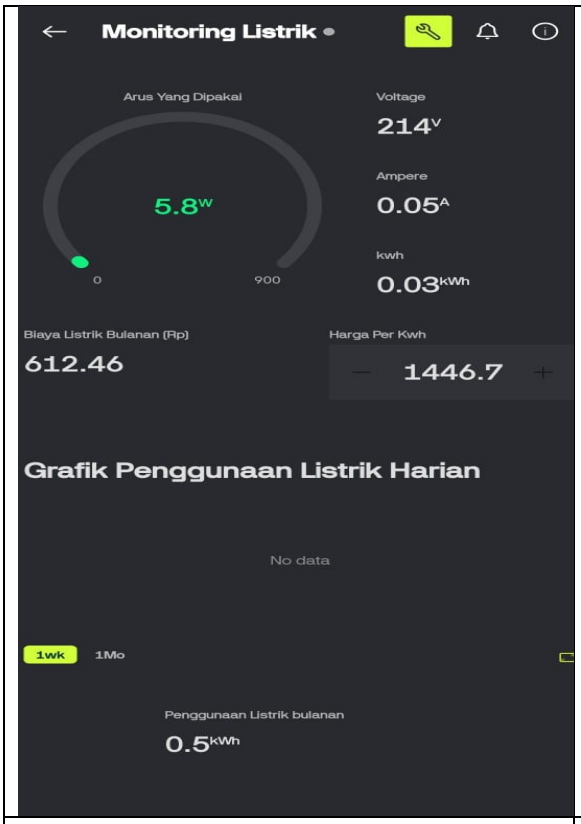

Figure 3. Monitoring Dashbord

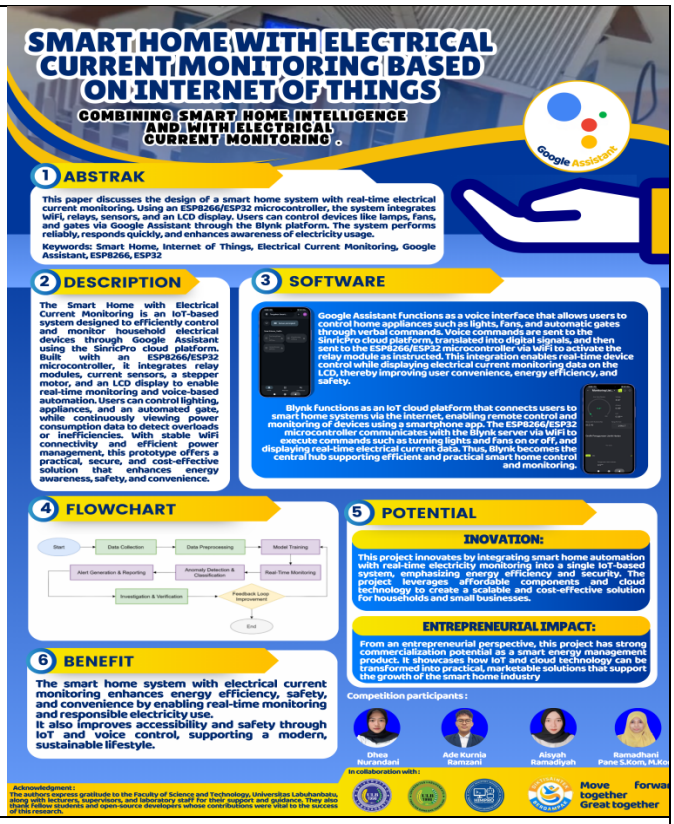

Figure 2. SMARTHOME-Products

The dashboard also calculates the **estimated monthly electricity cost**, which is displayed as **Rp 612.46**. This cost estimation is based on the electricity tariff set in the system, where the **price per kWh** is defined as **Rp 1,446.7**. Users can adjust this tariff value to match real electricity pricing, allowing the system to provide accurate cost predictions.Below the main indicators, the dashboard includes a section for the **daily electricity usage graph**. In the current display, no data is available, indicating that daily usage data has not yet been recorded or visualized. Users can select different time ranges, such as **1 week (1wk)** or **1 month (1Mo)**, to analyze historical consumption patterns.Finally, the dashboard shows the **monthly electricity usage**, which is recorded as **0.5 kWh**. This feature helps users monitor long-term energy consumption and supports energy efficiency analysis. Overall, this monitoring dashboard plays a crucial role in the Smart Home system by enabling **real-time monitoring**, **cost estimation**, and **data-driven decision-making** to promote efficient and responsible electricity usage.

3. Novelty and uniqueness

The novelty of this research lies in the integration of smart home control and continuous electrical current monitoring within a single IoT-based system. Unlike most existing smart home implementations that primarily focus on device automation, this system emphasizes real-time energy usage awareness by continuously displaying electrical current data while the system is operating. This approach provides users with direct feedback on electricity consumption, encouraging more efficient and responsible energy usage.

The uniqueness of the proposed system is demonstrated through the combination of voice-controlled automation using Google Assistant, cloud-based device management via Bylink, and local real-time visualization using an I2C LCD. Additionally, the system integrates an automatic gate mechanism using a stepper motor, which is rarely combined with electrical current monitoring in typical smart home prototypes. The use of a single microcontroller to manage automation, monitoring, and visualization enhances system simplicity, cost efficiency, and reliability, making the proposed solution suitable for practical smart home applications.

4. Benefit to mankind

The development of a smart home system with electrical current monitoring provides meaningful benefits to mankind by improving energy efficiency, safety, and everyday convenience. Real-time monitoring of electrical current enables users to understand their electricity consumption patterns and encourages more responsible energy usage, leading to reduced power waste and lower household expenses. This supports global efforts toward sustainable energy management and environmental conservation.

In addition, the system enhances household safety through continuous monitoring and remote control of electrical appliances, reducing the risk of electrical overloads, short circuits, and fire hazards. The integration of IoT technology and voice-based control improves accessibility for elderly users and individuals with physical limitations. Overall, this smart home solution contributes to a safer, more efficient, and technology-driven lifestyle that aligns with modern societal needs.

5. Innovation and Entrepreneurial Impact

This project promotes innovation by integrating smart home automation with real-time electrical current monitoring in a single IoT-based system. Unlike conventional smart home solutions that focus mainly on device control, this system emphasizes energy awareness, safety, and data-driven decision making. The use of affordable microcontrollers, current sensors, and cloud platforms enables the development of a scalable and cost-effective solution that can be easily adopted by households and small businesses.

From an entrepreneurial perspective, this project has strong commercialization potential as a smart energy management product or service. It encourages entrepreneurship by demonstrating how emerging technologies such as IoT and cloud computing can be transformed into practical solutions with economic value. The system can be further developed into a startup product, customized for different market segments, and contribute to the growth of the smart home and energy technology industry.

6. Potential commercialization

The Smart Home with Electrical Current Monitoring system has strong potential for commercialization due to its practical functionality, scalability, and growing market demand for energy-efficient smart home solutions. The system can be developed into a market-ready product targeting residential users, boarding houses, apartments, and small businesses that require efficient energy management and remote device control. By utilizing affordable hardware components and cloud-based platforms, the production cost can be kept relatively low, making the product accessible to a wider consumer segment.

Furthermore, this system can be commercialized through multiple business models, such as direct product sales, subscription-based monitoring services, or customized smart home installation

packages. Partnerships with property developers, electrical service providers, or smart home integrators can further expand market reach. With increasing awareness of energy conservation and smart living, this product has strong potential to compete in the smart home and energy management market.

7. Acknowledgment

The authors would like to express their sincere gratitude to the Faculty of Science and Technology, Information Technology Study Program, Universitas Labuhanbatu, for the academic support, facilities, and learning environment provided during the completion of this research. Special appreciation is extended to the lecturers and academic supervisors of the Information Technology Study Program for their guidance, constructive feedback, and continuous encouragement throughout the research process. The authors also acknowledge the support from laboratory staff and fellow students who contributed through technical assistance and valuable discussions. Furthermore, appreciation is given to the developers of open-source platforms, libraries, and IoT tools that supported the implementation of this smart home system. Their contributions played an important role in the successful realization of this research.

8. Researchers' Biography

Dhea Nurandani is an undergraduate student in the Information Technology Program, Faculty of Science and Technology, Universitas Labuhanbatu. She is actively involved in academic and organizational activities, serving as Secretary of the Student Association and as a leader in community-based public speaking programs. Her interests include information technology, education, IoT applications, and communication development. She has participated in various national and international competitions, earning several gold and silver medals in innovation, robotics, and technology categories. Her experiences in teaching, media production, and organizational management support her collaborative, communicative, and results-oriented approach to research and innovation.

Aisyah Rahmadiyah Manoppo, was born in Bumi Palma, Riau, on July 29, 204. I am currently an active undergraduate student in the Information Technology Study Program, Faculty of Science and Technology, Universitas Labuhanbatu.I have a strong interest in the field of Information Technology and am committed to continuously developing my academic abilities as well as supporting skills. I am accustomed to being disciplined, responsible, and capable of working independently as well as collaboratively in a team.Through the learning process and experiences I have gained during my academic journey, I strive to become an adaptive individual with critical thinking skills and the ability to contribute positively to both the academic environment and society.

Ade Kurnia Ramzani was born in Aek Paing on August 12, 2006. The author completed his elementary education at SD Swasta TPI, junior high school at MTS Negeri 2 Bilah Barat, and senior high school at SMA Negeri 1 Rantau Utara. On September 17, 2024, the author was accepted as a student at Labuhanbatu University, Faculty of Science and Technology, Information Technology Study Program. During his education, the author had an interest in the field of Programmer which later became the basis for compiling a Journal entitled Smart home with electrical current monitoring based on Internet of things.

Rahmadani Pane. The author was born in Marindal on May 10, 1986. He earned a Bachelor's degree in Computer Education from STMIK Potensi Utama in 2008, and then continued his studies in the Master of Computer program at Universitas Putra Indonesia YPTK Padang in 2011. He is currently serving as the Head of the Information Technology Study Program, Faculty of Science and Technology, Universitas Labuhanbatu, Labuhanbatu, Indonesia. His research interests focus on Databases, Web Programming, Internet of Things (IoT), Decision Support Systems, and Artificial Intelligence. He can be contacted via email at: rahmadanipane@gmail.com

Curtain Control System based on Light Intensity

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ABSTRACT
This project fulfils the growing need for smart home systems that optimize energy efficiency and user comfort through the creation of an ambient light intensity-based curtain control system. Manual control of the curtain is typically inconvenient and fails to take maximum advantage of natural light, and therefore there is a likelihood of using more artificial light or discomfort due to excessive glare. The primary problem this system is meant to solve is wastage of natural light in indoor rooms. Our solution is to utilize a Light Dependent Resistor (LDR) sensor to measure light intensity, an ESP32 microcontroller to match the reading against saved values in the form of thresholds, and a servo motor for curtain movement. Preliminary findings show the capability of the system in sensing light variation precisely and automatically adjusting curtain positions, hence optimizing indoor lighting and temperature. The system contributes significantly to power saving through the reduction of the use of artificial light and the provision of passive heating control, offering a convenient and self-controlled approach to smart homes.

Keywords: Curtain Control System, Natural Light Management, IoT, Environmental Control.

1. Product Description
The Curtain Control System Based on Light Intensity is an intelligent home automation solution designed to optimize indoor lighting conditions and improve energy efficiency through automatic curtain control. The system utilizes an LDR sensor to continuously monitor ambient light intensity and an ESP32 microcontroller to process sensor data and make real-time decisions. Based on predefined light thresholds, a servo motor is activated to open or close the curtains automatically, reducing the need for manual intervention. The system also supports manual control through push buttons and remote operation via the Blynk IoT platform, allowing users to monitor and control curtain positions using a smartphone. An LCD display provides real-time feedback on light conditions, system mode, and curtain status, making the system user-friendly and practical for smart home environments.

2. System Architecture and Design
Figure 1 illustrates the block diagram of the system, detailing the interaction between input sensors, the ESP32 processing unit, and output actuators. The logical flow of the motor during opening and closing of the curtain, is mapped out in **Figure 2**. The physical hardware assembly is shown in the system prototype in **Figure 3**, while the real-time cloud-based logging of curtain status ("Open" or "Closed") can be seen in the website output displayed in **Figure 4**

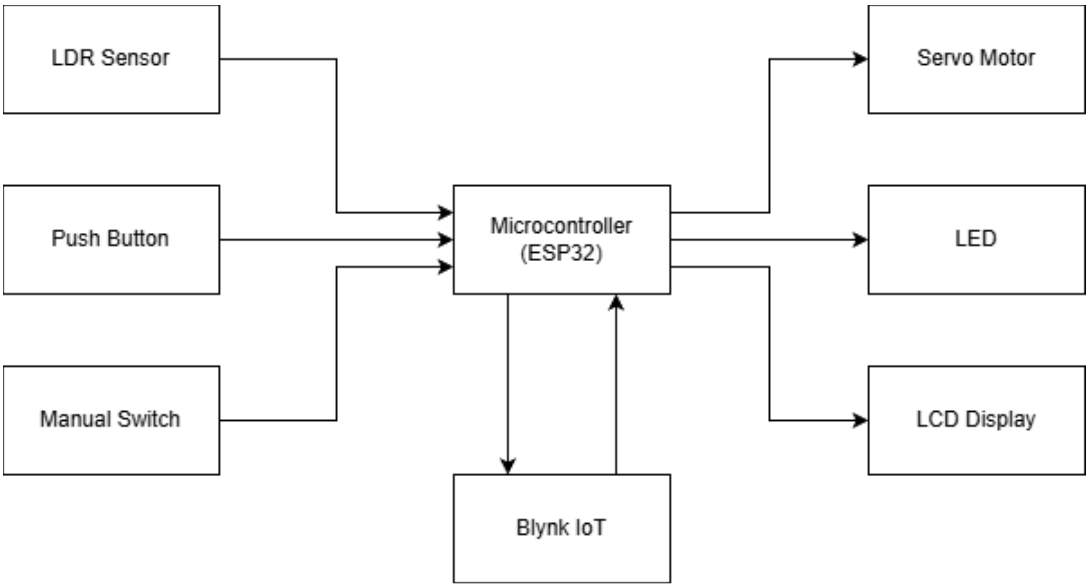

Figure 1. Block Diagram of the System.

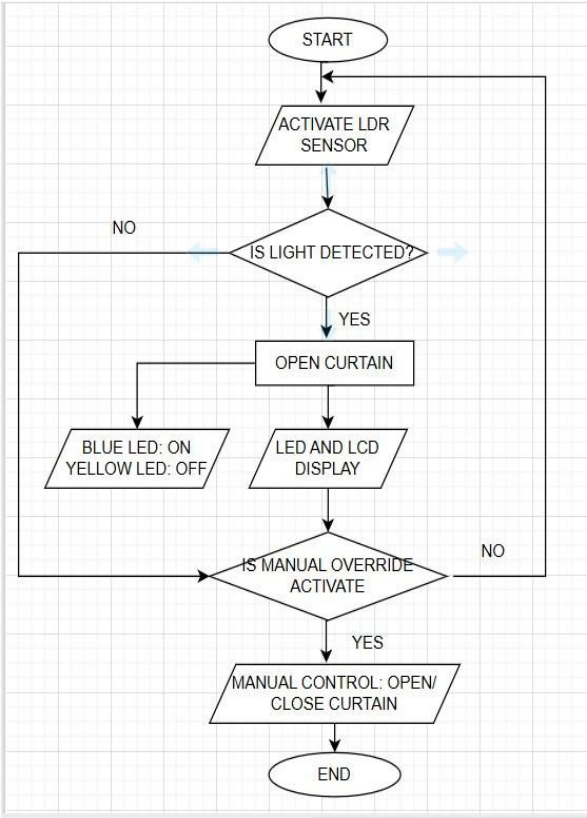

Figure 2. System Flow Chart.

Figure 3. System Prototype.

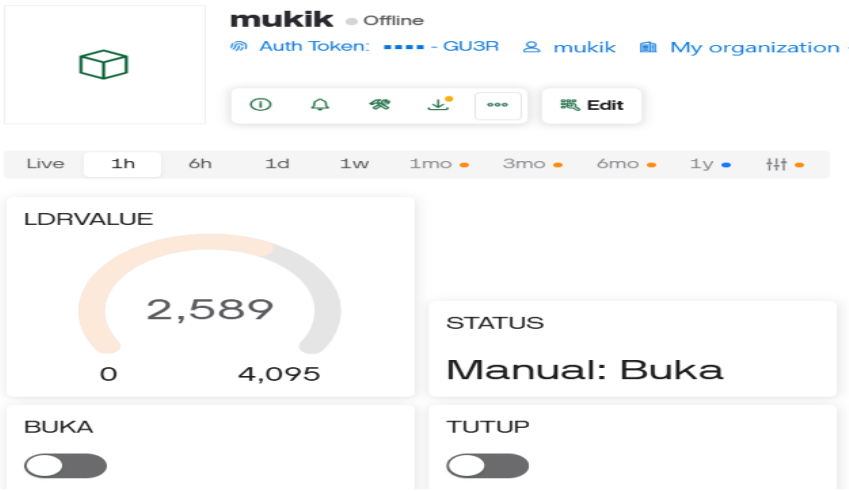

Figure 4. Website Output.

3. Novelty and uniqueness

The uniqueness of this project lies in its real-time, sensor-driven approach to curtain automation combined with IoT-based remote accessibility. Unlike conventional curtain systems that rely on fixed timers or manual operation, this system dynamically responds to actual ambient light conditions, enabling more precise daylight management. The integration of automatic mode, manual override, and remote control within a single platform enhances flexibility and usability. Furthermore, the use of ESP32 with built-in Wi-Fi and the Blynk IoT platform provides a low-cost yet scalable solution that can be easily expanded or integrated into broader smart home ecosystems, distinguishing it from traditional standalone automation systems.

4. Benefit to mankind

This innovation contributes significantly to improving daily living comfort while promoting sustainable energy usage. By maximizing the use of natural daylight and minimizing unnecessary reliance on artificial lighting, the system helps reduce electricity consumption and associated costs. It also enhances indoor comfort by preventing excessive glare and heat during high sunlight intensity and improving lighting conditions during low-light periods. The system is particularly beneficial for residential homes, offices, and educational buildings, where consistent light management is crucial. Additionally, automated curtain control reduces physical effort for users, making it especially helpful for elderly individuals or users with mobility limitations.

5. Innovation and Entrepreneurial Impact

From an innovative perspective, the project demonstrates the practical application of IoT, embedded systems, and environmental sensing in addressing real-world energy efficiency challenges. It shows how simple sensors and microcontrollers can be transformed into intelligent decision-making systems for smart living environments. Entrepreneurially, this system has strong potential as an affordable smart home product that can be adapted for various building types. Its modular design allows future enhancements such as temperature-based control, adaptive algorithms, voice assistant integration, or machine-learning-driven user preference analysis. This makes the project suitable as a foundation for startup development or commercialization in the growing smart home and green technology markets.

6. Potential commercialization

The Curtain Control System Based on Light Intensity has promising commercialization potential due to the increasing demand for smart, energy-efficient home solutions. The system is developed using cost-effective and widely available components, enabling economical mass production. It can be marketed as a standalone smart curtain controller or integrated into existing smart home systems. Potential customers include homeowners, property developers, office buildings, hotels, and smart building solution providers. With improvements in industrial design, mobile application interface, and regulatory compliance, the system can be positioned as a commercial IoT-based curtain automation product that supports sustainable living and smart energy management.

7. Acknowledgment

I would like to express my deepest gratitude to all the individuals who supported me to made this project, "Curtain Control System Based on Light Intensity," a success. First and foremost, I am incredibly thankful to my supervisor for her advice, comments, and support during this research. I am also greatly indebted to my family and friends for their motivation and understanding along the way. Finally, I would also like to thank the peers and the faculty members for their feedback and the congenial atmosphere offered towards this endeavour.

8. Researchers' Biography

Danish Zahirul Iqbal Bin Zainalabidin is a final-year student of the Diploma in Electrical Engineering (Electronic) at UiTM. He has excelled in numerous subjects, including Microprocessor Systems, Electronics, and Digital Systems. He plans to pursue his engineering degree in 2026.

Dr. Fadila Mohd. Atan is a senior lecturer at Universiti Teknologi MARA (UiTM) Pasir Gudang specializing in optical and photonic systems. She receives her PhD from Universiti Teknologi Malaysia (UTM) in electrical engineering and since then has been actively working in her field. Her work primarily explores dynamics bandwidth allocation, network layer security, and integration of innovative approaches in engineering education.

Nur Asfahani Ismail has been serving as a lecturer at UiTM Pasir Gudang since 2014. She obtained her PhD in Optical Fibre Communication from Universiti Teknologi Malaysia (UTM) in 2025. Over the years, she has guided numerous students in their final year projects and earned recognition from the university for her contributions. Her research interests focus on IoT-based systems and machine learning.

Dr. Nor Affida M. Zin is a Senior Lecturer at UiTM Pasir Gudang Campus. She holds a Ph.D in Advanced Optical Networking, focusing on deterministic and time-sensitive services in Passive Optical Network. She has authored numerous high-impact journal articles and conference papers on PON technology. She is actively collaborating with academia and industry to enhance PON frameworks and developments in Malaysia.

Automated Smart Office For Energy Optimization For Modern Workspace

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ABSTRACT

In today's modern office settings, electrical appliances are often left on when not in use which may lead to unnecessary energy consumption and make the electricity bill higher. The growth of smart technologies and the Internet of Things (IoT) enables automated systems that can optimize energy usage in real time. This project aims to develop a system that controls electrical appliances based on occupancy detection, light intensity, and temperature. The system is driven by an ESP32 microcontroller and integrates multiple sensors, including an ultrasonic sensor for parking occupancy detection, an LDR for ambient light measurement, a DHT11 temperature sensor, and an ACS712 current sensor for monitoring electrical usage. Based on the collected data, the system automatically controls lighting and ventilation to improve energy efficiency. An LCD provides real-time system status, while a mobile application allows remote monitoring and manual override. The ultrasonic sensor also functions as a master switch to turn off appliances when the parking area is empty. Overall, the system reduces energy wastage, minimizes human error, and enhances user convenience, making it suitable for modern office environments.

Keywords: Smart Office Automation, Internet Of Things (IoT), Energy Effieciency, Occupancy Detection, ESP32 Microcontroller

1. Product Description

The Automated Smart Office For Energy Optimization For Modern Workspace is a smart office automation system designed to reduce energy wastage and enhance comfort and security in modern workplaces. The system is controlled by an ESP32 microcontroller and integrates multiple sensors, including an ultrasonic sensor for occupancy detection, an LDR for measuring light intensity, a DHT11 sensor for temperature monitoring, and an ACS712 current sensor for tracking electrical usage. Using real-time sensor data, the system automatically controls lighting and ventilation so that electrical appliances operate only when required. An LCD provides live system status, while a Blynk-based mobile application allows users to monitor conditions remotely and perform manual overrides. Additionally, sensor data is collected and stored in Google Sheets for performance analysis and visualization. This project demonstrates a low-cost, efficient, and scalable smart office solution that supports energy efficiency, reduces human error, and promotes sustainable office management

2. Methodology And Result

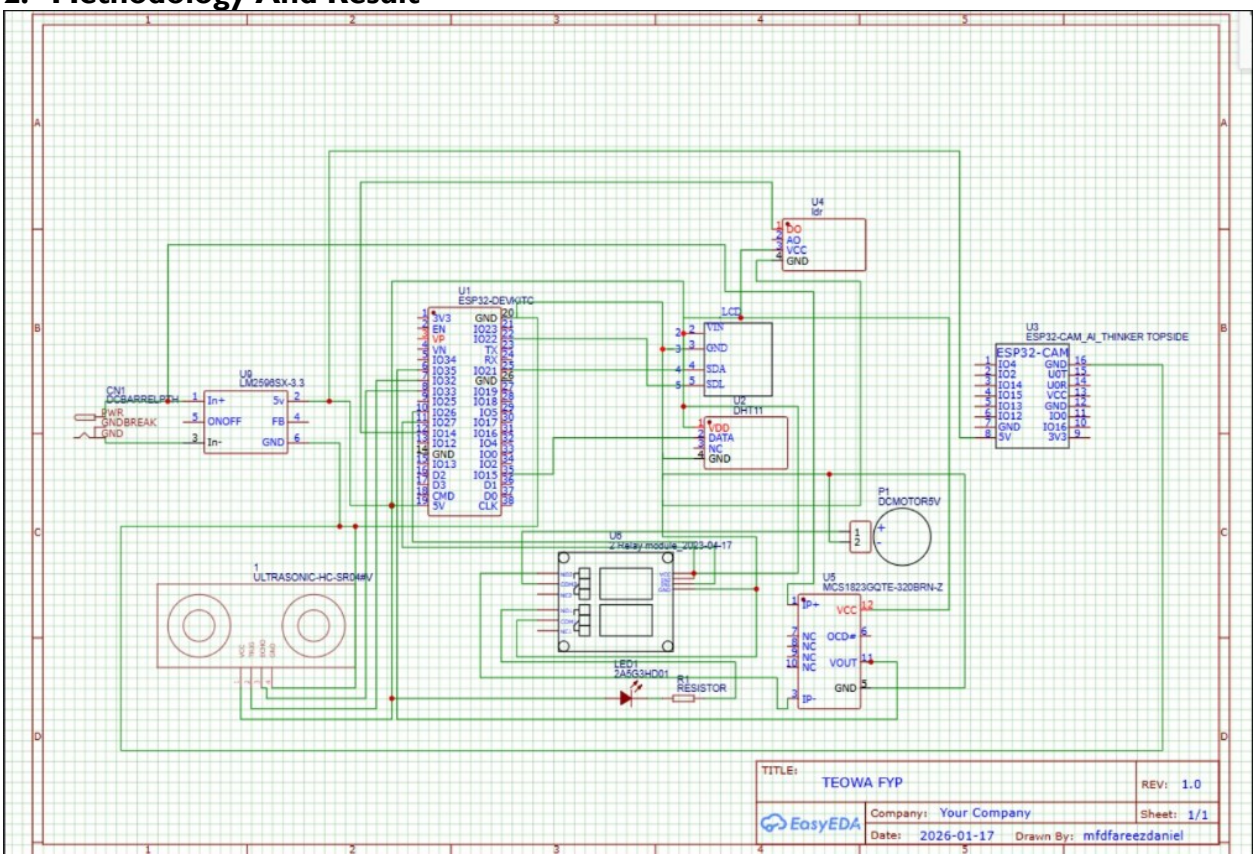

Figure 1. Schematic Diagram Of Automated Smart Office For Energy Optimization For Modern Workspace.

The hardware architecture of the Automated Smart Office For Energy Optimization For Modern Workspace. As illustrated in **Figure 1**, this project is centered around an ESP32-DevKitC microcontroller, which serves as the primary processing unit for all automation logic. Power is managed through an LM2596S- 5 voltage regulator to ensure stable operation of the sensors and modules. The system integrates an HC-SR04 ultrasonic sensor for occupancy detection, a DHT11 for environmental temperature monitoring, and an LDR for ambient light sensing. For energy tracking, an ACS712 current sensor is connected to monitor the electrical load of appliances. Control is executed via a 2-channel relay module, which acts as the physical interface to toggle lighting and ventilation systems. Additionally, the schematic includes an ESP32-CAM for security surveillance and an I2C LCD for local status display, creating a comprehensive IoT-based management system. The operational logic of the Automated Smart Office is structured into a continuous loop that prioritizes energy conservation through intelligent presence detection. As illustrated in **Figure 2**, the process begins by initializing the ESP32, sensors, and communication modules before immediately reading the ultrasonic sensor to determine room occupancy. If no occupancy is detected, the system automatically deactivates lighting and ventilation, updating the status to "Park empty" on both the local LCD and the Blynk application. Conversely, when presence is detected or an override is triggered, the system reads environmental data from the DHT11, LDR, and ACS712 sensors to execute automated control or allow for manual

intervention via the mobile app. The cycle concludes by streaming live video from the ESP32-CAM and refreshing all monitoring interfaces, ensuring seamless remote management and real-time system feedback.

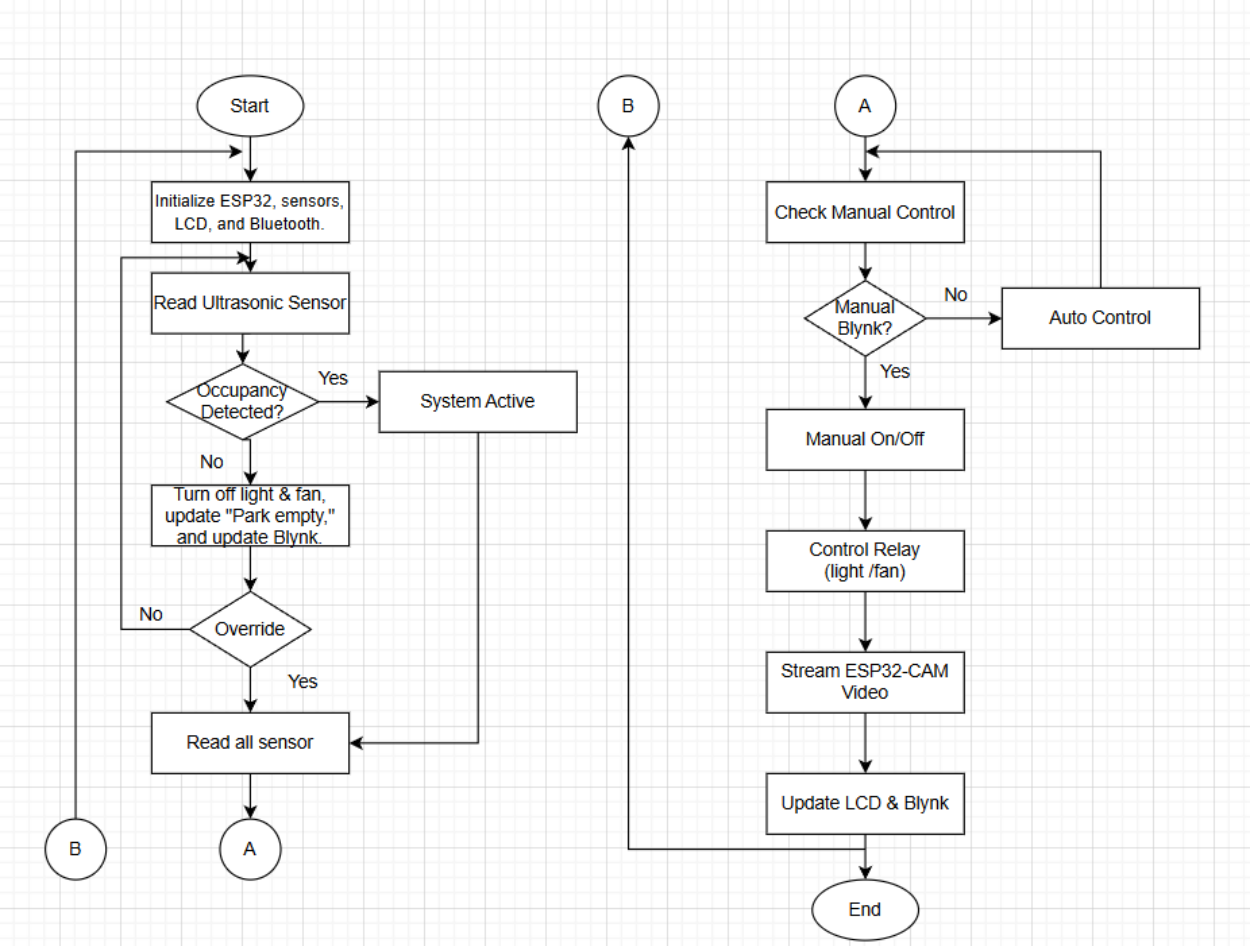

Figure 2. Flow Chart of Automated Smart Office For Energy Optimization For Modern Workspace.

3. Novelty and uniqueness

The novelty of Automated Smart Office For Energy Optimization For Modern Workspace lies in the integration of occupancy-based control, environmental sensing, and remote monitoring into a single, low-cost smart office system. Unlike conventional automation systems that rely on manual operation or fixed schedules, this system uses an ultrasonic sensor as a master switch to automatically disable electrical appliances when no occupancy is detected, effectively reducing unnecessary energy consumption. The combination of light intensity, temperature, and current sensing allows the system to make intelligent decisions based on real-time conditions rather than preset values. In addition, the use of Blynk and Google Sheets enables real-time monitoring, data logging, and visualization without the need for complex servers or paid platforms. The inclusion of an ESP32-CAM for security monitoring further enhances the system by providing visual surveillance alongside automation features. This compact and modular design makes the system scalable, easy to implement, and suitable for real-world office environments, distinguishing it from basic smart control systems.

4. Benefit to mankind

This project directly addresses the global challenge of energy conservation by reducing unnecessary electricity consumption in commercial spaces. By automating lighting and ventilation based on real-time occupancy and environmental data, it minimizes the carbon footprint of modern offices. Beyond environmental impact, the system enhances user safety through integrated ESP32-CAM surveillance and improves workplace comfort by maintaining optimal temperature and lighting levels automatically. For organizations, the low-cost nature of the ESP32 and the use of free platforms like Blynk and Google Sheets make advanced energy management accessible even to small businesses and institutions with limited budgets. Ultimately, this innovation promotes a culture of sustainability and resource efficiency, contributing to a greener and more technologically integrated society.

5. Innovation and Entrepreneurial Impact

The "Automated Smart Office" promotes innovation by demonstrating how sophisticated automation can be achieved through affordable, open-source hardware and software. It encourages a shift from reactive to proactive energy management within the institution, providing a scalable model for other departments to follow. From an entrepreneurial perspective, the project highlights a gap in the market for budget-friendly, modular IoT solutions that combine security with energy optimization. By utilizing data logging for performance analysis, it empowers managers to make data-driven decisions regarding utility expenses. This project fosters an entrepreneurial mindset among students and researchers by bridging the gap between theoretical electrical engineering principles and a viable, market-ready product that addresses real-world economic and environmental pain points.

6. Potential commercialization

The system has high commercial potential due to its modular design, which allows for easy installation in both new and existing office layouts. Target markets include SMEs (Small and Medium Enterprises), educational institutions, and co-working spaces looking to reduce operational costs. Unlike high-end, proprietary building management systems, this solution offers a low-cost entry point using mass-produced components like the ESP32 and ACS712 sensors. Revenue can be generated through the sale of hardware kits, customized installation services, or a subscription-based model for advanced data analytics and energy-saving reports derived from Google Sheets data. Furthermore, the integration of security features via the ESP32-CAM adds a value proposition that standard energy-saving devices lack, making it a competitive "all-in-one" workplace solution.

7. Acknowledgment

I would like to express the deepest gratitude my supervisor, Norbaiti Binti Sidik , for her invaluable guidance, technical expertise, and continuous support throughout the development of the Automated Smart Office For Energy Optimization For Modern Workspace. Special appreciation is given for the support received during the hardware integration and testing of the ESP32 microcontroller and sensor systems. This project was made possible through the availability of the necessary infrastructure to conduct in Internet of Things (IoT) applications and energy-efficient automation. This work was made possible through the collective support of those dedicated to advancing sustainable engineering solutions.

8. Researchers' Biography

Muhammad Fareez Daniel Bin Hairullizam is a final-year student from the Centre for Electrical Engineering Studies at Universiti Teknologi MARA (UiTM), Johor Branch, Pasir Gudang Campus. His research focuses on the intersection of Internet of Things (IoT) and energy sustainability. He has successfully developed an Automated Smart Office system that integrates ESP32 microcontrollers with multi-sensor arrays to optimize power consumption in modern workspaces. His technical expertise includes microcontroller programming, real-time data logging via Google Sheets, and mobile application integration through Blynk. He is committed to creating low-cost, scalable automation solutions that reduce energy wastage and promote sustainable office management.

Mrs Norbaiti Binti Sidik received her first formal education at government primary school, Sekolah Kebangsaan Batu Lima in Sik Kedah. The second foundation, her academic journey was laid at Arabic high school established as Maktab Mahmud Alor Setar, Kedah Darul Aman. Her studies continued at Universiti Kebangsaan Malaysia in Bandar Baru Bangi Selangor right after completed 1 year Science Matriculation Certificate at Science Matriculation Centre, Ipoh Perak Darul Ridzuan. She graduated her Bachelor Engineering Degree in Electrical, Electronics and System within 3 years from Universiti Kebangsaan Malaysia, Bandar Baru Bangi Selangor Darul Ehsan and she further developed her academic and professional skills by obtaining Master Engineering Degree in Communication and Computer also from the same university in 2002. She is very committed, passionate and dedicated in education line who is now a senior lecturer and having experienced more than 15 years in teaching & learning and lecturing at Electrical Engineering Studies, Universiti Teknologi MARA, Johor Branch, Pasir Gudang Campus, Johor Darul Takzim.

Nur Iqtiyani Ilham is a Lecturer at the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM) Johor Branch, Pasir Gudang Campus, Malaysia. She obtained her PhD in Electrical Engineering from UiTM, along with a Master of Engineering from the University of Malaya in 2014 and dual Bachelor of Electrical Engineering (Hons.) degrees from Universiti Kebangsaan Malaysia and the University of Duisburg-Essen, Germany, in 2008. Her research interests focus on renewable energy policy, battery energy storage systems, distributed energy resources, smart grids, energy economics, net-zero emissions, and multi-criteria decision-making techniques. She has extensive academic and industry experience, has supervised more than 30 undergraduate final-year projects, published widely in journals and book chapters, and actively serves as a reviewer and jury member for research and innovation activities at national and international levels.

Keli.io: Water Quality Monitoring System for Small-Scale Catfish Farming

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ABSTRACT

Keli.io is a portable IoT-based water quality monitoring system developed to support small-scale and community-based catfish farming. Traditional aquaculture practices often rely on manual and infrequent water testing, which is unable to detect sudden or gradual changes in water conditions that may lead to fish stress, slow growth, or unexpected mortality, particularly during the early juvenile stage. To address this limitation, Keli.io integrates multiple water quality sensors with an ESP32 microcontroller to continuously monitor key parameters including pH, total dissolved solids (TDS), temperature, and oxidation-reduction potential (ORP). Real-time sensor readings are displayed locally through an OLED screen, while all data are logged with timestamps for long-term trend analysis and decision support. The system implements threshold-based alert notifications to provide early warnings when abnormal water conditions or low battery levels are detected, enabling timely intervention. Designed as a low-cost and portable device, Keli.io can be easily deployed across multiple ponds for both water preparation and routine monitoring. The proposed system offers a practical and data-driven solution to improve pond management efficiency and promote sustainable catfish farming practices.

Keywords: Internet of Things (IoT), Water Quality Monitoring, Aquaculture Technology

1. Product Description

Small-scale catfish farming commonly relies on manual and periodic water quality checks, which are often insufficient to detect rapid or subtle changes in pond conditions. In practice, farmers frequently experience unexplained fish stress or mortality, particularly during the early growth stage of juvenile catfish, due to undetected fluctuations in critical parameters such as pH, dissolved solids, and water temperature. The lack of affordable, portable, and continuous monitoring tools limits timely intervention and forces farmers to depend on assumptions rather than data-driven decisions. Existing monitoring solutions are either costly, fixed in location, or require constant internet connectivity, making them impractical for small-scale and community-based aquaculture operations. These challenges highlight the need for a low-cost, portable, and intelligent water quality monitoring system capable of providing real-time information, historical data logging, and actionable alerts to support effective water management and improve catfish farming sustainability. The Keli.io system integrates water quality sensors with an ESP32 microcontroller, an OLED display, SD card storage, and a web-based dashboard to support real-time and long-term water quality monitoring for small-scale catfish farming. Its portable design allows flexible

deployment across multiple ponds, while data logging enables informed decision-making based on historical trends.

4. Methodology

Figure 1 illustrates the system architecture of the developed Keli.io device. The ESP32 microcontroller serves as the main processing unit, receiving input from pH, TDS, and water temperature sensors. Real-time sensor readings are displayed locally on an OLED screen for immediate reference. All collected data are stored on an SD card and uploaded to cloud storage twice daily for record-keeping and further analysis. The system also includes alert notification features, such as warnings for excessively high pH levels and low battery conditions when the power level drops below 20%. **Figure 2** presents the flowchart of the overall system operation. Sensor data are continuously acquired and processed by the ESP32 microcontroller to evaluate water quality status. The system determines whether the water conditions are suitable for catfish farming or if further water treatment is required. Water quality monitoring is particularly critical during the early growth stage of juvenile catfish, while mature catfish require less frequent monitoring. Therefore, Keli.io is designed as a portable device, enabling flexible use for both water preparation and routine monitoring applications. **Figure 3** illustrates the development and validation stages of the Keli.io system. **Figure 3(a)** shows the 3D design of the hardware casing created using Tinkercad software, while **Figure 3(b)** presents the fully assembled Keli.io device enclosed in the 3D-printed casing. **Figure 3(c)** demonstrates on-site testing of the developed hardware at the community catfish pond (Kebun Komuniti), confirming its portability and practical deployment. **Figure 3(d)** displays the recorded water quality data visualized through the web-based application, highlighting real-time monitoring and data logging capabilities of the system. The Keli.io device stores water quality data locally in its internal memory twice daily when internet connectivity is unavailable, capturing key parameters such as pH, temperature, and TDS. Once internet access is restored, the stored data are automatically uploaded to cloud storage to clear memory space and enable centralized analysis. By combining consistent sensor data with manually recorded farming information, such as the number of juvenile catfish stocked and subsequent mortality counts, the plotted results allow farmers to identify water quality trends linked to fish health, supporting better farm record-keeping, future planning, and loss prevention.

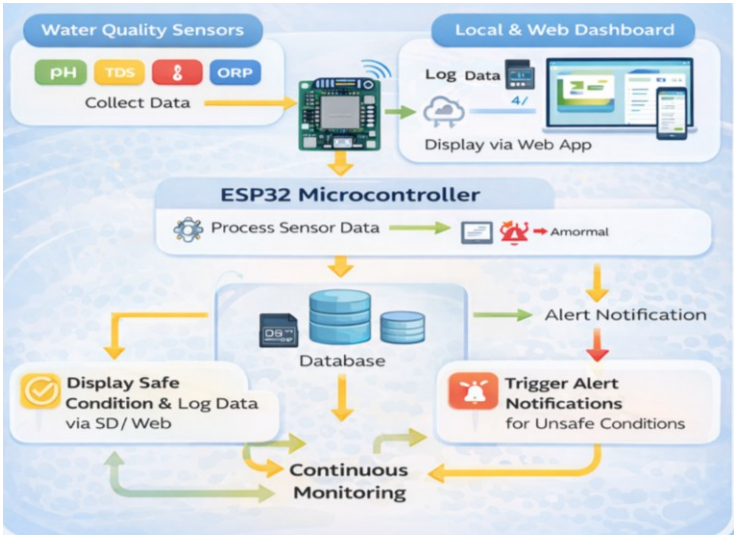


Figure 1. Keli.io system architecture diagram.

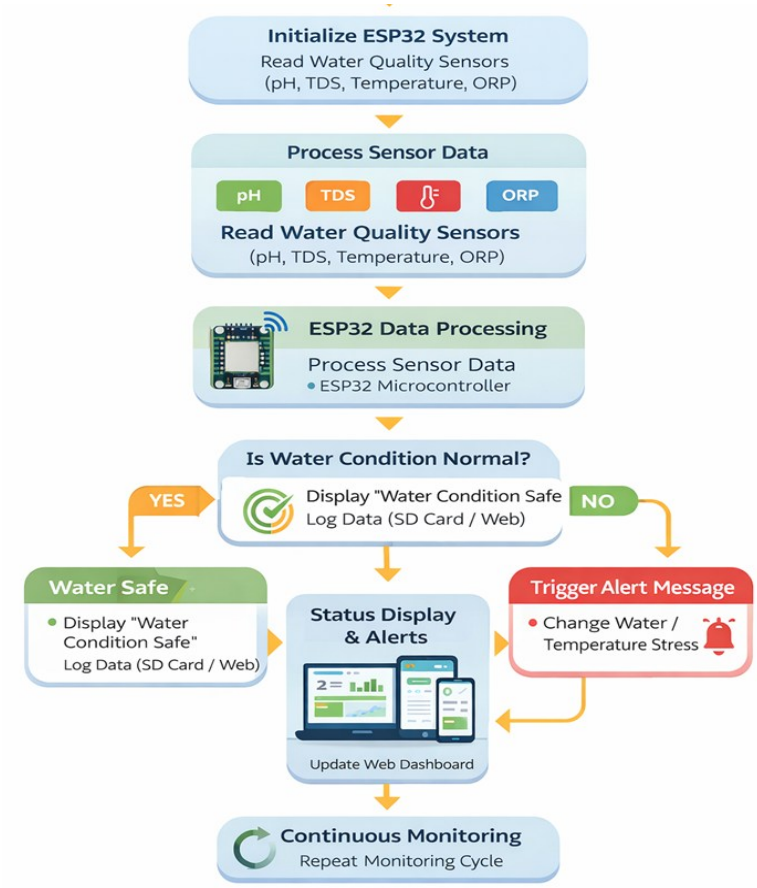
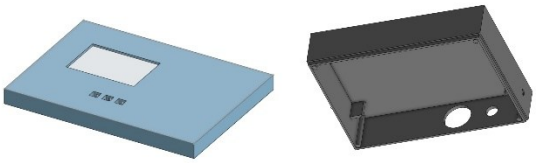
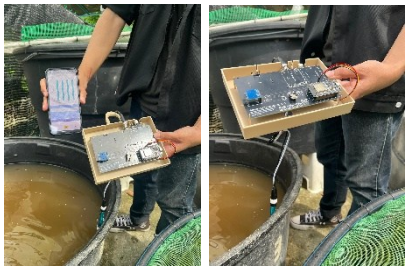


Figure 2. Keli.io system operation flow chart.

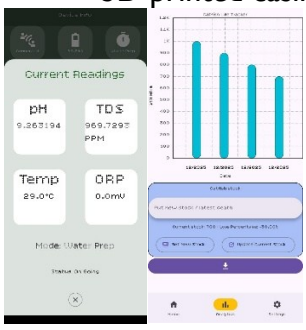


(e) 3D design of Hardware casing using Thinker CAD Software

(f) The actual developed hardware with 3D printed casing



(g) The testing of developed hardware on site (Kebun Komuniti)



(h) The plot of data output saved in web apps

Figure 3. Keli.io system hardware testing and output display.

5. Novelty and uniqueness

The novelty of Keli.io lies in its portable, standalone IoT-based water quality monitoring approach specifically designed for small-scale and community-based catfish farming. Unlike conventional aquaculture monitoring systems that rely on fixed installations, laboratory testing, or continuous internet connectivity, Keli.io operates as a self-contained device with local display, onboard data logging, and optional web-based visualization. Another key uniqueness is the inclusion of time-stamped SD card data storage, allowing long-term trend analysis without reliance on cloud infrastructure. The portable design allows the device to be shared across multiple ponds, significantly reducing deployment cost. By emphasizing affordability, modularity, and ease of use, Keli.io offers a practical innovation tailored to real operational constraints faced by community aquaculture farmers.

6. Benefit to mankind

Keli.io provides significant benefits to small-scale aquaculture communities by improving water quality awareness and reducing unexplained fish mortality. Continuous monitoring enables early detection of unsafe water conditions, allowing timely intervention before stress or mass fish deaths occur. This directly supports food security, income stability, and sustainable livelihoods among community-based farmers.The system's affordable and portable design lowers the barrier to technology adoption, making smart aquaculture tools accessible to resource-limited users. By promoting data-driven decision-making, Keli.io helps farmers better understand environmental trends affecting fish health. In the long term, improved pond management contributes to reduced environmental impact, more efficient resource use, and enhanced resilience of local food production systems.

7. Innovation and Entrepreneurial Impact

Keli.io promotes innovation by transforming IoT sensing technologies into a practical, low-cost solution aligned with real community needs. The project demonstrates how academic research and student-led development can generate functional prototypes with clear societal and commercial value. The modular hardware and software architecture encourages further enhancement, customization, and local innovation.From an entrepreneurial perspective, Keli.io has potential to support small-scale manufacturing, system assembly services, user training, and maintenance support within local communities. The system can be adapted for various aquaculture settings, opening opportunities for spin-off products and service-based business models. Through hands-on development and real-world deployment, the project nurtures an innovative-driven and entrepreneurial culture within educational institutions and the agrotechnology sector.

8. Potential commercialization

Keli.io has strong potential for commercialization as an affordable water quality monitoring solution for small-scale aquaculture operators, cooperatives, and community farming projects. The system can be commercialized as a standalone device or offered as part of a bundled service including installation, calibration, data analysis, and technical training. Its modular design allows future upgrades such as wireless alerts, mobile applications, or predictive analytics, increasing product scalability and market appeal. Potential commercialization pathways include partnerships with local aquaculture suppliers, agricultural technology distributors, and government-supported

smart farming initiatives. With increasing demand for sustainable and smart aquaculture solutions, Keli.io addresses a clear market gap for low-cost, portable, and user-friendly monitoring systems.

9. Acknowledgment

The authors would like to acknowledge faculty of Electrical engineering, Universiti Teknologi MARA (UiTM), Johor Branch, Pasir Gudang Campus for technical support and facilities provided throughout the development of this project. Appreciation is also extended to community aquaculture partners at 'Kebun Komuniti Wanita Taman Mawar Fasa 5' for their cooperation and valuable feedback during system testing and validation.

10. Researchers' Biography

Noor Hafizah Khairul Anuar received her Ph.D. in Electrical Engineering from Universiti Teknologi Malaysia (UTM) in 2025, with a research focus on sensor development, instrumentation, and deep learning. She obtained her M.Sc. in Electrical Telecommunication Engineering and Information Technology from Universiti Teknologi MARA (UiTM) in 2012, and her B.Eng. in Electrical Telecommunication Engineering from Universiti Teknologi Malaysia (UTM) in 2008. She is currently serving as a lecturer at the Faculty of Electrical Engineering, Universiti Teknologi MARA (UiTM), Johor Branch.

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Herbal Air Relief: A Natural Solution for Sinusitis and Respiratory Comfort

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ABSTRACT

Herbal Air Relief is a natural nasal inhaler designed to provide immediate relief for individuals suffering from sinusitis and respiratory discomfort. Developed in response to the high prevalence of sinus problems in Malaysia, which affects approximately 12.8% of the population, this innovation utilizes a pure herbal formulation. The product is uniquely crafted from a blend of five essential oils, which include eucalyptus, rosemary, peppermint, lavender, and tea tree, combined with menthol crystals and coconut oil. Unlike synthetic medications that may cause side effects, Herbal Air Relief offers a safe, chemical-free alternative that is portable and easy to use for students, office workers, and travelers. By providing a fast-acting solution for nasal congestion and facial pressure, the product improves daily productivity and sleep quality. The business model demonstrates strong commercialization potential through both online platforms and partnerships with established pharmacy chains and local gift shops.

Keywords: Sinusitis, Essential Oils, Natural Remedy, Nasal Inhaler, Agropreneurship

1. Product Description

Sinusitis is a widespread health issue in Malaysia. Most infected individuals experience daily challenges, including nasal congestion, facial pressure, headaches, difficulty breathing, and discomfort. Therefore, Herbal Air Relief takes the opportunity to address sinus issues by providing a natural inhaler formulated with pure essential oils, coconut oil, and a bit of menthol crystals, which support easier breathing and provide immediate relief. Herbal Relief is a lightweight, portable nasal aspirator formulated with 100% natural ingredients. The core formulation features eucalyptus and peppermint for their potent decongestant properties, rosemary to reduce inflammation, tea tree to inhibit bacterial growth, and lavender for a soothing aromatic balance. Menthol crystals are added to enhance the cooling sensation, and coconut oil helps the aroma last longer while stabilizing the mixture. The product is housed in a simple, twist-cap tube designed for convenience, making it suitable for users aged 12 and above. Each unit is manually assembled to ensure strict quality control and consistency.

Production process of herbal air relief and packaging for the market

Raw Materials: Essential Oils (Eucalyptus, Peppermint, Lavender, Rosemary and Tea Tree), Coconut oil and Menthol Crystal.

Menthol Crystal are measured and placed in a beaker.

All essential oils used are dropped into the mixture according to their measurements.

Coconut oil is measured and placed in a beaker.

After mixing well, insert the cotton until it absorbs well, and insert it into the tube.

Figure 1. The flowchart of the production process of Herbal Air.

Stick the sticker, cover it with shrink wrap, and use a hot air.

The final product Herbal Air

Figure 2. Continue the flowchart of the production process of Herbal Air.

2. Novelty and uniqueness

The primary novelty of Herbal Air Relief lies in its specific, research-based dilution ratio, which combines five distinct essential oils to target the symptoms of sinusitis, congestion, inflammation, and pressure without synthetic additives. Additionally, its integration into the social enterprise company DumoWongi as part of an agropreneurship platform for the internship program in Sabah underscores the use of natural, locally accessible expertise to develop a professional-grade wellness product. While many market alternatives rely on camphor or synthetic menthol, this product uses pure menthol crystals derived from *Mentha arvensis*. The product is made from natural herbal essential oils, produced from eucalyptus and peppermint crops, organically grown by the local farmers at DumoWongi.

3. Benefit to mankind

This innovation provides a significant health benefit by offering a non-medicated, non-drowsy solution for chronic sinus sufferers. By naturally alleviating symptoms like headaches and difficulty breathing, it helps users maintain focus and productivity in air-conditioned or cold environments. It empowers individuals to manage their respiratory health safely and confidently,

reducing the long-term reliance on chemical-based sprays that may have adverse effects. Besides that, this product can be an alternative for the patient to choose. It increases awareness and encourages customers to support a local product that is safe to use, as its main ingredient comes from a plant-based source and contains no synthetic materials.

4. Innovation and Entrepreneurial Impact

Herbal Air Relief contributes to the agropreneurship culture by demonstrating the transition from raw agricultural extracts to high-value consumer health products. The project utilizes a robust business idea to manage operations, from sourcing high-quality raw materials to establishing a multi-channel distribution network. The raw material also comes from local farmers registered with a social enterprise. In addition, it offers job opportunities and serves as a source of side income for the farmer, grower, and intern. This project fosters local economic growth through partnerships with local retailers such as Kadaiku and Big Pharmacy, demonstrating that student-led innovations can meet professional industry standards and consumer demands.

5. Potential commercialization

The product has a clear path to commercial viability with a calculated selling price of **RM 10**, offering a significant margin over the cost per unit of **RM 3.95**. Revenue streams are diversified through direct unit sales, bundle packs for frequent users, and wholesale supply to reputable health and wellness stores like Watsons and Big Pharmacy. The digital presence on TikTok and Instagram, coupled with an official website, ensures a nationwide reach across Malaysia. Growth opportunities driven by the product's lightweight, portable packaging and its natural, locally produced nature, which promote better product quality domestically through e-commerce.

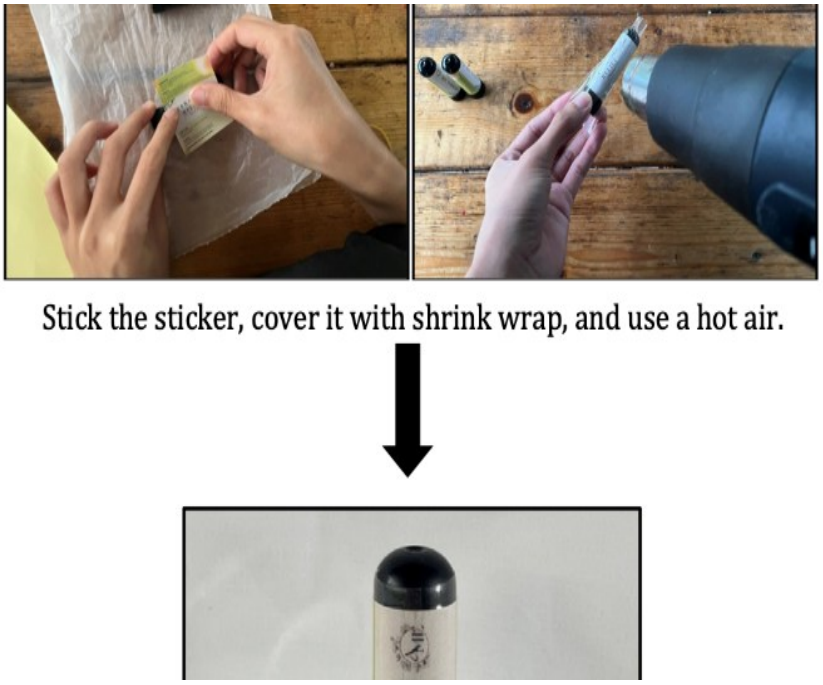

Figure 3. The customer buys the Herbal Air Relief and provides product feedback.

k the sticker, cover it with shrink wrap, and use a hot

The final product Herbal Air

chart of the production process of Herbal Air.

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Figure 4. The Herbal Air Relief product feedback.

6. Acknowledgment

The author wishes to express sincere gratitude to Mrs. Irene Mositol, the founder of DumoWongi, for her invaluable mentorship throughout the 20-week apprenticeship and project completion.

7. Researchers' Biography

Amielia Maisarah Mohd Azizi is a student at the Universiti Teknologi Mara (UiTM) Sabah Branch, studying in Diploma in Agropreneurship (AT113).

Nur Aziemah Jasni is a lecturer and researcher at the Universiti Teknologi MARA (UiTM) Sabah Branch, specializing in plantation management, agribusiness, and agropreneurship. With over 10 years of experience, she has achieved many innovation awards locally and internationally. In addition to her academic role, she is passionate about community engagement and agro-based innovation. She continues to inspire her students and colleagues with her dedication to research and teaching. Her commitment to academic excellence and her contributions to plantation management, agribusiness, and entrepreneurship have earned her recognition within the academic community, and her work continues to inspire the next generation of scholars.

Ts. Dr. Rozlianah Fitri Said is a Senior Lecturer and dedicated researcher at Universiti Teknologi MARA (UiTM), Sabah Branch. With over 20 years of extensive experience, she specializes in the fields of crop protection, agricultural science and technology, plant-microbe interactions, agropreneurship, and student leadership and development. Her dedication to agricultural innovation has earned her numerous local and international awards. Passionate about community engagement, she connects academia with society and collaborates with industry, government, and academia to solve real-world challenges.

Multi-purpose Agricultural UGV

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ABSTRACT
Agriculture faces increasing pressure to boost productivity while minimizing labor and environmental impact. This project presents the design and development of a remote-controlled, multi-purpose unmanned ground vehicle (UGV) aimed at enhancing efficiency in small- to medium-scale agricultural operations. The UGV is engineered to perform a variety of field tasks such as lawn mowing, fertilizing, and watering, all controlled via a wireless interface. Its modular design allows for quick tool interchangeability, while its rugged chassis and electric drive system ensure reliable operation across uneven terrain. From a socio-economic perspective, this product significantly reduces reliance on manual labor, providing a more convenient, safer, and efficient solution for harvesting or planting operations. Commercially, the system bridges the gap between manual tools and expensive autonomous machinery, featuring a scalable design that can be upgraded to a centralized specification with advanced features such as sowing and pesticide spraying.

Keywords: Unmanned Ground Vehicle, Multi-purpose Agricultural Robot, Radio frequency Controlled, Programmable Microcontroller.

1. Product Description
The UGV is engineered to perform a variety of field tasks such as lawn mowing, fertilizing, and watering, all controlled via a wireless interface. Its modular design allows for quick tool interchangeability, while its rugged chassis and electric drive system ensure reliable operation across uneven terrain.

2. System Design and Functionality
The UGV is engineered to perform a variety of field tasks such as lawn mowing, fertilizing, and watering, all controlled via a wireless interface. Its modular design allows for quick tool interchangeability, while its rugged chassis and electric drive system ensure reliable operation across uneven terrain. The complete operational architecture, detailing the interaction between the operator, wireless signals, and the UGV's internal power and task modules, is illustrated in **Figure 1**. To demonstrate the scalability of the design, the differences between the current standard configuration and future advanced capabilities are detailed in **Table 1**. The standard model focuses on essential maintenance, while the advanced concept introduces complex farming tasks.

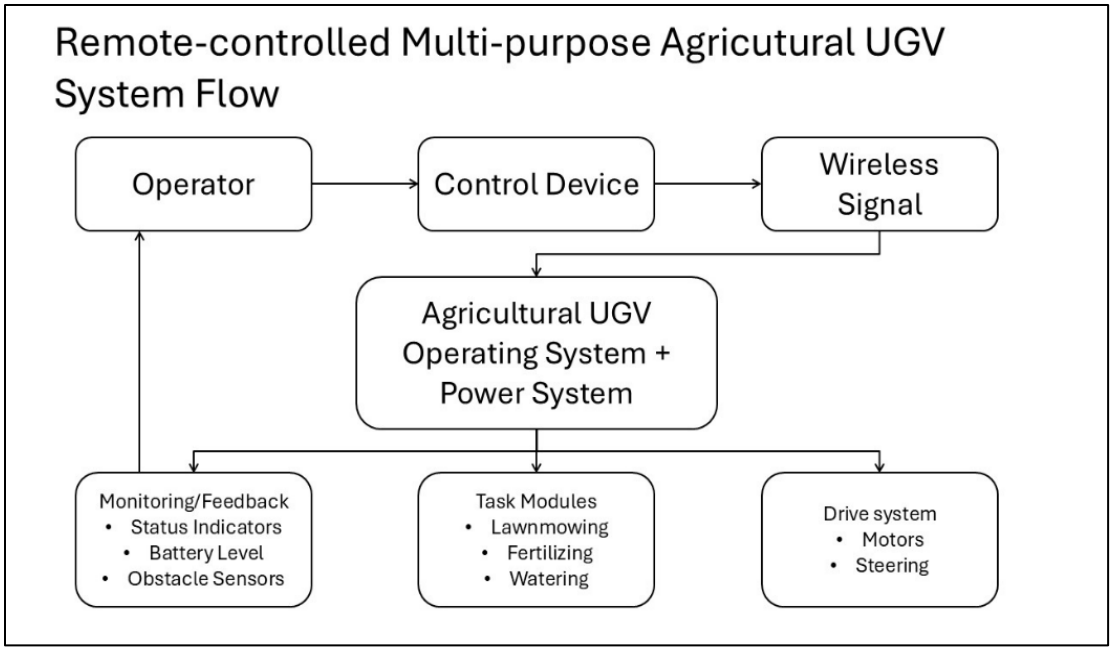


Figure 1. System flow of Remote-controlled Multi-purpose Agricultural UGV.

Table 1. Features of Remote-controlled Multi-purpose Agricultural UGV.

Features	***Standard Model***	***Advanced Model (Concept Prototype)***
Lawn mowing	*Available*	*Available*
Fertilizing	*Available*	*Available*
Watering	*Available*	*Available*
Obstacles Sensing	*Available*	*Available*
All-terrain Capability	*Available*	*Available*
Plowing and Sowing	*Not Available*	*Available*
Pesticide Spraying	*Not Available*	*Available*
Harvesting	*Not Available*	*Available*

3. Novelty and uniqueness

The novelty of our product lies in its **modular and customizable design**, which allows users to select and integrate only the features they need, rather than being limited to a fixed set of functions. The remote-controlled interface further enhances its uniqueness, enabling convenient operation from a distance and minimizing direct human involvement in potentially hazardous or labor-intensive tasks.

4. Benefit to mankind

It can reduce reliance on manual labor and provide more convenient and efficient harvesting or planting operations. By merging versatility, user-centered customization, and ease of operation, our UGV introduces a new level of flexibility and efficiency to small- and medium-scale farming practices.

5. Innovation and Entrepreneurial Impact

Unlike conventional agricultural machines that are typically specialized for a single task, our UGV integrates multiple operations—such as lawn mowing, fertilizing, and watering—into one compact system, reducing the need for separate equipment. This versatility not only enhances cost-effectiveness but also allows farmers to upgrade or customize the vehicle as their needs evolve, for instance by adding advanced modules for sowing, harvesting, or pesticide spraying.

6. Potential commercialization

The commercialization potential of the remote-controlled, multi-purpose agricultural UGV lies in its ability to bridge the gap between traditional manual farming practices and costly, large-scale autonomous machinery. By focusing on small- to medium-scale farms, the product delivers an affordable, scalable solution that can be tailored to the specific needs of farmers. The standard model offers core functions such as lawn mowing, fertilizing, and watering, making it immediately valuable for daily operations. The advanced model expands capabilities with high-value features including plowing, sowing, harvesting, and pesticide spraying. This tiered approach enables farmers to adopt the technology incrementally, reducing upfront investment while ensuring long-term adaptability. Its modular design further creates opportunities for aftermarket sales of tool attachments and software upgrades, establishing a sustainable revenue stream. Commercialization can also be strengthened through partnerships with agricultural cooperatives, government subsidy programs, and collaborations with aggrotech distributors, ensuring broad accessibility.

7. Acknowledgment

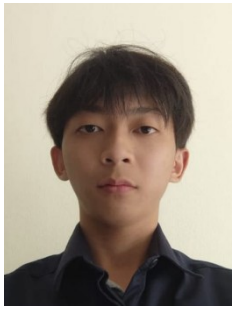
We would like to extend our sincere gratitude to the organizers of I-TIEC for providing the platform and opportunity to participate in this prestigious event. We also would like to express our sincere gratitude to Dr. Teng Howe Cheng and Ms. Nurul Hidayah Binti Hisham for their invaluable guidance and constructive feedback. We would also like to thank VTAR Institute for providing the financial support and resources necessary for this project.

8. Researchers' Biography

Yap Yuan Yong is a DKM student currently pursuing Electronics and Equipments DKM4 at VTAR Institute. He previously had experiences in electrical and solar industry. In April 2025, VTAR Institute had selected him to be part of the exchange program between VTAR Institute and Quzhou College of Technology in Zhejiang, China. He envisions himself to be an impactful leader with strong skills in research, planning, and strategic decision-making to support sustainable development in modern infrastructure for the better future world.

Loh Gang Zheng is a DKM student currently pursuing Electronics and Equipments DKM4 at VTAR Institute. He previously had experiences in diagnostic and maintenance on industrial machines and production lines. In April 2025, VTAR Institute had selected him to be part of the exchange program between VTAR Institute and Quzhou College of Technology in Zhejiang, China. He aims to master strong skills in innovation, planning, and strategic decision-making to support sustainable development in modern tech industry for the future world.

Alvin Wo Xiao Xiang is a SKM student currently pursuing Electronics and Equipments SKM3 at VTAR Institute. From a young age, he had a strong interest in disassembling and repairing various electronics. Under his father's influence, he developed a deep passion for circuit board repair and power systems. Adhering to a craftsman's spirit of striving for excellence, Alvin aims to become an outstanding electronic technician by combining practical experience with theoretical knowledge through systematic professional training.



Liew Shu Yong is a SKM student currently pursuing Electronics and Equipments SKM2 at VTAR Institute. He has a strong interest in electronics industry and is determined to learn the knowledge of electronic components through professional training and put it into practice.

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Load Monitoring System For Home Appliances

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ABSTRACT

This project aims to develop a Load monitoring system for home appliances. The energy consumption used by home appliances is unpredictable and can cause the energy consumption to be very high without realizing it. This situation shows that a Load monitoring system is very necessary to solve this problem. This system is designed to help users be aware of the energy consumption used by home appliances. This system only has one main processing unit, namely the ESP32 microcontroller. Various sensors have been connected to the ESP32 such as the SCT 013 sensor (measures electric current), the DHT11 sensor (detects temperature) and the TTP223 (touch sensor). These sensors will send data to the microcontroller for processing and will be displayed on the output. The sensor readings will be displayed on the I2C LCD and Blynk, while the LED will be activated when the amount of energy used exceeds the set limit. This system is also connected to the Blynk application as an IoT to transfer data to users. The data also will be sent to Google Sheet so the data can be recorded. This system is designed to help and inform users of excessive energy consumption. The overall results of this project show that this system successfully demonstrates its ability to detect electromagnetic radiation and respond automatically as a protective measure but needs many improvements to make it more functional.

Keywords: Load Monitoring System, ESP32 microcontroller, SCT 013 current sensor, DHT11, I2C LCD

1. Product Description

Load Monitoring System for Home Appliances is designed to help people to monitor their home appliances power usage. This system is connected with IoT technology such as Blynk and Google Sheet. Since people nowadays often use their appliances frequently that can lead to electricity bills rising sharply and it wastes money. One of the solutions is by developing a load monitoring system. This system is built with multiple sensors such as SCT 013 current sensor, touch sensor and temperature sensor that connect to one main microcontroller, ESP32. SCT 013 can only measure AC current and must be clamped on live wire. If it was clamped with either earth or neutral wire, it would give nonsense results or zero. All sensors will read data and will be displayed on LCD and it will be sent to IoT applications to record the data. These IoT applications will help users to monitor their daily appliances usage live broadcast. All the data recorded before also can be accessed to help users make analysis or plan their future load usage. This system will trigger a red LED if the power usage exceeds the limit. Formula P = IV is used to measure power. In this system, the voltage sensor did not include and must be set by users itself by using the Blynk application. But users must know how much the appliance's voltage range is.

2. Block Diagram, Flowchart and List of Components

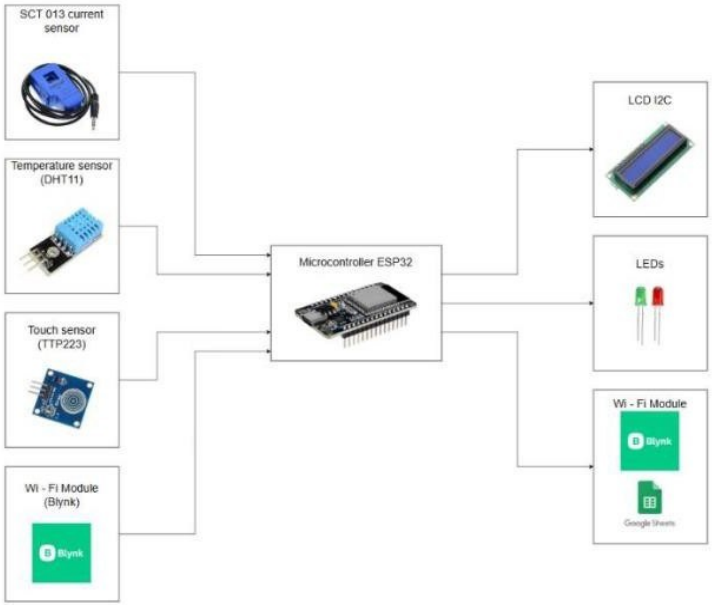

Figure 1. Block diagram of Load Monitoring System.

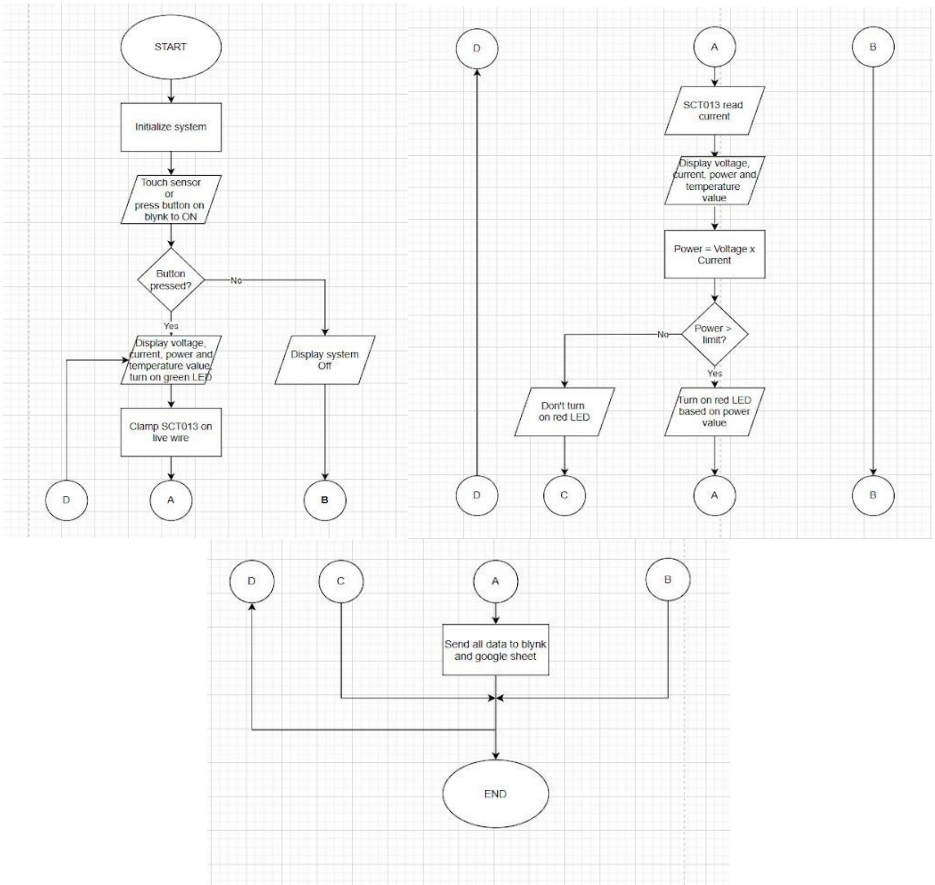

Figure 2. Flowchart of Load Monitoring System.

Figure 1 shows the block diagram of the load monitoring system. The system contains command electronics components such as ESP32, dht22, touch sensor, LCD I2C and LED. Based on the diagram, the dht11 sensor, SCT013, touch sensor and Blynk are assigned as inputs. These components will send data to the microcontroller (ESP32) to be processed and produce the output related to the LCD I2C, LED, Blynk app and Google sheet. The function of the dht11 sensor is to get a temperature reading to determine the surrounding temperature. Next, the touch sensor is used as an On and Off button for the system. The SCT013 is a type of sensor that can only measure AC current. All these components will read the data and will send it to the ESP32 to be processed and then will be displayed at the output. At LCD I2C, the output of temperature, voltage, current and power value will be displayed. Same goes to LEDs where it will light a red LED to give warning to the user if the power usage exceeds the limit and green LED as an indicator of On and Off system. Blynk app is an IoT application that can do two processes which is the On and Off button and voltage adjuster as an input and also display all the information as an output to users by using online devices such mobile phones or laptops. Google sheet also did the same work where it will display all live and recorded data. **Figure 2** shows a flow chart of the Load Monitoring System. The flow chart shows how the system operates from the beginning until the end. The system starts with turning on the system followed by initializing the system. Then, the system will ask the user to touch the touch sensor or push button on Blynk to turn on the system. When the system is On, green LED will turn On and the value of current, power and temperature will be displayed. If the sensor is not touched, display 'system Off' on LCD and do not turn on green LED. Next, all sensor input will be executed to take the relevant reading. For the temperature sensor (DHT11), it will read the temperature of the surrounding area while the SCT013 sensor will detect AC current. Voltage values need to be set manually on Blynk since there are no voltage sensors used. Then, power value will be calculated using the P = IV formula. All the data will be displayed on LCD and will be sent to Blynk and Google sheet to be recorded. When the power usage exceeds the specific limit, the red LED will turn On and vice versa. Overall, the flowchart presents the flow of how the Load Monitoring system works. By integrating inputs and outputs, the system effectively addresses the objective to ensure public safety.

Table 1. List of components.

No	Component	Function
1	Microcontroller ESP32	Control the system by processing inputs and outputs data
2	SCT 013 current sensor	Read AC current
3	TTP223 Touch sensor	Allow the users to turn on and off the system
4	DHT11 Temperature sensor	Monitor surrounding temperature
5	LCD I2C	Display voltage, current, power and temperature data
6	LEDs	Green LED as an indicator whether the system in on or off and Red LED as an indicator to show that the power usage is exceeds limit
7	Wi - fi module Blynk and Google Sheet	Provides remote monitoring and control of the system via the Internet

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3. Novelty and uniqueness

The creation of a real-time electrical load monitoring system that combines temperature sensing, power estimation, current measurement, and Internet of Things-based visualization onto a single ESP32-based platform serves as an example of the project's novelty. This project introduces a user-adjustable voltage parameter via a mobile application to simulate real-world voltage variations, enabling more flexible power analysis, in contrast to current systems that mainly focus on energy monitoring. Furthermore, the system offers dual-mode control via a cloud-based application and a physical touch sensor, improving usability and operational dependability. This system is further distinguished by the integration of local feedback via an I2C LCD and LED indicators for overload conditions, which guarantee continuous monitoring even in the absence of internet connectivity. The proposed system is unique in terms of functionality, accessibility, and suitability for low-cost smart energy management applications because of these combined features.

4. Benefit to mankind

A load monitoring system for home appliances offers various benefits to users. It offers a fairly good amount of monitoring data where it is able to help users monitor the use of their home appliances and can make an initial plan in its use. This system is also equipped with
IoT technology where users can monitor data only by using electronic devices such as smartphones if they are in a place far from this system. It is also equipped with an indicator to warn users if their use exceeds the limit. It can be said that this system has several useful features compared to existing monitoring tools. So, this system is very helpful to users in their daily lives.

5. Innovation and Entrepreneurial Impact

By combining an ESP32 microcontroller with Internet of Things technology, this project presents a novel real-time electrical load monitoring system that automatically measures and monitors voltage, current, power, and temperature. By offering remote access via a mobile application and real-time data display via an I2C LCD, the system does away with the need for manual measurement. System flexibility and usability are improved by user interactive features like touch control and adjustable voltage simulation via the mobile application. This project offers a unique real-time electrical load monitoring system that automatically measures and monitors voltage, current, power, and temperature by fusing an ESP32 microcontroller with Internet of Things technology. The system eliminates the need for manual measurement by providing real-time data display via an I2C LCD and remote access via a mobile application. Touch control and adjustable voltage simulation through the mobile application are examples of user-interactive features that enhance system flexibility and usability.

6. Potential commercialization

Because of its affordable hardware components, scalable architecture, and useful functionality, the developed system shows great commercialization potential. The system can be manufactured at a comparatively low cost and provide real-time monitoring of voltage, current, power, and temperature by using widely available sensors and an ESP32 microcontroller. The system is appropriate for smart home applications, small offices, and educational institutions because of its integration with an IoT platform, which allows users to access energy consumption data remotely. Furthermore, by giving users early warning, the overload indication feature improves safety and raises its market value as a preventive energy management solution.

7. Acknowledgment

First of all, thanks to my supervisor, Dr Zatul Iffah binti Abd Latiff who always helps with this Final Year Project from the beginning until the end. With her great help and all the great ideas that came out from her, this project can be done properly. Also, disclosure about the use of appropriate software for this project. Her help gives me more knowledge about this project. Another thanks to all Electrical Engineering lecturers who teach and share their knowledge which really helps this project run smoothly. Lastly, a thousand thanks to family members and friends who always give support and motivation to produce this project.

8. Researchers' Biography

Muhammad Nurakmal Arsul Nursyafig is a final – year student from the Centre for Electrical Engineering Studies at Universiti Teknologi MARA (UiTM), Johor Branch, Pasir Gudang Campus. He started studying electrical engineering at Technic Institute Johor Bahru and then continued his study at UiTM. He is successfully developing a system that can monitor home appliances load usage with the integration of Internet of Things (IoT). He is committed to create a low – cost and sustainability system that can give good to people.

Zatul Iffah Abd Latiff completed her PhD studies in Universiti Teknologi MARA, focusing on the research of Space and Earth Electromagnetism. She received her Bachelor of Engineering Degree in Electrical Engineering from Korea University, South Korea in 2010 and her Master of Science in Telecommunication and Information Engineering from Universiti Teknologi MARA (UiTM), Malaysia in 2013. She is one of the co-researchers of MAGDAS (Magnetic Data Acquisition System) network who is responsible for monitoring and maintaining one of the MAGDAS observatories located in Johor, Malaysia. Her research interests include geomagnetically induced currents (GICs) activity in the equatorial and low latitude region, space weather activity, ionospheric currents, Earth's electromagnetism, and application of ground magnetic and satellite data.

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