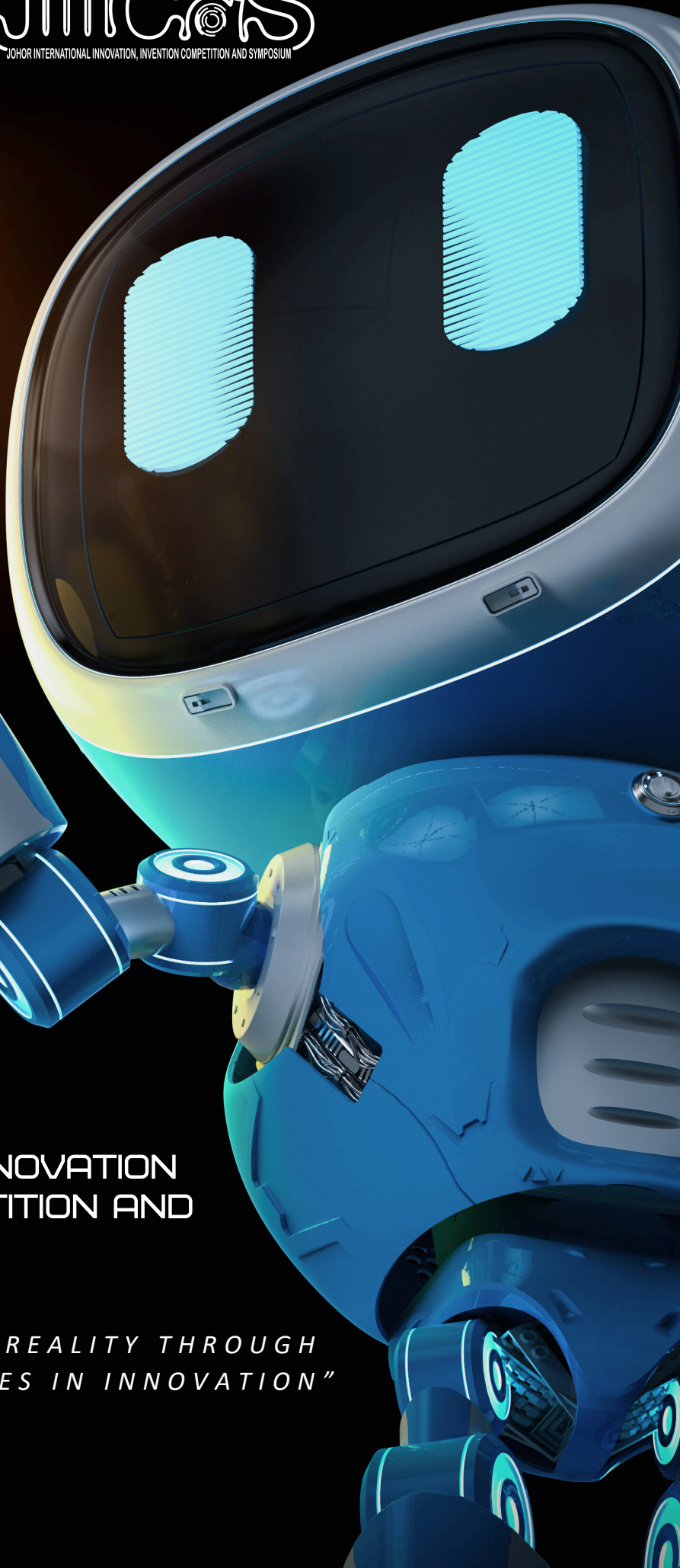
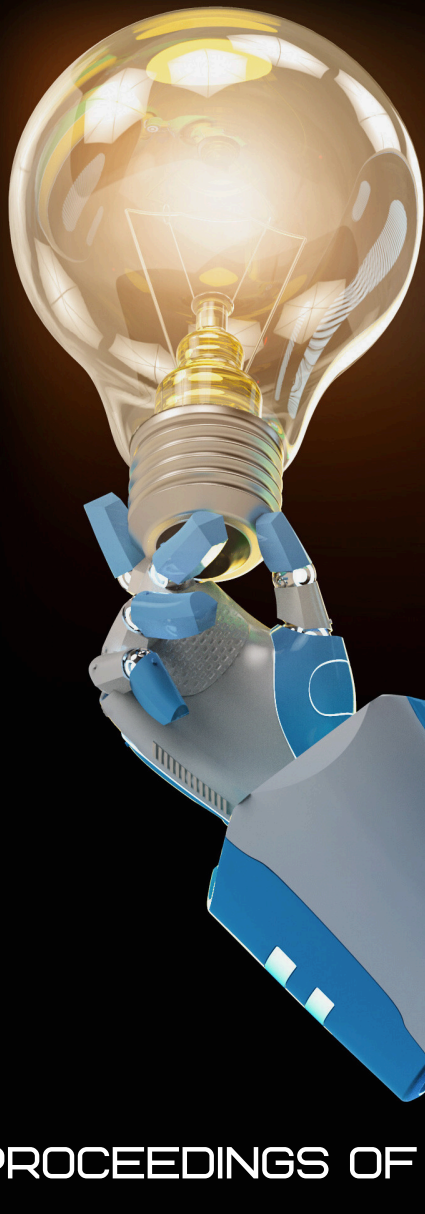




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2025
JOHOR INTERNATIONAL INNOVATION, INVENTION COMPETITION AND SYMPOSIUM



PROCEEDINGS OF

Johor

INTERNATIONAL INNOVATION
INVENTION COMPETITION AND
SYMPOSIUM
2025

"BRIDGING IDEAS AND REALITY THROUGH
EMERGING TECHNOLOGIES IN INNOVATION"



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PREFACE

In the name of Allah, the Almighty who grants us knowledge, wisdom, and guidance, and with salutations upon the Prophet Muhammad (peace be upon him) who has shown us the way of truth and enlightenment, we begin this preface with gratitude. We are grateful to Allah for His blessings and strength that have enabled us to complete this proceedings.

This proceedings compiles the extended abstracts submitted to the **Johor International Innovation, Invention Competition and Symposium 2025 (JIIICaS 2025)**. JIIICaS continues to serve as a virtual platform for students, researchers, and innovators to present their ideas and showcase their inventions. The programme aims to inspire creative thinking, encourage applied innovation, and nurture a spirit of collaboration among participants from diverse backgrounds.

Each abstract in this proceedings provides an overview of the respective innovation or project, highlighting the uniqueness, potential impact, and relevance to current technological and societal needs. It is our hope that this proceedings will become a source of reference and inspiration, not only for the participants but also for future innovators and change-makers. May the innovations presented here spark new ideas that lead to real-world solutions and meaningful progress.

We express our heartfelt appreciation to all contributors, supervisors, reviewers, and the entire organising committee whose dedication and commitment have brought JIIICaS 2025 to fruition.



RECTOR'S FOREWORD



Assalamualaikum warahmatullahi Wabarakatuh and warm greetings to all.

ALHAMDULILLAH, with great pleasure, I welcome all participants, jury members, organisers, and distinguished guests to the **Johor International Innovation, Invention Competition, and Symposium 2025 (JIIICaS 2025)**. Your presence reflects our shared commitment to advancing innovation and creativity as key drivers of progress.

This year's theme, **"Bridging Ideas and Reality through Emerging Technologies in Innovation,"** demonstrates how emerging technologies could transform ideas into real solutions that address global challenges.

Innovation thrives where visionary thinking meets practical application, creating value for society and industry. We are delighted to have received over 72 extended abstracts from diverse fields, demonstrating the passion of our researchers, innovators, and students in contributing to Malaysia's position in the global innovation landscape.

In line with the **13th Malaysia Plan (RMK-13)** and the **Malaysia MADANI** vision, UiTM Johor is committed to fostering a strong ecosystem for research, technology adoption, and industry collaboration. JIIICaS serves as an excellent platform to connect academia with industry, driving impactful innovations.

My heartfelt appreciation goes to the **Faculty of Computer and Mathematical Sciences (FSKM), UiTM Johor Branch, Pasir Gudang Campus**, and to all who made this event possible.

Congratulations to all participants. May this competition and symposium inspire us to push boundaries, harness emerging technologies, and bridge ideas with reality for a better future.

Thank you, and I wish everyone success throughout this event.

ASSOCIATE PROFESSOR DR. SAUNAH ZAINON

Exercising the Functions of the Rector
Universiti Teknologi MARA
Johor Branch



ASSISTANT RECTOR'S FOREWORD



Assalamualaikum Warahmatullahi Wabarakatuh,
Salam Sejahtera, Salam Malaysia MADANI and UiTM Dihatiku.

It is with great pleasure and sincere appreciation that I extend my congratulations to the organising committee of the **Johor International Innovation, Invention Competition and Symposium (JIIICaS) 2025**. Now in its third year, JIIICaS has established itself as a distinguished platform for fostering innovation, creativity, and interdisciplinary collaboration across and beyond the academic community.

This year's theme, **"Bridging Ideas and Reality through Emerging Technologies in Innovation,"** is both timely and

forward-looking. As we navigate a world shaped by rapid technological advancement, the ability to translate novel ideas into real-world applications has never been more critical. Technologies such as artificial intelligence, the Internet of Things, and extended reality are no longer distant concepts but they are accessible tools with the capacity to solve complex societal challenges.

I am pleased to note that JIIICaS 2025 has received hundreds of entries, reflecting enthusiastic participation from both secondary schools and institutions of higher learning across multiple categories. Conducted fully online, this year's programme continues to provide an inclusive and dynamic platform for participants from diverse academic and professional backgrounds to present their innovative solutions and creative thinking.

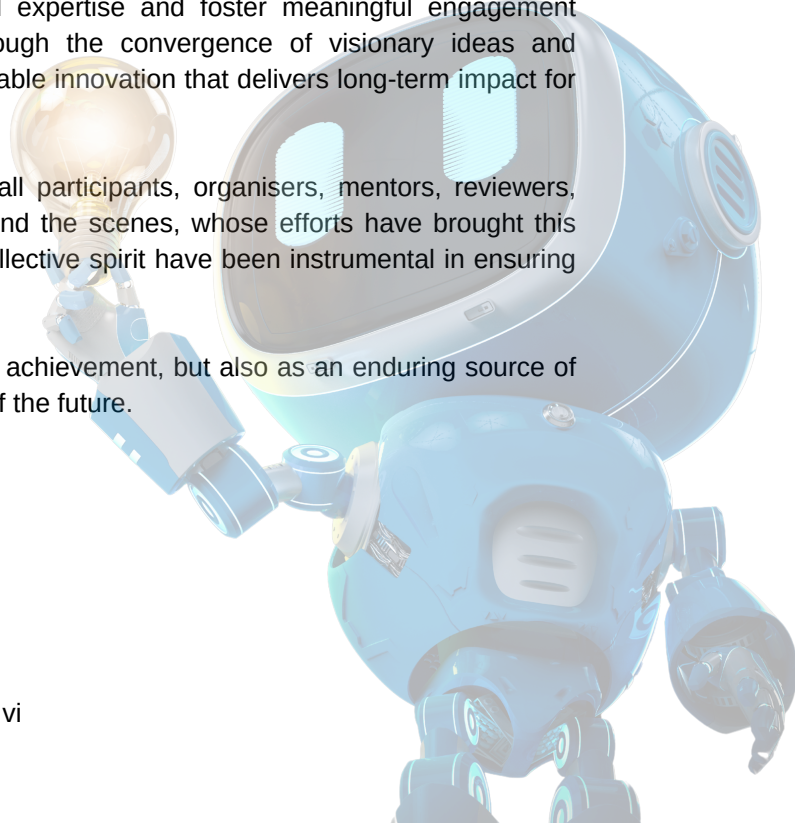
Beyond serving as a competition, JIIICaS plays **a strategic role in cultivating a culture of innovation within the Johor community**. With the strong support of UiTM and our collaborative partners, the initiative seeks to showcase local expertise and foster meaningful engagement between academia, industry, and society. Through the convergence of visionary ideas and emerging technologies, we aspire to drive sustainable innovation that delivers long-term impact for the state and the nation.

I would like to extend my deepest gratitude to all participants, organisers, mentors, reviewers, sponsors, and contributors, both visible and behind the scenes, whose efforts have brought this programme to realisation. Your dedication and collective spirit have been instrumental in ensuring its continued success.

May this publication serve not only as a record of achievement, but also as an enduring source of inspiration for the innovators and changemakers of the future.

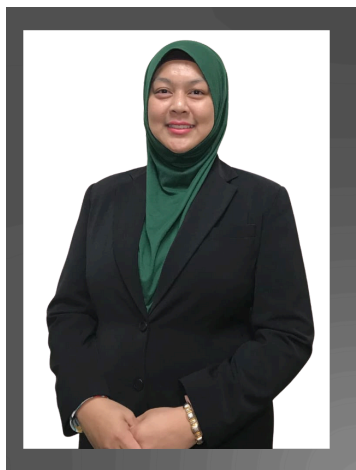
Thank you.

DR. SITI KHADIJAH BINTI ALIAS
Assistant Rector
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COORDINATOR'S OF UNDERGRADUATE PROGRAMMES FOREWORD



Assalamualaikum Warahmatullahi Wabarakatuh,
Salam Sejahtera, Salam Malaysia MADANI and UiTM Dihatiku.

Alhamdulillah, with gratitude to Allah S.W.T., I am honoured to contribute this message for the **Johor International Innovation, Invention Competition and Symposium 2025 (JIIICaS 2025)**, proudly organised by the Faculty of Computer and Mathematical Sciences, UiTM Johor Branch.

As the Coordinator of Undergraduate Programmes, I take this opportunity to highlight the commitment and dedication of our academic and administrative staff who have worked tirelessly to bring this programme to life.

Their combined expertise, professionalism, and collaborative spirit have been the foundation of JIIICaS 2025, ensuring its continued growth and success over the years.

The theme of this year's symposium, **"Bridging Ideas and Reality through Emerging Technologies in Innovation"**, reflects our collective vision of empowering communities through innovation and research. By leveraging the potential of emerging technologies, JIIICaS 2025 provides an impactful platform for participants from various backgrounds to share solutions that address real-world challenges, while strengthening the role of academia as a driver of progress.

I extend my deepest appreciation to the organising committee, reviewers, collaborators, and sponsors for their invaluable contributions. Your dedication not only enhances the academic and professional ecosystem of UiTM Johor Branch, but also inspires meaningful partnerships between universities, industries, and society.

To all participants, may JIIICaS 2025 serve as a catalyst for creativity, collaboration, and lifelong learning. Let this platform continue to inspire innovations that benefit our nation and beyond. We sincerely hope to welcome your participation again in our next edition of JIIICaS in 2027.

Thank you.

Wabillahi taufiq walhidayah, wassalamualaikum warahmatullahi wabarakatuh.

DR. WAN MUNIRAH BINTI WAN MOHAMAD
Coordinator of Undergraduate Programmes
Faculty of Computer and Mathematical Sciences
Universiti Teknologi MARA Johor Branch
Pasir Gudang Campus





PROGRAM DIRECTOR'S FOREWORD



Assalamualaikum warahmatullahi wabarakatuh,
Salam Sejahtera, Salam Malaysia MADANI, and Salam UiTM
Dihatiku.

Alhamdulillah, all praise be to Allah S.W.T., the Most Gracious and the Most Merciful, for granting us the opportunity and strength to successfully organise JIICaS 2025.

First and foremost, I would like to express my deepest appreciation to the dedicated committee members. Your unwavering commitment and tireless efforts behind the scenes, despite your other responsibilities, have been the driving force in ensuring the smooth delivery of this event. Your teamwork, perseverance, and professionalism are truly commendable.

To our JIICaS 2025 innovators, congratulations and well done! Your passion and determination have transformed ideas into impactful innovations, serving as a powerful reflection of the bright future of innovation in Malaysia and beyond.

I would also like to extend my sincere gratitude to all our partners, sponsors, and collaborators. Your trust, support, and cooperation have been instrumental in making this programme a success. Your belief in the value of innovation and education strengthen our shared vision for progress.

This year's e-book of abstracts presents a remarkable collection of creative and forward-thinking contributions, each reflecting the participants' commitment to excellence and their capacity to address real-world challenges through innovation. More than a publication, it stands as a tribute to the power of ideas and the boundless potential of our future innovators.

JIICaS 2025 also provides an invaluable platform for networking and collaboration. It brings together brilliant minds from various disciplines and backgrounds, offering opportunities to share insights, spark inspiration, and ignite future research partnerships. We hope this synergy will fuel even greater innovations in the years to come.

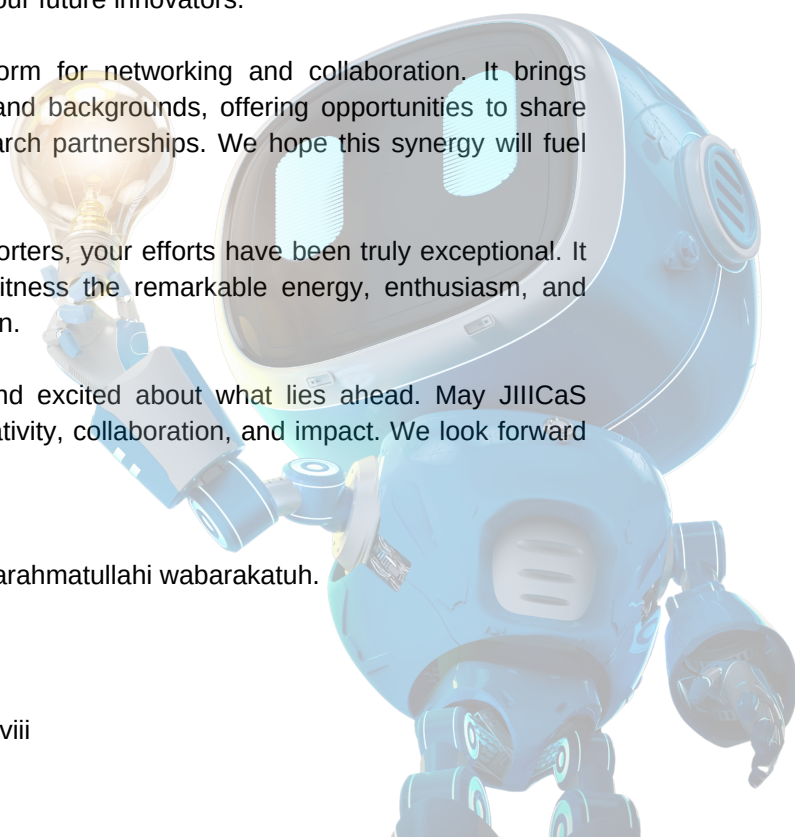
To all contributors, participants, judges, and supporters, your efforts have been truly exceptional. It has been both an honour and a pleasure to witness the remarkable energy, enthusiasm, and excellence that have shaped this year's competition.

As we close this chapter, I remain optimistic and excited about what lies ahead. May JIICaS continue to serve as an inspiring platform for creativity, collaboration, and impact. We look forward to welcoming you all once again at JIICaS 2026!

Thank you.

Wabillahi taufiq walhidayah, wassalamualaikum warahmatullahi wabarakatuh.

DR. GHAZALI SEMIL @ ISMAIL
Program Director of JIICaS 2025



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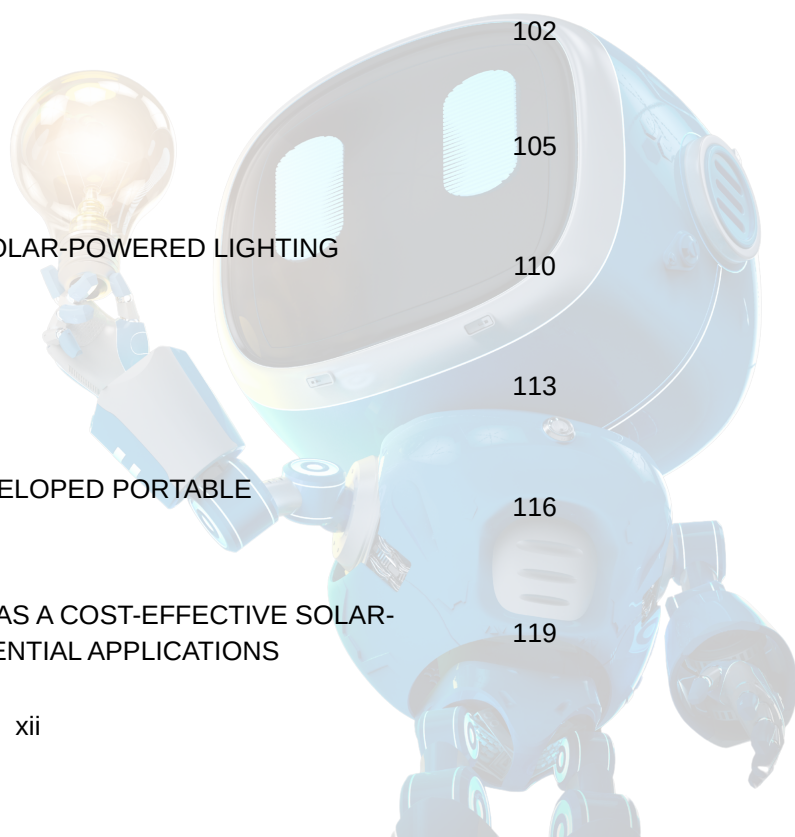


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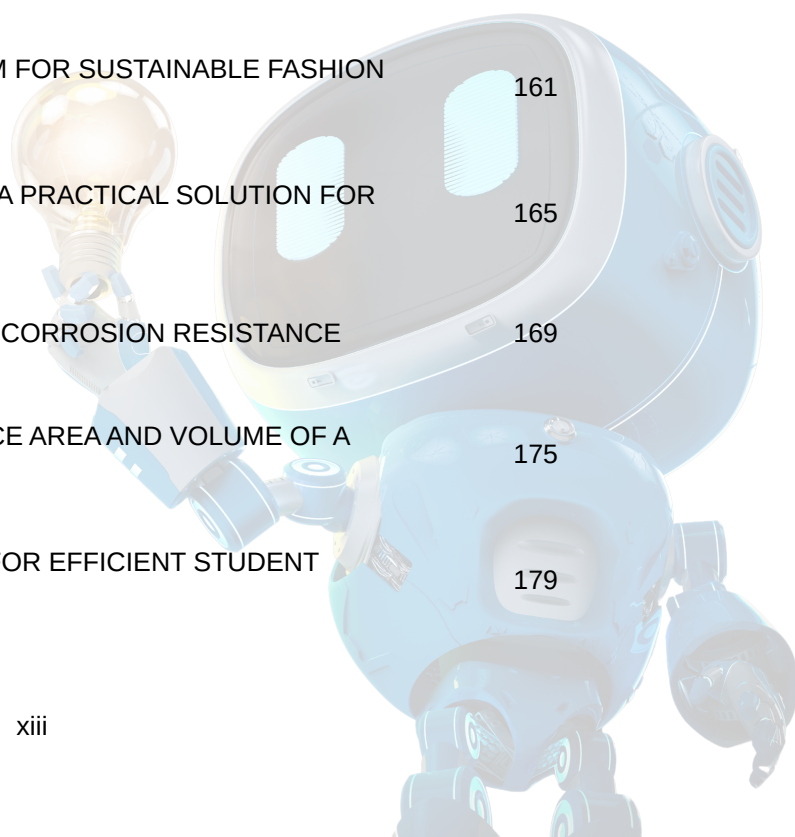


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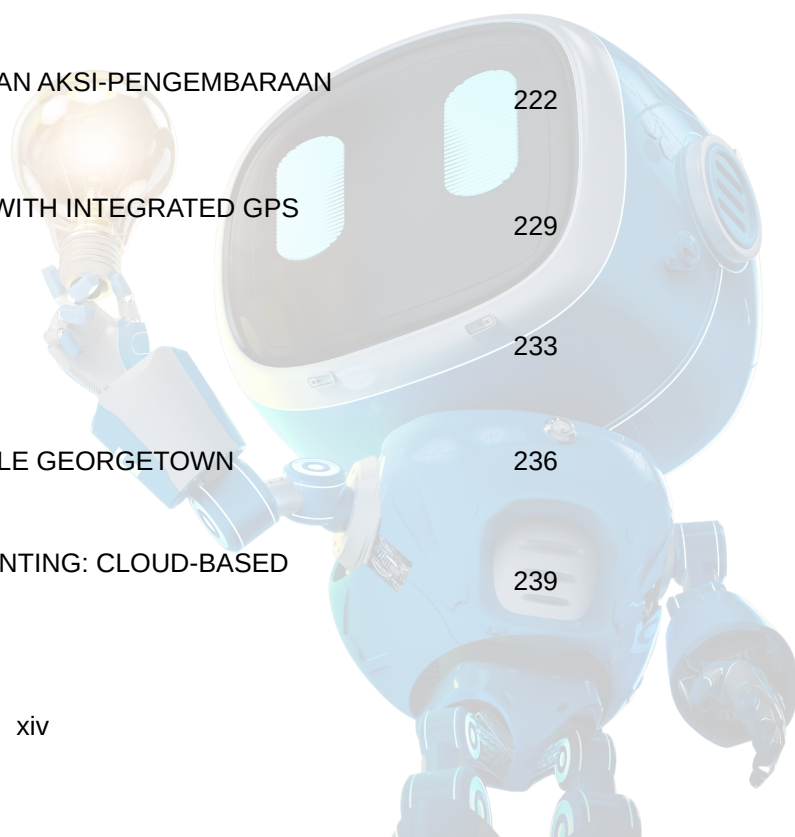
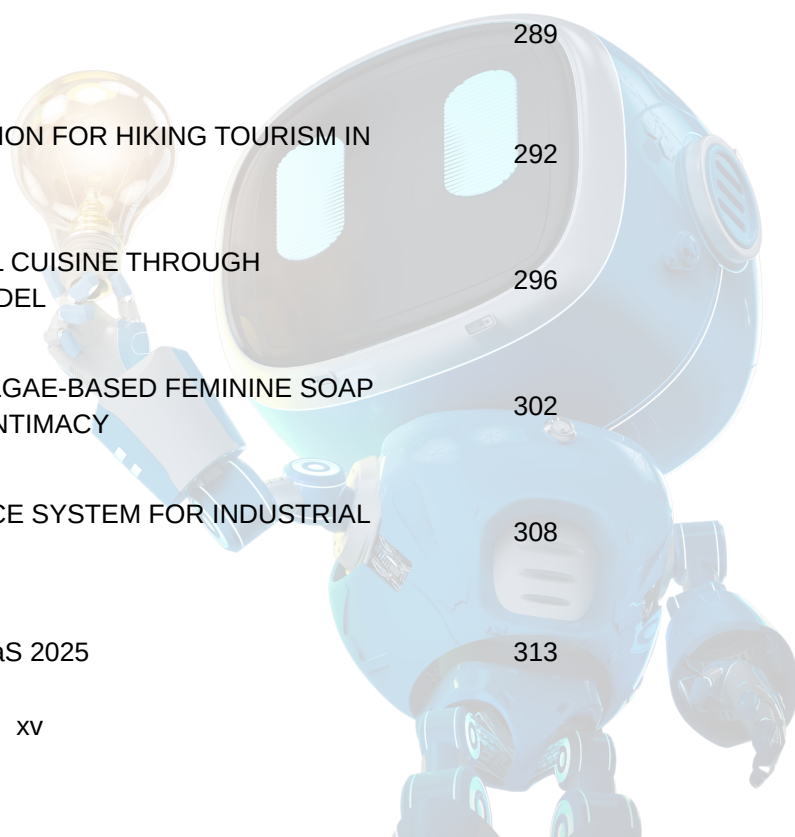


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DIGITALISING THE RECRUITMENT PROCESS WITH FUZZY LOGIC: IMPLEMENTATION FOR CORROSION ENGINEER SELECTION

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ABSTRACT

Recruitment plays a pivotal role in ensuring organisations select the most qualified and suitable individuals, particularly in technical fields such as corrosion engineering, where specific skills and expertise are essential. This study presents the development and application of a Fuzzy Inference System (FIS) to support the recruitment process at Idemitsu Sdn. Bhd., aiming to enhance objectivity, consistency, and efficiency. Traditional recruitment methods often involve a high degree of subjectivity and complexity, especially when evaluating candidates across multiple qualitative and quantitative criteria. To address these challenges, the FIS applies fuzzy logic principles to assess key attributes, including academic qualifications, professional certifications, industry experience, and technical skills. These criteria were converted into standardised, homogenised inputs for the system, allowing for a structured and balanced evaluation of each candidate. A customised Excel-based interface was developed to operationalise the FIS, enabling real-time input of candidate data and immediate output of suitability scores. Based on these scores, the system provides instant recommendations for acceptance or rejection, thus streamlining the decision-making process. The integration of fuzzy logic into the recruitment framework proved to be effective in reducing human bias, improving transparency, and ensuring that hiring decisions are based on a consistent set of standards. By offering a systematic and replicable evaluation method, the FIS supports data-driven recruitment practices that are particularly beneficial for roles requiring technical precision and expertise. The outcomes of this research demonstrate the significant advantages of utilising intelligent systems such as FIS in human resource management, ultimately contributing to more equitable and efficient hiring outcomes.

Keywords: Fuzzy Inference System (FIS), Recruitment Evaluation, Decision Making Efficiency

1.0 INTRODUCTION

Corrosion is a serious issue in industries such as manufacturing, oil and gas, and petrochemicals. It not only weakens the structural integrity of equipment but also increases operational costs, reduces productivity, and creates safety risks (Uhlir, 2011). Companies like Idemitsu Sdn. Bhd., which operate in harsh and chemically aggressive environments, are especially vulnerable. In such settings, corrosion engineers play a critical role in applying prevention strategies to ensure equipment reliability and minimise maintenance costs. The job of a corrosion engineer requires both technical expertise and strategic thinking. These professionals are responsible for selecting corrosion-resistant materials, designing protective systems, and ensuring compliance with safety standards. In some roles, such as subsea engineering, they must also have a strong understanding of metallurgy, chemistry, and physics, along with practical knowledge of methods like cathodic protection, coatings, and chemical inhibitors (Cicek, 2014). Because of the importance of their decisions, hiring the right person for the role is vital.

Unfortunately, the current recruitment process at Idemitsu relies on traditional methods like resume screening and interviews. While common, these methods are often subjective and inconsistent. They do not provide a structured way to measure complex qualities like technical skills, adaptability, or industry experience (Denert, 2020). This can result in biased decisions and the hiring of candidates who may not meet the real demands of the job (Pletcher & Walsh, 1993). To overcome these challenges, this study proposes the use of a Fuzzy Inference System (FIS). FIS applies fuzzy logic to assess both measurable and qualitative aspects of each candidate. By using a rule-based system with defined criteria and weightage, FIS allows for more comprehensive and objective evaluations (Ross, 2010). It takes into account a combination of technical qualifications, certifications, academic performance, soft skills, and relevant experience to produce fair and consistent outcomes.

The use of FIS also aligns with current trends in HR, where data-driven tools are being adopted to improve hiring decisions. For Idemitsu, this could not only improve the selection of corrosion engineers but also serve as a pilot project for hiring other technical roles in the future (Kline, 2024). Furthermore, the system can be easily integrated with familiar platforms like Excel. In conclusion, the current hiring process at Idemitsu Sdn. Bhd. lacks the structure and objectivity needed for selecting corrosion engineers effectively. By implementing an FIS-based approach, the company can reduce bias, speed up recruitment, and ensure better alignment with its goals for safety, reliability, and operational Excellence.

2.0 OBJECTIVE

The objectives of this study are:

1. To develop the FIS to generate a shortlist of qualified candidates for corrosion engineer position at Idemitsu Sdn. Bhd.
2. To evaluate the performance of the FIS implemented in Fuzzy Logic Toolbox by comparing its results with manual calculations.
3. To generate an Excel file with MATLAB to simplify data inputs and output variable processing for HR managers' decision-making.

3.0 METHODOLOGY

This chapter describes how a Fuzzy Inference System (FIS) was developed to help Idemitsu Sdn. Bhd. improve the selection of corrosion engineers. Choosing the right candidate is challenging because it involves assessing factors like education, experience, skills, and certifications, which are not always easy to measure. The FIS uses fuzzy logic to handle this uncertainty and turns vague information into clear scores. It uses membership functions to classify each input as Low, Medium, or High, then applies "IF-THEN" rules to generate a decision. The final result is a score that helps compare candidates fairly and objectively. The system was improved with feedback from experts and tested using past recruitment data to make sure it fits the company's real needs.

The FIS uses four main criteria: academic qualification, certification, industry experience, and skills. Candidates needed at least a Mechanical Engineering degree, and higher education levels scored better. Skills were rated based on technical ability in related industries, and certifications were scored based on the number of relevant credentials. Work experience was grouped into Low, Medium, and High depending on how closely it matched the job. These categories were created with input from Idemitsu. Once the FIS was built in MATLAB, it was connected to Excel so HR could easily input data and get results. This made the system practical for real use and ensured consistent, unbiased decision-making that supports the overall hiring process.

3.1 FUZZY SYSTEM

The Fuzzy Inference System (FIS) is used to help select corrosion engineers by evaluating four main factors: academic qualification, certification, industry experience, and skills. These inputs help the company ensure that candidates are assessed thoroughly for their suitability. The result of the system is simple, candidates are either accepted or rejected, which makes decision-making more accurate and reduces bias. To make the system flexible and precise, it uses two types of membership functions: trapezoidal and triangular. Trapezoidal functions are used for broader categories like 'Low' or 'High' certification levels, while triangular functions are used for more specific levels like 'Medium'. For clear and fixed categories, such as academic qualifications, exact (crisp) data is used to avoid any confusion during comparison.

Table 1: Linguistic Variables, Values, and Types of Membership Functions

	Linguistic Variables	Linguistic Values	Types of Membership Functions	Range
Inputs	Academic Qualification	Diploma	Triangular	[-0.50, 0.00, 0.50]
		Degree	Triangular	[0.50, 1.00, 1.50]
		Master	Triangular	[1.50, 2.00, 2.50]
	Certification	Low	Trapezoidal	[0.00, 0.00, 1.00, 2.00]
		Medium	Triangular	[1.00, 2.00, 3.00]

	Industry Experience	High	Trapezoidal	[2.00, 3.00, 5.00, 5.00]
		Low	Trapezoidal	[0.00, 0.00, 0.50, 1.00]
		Medium	Triangular	[0.50, 1.00, 1.50]
		High	Trapezoidal	[1.00, 1.50, 2.00, 2.00]
	Skills	Low	Trapezoidal	[0.00, 0.00, 1.00, 2.00]
		Medium	Triangular	[1.00, 2.00, 3.00]
		High	Trapezoidal	[2.00, 3.00, 5.00, 5.00]
Output	Result	Reject	Trapezoidal	[0.00, 0.00, 4.00, 5.00]
		Accept	Trapezoidal	[7.00, 8.00, 10.00, 10.00]

3.2 IMPLEMENTATION

The Fuzzy Inference System (FIS) developed for selecting corrosion engineers at Idemitsu Sdn. Bhd. used MATLAB's Fuzzy Toolbox and focused on four key inputs: academic qualification, certification, industry experience, and skills. These inputs were represented using trapezoidal and triangular membership functions, and the system output was a simple decision—accept or reject. A total of 81 fuzzy rules were created to link the inputs to the final decision. The process involved converting inputs into fuzzy values (fuzzification), applying rules, and then converting the results into a final score (defuzzification). For example, a score of 2.2593 fell under the "reject" category. To make it easier for HR to use, the system was linked with Excel, allowing candidate data to be entered and processed without needing to use MATLAB directly. This integration made the recruitment process more consistent, efficient, and fair.

4.0 RESULT

This study aims to evaluate candidates for corrosion engineering roles using fuzzy inference systems (FIS) implemented through Excel integration. This software tools process candidate data and utilise fuzzy logic to evaluate key factors such as academic qualifications, certifications, industry experience, and skills. The outputs from both the MATLAB App Designer and the Excel-integrated FIS system were compared with manual calculations to verify the accuracy and consistency of the fuzzy logic model.

4.1 RESULTS FROM THE FIS SYSTEM

The FIS system processes candidate data by evaluating four key input variables:

- Academic Qualification: Coded as 0 for Diploma, 1 for Degree, and 2 for Master's.
- Certification: Coded as Low (1), Medium (2-3), and High (4-5).
- Industry Experience: Coded as Low (0), Medium (1), and High (2).
- Skills: Coded as Low (1), Medium (2-3), and High (4-5).

The fuzzy logic system applies these inputs to predefined rules, which output a score. Candidates with a score above 7 are classified as Accepted, while those with a score below 5 are classified as Rejected.

Table 2: Example of Candidate Resume

Candidates	Input Variables				Outputs Variable	
	Academic Qualification	Certification	Industry Experience	Skills	Result	
1	0	1	0	1	2.23	Reject
2	1	2	2	3	8.76	Accept
3	2	3	1	5	8.76	Accept
4	1	4	2	1	2.23	Reject
5	2	5	1	4	8.76	Accept

This candidate's high academic qualifications, extensive certification, and skills led to their acceptance.

4.2 COMPARISON OF FIS WITH MANUAL CALCULATION

The results from the FIS system were compared to manually calculated results to verify the correctness of the fuzzy logic model. The table below summarises the comparison:

Table 3: Comparison results of FIS with manual comparison

Candidate	FIS Score (Excel Integration)	Manual Calculation
1	2.23	2.2593
2	8.76	8.7333
3	8.76	8.7333
4	2.23	2.2593
5	8.76	8.7333

As shown, the FIS output and manual calculations produced almost identical scores, with only minor differences due to rounding or the evaluation method used in MATLAB and Excel. The eligibility decision (Accepted or Rejected) was consistent across both methods, confirming the validity and accuracy of the fuzzy logic system.

4.3 SOFTWARE TOOLS FOR CANDIDATE INPUT MANAGEMENT

For efficient candidate data entry and evaluation, Excel Integration is used. This method allows HR managers to enter candidate data into an Excel sheet. The data is processed by the fuzzy logic system, and the results are output in Excel, enabling HR managers to easily manage and evaluate large amounts of data.

4.4 RESULT IN EXCEL

The integration of Excel with MATLAB's fuzzy logic system made it easier and more efficient for HR managers to evaluate candidates. By entering candidate details into an Excel sheet and clicking a "Run" button, the system automatically processed the data using the FIS and returned accurate results. These results were shown in MATLAB and sent back to Excel for easy review and reporting. This setup saved time and reduced human error in the hiring process.

For instance, a candidate with a Master's degree, three certifications, and related industry experience received a score that clearly reflected their strengths. The fuzzy system handled overlapping categories like skills and certifications well, giving a more accurate evaluation. The smooth connection between Excel and MATLAB allowed HR to easily compare multiple candidates and make better, more objective decisions. Overall, combining fuzzy logic with Excel created a practical and reliable way to assess candidates for corrosion engineering roles. It gave consistent results that matched manual evaluations and made the whole recruitment process faster and clearer. This system helped HR teams make fairer decisions and reduced the chances of mistakes, proving its value in supporting smarter hiring.

	A	B	C	D	E	F
1	AcademicQualification	Certification	IndustryExperience	Skills	Result	
2	0	1	0	1	2.23406593	
3	1	2	2	3	8.75882353	
4	2	3	1	5	8.75882353	
5	1	4	2	1	2.23406593	
6	2	5	1	4	8.75882353	
7						

Figure 1: Excel Output from FIS Integration for Corrosion Engineer Selection.

5.0 CONCLUSION

This chapter explains how an Excel-based Fuzzy Inference System (FIS) was created to help Idemitsu Sdn. Bhd. evaluate candidates for the corrosion engineer role. The system was designed to

make the hiring process more objective and consistent by using fuzzy logic to rate candidates based on education, certifications, experience, and technical skills. Excel was used because it is user-friendly and flexible. Through fuzzy rules and membership functions, the system converted inputs like "low," "medium," or "high" into scores, making it easier to compare and assess applicants. A total score above 7 indicated a suitable candidate for the next stage of selection.

The results showed that the system provided a fair and organised way to evaluate candidates. It helped reduce bias by using the same evaluation criteria for everyone. Although Excel didn't automatically label candidates as "Accept" or "Reject," HR staff could easily understand the scores and decide accordingly. The system was also tested by comparing its output to manual evaluations. Despite minor rounding differences, both methods gave the same conclusions, proving the system's accuracy and reliability in supporting hiring decisions.

Using Excel to run the FIS allowed HR to review many candidates at once and keep everything well-documented. While there were some limitations, like needing HR to manually check final scores and the system depending on expert knowledge, it still offered major benefits. Future improvements could include adding automatic "Accept" or "Reject" labels and using machine learning to make the system smarter and more adaptable. Overall, the study shows how fuzzy logic, even in a simple tool like Excel, can improve hiring decisions by making them more data-driven and transparent.

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DECISION-MAKING SYSTEM FOR PROPERTY BUYING

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ABSTRACT

Buying a property can be overwhelming, especially when considering factors like affordability, location, and property features. To simplify this process, the Decision-Making System for Property Buying was developed as a web-based platform to assist users in Malaysia. The system includes an Affordability Calculator that uses both the Debt Service Ratio (DSR) method and a Household Income-Based Loan Calculator to help users assess their financial capacity. It also offers a Property Comparison Tool that allows users to compare property details such as price, size, and amenities side-by-side. An AI-powered Property Assistant (chatbot) is integrated to provide instant support, answer queries, and perform loan calculations. Additionally, the "Properties You Might Like" feature recommends listings based on user preferences, making it easier to discover suitable options. Real estate negotiators (RENs) can submit property listings for admin approval, while the admin dashboard helps manage and monitor the system efficiently. Developed using the Waterfall Methodology, the system was tested through both functional and User Acceptance Testing to ensure usability and effectiveness. Ultimately, the system aims to support users in making informed property decisions and streamline the property management process.

Keywords: Property Buying System, Affordability Calculator, AI-Powered Chatbot, Real Estate Decision Support, Waterfall Methodology

1.0 INTRODUCTION

In today's competitive real estate landscape, purchasing a property is one of the most significant and complex financial decisions faced by individuals. The process involves evaluating a range of factors, including affordability, location, property features, and financing options. For many buyers, especially first-time homeowners in Malaysia, navigating through these considerations can be overwhelming (Chong et al., 2017). Traditional methods such as browsing online listings or consulting real estate agents often fall short in providing a comprehensive, guided experience that supports informed decision-making.

As a result, buyers are left to manually compare properties and estimate financial commitments, increasing the likelihood of confusion or poor choices. To address these challenges, digital platforms and decision-support systems have emerged as powerful tools in enhancing the property-buying experience (Kam et al., 2021). The proposed Decision-Making System for Property Buying aims to simplify this process by offering a web-based solution tailored to the Malaysian market. It features a combination of financial calculators, interactive tools, and intelligent support systems that guide users through the decision-making journey. By integrating relevant modules such as affordability analysis and property comparison, the system empowers users with data-driven insights and structured pathways to evaluate their housing options.

One of the key features of this system is the Affordability Calculator, which uses both the Debt Service Ratio (DSR) method and Household Income-Based Loan Calculator to assess users' financial readiness. In addition, the Property Comparison Tool enables side-by-side evaluations of key property attributes such as price, size, and amenities. To further enhance user experience, an AI-powered Property Assistant is embedded within the platform. This chatbot not only assists in answering user queries but also performs loan calculations and recommends properties based on preferences, creating a more dynamic and supportive environment.

To ensure credibility and usability, the system underwent functional and user acceptance testing, which indicated high levels of user satisfaction and system effectiveness. The platform also incorporates administrative functionalities where Real Estate Negotiators (RENs) can submit property listings for approval, while administrators can manage listings and users efficiently via a dedicated dashboard. Developed using the Waterfall Methodology, the system provides a structured and complete experience

that streamlines the decision-making process. Ultimately, the system bridges the gap between user needs and technological capabilities, delivering a holistic platform for smarter, more confident property buying decisions.

2.0 OBJECTIVES

The primary objective of this project is to develop a web-based decision-making system that effectively supports property buyers in Malaysia. To achieve this, the project first aims to identify the essential factors and features that should be incorporated into the platform to align with user needs and expectations. This includes understanding what tools and functionalities are most beneficial in guiding users through the property selection process. Secondly, the project seeks to design an intuitive and user-friendly interface, emphasizing a budget-based property search feature that enables users to filter and explore listings according to their financial capabilities. Lastly, the system will be developed and rigorously validated through user testing and performance evaluations to ensure that it performs effectively, delivers a seamless experience, and truly aids users in making well-informed property buying decisions.

3.0 METHODOLOGY

The methodology adopted for this project was the Waterfall Model, a widely recognized software development framework. The Waterfall Model offered a systematic and linear approach, ensuring that each stage of development flowed sequentially into the next. This methodology was suitable for the project because it allowed for clear documentation, proper verification at each step, and ensured that the project requirements were fully addressed. The project began with gathering and analysing requirements to determine the features and functionalities needed for the property buying decision-making system. Once the requirements were established, the system's design was carefully planned, including the architecture and user interface. The design phase laid the foundation for the development and implementation process, where the system was coded and integrated to meet the specified requirements.

Following the development stage, multiple testing cycles were carried out to identify and resolve any functional or performance issues. These included unit testing, integration testing, system testing, and User Acceptance Testing (UAT), ensuring that the system performed reliably and met user expectations. Once the testing phase was successfully completed, the system was deployed for use. The final stage involved system maintenance to address any post deployment issues and ensure long-term functionality. The Waterfall Model ensured that each stage was completed and verified before progressing to the next. This structured approach facilitated the smooth and systematic development of the Decision-Making System for Property Buying, ensuring the delivery of a fully functional, user-friendly, and reliable system.

3.1 Phase 1: Business Understanding

In this phase, the project's main objectives are defined, and a comprehensive understanding of the business context is developed. The focus is on identifying the primary goals, requirements, and constraints from a business perspective. Key stakeholders are engaged to ensure their needs and expectations are understood and integrated into the project plan. This phase culminates in the creation of clear project objectives, a defined scope, and a detailed project plan with success criteria that will guide the subsequent phases.

3.2 Phase 2: Data Understanding and Data Preparation

In this phase, the process begins with the collection of raw data from relevant sources, such as questionnaires. The primary goal is to gain a comprehensive understanding of the data's content, quality, and structure. This involves conducting exploratory data analysis (EDA) to identify patterns, inconsistencies, and potential insights. Initial reports are generated to document these findings, which help in assessing data quality and forming hypotheses for further analysis.

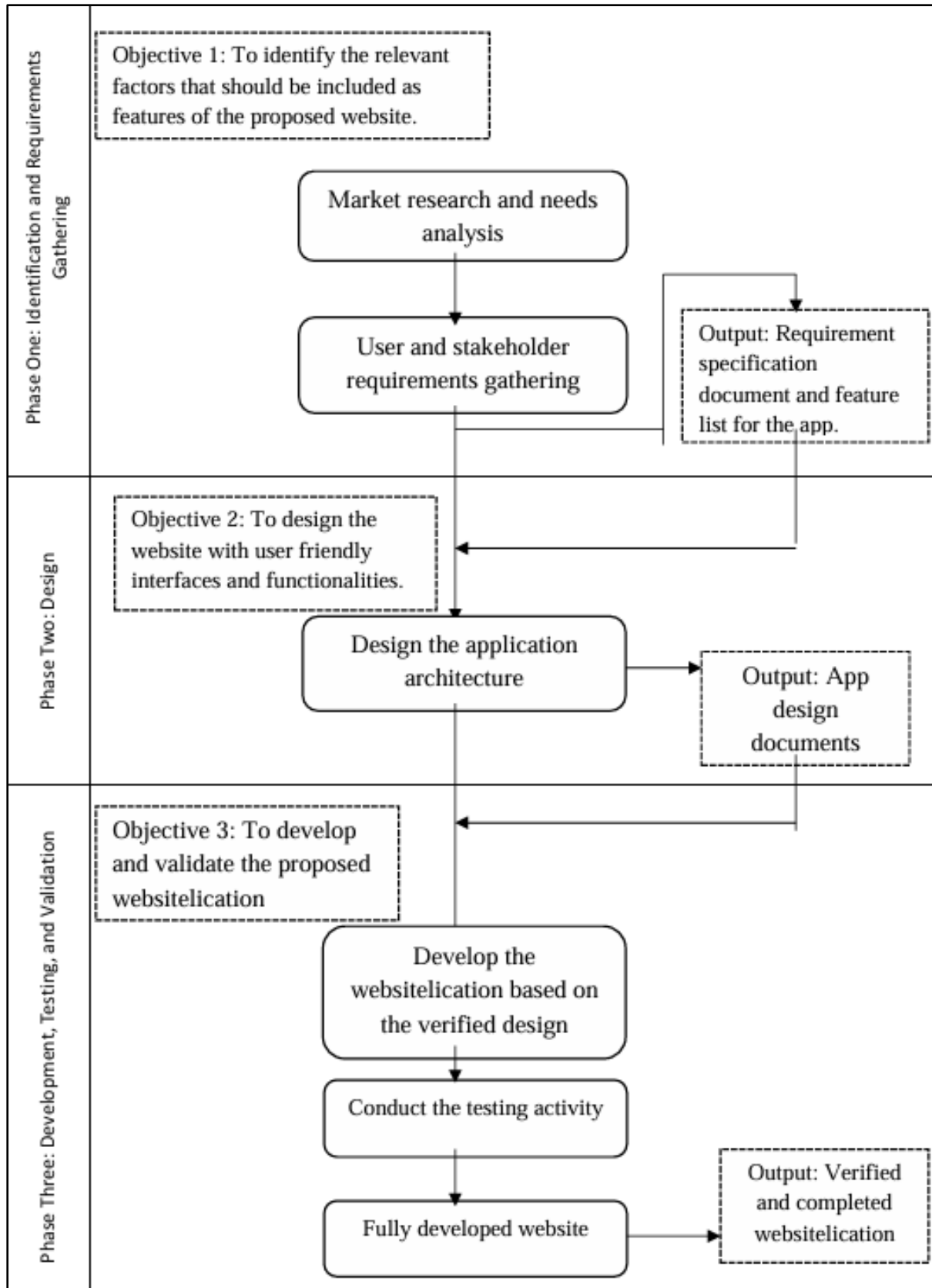


Figure 1: Project Framework

Subsequently, the focus shifts to data preparation, where the raw data is cleaned and pre-processed to ensure its readiness for modelling. This step includes handling missing values, resolving inconsistencies, and transforming the data into a standardised format. The output of this phase is a well-prepared dataset, along with detailed documentation of the data collection and preparation process. This phase is crucial as it lays the groundwork for accurate and effective modelling in the subsequent stages.

3.3 Phase 3: Modelling and Evaluation

In Phase 3, the focus is on developing and assessing models that align with the business objectives outlined in the first phase. The modelling stage begins by selecting appropriate algorithms and techniques that best fit the prepared dataset. Various models are developed, trained, and refined to uncover patterns and make predictions that address the project's goals. After the models are built, the evaluation phase begins, where these models are rigorously tested and validated to ensure they meet the desired performance criteria. This phase is crucial for confirming that the models not only perform well statistically but also effectively address the business questions and challenges identified earlier. The deliverables from this phase include the finalized models, an evaluation report summarizing the performance of each model, and recommendations for deployment in the next phase.

3.4 Phase 4: Deployment

The final phase focuses on deploying the developed models and visualised data insights for stakeholder use. This involves creating the necessary documentation, such as a user guide, to support the deployment process. The visualised insights are made accessible to stakeholders, enabling them to make informed decisions based on the analysis. The deployment phase ensures that the system is effectively delivered and integrated into the business environment.

4.0 RESULTS

The Decision-Making System for Property Buying successfully meets its objectives by offering a platform that simplifies property search, comparison, and decision-making for users. Through features like affordability calculation, property comparison, and tailored recommendations, the system bridges the gap between property buyers, RENs, and admins. While certain limitations remain, the proposed future enhancements can elevate the system's usability and effectiveness, ensuring it remains relevant and valuable to its users in an evolving market. The project demonstrates the potential of technology-driven solutions in empowering informed decisions in the property market.

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PIONEERING AN INFRARED-POWERED SMART PET HYDRATION FOUNTAIN FOR SEAMLESS CONVENIENCE

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ABSTRACT

Typically, pet owners resort to traditional bowls for their pets' daily nourishment, including hydration. However, the demanding nature of modern lifestyles often leaves cat owners with insufficient time to attend to their pets' water needs, posing significant health risks due to potential water contamination. To address this challenge, this project proposes the development of an innovative pet water fountain featuring an Infrared Sensor with an automatic On-Off switch, ensuring precise water regulation. Maintaining clean water is paramount in safeguarding pets against various ailments. When the pet approaches this advanced water fountain, a controlled stream of water is activated, seamlessly switching on and off in response to pet movement. It is envisioned that this inventive solution will effectively alleviate the concerns of pet owners regarding their pets' hydration needs.

Keywords: Infrared Sensor, Pet Hydration

1.0 INTRODUCTION

Water is one of the basic needs for all living things. Besides humans, animals also need water to survive. Water is essential to maintain pets' bodies and make pets' bodies function properly. Usually, pet owners will provide water in an open container. This contaminates the drinking water, has a negative health impact, and causes other health issues. It is important to keep the water provided clean all the time. The development of intelligent systems for automated pet care has gained considerable attention in recent years, particularly in the context of food and water dispensing technologies. Li and Ji (2021) designed an automatic control system for a smart water dispenser, highlighting the role of embedded systems and sensors in achieving real-time automation. Extending this concept, Jayaprakash et al. (2025) introduced a patented feeder robot integrating both food and water dispensing mechanisms, along with mobility and surveillance features, showcasing a multifunctional approach to pet care automation. Similarly, Amans and Umar (2025) fabricated a microcontroller-based automatic pet food dispenser, focusing on the ease of use and reliability of feeding mechanisms.

Bhagat et al. (2024) provided a comprehensive review of various automatic pet feeding systems, noting that sensor technologies and timing modules have significantly improved operational efficiency. Aransiola and Adegbite (2022) emphasized the importance of load sensors in monitoring food levels, thereby ensuring precise feeding control. Meanwhile, Vineeth et al. (2020) explored the application of digital image processing in pet feeders, demonstrating an advanced method of food recognition and portioning. These studies collectively highlight the growing trend toward integrating smart technologies—such as sensors, image processing, and automation—into pet care systems, improving both convenience and animal welfare. In addition, an integration of microcontroller-based systems in automated dispensers has seen significant growth in recent years. Koh et al. (2024) introduced a Smart Water ATM that utilises Arduino and RFID technology for secure and efficient water dispensing. This kind of design can be adapted to pet water fountains, providing contactless activation and real-time control. Furthermore, clean water can keep pets healthy and also hydrated. The risk of dirty water includes various diseases, high medical costs, and animal mortality rates in our country. Additionally, water contains unsafe levels of contaminants can cause disease which can result in death. Based on the factors above, a replacement for the pet's water bowl is needed.

2.0 OBJECTIVE

Most pet owners work and have no time to fill or give water to pets with the busyness of daily work or go out on vacation for a long period of time. With the presence of this product, the pet's owner does not need to worry about leaving pets while not at home. The main objectives of this project are to design an Auto on/off pet water fountain to provide access to water for the pets and to fabricate a unit of Auto on/off pet water fountain.

3.0 METHODOLOGY

Figure 1 shows finalized design for an Infrared-Powered Smart Pet Hydration Fountain. This is the improved design based on comments and advice given from the lecturer during the presentation. Among the improvement are the shape of the body and the materials used for the body.

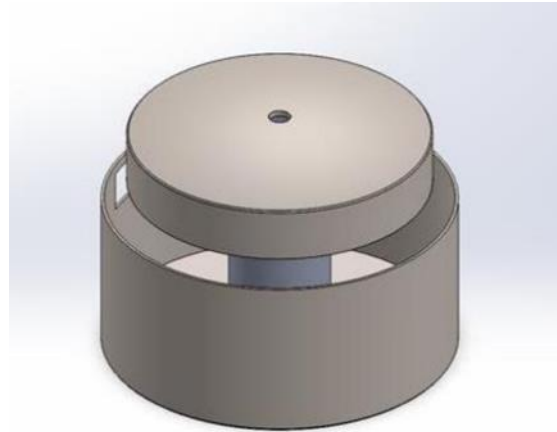


Figure 1: Final detail design

For the fabrication process, it is the process of creating something from semi-finished or raw materials rather than the pre-assembled part to form a complete structure. Examples of the fabrication process are cutting, grinding, welding, polishing, and drilling. This subtopic contains procurements, equipment, tools and step by step fabrications process. Figure 2 shows the step-by-step fabrication for the Infrared-Powered Smart Pet Hydration Fountain.



Figure 2: Fabrication Detail

The product development testing process verifies that the product works as planned. This phase begins once the product requirements have been implemented. Through product testing, manufacturers can set technical standards for their products to produce high-quality materials that achieve the objectives of the product.

4.0 RESULT

Final fabricated working prototype takes place at several phases of the product design process, including early on to test the design's shape, fit, and function and after to ensure that the design details fit technical objectives. Figure 3 shows the complete product with all the components and parts when assembled.

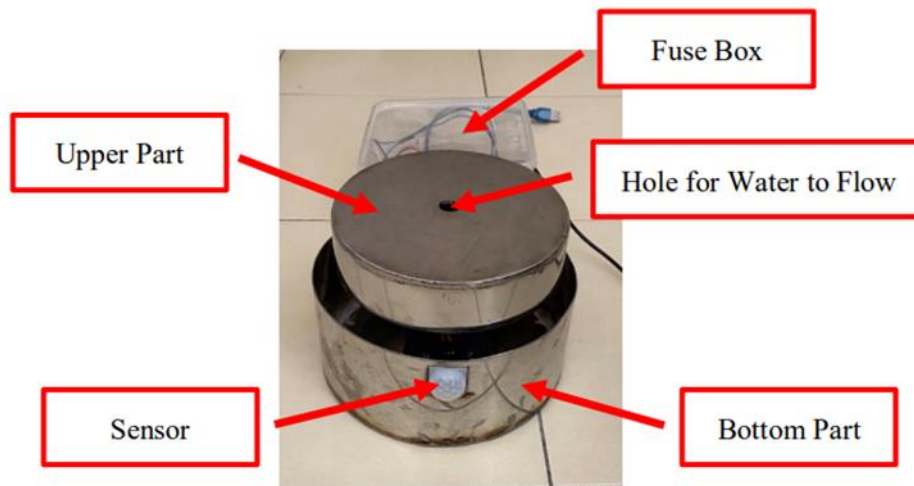


Figure 3: Final fabricated working prototype

5.0 CONCLUSION

Based on the project product, it can be concluded that the design and fabrication Infrared-Powered Smart Pet Hydration Fountain achieved the objectives, which are to design an Auto on/off pet water fountain to provide access water for the pets, and to fabricate a unit of Auto on/off pet water fountain. The prototype managed to get the job done and did it almost perfectly. This product was likewise successfully fabricated according to the specifications in the period provided, which was completed within 7 weeks. Besides, this project has fulfilled all the criteria and customers' requirements. This innovation undeniably has many advantages. The consideration of the need is to make sure a great product is created so that it will satisfy the user. Furthermore, the product also offers satisfaction in terms of portability. Generally, this product has a high chance in the market. Overall, it is hoped this innovation can show potential to be recognized among users.

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WASTED SHELLS, PROTECTED STEEL: A GREEN INHIBITOR FROM THE KITCHEN

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ABSTRACT

Extensive efforts have been devoted to enhancing corrosion control, particularly during engineering systems' design and operational phases, with growing attention on corrosion monitoring techniques. In line with sustainable development goals, kitchen waste has been identified as a potential source of environmentally friendly corrosion inhibitors for mild steel. This study evaluates the effectiveness of kitchen waste extract in inhibiting the corrosion of AISI 1020 carbon steel in a 1 M hydrochloric acid solution. Different extract concentrations were tested over immersion periods of up to 7 days using weight loss measurements. The results revealed that increasing the concentration of the kitchen waste inhibitor led to a significant improvement in corrosion resistance. The highest inhibition efficiency observed indicates the ability of the extract to form a protective layer that suppresses the corrosion process. These findings demonstrate that kitchen waste can serve as an effective and sustainable natural corrosion inhibitor by reducing the rate of metal degradation in aggressive acidic environments.

Keywords: Organic, Mild Steel, Corrosion, Inhibitor, Waste

1.0 INTRODUCTION

Corrosion is a critical issue that significantly affects carbon steel surfaces, particularly in aggressive environments such as acidic and alkaline media commonly found in oil and gas pipelines, boilers, and structural applications. This phenomenon leads to surface deterioration, equipment failure, reduction in mechanical performance and flexural capacity, and weakening of surface bonding characteristics (Nace International, 2016).

Several strategies have been employed to mitigate corrosion, including alloying, reduction of metallic impurities, application of surface coatings, and cathodic protection. Among these, the use of corrosion inhibitors has gained substantial attention due to their cost-effectiveness, simplicity, and efficiency, especially in acidic and alkaline environments. Corrosion inhibitors function by forming a protective barrier on the metal surface, thereby slowing down the electrochemical reactions. They are generally classified into anodic, cathodic, or mixed types, depending on their mechanism of action and their influence on the oxidation and reduction reactions on the metal surface (Mwakalesi, 2023).

Despite their widespread use, conventional corrosion inhibitors are often synthesized from toxic and hazardous chemicals, posing significant risks to human health and the environment. Prolonged exposure to inorganic inhibitors has been linked to adverse health effects in humans, toxicity to flora and fauna, and negative impacts on ecological systems and water quality in both surface and groundwater (Ezughra & Aralu, 2023).

Considering these concerns, there is a growing demand to replace synthetic corrosion inhibitors with eco-friendly, biodegradable, and non-toxic alternatives. Natural substances derived from renewable sources, such as plants including their leaves, roots, peels, fruits, and flowers, have been widely investigated as sustainable corrosion inhibitors. These natural inhibitors are believed to reduce environmental pollution and health hazards while maintaining adequate corrosion protection (Gao et al., 2021; Ghahremani et al., 2021; Haldhar, Prasad, Kamboj, et al., 2021; Haldhar, Prasad, Mandal, et al., 2021; Jane & Matthew, 2021; Lubna et al., 2021; Manohar et al., 2021; Punniyakotti et al., 2021; Rajesh et al., 2020; Zhang et al., 2023; Zhou et al., 2015).

Corrosion inhibitors remain vital to many industrial applications due to their ease of use, effectiveness, and ability to offer in-situ protection without interrupting operational processes. Recent research has focused on exploring naturally derived inhibitors under green chemistry principles, aligning with sustainable development goals and environmental conservation efforts.

2.0 OBJECTIVE

The objective of this study is:

1. To evaluate the characteristics of waste materials through Fourier Transform Infrared Spectroscopy (FTIR)
2. To study the effectiveness of waste materials as corrosion inhibitors for mild steel.

3.0 METHODOLOGY

3.1 MATERIAL SELECTION

In this study, mild steel samples were examined using XRF spectroscopy to analyse their elemental composition. Table 1 is provided for reference.

Table 1: Elemental composition of mild steel

Element	Percentage (%)
Ferrum	99.00
Manganese	0.560
Carbon	0.316
Silicon	0.168
Phosphorus	0.022
Sulphur	0.012
Chromium	0.193
Nickel	0.081
Copper	0.023

3.2 SAMPLE PREPARATION

Sample preparation for this study is shown in Figure 1.

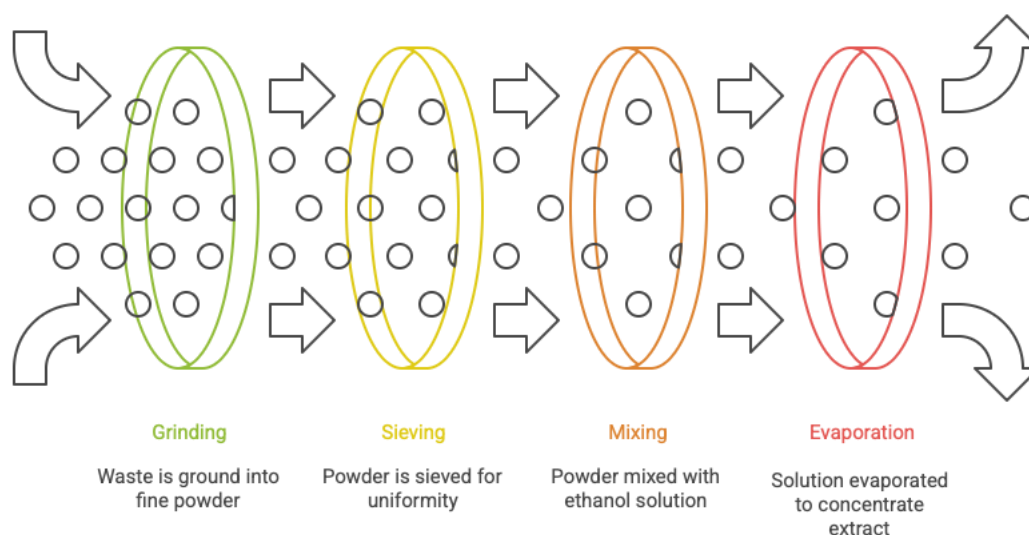


Figure 1: Corrosion inhibitor extraction process

3.2 WEIGHT LOSS DETERMINATION

This study measured static weight loss based on ASTM G1-03 to determine inhibitor efficiency and corrosion rate. It investigated the effect of waste corrosion inhibitors on mild steel in an acidic condition. Figure 2 shows the procedures of static weight loss.

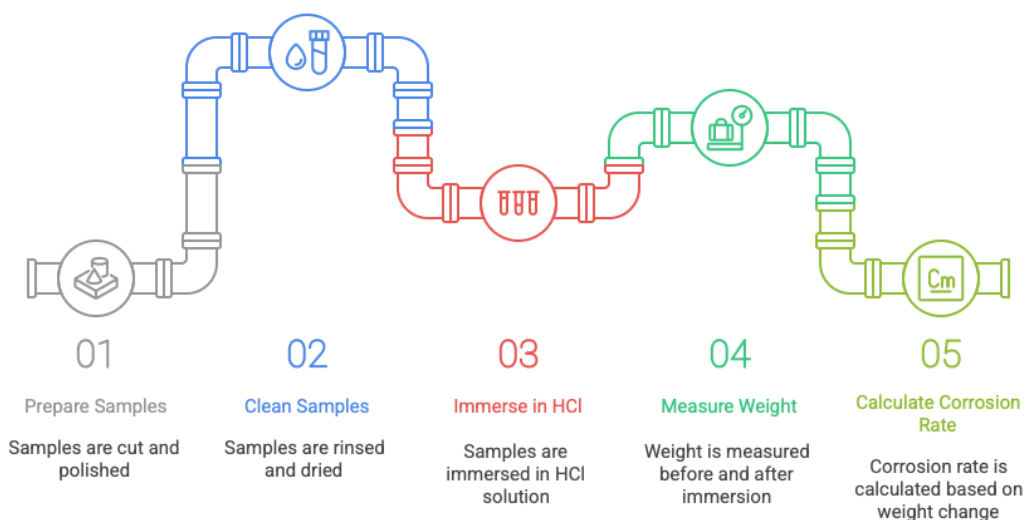


Figure 2: Weight loss procedures

4.0 RESULT

Figure 3 presents the FTIR spectrum of the waste from the kitchen, confirming the presence of heteroatoms and functional groups that are responsible for the corrosion inhibition process. A broad absorption band observed in the 3354.96 cm^{-1} corresponds to O–H stretching vibrations, typically associated with hydroxyl groups or adsorbed water. The peak at 2968 cm^{-1} indicates the stretching vibrations of C–H and CH_2 functional groups, suggesting the presence of organic components in the powder.

A significant peak around 1400.46 cm^{-1} is attributed to the asymmetric stretching of the carbonate (CO_3^{2-}) group, which is a significant constituent of the powder. Furthermore, a prominent peak at 874.39 cm^{-1} corresponds to the out-of-plane bending vibrations of the $\text{C}=\text{O}$ bond, also confirming the presence of the compounds.

These spectral features collectively suggest that the waste materials contain functional groups and heteroatoms such as oxygen, which play a crucial role in the adsorption process onto the metal surface. The presence of these heteroatoms facilitates the formation of a protective film by lowering the adsorption energy, thereby enhancing the inhibition efficiency and protecting the metal surface from corrosion.

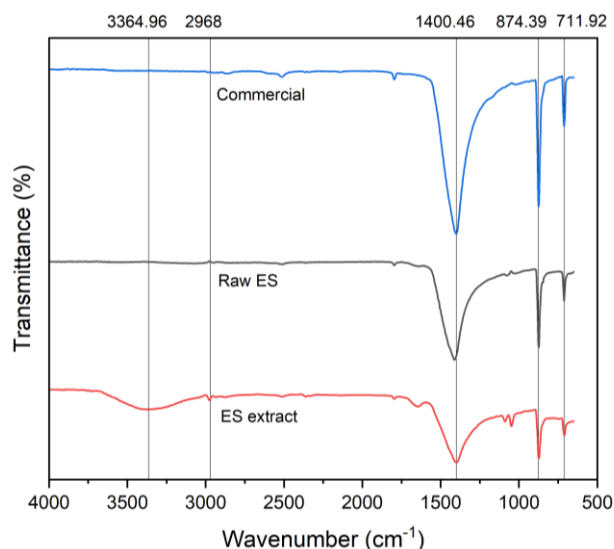


Figure 3: FTIR spectrum of waste materials from the kitchen

The weight loss method was used to compare the concentration of waste materials from 0g, 3g, 9g, and 15g. Figure 4 shows the corrosion rate data and the corresponding inhibitor efficiency (IE). The data shows that after immersion in acidic solutions, the control sample without any additive exhibited the highest corrosion rate of 4.1401 mm/year. In contrast, the addition of 3 grams of inhibitor significantly reduced the corrosion rate to 0.5683 mm/year compared to the untreated sample. Further increases in inhibitor concentration up to 15 grams continued to reduce the corrosion rate, indicating a clear trend of enhanced protection with increasing inhibitor dosage.

Unlike the corrosion rate, the inhibition efficiency showed a direct relationship with the inhibitor dosage. After immersion for 3 grams, the maximum inhibition efficiency of 84.45% was achieved. The highest inhibition efficiency recorded was 96.36% at 15 grams. This indicates that a higher concentration of inhibitors enhances the formation of a protective barrier on the metal surface, mitigating corrosion.

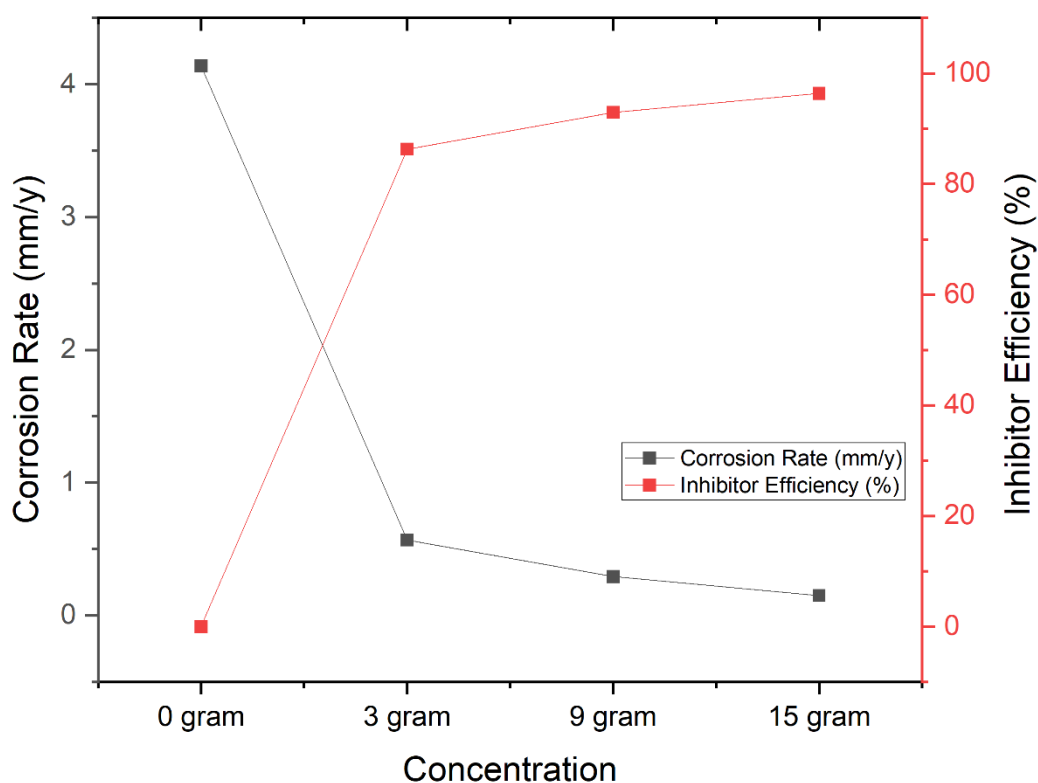


Figure 4: Corrosion rate (mm/y) versus inhibitor efficiency (%)

5.0 CONCLUSION

The findings of this study demonstrate the effectiveness of waste materials from the kitchen as a natural corrosion inhibitor for mild steel in an acidic environment. The presence of carbonyl, confirmed by prominent peaks in the FTIR spectrum, plays a crucial role in forming a protective barrier that inhibits corrosion on the steel surface. Weight loss analysis reveals that increasing the inhibitor concentration enhances the inhibition efficiency, with the highest concentration of 15 grams achieving the most significant reduction in corrosion rate.

Overall, the results highlight the promising potential of waste materials from the kitchen as a green, cost-effective, and sustainable corrosion inhibitor, offering an environmentally friendly alternative to conventional synthetic inhibitors for protecting mild steel in acidic solutions.

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The Immersive AR Sales Dashboard: Real-Time Analytics for Enhanced Retail Decision-Making and Customer Engagement

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ABSTRACT

The Immersive AR Sales Dashboard: Real-Time Analytics for Enhanced Retail Decision-Making and Customer Engagement is a prototype leveraging augmented reality (AR) to enable real-time stock tracking and sales analysis in physical retail environments. It addresses inefficiencies caused by manual inventory management and inadequate demand analysis, which lead to wasted resources and higher operational costs. Built using Reality Composer and integrated with CRM and ERP systems, the dashboard overlays real-time sales data, stock levels, and predictive analytics onto physical shelves. This solution aims to boost customer's engagement by 40% through interactive AR experiences, such as product information and personalised recommendations, while aiding retail managers with data-driven decisions via live metrics like sales trends and inventory status. Providing a user-friendly interface for sales teams and analysts centralises critical KPIs such as stock availability and high-demand product performance into a scalable, immersive platform. The innovation supports sustainable practices by optimising resource allocation. It aligns with market demands for AR-driven business models, offering licensing and SaaS opportunities across retail, manufacturing, and real estate sectors. Through bringing benefits on SDG 8: Decent Work and Economic Growth, SDG 9 Industry, Innovation and Infrastructure, SDG 12: Responsible Consumption and Production, and SDG 13: Climate Action, this ideation could bring new market opportunities, hence enhancing the supply chain management. This AR integration revolutionises sales strategies, improving efficiency, customer satisfaction, and operational sustainability.

Keywords: Augmented Reality, Demand Analysis, Reality Composer, Supply Chain, SDG

1.0 INTRODUCTION

AR sales dashboard is a prototype that blends augmented reality and business analytics in physical retail store. The usage of augmented analytics helps in forecasting capabilities and unintentionally removing human bias in decision-making. AR sales dashboard helps managers and business analysts in making decisions and cutting unnecessary cost such as keeping products that are less demanded by the customers and prevent them from keeping stocks for a long period of time since it will lead to higher cost.

2.0 OBJECTIVE

1. Boost customer's engagement
2. Facilitate retail manager's decision-making process
3. Helping business analyst produce better insight with real place data presentation
4. Deliver real-time data on sales for informed decisions
5. Increase customer's satisfaction

3.0 METHODOLOGY

Building prototype by using Reality Composer in iPad to demonstrate real world environments and virtual environments.

Integrate real time Customer Relationships Management (CRM) and Enterprise Resource Planning (ERP) by building some sales per day over time graph to help user gain information about the sales of a certain product daily.

Creating a user-friendly interface for the sales representatives and customers to help them understand the situation and facilitate them in decision-making.

The idea fits into existing workflow where retailers do not need to change their business plan. They only need to add a simple quick response (QR) code to enable them to track on specific products at specific shelves level and tracking live heatmap on the store floor plan.

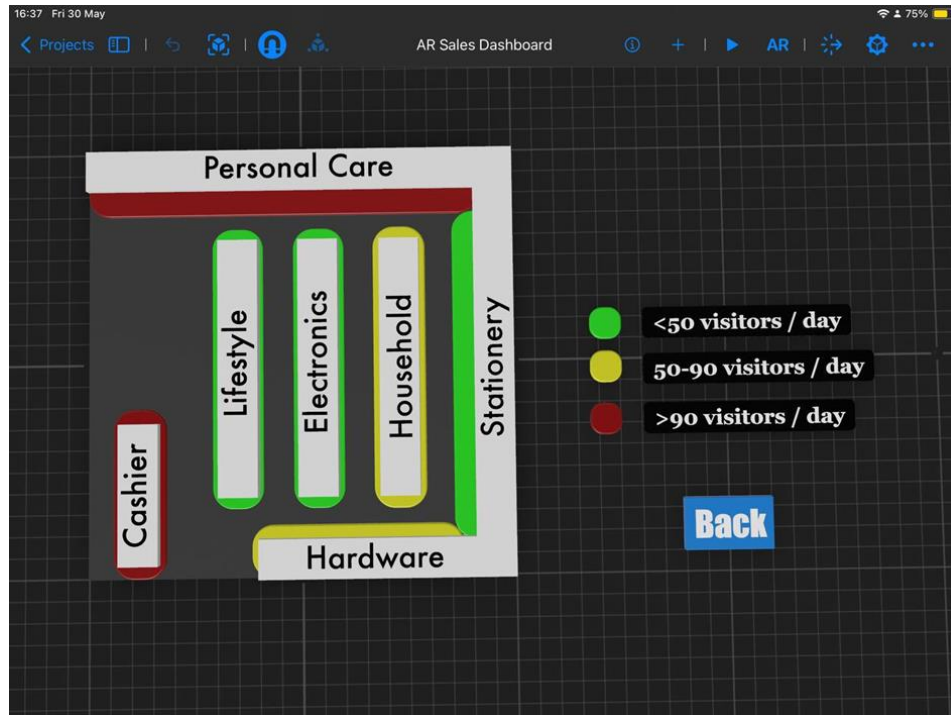


Figure 1: The prototype of heatmap of a retail store in Reality Composer

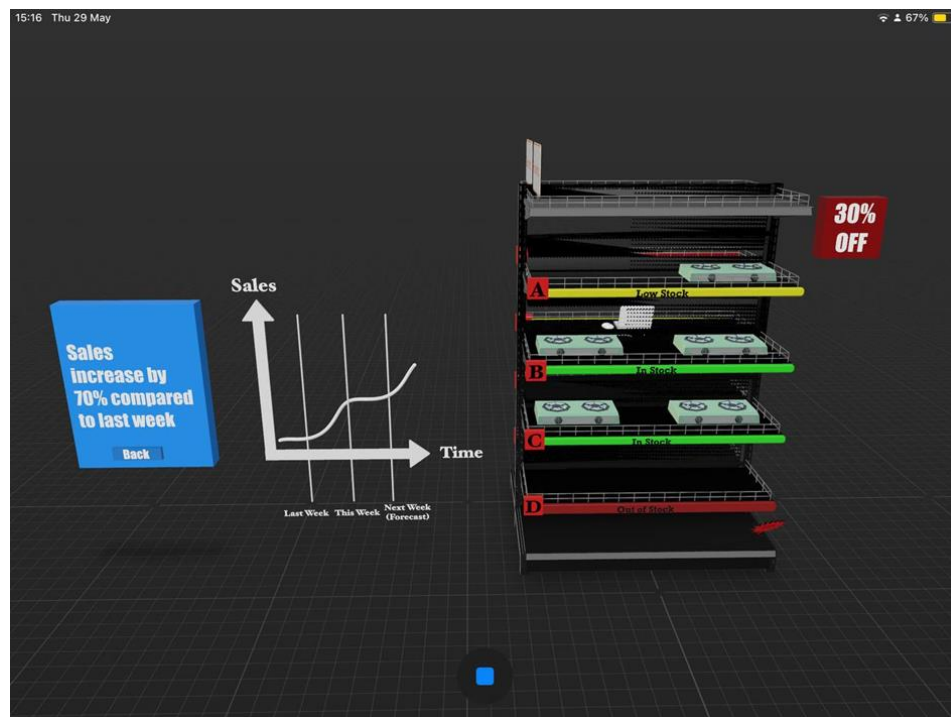


Figure 2: The prototype of product analysis in Reality Composer

The idea is to create user interface and user experience intuitively, easy access and understandable. User retention is highly acknowledged as one of the main success indicators within processes concerning an app. Retention, as defined by Anderson and Narus (2017), refers to the ability of an app to engage itself with a user over a given amount of time. Well-designed user experiences can directly work toward retaining users by ensuring a fun, smooth, and frictionless time spent with an app. A study by Forrester Research (2016) indicated that well-designed user experiences carry people through the

app longer than expected, with research suggesting that a 1% decrease in customer's satisfaction leads to a 10% reduction in retention rates.

It is important to focus on building a design that could persuade consumers to increase their trust in particular brand and facilitate in purchasing the best quality products. AR is most effective when product-related uncertainty is high, demonstrating the technology's potential to increase sales by reducing uncertainty and instilling purchase confidence (Tan, Y.-C., Chandukala, S. R., & Reddy, S. K. (2021)).

In the context of retail innovation, the integration of an AR Sales Dashboard emerges as a transformative tool, redefining collaboration and data-driven decision-making across supply chain networks. Innovation at both retail and vendor levels remains inherently complex, necessitating cross-organisational and multidisciplinary coordination (Nonaka & Takeuchi, 1995; von Hippel, 1994). However, the AR Sales Dashboard introduces a paradigm shift by centralising real-time financial and operational insights, such as invoice tracking, Days of Sales Outstanding (DSO), and buying trends. This innovation fosters dynamic interactions at the buyer–seller interface, where shared access to transparent metrics enables proactive risk mitigation, aligned forecasting, and agile responses to market demands. By bridging information gaps between retailers and suppliers, the dashboard not only streamlines accounts receivable processes, but also cultivates a collaborative ecosystem critical for modern supply chain resilience and efficiency.

Integrating Lean Six Sigma into the development of an AR Sales Dashboard enables retailers to analyse and optimise spatial and operational inefficiencies through heatmaps, fostering data-driven decision-making. By applying the DMAIC (Define, Measure, Analyse, Improve, Control) framework, the dashboard aligns with Lean Six Sigma's goal of reducing waste and enhancing efficiency. In the Define phase, heatmaps identify critical areas like customer flow or product placement. The Measure phase quantifies metrics (e.g., inventory turnover, checkout bottlenecks) via real-time data overlays. During Analyse, statistical tools pinpoint root causes of inefficiencies, such as low sales in low-traffic zones. The Improve phase uses AR simulations to test layout or staffing changes, while the Control phase ensures sustained performance through continuous monitoring. Heatmaps, integrated into the AR dashboard, provide visual insights for cross-functional collaboration, enabling adjustments to product placement, staffing, or promotions to enhance customer's satisfaction and operational agility. This synergy between methodologies streamlines processes, reduces variability, and strengthens supply chain resilience.

4.0 RESULT

After conducting on few online researches through websites, journals, articles and publications, the AR sales dashboard idea is an invention and could bring a new market opportunity for the business owner. Improvements for the prototype could be done and transforming it into an actual product may change the business practice around the world. The live time and live place data presentation help employees to get instant result on the sales, demands and offers that consumer can enjoy. According to Theory of X, and Y by Douglas McGregor, effective communication through data presentation can increase employee's motivation. Employees should also have time to comprehend on their tasks, which gives them an opportunity for growth (Salvendy, 2012). This will lead to better decision-making, thus making this as a medium for them to grow in their career.

5.0 CONCLUSION

The AR sales dashboard is a new way of tracking on-demand products, analysing consumer behaviour, understanding customers segmentation and enhancing decision-making through real place data visualisation. The application of AR is not only beneficial for the business, but also complies with the Sustainable Development Goals (SDG), showing that this prototype will change the business practice for the better.

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TOWER OF CALCULUS

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ABSTRACT

Tower of Calculus is an educational game designed to enhance students' understanding of calculus concepts in a fun and interactive way. Inspired by the physical game Jenga, this activity combines hands-on engagement with intellectual challenge. Each wooden block is numbered and linked to a calculus question, covering topics such as limits, derivatives, chain rule, implicit differentiation, and integration. Players take turns pulling a block from the tower. The number on the block corresponds to a specific question they must answer. A correct answer allows the player to keep his or her block and continue the game. An incorrect answer triggers a penalty, which may include answering bonus questions, skipping a turn, or forfeiting points. To add strategic excitement, players can earn Power Cards by achieving milestones or selecting special blocks, allowing them to skip penalties, freeze opponents, or gain hints. This game not only reinforces mathematical skills but also encourages teamwork, critical thinking, and perseverance under pressure. By transforming abstract calculus problems into a dynamic classroom experience, Tower of Calculus bridges the gap between theory and practice, making learning both memorable and meaningful.

Keywords: Calculus, Tower, Block

1.0 INTRODUCTION

Tower of Calculus is an educational innovation inspired by the classic block-stacking game *Jenga*, aimed at enhancing students' conceptual understanding of calculus through interactive, hands-on learning. The motivation behind this innovation stems from the persistent challenge faced by educators as students often perceive calculus as abstract, rigid, and disconnected from real-life applications. As a result, traditional instructional approaches may lead to disengagement, reduced motivation, and poor content retention among learners.

In order to address these challenges, Tower of Calculus integrates kinesthetic learning and collaborative problem-solving into the teaching of core calculus topics such as limits, derivatives, and integration. The goal is to make abstract mathematical concepts more concrete by allowing students to physically interact with problem scenarios embedded within gameplay. This strategy aligns with research highlighting the positive impact of educational games on student engagement and comprehension.

Studies have shown that board games and gamified learning environments can significantly improve content mastery, motivation, and classroom dynamics. For example, Alejandria et al. (2023) reported that students demonstrated improved understanding of the Periodic Table through a board game approach. Similarly, Othman et al. (2021) and Tukiman (2021) emphasised the effectiveness of STREAM-based and gamification strategies in enhancing mathematical reasoning among school students. Mahat et al. (2018) compared traditional and interactive games in learning integration techniques and found higher levels of engagement and understanding in the gamified group. Furthermore, Pope et al. (2021) highlighted how board games serve as powerful tools to support active learning and reinforce abstract content through repeated, playful practice.

Building upon these foundations, Tower of Calculus introduces a novel approach by merging tactile play, strategic decision-making, and curriculum-aligned question sets into one cohesive learning experience. It aims to not only facilitate understanding but also foster a positive attitude towards learning calculus among secondary and pre-university students.

2.0 OBJECTIVE

This project aims to achieve the following objectives:

1. To promote student engagement and active learning in calculus through gamified instruction.
2. To reinforce understanding of key calculus topics such as limits, derivatives, and integration via interactive practice.
3. To cultivate collaborative learning, critical thinking, and problem-solving skills among students.

3.0 METHODOLOGY

Tower of Calculus is a physical and collaborative board game that adapts the mechanics of the classic Jenga game into an educational tool for teaching core calculus concepts. The game consists of a tower built using 54 color-coded wooden blocks. Each block colour corresponds to a different type of mathematical question or game consequence:

3.1 GAME DESIGN AND COLOR-CODED SYSTEM

The Tower of Calculus incorporates a unique colour-coded block system, each colour representing a different challenge or effect during gameplay. The core mechanic involves players removing wooden blocks from a stacked tower, like the classic Jenga game, but with integrated calculus problem-solving tasks.

Before attempting to remove a block, the player must roll a six-colour dice. The result of the roll determines the colour of the block the player must pull. Each colour corresponds to a specific action:

Table 1: Description of Each Block Colour and Its Function in the Game

Block Colour	Meaning / Action
White	Answer a Geometry question
Black	Answer a Differentiation question
Green	Receive a Power Card
Blue	Answer an Integration question
Yellow	Answer a Limit question
Red	Draw a Penalty Card

All questions are drawn from a card provided based on colour of the block and categorised according to subtopics. Players are given 30 seconds to answer their assigned question. If the answer is correct, they earn two points and may proceed to pull the block using only one hand and stack it. If incorrect, the player will not get any point but can still pull the block and stack it. One-point bonus will be given to player or using powers wisely or surviving a penalty. This rule system enforces academic discipline, encourages critical thinking, and heightens the level of suspense as players strategise not only which blocks to target, but also how confidently they can handle the associated content.

3.2 POINT SYSTEM AND PLAYER INTERACTION

The point and interaction system in Tower of Calculus is designed to promote motivation, accountability, and a balance of challenge and reward. Correct answers award players or teams with two points, while incorrect responses result in no points and a lost opportunity to interact with the tower. Most importantly, no player can proceed with pulling a block, unless they first answer the relevant question correctly. This rule reinforces the educational purpose of the game and creates a strong link between knowledge acquisition and physical engagement.

Green blocks introduce a strategic advantage by allowing players to draw a Power Card. These cards offer special abilities, such as doubling points, skipping penalties, or swapping questions with another player. In contrast, red blocks represent risk and require players to draw a Penalty Card, which might include consequences such as losing points, skipping a turn, or granting an advantage to the opposing team. The game also enforces solo problem-solving—no help or collaboration is permitted during a player's turn ensuring everyone demonstrates independent understanding of the concepts involved.

The game continues until the tower collapses, at which point the player or team with the highest score is declared the winner. This structure transforms traditional learning into a dynamic experience that combines cognitive reasoning, motor coordination, and strategic gameplay. By integrating

mathematical problem-solving with tactile play and layered decision-making, Tower of Calculus provides an immersive and memorable approach to mastering key calculus concepts.

4.0 RESULT

Initial implementation of Tower of Calculus in the classroom demonstrated a marked improvement in student participation, enthusiasm, and engagement during calculus lessons. Students who previously perceived the subject as abstract and intimidating showed increased willingness to participate and attempt problem-solving through gameplay. Feedback gathered through observation and informal interviews indicated that the interactive nature of the game helped demystify complex concepts, foster peer-to-peer learning, and provide a more accessible entry point into topics such as limits, differentiation, and integration.

Teachers noted significant positive changes in classroom dynamics, where learners appeared more confident, collaborative, and expressive. The game environment provided opportunities for formative assessment as instructors could gauge students' understanding in real-time while facilitating or observing gameplay. Moreover, the built-in strategy elements through the use of Power and Penalty Cards, encouraged higher-order thinking, planning, and anticipation, which aligned well with key learning outcomes.

The novelty of Tower of Calculus lies in its unique combination of tactile, visual, and cognitive elements. By transforming passive note-taking into an active learning experience, the game bridges the gap between kinesthetic engagement and rigorous academic content. This pedagogical innovation revitalises the learning of calculus by infusing fun and competitiveness into a subject that is traditionally seen as difficult and rigid.

5.0 CONCLUSION

Tower of Calculus introduces a creative, effective, and student-centred approach to teaching and learning calculus. By combining hands-on physical interaction with gamified learning strategies, the innovation successfully breaks down the complexity of advanced mathematical concepts into engaging and manageable challenges. It not only improves students' conceptual understanding, but also enhances classroom interaction, promotes teamwork, and builds essential soft skills such as communication, decision-making, and problem-solving.

The use of colour-coded blocks, dynamic game rules, and level-appropriate questions ensure the game remains inclusive, scalable, and adaptable to various educational contexts. Its flexibility allows integration across different student levels and learning environments, from high school to pre-university programs. Furthermore, the game supports differentiated instruction by offering multiple levels of difficulty and real-time feedback for learners.

In conclusion, Tower of Calculus has strong potential to be adopted as a supplementary learning tool in mathematics education. Its innovative format redefines how students engage with calculus, transforming it from a feared subject into an interactive, collaborative, and enjoyable experience. With proper implementation and support, this game-based approach could play a significant role in promoting active learning and nurturing a more positive attitude toward mathematics as a whole.

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The development and implementation of Tower of Calculus would not have been possible without the support and encouragement of various parties. We would like to express our sincere gratitude to Universiti Teknologi MARA (UiTM) for providing the platform, guidance, and resources necessary for the success of this innovation. Special thanks are extended to the faculty members, mentors, and academic staff who offered valuable insights and constructive feedback throughout the development process. We also acknowledge the support of fellow colleagues and students whose active participation, cooperation, and enthusiasm played a vital role during the trial sessions. This project stands as a testament to UiTM's continuous commitment to promoting educational excellence, creativity, and student-centred learning in line with the university's vision and mission.

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EMPAYAR KALKULUS: TRANSFORMASI PEMBELAJARAN MATEMATIK MELALUI GAMIFIKASI

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ABSTRAK

Empayar Kalkulus ialah satu inovasi permainan papan pendidikan berasaskan konsep pelaburan seperti Monopoli yang direka khas untuk membantu pelajar menguasai topik utama kalkulus seperti had, pembezaan, dan pengamiran. Permainan ini diwujudkan sebagai pendekatan interaktif bagi menggantikan kaedah pengajaran tradisional yang sering dianggap membosankan dan sukar difahami oleh pelajar. Pemain bergerak di papan berdasarkan gulungan dadu dan akan mendarat di petak-petak yang mempunyai nilai pelaburan atau cabaran soalan. Pemain boleh membeli tanah menggunakan wang permainan atau dengan menjawab soalan kalkulus dengan betul. Petak khas seperti "Fortune" (soalan mudah), "Unfortune" (soalan sukar), dan "Penjara" menambah elemen kejutan dan strategi dalam permainan. Pemain juga boleh menaik taraf tanah dengan menjawab soalan tambahan. Konsep ini menggalakkan pemikiran kritikal, pembelajaran aktif, dan kolaboratif dalam suasana santai. Kajian awal menunjukkan peningkatan minat pelajar terhadap subjek dan kefahaman konsep secara lebih mendalam. Inovasi ini sesuai digunakan sebagai alat bantu mengajar atau aktiviti luar bilik darjah yang menyeronokkan dan bermakna.

Kata Kunci: Empayar, Permainan Papan, Kalkulus

1.0 PENDAHULUAN

Empayar Kalkulus merupakan satu inovasi pendidikan berasaskan permainan papan yang direka khas untuk membantu pelajar menguasai konsep-konsep penting dalam topik kalkulus. Kalkulus merupakan antara cabang matematik yang paling mencabar untuk dikuasai, bukan sahaja oleh pelajar pra-diploma dan diploma, malah turut memberi kesukaran kepada pelajar di peringkat ijazah sarjana muda. Kefahaman terhadap konsep seperti had, pembezaan dan pengamiran memerlukan pelajar berfikir secara abstrak, logik dan berstruktur. Namun begitu, pendekatan pengajaran secara tradisional seperti kuliah semata-mata sering kali gagal menarik minat pelajar dan kurang memenuhi keperluan pelbagai gaya pembelajaran.

Bagi mengatasi cabaran ini, pendekatan berasaskan gamifikasi dan permainan pendidikan telah diketengahkan oleh ramai penyelidik sebagai alternatif yang berkesan. Menurut Alejandria et al. (2023), penggunaan permainan papan pendidikan sebagai alat bantu dapat meningkatkan kefahaman pelajar dalam subjek Sains seperti Jadual Berkala Unsur. Kajian oleh Othman et al. (2021) pula menunjukkan keberkesanan modul STREAM melalui permainan BizMath dalam kalangan murid sekolah rendah. Manakala Tukiman (2021) membuktikan bahawa pendekatan pengajaran kreatif berasaskan gamifikasi mampu meningkatkan penglibatan pelajar dalam pembelajaran statistik.

Melalui pendekatan yang sama, Empayar Kalkulus menggabungkan elemen strategi seperti dalam permainan Monopoli dengan kandungan soalan kalkulus yang merangkumi topik had, pembezaan dan pengamiran. Berbeza dengan permainan biasa, pelajar bukan hanya bergantung kepada nasib semata-mata, tetapi juga perlu menggunakan pengetahuan dan kemahiran menyelesaikan masalah untuk membuat keputusan, membeli hartanah, serta menaik taraf aset bagi membina empayar dan memenangi permainan.

Tambahan pula, Mahat et al. (2018) dalam kajian mereka mendapati bahawa penggunaan permainan interaktif – sama ada dalam bentuk digital atau fizikal – memberikan impak positif dalam pengajaran teknik pengamiran berbanding kaedah konvensional. Pope et al. (2021) turut menyokong pandangan ini dengan menyatakan bahawa permainan papan mampu menjadi alat bantu pengajaran yang berkesan dalam membantu pelajar memahami konsep secara aktif dan menyeronokkan.

Secara keseluruhannya, permainan ini direka bentuk untuk meningkatkan motivasi dan penglibatan pelajar melalui suasana pembelajaran yang menyeronokkan, kompetitif dan interaktif. Ia juga memberikan peluang kepada guru untuk menyampaikan topik-topik kompleks dalam bentuk aktiviti yang lebih menarik, fleksibel dan mudah difahami.

2.0 OBJEKTIF

Diantara objektif kajian adalah:

1. Meningkatkan minat pelajar terhadap pembelajaran kalkulus melalui pendekatan gamifikasi.
2. Menyediakan kaedah pembelajaran alternatif yang menyeronokkan dan mudah difahami.
3. Menggalakkan pemikiran kritikal, kemahiran menyelesaikan masalah dan kerja berpasukan dalam kalangan pelajar.

3.0 METODOLOGI

Permainan dibina berasaskan konsep gamifikasi dalam pendidikan yang menggabungkan elemen strategi, hiburan dan pembelajaran kalkulus. Objektif utama metodologi ini adalah untuk mencipta satu pengalaman pembelajaran yang menyeronokkan, mencabar dan bermakna bagi pelajar menengah atas dan pra-universiti yang sedang mempelajari topik-topik kompleks seperti had, pembezaan dan pengamiran.

Permainan ini dibangunkan berdasarkan model permainan papan klasik pelaburan (seperti Monopoli), tetapi diubah suai dengan memasukkan komponen soalan matematik sebenar sebagai mekanisme utama untuk pembelian, naik taraf hartanah, dan interaksi khas. Reka bentuk permainan memberi penekanan kepada aspek pemahaman konsep melalui pengulangan, aplikasi, dan penyelesaian masalah dalam konteks permainan yang santai.

3.1 REKA BENTUK PERMAINAN

Papan permainan mengandungi pelbagai petak termasuk tapak hartanah, petak khas seperti START, Penjara, Cukai, dan petak 'Fortune'. Pemain akan bergerak mengikut bilangan mata dadu. Pemain boleh membeli tanah yang belum dimiliki atau menjawab soalan kalkulus untuk mendapatkan diskaun atau tanah percuma bergantung kepada peraturan. Pemain juga boleh menaik taraf hartanah dengan menjawab soalan tambahan bagi meningkatkan nilai sewa.

3.2 SISTEM SOALAN & KAD

Terdapat empat jenis kad dalam permainan: Kad Soalan Biasa, Kad Jail (soalan sukar), Kad Fortune (kesan positif/negatif), dan Kad Tapak (menyatakan harga beli, sewa, dan kos naik taraf). Soalan dikategorikan mengikut topik kalkulus (had, derivatif, pengamiran) dan tahap kesukaran. Setiap tindakan penting dalam permainan seperti membeli hartanah, naik taraf atau keluar dari penjara memerlukan pemain menjawab kad soalan yang berkaitan.

3.3 MEKANISME EKONOMI PERMAINAN

Setiap pemain bermula dengan jumlah wang maya yang ditetapkan. Wang diperoleh melalui sewa, bonus petak khas, dan ganjaran atas jawapan yang betul. Setiap kali pemain melepasi petak START, mereka perlu menjawab soalan. Jawapan betul memberi \$3,000 manakala jawapan salah hanya memberi \$1,500. Naik taraf hartanah memberi pulangan sewa lebih tinggi, dan pemain perlu bijak merancang pelaburan berdasarkan kemampuan menjawab soalan dan strategi permainan.

3.4 KEUNIKAN & PENYESUAIAN PENDIDIKAN

Permainan ini tidak hanya fokus kepada hiburan tetapi dirancang untuk meningkatkan kemahiran menyelesaikan masalah, komunikasi dan pemikiran logik pelajar. Dengan memasukkan kalkulus dalam konteks dunia sebenar seperti pelaburan hartanah maya, pelajar lebih mudah memahami aplikasi konsep matematik dalam situasi praktikal. Struktur permainan yang fleksibel juga membolehkan guru menyesuaikan tahap kesukaran dan jenis soalan mengikut keperluan pelajar.

4.0 KEPUTUSAN

Penggunaan permainan ini telah diuji secara rintis dalam beberapa kelas Kalkulus II diperingkat diploma. Maklum balas daripada guru dan pelajar menunjukkan peningkatan minat, penglibatan aktif semasa pembelajaran dan kefahaman konsep yang lebih baik.

Keunikan utama permainan ini ialah gabungan antara strategi permainan hartanah dengan keperluan akademik menjawab soalan kalkulus. Ini membolehkan pelajar belajar secara tidak langsung dalam suasana menyeronokkan.

Pelajar juga menunjukkan peningkatan skor latihan selepas sesi permainan berbanding pengajaran tradisional. Guru melaporkan bahawa pelajar lebih berani bertanya dan lebih kerap berdiskusi semasa permainan dijalankan.

5.0 KESIMPULAN

Empayar kalkulus membuktikan bahawa pendekatan gamifikasi boleh menjadi kaedah berkesan dalam menyampaikan topik-topik sukar seperti kalkulus. Permainan ini bukan sahaja menyeronokkan, tetapi juga memberi manfaat pendidikan yang jelas melalui peningkatan prestasi dan minat pelajar.

Inovasi ini berpotensi digunakan secara lebih meluas di sekolah menengah, kolej atau pusat tuisyen sebagai alat bantu mengajar atau aktiviti kokurikulum. Ia juga boleh dikembangkan ke versi digital atau diperluaskan ke topik-topik matematik lain.

PENGHARGAAN

Terima kasih diucapkan kepada semua pihak yang telah memberi sokongan dan galakan dalam pembangunan inovasi ini, terutamanya UiTM, para pelajar, dan pensyarah yang memberi ruang dan peluang untuk menyertai pertandingan inovasi ini.

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MATHMATTER – STATFARM

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ABSTRACT

StatFam is an educational card game designed to make learning statistics more engaging, interactive, and memorable. Inspired by the classic “Happy Family” game, StatFam helps students reinforce their understanding of key statistical concepts by matching related cards into thematic “families.” Each family represents a subtopic such as Time Series Components, Sampling Methods, Measures of Central Tendency, or Questionnaire Design, with four cards that include keywords and concise definitions. Players take turns requesting cards to complete sets, encouraging active recall, peer interaction, and content mastery. StatFam addresses common challenges in learning statistics, especially rote memorisation and low engagement, by turning abstract concepts into a fun and collaborative activity. The game supports classroom learning, revision sessions, and informal study groups, and it is adaptable to other subjects. With its low-cost design and scalable format, StatFam promotes 21st-century skills such as critical thinking, communication, and collaboration, making it a practical and impactful teaching tool.

Keywords: Family, Statistics

1.0 INTRODUCTION

The learning of statistics often poses a challenge to students due to abstract terminology, numerous subtopics, and the lack of engaging tools to reinforce memory and understanding. Traditional teaching methods—such as rote memorisation of definitions, subtopic classification, and interpretation—may not cater effectively to students with diverse learning styles, particularly visual and kinesthetic learners.

Numerous studies have highlighted the effectiveness of using educational games as supplementary tools in teaching abstract or difficult topics. For example, Alejandria et al. (2023) showed that board games could significantly enhance students’ engagement and conceptual understanding in the periodic table. Similarly, Tukiman (2021) emphasised the importance of gamification strategies such as SLStat in improving motivation and retention in statistical learning. Furthermore, Othman et al. (2021) validated the integration of STREAM elements into educational games to support multidisciplinary learning in primary schools. These findings are echoed in online literature, where Pope et al. (2021) argue that board games serve as powerful cognitive anchors in classroom instruction.

To address this pedagogical gap, MathMatter – StatFam was developed as a card-based innovation that applies game-based learning principles to make the acquisition of statistical knowledge more enjoyable and effective. It allows learners to recall, reinforce, and retain core statistical concepts through an interactive “family collection” mechanism inspired by quartet-style gameplay.

This innovation also supports collaborative and inquiry-based learning, helping students to visually map relationships between subtopics, communicate effectively, and develop critical thinking skills. Inspired by works such as Mahat et al. (2018), which compared traditional versus interactive learning games, this project positions StatFam as a versatile and scalable tool adaptable for classrooms, camps, and remote learning environments.

2.0 OBJECTIVE

The objectives of this innovation are as follows:

1. To design an engaging card-based game that enhances understanding and memorisation of core statistical concepts.
2. To encourage collaborative and inquiry-based learning through gameplay.
3. To provide a reusable and adaptable educational tool that complements conventional statistical instruction in schools and universities.

3.0 METHODOLOGY

MathMatter – StatFam is described in terms of its features, functionality, usefulness, and practicality in the context of statistical learning. The product is a card-based educational game designed to promote the understanding of statistical concepts through interactive, memory-based gameplay. The methodology highlights the structure of the game, the components used, how the game is played, and how it aligns with pedagogical objectives such as reinforcement, engagement, and collaboration. By breaking down the core elements of the game and the process of its classroom implementation, this section outlines how the innovation functions both as a learning tool and as a practical supplement to traditional teaching methods.

3.1 GAME DESIGN AND COMPONENTS

The MathMatter – StatFam game consists of a total of 64 cards, divided into thematic “families” based on key subtopics in statistics such as Data Distribution, Sampling Methods, Time Series, and Measures of Central Tendency. Each family includes four unique cards, each representing one aspect of the subtopic. Every card includes:

- A Family Name (e.g., “Time Series Components”)
- A Card Title (e.g., “Trend”)
- A concise definition
- An optional icon or illustration for enhanced visual recognition

3.2 GAME RULES AND PLAY MECHANICS

The game supports 3 to 6 players or can be played in team format. Each player receives 5 cards at the beginning. Players take turns asking others for a specific card from a specific family (e.g., “Do you have ‘Seasonal’ from ‘Time Series Components’?”). If the opponent has the card, he or she must surrender it, and the asking player gets another turn. If not, the player draws from the draw pile and ends his or her turn. Players form “families” by collecting all 4 cards from the same subtopic. Each family collected is displayed face-up and earns one point.

3.3 FLEXIBILITY AND SCALABILITY

The game is designed to be adaptable across academic levels cards can be customised according to the syllabus. Visual aids, symbols, and keywords are incorporated to aid different learning styles. The gameplay can also be extended to digital platforms in the future.

4.0 RESULT

MathMatter – StatFam demonstrates strong potential as an effective educational tool in enhancing students' mastery of statistical concepts. Through its engaging game-based format, the product promotes active engagement with statistical vocabulary, allowing learners to repeatedly encounter and recall important terms in a low-pressure, interactive environment. This repetitive exposure, combined with the need to communicate and ask questions during gameplay, leads to improved retention, conceptual clarity, and long-term memory.

Observations from preliminary classroom testing conducted with diploma students revealed that participants showed higher enthusiasm, increased motivation, and stronger participation compared to traditional revision practices such as worksheets or textbook exercises. Students appeared more eager to learn, and even weaker learners were more willing to engage in the discussion due to the fun and competitive nature of the game.

Furthermore, the game environment encourages peer-to-peer learning, where students naturally explain definitions and strategies to one another while playing. This contributes to collaborative

discussion, critical questioning, and strategic thinking. Teachers also noted a positive shift in classroom dynamics, with increased interaction and spontaneous learning moments.

The innovation's uniqueness lies in its ability to blend classic "quartet-style" mechanics commonly associated with entertainment into a structured academic framework, focusing on curricular content that is often perceived as dry or difficult. This integration of play and pedagogy is rarely explored in conventional statistical teaching tools, making MathMatter – StatFam not only novel but also pedagogically relevant and effective.

5.0 CONCLUSION

In conclusion, MathMatter – StatFam represents a practical, impactful, and scalable innovation in the realm of statistics education. It addresses key learning challenges by offering an interactive, student-centred approach to reinforce understanding and memorisation of essential statistical concepts. As an alternative to passive revision methods, it enables learners to actively engage with the subject matter, bridging the gap between theory and application through meaningful play.

The game serves as a versatile supplementary tool for teachers, suitable for classroom instruction, group revision, educational camps, or even individual study. Its adaptability allows educators to tailor the content to various academic levels or topics, making it relevant for both school and pre-university environments.

Beyond improving knowledge acquisition, the innovation also nurtures 21st-century skills such as communication, collaboration, critical thinking, and independent learning. The product's modular design further allows for future expansion into other mathematical domains (e.g., algebra, geometry, probability) or transformation into a digital gamified version, which could reach a broader user base through mobile platforms or online learning environments.

Ultimately, MathMatter – StatFam contributes to pedagogical advancement by proving that serious learning can occur through creative and enjoyable methods. Its development reflects a shift towards more inclusive, engaging, and impactful educational practices in line with modern learning needs.

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One-Step Rapid Synthesis of 94.78% Pure Gold Nanoparticles without Post-Processing

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ABSTRACT

Gold nanoparticles (AuNPs) have attracted significant attention due to their unique optical, electronic, and catalytic properties. Among various synthesis methods, the Turkevich method is widely used for its simplicity and cost-effectiveness. Despite the popularity of the Turkevich method, achieving consistently high-purity AuNPs with minimal by-products remains a challenge. This work aims to optimize the Turkevich method by adjusting the citrate-to-gold molar ratio and synthesis temperature to maximize the purity of gold nanoparticles. In this study, AuNPs were synthesized by reducing HAuCl₄ using trisodium citrate at a molar ratio of 2.3 under controlled heating at 90°C. One of the most significant advantages of this approach is its simplicity and speed; the entire synthesis process can be completed in as short as 11 minutes, from the point the gold precursor begins boiling to the final blackcurrant-colored solution. The reaction was monitored by visual color change, and the resulting nanoparticles were characterized using Energy Dispersive X-ray (EDX) analysis. For EDX sample preparation, the AuNP solution was drop-cast onto a glass slide, incubated for 48 hours to dry, and then baked at 100°C for 15 minutes. EDX results revealed a high gold content of 94.78 wt%, with minimal presence of carbon (3.04 wt%), oxygen (1.96 wt%), and sodium (0.22 wt%). No detectable chloride was observed. Notably, this high level of purity was achieved without the need for any post-synthesis purification steps, further enhancing the practicality and efficiency of the method. The modified Turkevich method using a molar ratio of 2.3 at 90°C offers a simple, rapid, yet effective approach to produce highly pure AuNPs with minimized contamination, with potential applications in biosensing, catalysis, and nanomedicine.

Keywords: Gold Nanoparticles (AuNPs), Turkevich Method, High Purity Nanomaterials, Energy Dispersive X-ray (EDX) Analysis

1.0 INTRODUCTION

Gold nanoparticles (AuNPs) have emerged as a vital component in nanotechnology due to their exceptional optical, electronic, and catalytic properties. These characteristics make AuNPs highly suitable for applications in biomedicine, sensing, and catalysis (Bai et al., 2020; Kapil et al., 2021; Milan et al., 2022). Among the various synthesis techniques available, the Turkevich method is one of the most widely used due to its simplicity, cost-effectiveness, and ability to produce nanoparticles in aqueous solutions.

A critical challenge in conventional AuNP synthesis is the presence of excess citrate and non-AuNP components (such as chloride ions) that remain in the product solution and require characterization and removal before use. This is particularly problematic for biological applications, where these contaminants can cause interference, leading to misleading results. For instance, during in vitro cytotoxicity assessments, the presence of excess citrate, rather than the AuNPs themselves, has been shown to reduce cell viability and impair proliferation of human alveolar cells (Balasubramanian et al., 2010).

The motivation for this innovation stems from the need to improve the quality and purity of AuNPs for advanced applications, where contamination from excess citrate and non-AuNP components can significantly affect performance. This study focuses on optimizing the synthesis parameters, specifically the citrate-to-gold molar ratio and reaction temperature to develop a more efficient, reproducible, and scalable method for producing high-purity AuNPs that eliminates the need for post-synthesis purification steps. The synthesis was conducted at a citrate-to-gold molar ratio of 2.3 under controlled heating at 90°C, without involving any post-synthesis purification steps. One of the key advantages of the optimized method is the rapid synthesis time, which can be completed in as short as 11 minutes from heating to nanoparticle formation. The resulting product demonstrates significantly enhanced purity, as

confirmed by Energy Dispersive X-ray (EDX) analysis, indicating its potential as a high-quality nanomaterial for various scientific and industrial applications.

2.0 OBJECTIVE

This study aims to improve the synthesis of gold nanoparticles by focusing on purity, efficiency, and simplicity. The objectives are:

1. To develop an optimized synthesis method for gold nanoparticles (AuNPs) using the modified Turkevich method with fixed citrate-to-gold molar ratio and reaction temperature.
2. To minimize the presence of impurities such as carbon, oxygen, sodium, and chloride in the final AuNP product through controlled synthesis conditions.
3. To establish a synthesis process with a reasonable duration that is simple, reproducible, and scalable for producing high-purity gold nanoparticles for scientific and industrial applications.

3.0 METHODOLOGY

This section describes the detailed steps involved in the synthesis of gold nanoparticles (AuNPs) using the modified Turkevich method. It covers the preparation of reactants, the controlled synthesis process, and the sample preparation for characterization, highlighting the practicality and efficiency of the approach in producing high-purity gold nanoparticles without requiring post-synthesis purification.

3.1 PREPARATION OF SOLUTIONS

Gold (III) chloride solution (HAuCl_4) (99.99% trace metals basis, 30 wt. % in dilute HCl) and trisodium citrate dehydrate ($\text{Na}_3\text{C}_6\text{H}_5\text{O}_7 \cdot 2\text{H}_2\text{O}$) (ACS reagent, $\geq 99.0\%$) were acquired from Sigma-Aldrich and Fisher Scientific, respectively. The synthesis began with the preparation of aqueous solutions of the gold precursor and the reducing agent. A 0.8 mM solution of HAuCl_4 was prepared using deionized water, while a separate 34 mM solution of trisodium citrate was also prepared in deionized water. Both solutions were freshly prepared prior to the synthesis to ensure reactivity and consistency.

3.2 SYNTHESIS OF GOLD NANOPARTICLES

Gold nanoparticles were synthesized by reducing HAuCl_4 with trisodium citrate under optimized conditions. The HAuCl_4 solution was heated to 90°C under constant stirring at 1000 rpm, and upon reaching a consistent boil, a specific amount of 34 mM trisodium citrate was quickly added to achieve a citrate-to-gold molar ratio of 2.3. The procedure for producing high concentration trisodium citrate, up to 34 mM, was adapted from previous work (Dong et al., 2020). The reaction was allowed to proceed at 90°C while the solution was visually monitored for colour change. Within approximately 11 minutes, the solution turned blackcurrant in colour, and the heating was turned off once no further colour changes were observed for 5 minutes. The solution was then removed from the heat and allowed to cool to room temperature. The synthesized AuNP solution was stored at 4°C before subsequent EDX characterization. This rapid and straightforward process did not involve any additional purification steps, making it both time-efficient and economically viable for larger-scale production due to its simplified workflow and reduced processing costs.

3.3 SAMPLE PREPARATION FOR EDX ANALYSIS

To analyse the elemental composition of the synthesized AuNPs, samples were prepared for EDX analysis. A 50 μl volume of the AuNP solution was drop-cast onto a clean glass slide and incubated at room temperature for 48 hours to allow drying of the sample. After drying, the slide was baked at 100°C for 15 minutes to enhance adhesion to the surface. The prepared sample was then subjected to Energy Dispersive X-ray (EDX) analysis to determine the weight percentages of elements present in the synthesized nanoparticles.

4.0 RESULT

The modified Turkevich method demonstrated exceptional performance in producing high-purity gold nanoparticles with remarkable efficiency and reproducibility. The synthesis process achieved a characteristic colour transition from pale yellow (HAuCl_4 solution) to deep blackcurrant consistently within 11 minutes total reaction time, comprising 5 minutes for heating the chloride solution to reach the desired 90°C temperature, followed by citrate addition and 6 minutes of continued heating. The heating was terminated after 6 minutes of citrate addition, as no further colour changes were observed beyond this point, indicating a complete nanoparticle formation.

EDX analysis revealed outstanding purity of the synthesised gold nanoparticles, achieving 94.78 wt% gold content without any post-synthesis purification steps. The elemental composition is presented in Table 1, showing minimal contamination with only trace amounts of carbon, oxygen, and sodium present. Notably, no detectable chloride residues were observed, confirming complete reduction of the gold precursor and effective chloride ion removal.

Table 1: Elemental composition of synthesized gold nanoparticles by EDX analysis

Element	Weight Percentage (wt%)
Carbon (C)	3.04
Oxygen (O)	1.96
Sodium (Na)	0.22
Chloride (Cl)	0.00
Gold (Au)	94.78

The key novelty of this work lies in the optimised citrate-to-gold molar ratio of 2.3, which represents a precise optimisation within the conventional range of 1.5 to 2.8 reported in literature (Dong et al., 2020). This specific ratio, combined with the 90°C synthesis temperature, enables direct production of high-purity nanoparticles without requiring the additional purification steps commonly necessary, such as centrifugation (Wulandari et al., 2008), ion exchange (Zhang et al., 2010), solvent extraction (Shalkevich et al., 2010), dialysis (Aqil et al., 2008), and diafiltration (Sweeney et al., 2006) to remove non-AuNP components. The developed method offers significant practical advantages over existing approaches, including:

- (1) rapid synthesis completion in 11 minutes,
- (2) elimination of time-consuming and costly purification procedures, and
- (3) economic viability for scaling due to simplified workflow and reduced processing requirements.

The results demonstrate exceptional performance with 94.78 wt% gold purity achieved directly from synthesis. The methodology's combination of high efficiency, exceptional purity, and process simplification represents a substantial advancement in nanoparticle synthesis technology with a clear impact for industrial applications and research scalability, establishing this innovation as a significant contribution to the field.

5.0 CONCLUSION

This study successfully developed a modified Turkevich method using a citrate-to-gold molar ratio of 2.3 at 90°C, producing high-purity gold nanoparticles (94.78 wt% Au) without post-synthesis purification steps. The method achieves complete synthesis within 11 minutes with reliable visual indicators, eliminating the need for expensive monitoring equipment. The key innovation resolves the traditional trade-off between synthesis speed and product purity in gold nanoparticle production. This contribution to the scientific community provides researchers with a simplified, reproducible method that reduces dependency on sophisticated analytical equipment, facilitating broader adoption in laboratories with limited instrumentation. The economic implications are significant, offering substantial cost advantages through eliminated purification procedures, reduced equipment requirements, and shortened processing times. The simplified workflow enhances scalability and economic viability for industrial applications, positioning this method as particularly attractive for large-scale production. This advancement establishes a new benchmark for gold nanoparticle synthesis with a clear impact for accelerating the translation of gold nanoparticle technologies from research to commercial implementation across biomedicine, catalysis, and electronics applications. Future work should focus on comprehensive characterisation of particle size distribution, long-term stability, and polydispersity index to further enhance the quality and application potential of the synthesised nanoparticles.

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THE MATH LABYRINTH: LEARNING THROUGH LEVEL

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ABSTRACT

Math Labyrinth is an educational innovation developed as an interactive digital game using the Scratch platform. The aim of the study is enhancing student engagement and mastery of essential mathematical concepts through gamification. The method involves the scratch programming tool, which is a block-based visual programming language developed by the Massachusetts Institute of Technology (MIT) to create coding for games, stories, and animations. Math Labyrinth is structured into three progressive levels. Level 1 focuses on identifying and applying the correct formulas for the area and volume of various 2D and 3D shapes, reinforcing students' ability to recall and use geometric formulas in practical contexts. Level 2 introduces differentiation, challenging players to solve problems involving basic derivatives in calculus, strengthening their understanding of rates of change. In Level 3, students must compute basic integrals, which serves as a bridge between theoretical concepts and practical applications. Math Labyrinth stands out for its creative fusion of interactive gameplay with curriculum-based content, transforming passive learning into an engaging and immersive experience. The dynamic maze structure encourages critical thinking, enhances problem-solving skills, and provides instant feedback, making it suitable for both classroom use and self-directed revision. Its accessible and student-friendly design supports 21st-century learning goals by promoting digital literacy, independent learning, and deeper conceptual understanding. Math Labyrinth not only makes the learning of mathematics more enjoyable and interactive but also nurtures confidence and competency through progressive challenges that cater to diverse student abilities.

Keywords: Maze, Gamification, Mathematics

1.0 INTRODUCTION

In recent years, the integration of game-based elements into educational contexts; commonly referred to as gamification has gained traction as an effective strategy to enhance student engagement, improve learning outcomes, and address the challenges of teaching abstract or complex subjects. In particular, the use of maze-based game mechanics has shown promising results in increasing motivation and cognitive involvement among learners. Antonova and Bontchev (2019) demonstrated that educational maze video games, when embedded with puzzle-based learning strategies, could significantly foster learner motivation and conceptual retention. Their findings suggest that maze structures, which naturally require exploration and problem-solving, are highly compatible with the learning process.

The potential of gamified maze environments has also been explored in online educational tools. Khairunisa (2021) investigated the use of the Maze Chase feature on Wordwall for teaching statistics and probability, and found that learners responded positively to the visual interaction and goal-driven tasks presented in the digital maze. These types of gamification tools were not only enjoyable but also encouraged learners to apply their knowledge to progress through the levels. Similarly, Tukiman (2021) emphasised the effectiveness of SLSTAT gamification pedagogy in enhancing engagement and creative thinking in statistical learning among school students.

Mathematics, especially at secondary and pre-university levels, is often perceived as a difficult and abstract subject, particularly in topics such as differentiation and integration. Mahat et al. (2018) conducted a comparative study between traditional teaching and digital interactive games in learning integration techniques. The study revealed that students exposed to computer-based gamified modules showed better understanding and retention compared to those taught using conventional methods. This supports the argument that interactive and visually guided learning systems are more effective in presenting complex mathematical ideas.

Inspired by these findings and driven by classroom observations of disengagement during traditional calculus lessons, The Math Labyrinth was developed as a digital learning innovation to transform the teaching of key calculus topics into an engaging, problem-solving experience. Built on the Scratch platform, this maze-based educational game integrates curriculum-aligned content within a multi-level structure, allowing students to progress through increasingly challenging questions in geometry, differentiation, and integration. The game requires students to solve mathematical problems correctly in order to unlock new paths and levels, with each stage offering unique visual maps and increasing cognitive difficulty. To complete the game, students must collect virtual keys by answering correctly and use them to uncover a final keyword, ensuring not only task completion but also conceptual mastery.

The Math Labyrinth addresses the need for active, visual, and self-directed learning experiences in the classroom. It supports 21st-century learning goals such as digital literacy, higher-order thinking, and student autonomy. This innovation was designed not only to supplement traditional instruction but also to reimagine how abstract mathematical content can be delivered in a way that is meaningful, interactive, and enjoyable.

2.0 OBJECTIVE

The objectives of this educational game include:

1. To develop a game-based learning tool that makes the learning of geometry, differentiation, and integration more interactive and enjoyable.
2. To promote students' understanding and application of mathematical formulas and concepts through a progressive, level-based maze structure.
3. To support 21st-century learning skills such as digital literacy, critical thinking, and self-directed learning using an accessible platform.

3.0 METHODOLOGY

Math Labyrinth is structured into three progressive levels, each targeting a different mathematical concept and gradually increasing in cognitive difficulty. The main objective of each level is to solve three sequential questions, which must be answered correctly in order to advance to the next level. In addition to solving the questions, players are also required to locate a hidden virtual key within each level. These keys are not merely symbolic; they serve a functional purpose where players must collect all three keys from Level 1, 2, and 3 to unlock the final password at the end of the game, allowing them to complete the challenge successfully.

There are three levels in the game. Below are the details of each level:

- a) Level 1 focuses on geometry, requiring players to identify and apply the correct formulas for calculating the area and volume of various 2D and 3D shapes.
- b) Level 2 introduces differentiation, where players must solve problems involving basic derivatives and rates of change.
- c) Level 3 presents integration, challenging players to compute basic integrals and understand their mathematical significance.

Each level is visually distinct, designed to resemble a unique maze environment that reflects the increasing complexity of the mathematics involved. Immediate feedback is provided for each attempt, allowing students to self-correct and reflect on their understanding. This iterative feedback loop reinforces learning through trial, error, and reward.

3.1 GAME DESIGN AND FUNCTIONALITY

Each level is designed as a digital maze using the Scratch platform, requiring players to navigate through paths, solve problems, and retrieve keys. The maze design incorporates custom-coded scripts for logic control, scoring, and visual interaction. Players move a character through the maze and interact with objects that trigger questions. When a correct answer is given, the path forward is opened. Upon answering all three questions correctly within a level, a virtual key is revealed, which players must collect before continue to the next stage.

The final stage (post-Level 3) includes a password challenge, where players must use all three collected keys to construct or reveal the final password needed to exit the labyrinth. This feature adds a layer of gamified reward and problem-solving, encouraging attention, memory recall, and motivation.

4.0 RESULT

The implementation of The Math Labyrinth in the classroom has shown promising outcomes in terms of student engagement, conceptual understanding, and motivation to learn mathematics, particularly in the topic of Calculus. This game-based learning tool was tested during several class sessions with pre-university and diploma students. Players were required to complete three levels, each consisting of three progressively challenging questions. At each level, students had to find a hidden key, which would later be used to unlock a final password at the end of the game.

The results indicate a noticeable improvement in students' understanding of core topics such as area and volume, basic differentiation, and simple integration. A significant number of students showed better performance in post-activity assessments compared to their initial attempts. In addition, feedback collected through reflection forms revealed that most students found it easier to grasp abstract mathematical concepts when presented visually and interactively through the Scratch-based platform. Many also noted that the challenge of finding hidden keys and answering questions correctly to progress kept them highly motivated and focused throughout the activity.

Moreover, the interactive nature of the game helped reduce students' anxiety towards complex topics like Calculus. The gamification elements in Math Labyrinth allowed students to revise and reinforce concepts in a more relaxed and enjoyable environment. The immediate feedback mechanism enabled students to identify their mistakes and correct them on the spot, which accelerated their learning process. Overall, the findings support the idea that Math Labyrinth is not just an engaging supplementary tool but also an effective formative assessment method that encourages active learning and improves retention.

5.0 CONCLUSION

In conclusion, The Math Labyrinth has proven to be an impactful and engaging educational innovation that transforms traditional mathematics instruction into a more interactive and student-centred experience. By combining curriculum-aligned content with game-based mechanics, Math Labyrinth offers a fresh and meaningful approach to teaching complex topics such as Calculus. Through its maze-like structure and level progression system, students are guided to apply their mathematical knowledge while sharpening their critical thinking and problem-solving skills.

The inclusion of challenges like answering level-based questions, collecting keys, and unlocking a final password creates a unique learning journey that fosters persistence and deeper understanding. Rather than being passive recipients of information, students become active participants in their learning process. This shift in engagement has a lasting impact on their confidence and willingness to approach difficult topics with curiosity and determination.

Most importantly, Math Labyrinth has already been implemented in real classroom settings, particularly during Calculus lessons, and has demonstrated its effectiveness through observable student progress and positive feedback. Teachers found it easier to capture students' attention and sustain participation, while students reported greater enjoyment and improved comprehension compared to traditional lecture-based methods.

Beyond its classroom success, Math Labyrinth holds strong potential for further development and commercialization. Its online accessibility, adaptability to different levels of mathematical proficiency, and compatibility with remote and in-person learning environments make it a versatile tool for educators. With additional modules, automated performance tracking, and broader curriculum integration, Math Labyrinth can evolve into a valuable educational platform suitable for schools, tuition centres, and home learners alike. This innovation represents a forward-thinking step toward modernizing mathematics education while keeping it fun, meaningful, and effective.

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PHYTOGENIC SYNTHESIS OF IRON OXIDE NANOPARTICLES USING *CYMBOPOGON* SP. FOR THE ADSORPTIVE REMOVAL OF AQUEOUS COPPER (II) IONS

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ABSTRACT

The contamination of global water sources by heavy metals such as lead, arsenic, copper, and mercury primarily due to rapid industrialization poses significant environmental and public health concerns. Among various treatment methods, adsorption has emerged as a preferred approach owing to its cost-effectiveness, operational simplicity, high efficiency, reusability, and eco-friendliness. However, the success of adsorption depends on the physicochemical characteristics of the adsorbents, which are influenced by their synthesis methods. In this context, biosynthesis using plant-based materials offers a sustainable and environmentally friendly route to produce nanoscale adsorbents. This study investigates the potential of lemongrass (*Cymbopogon* sp.) leaves extract as a reducing agent for the green synthesis of iron oxide nanoparticles (IONPs) and evaluates their effectiveness in removing copper (II) ions from aqueous solutions. Lemongrass leaves were water-extracted, filtered, and reacted with an iron salt precursor to form IONPs. Fourier Transform Infrared Spectroscopy (FTIR) was used to identify functional groups in both the extract and the synthesized nanoparticles. Functional groups such as O-H, C-H, C=C, and C-O were detected in the extract, while Fe-O bonds confirmed successful nanoparticle formation. Batch adsorption experiments were performed under various conditions, including copper ion concentrations (2000-4000 mg/L), temperatures (25-45°C), and stirring rates (100-200 rpm). The results revealed that adsorption efficiency was significantly influenced by these parameters, with a maximum removal efficiency of 24.26% achieved at 4000 mg/L, 150 rpm, 25°C, and 4 mg/L adsorbent dosage. This study highlights the potential of phylogenically synthesized IONPs as a green and effective solution for heavy metal removal from water and underscores the need for further optimization to improve removal efficiency.

Keywords: Iron Oxide, Nanoparticles, Heavy Metal, Biosynthesis

1.0 INTRODUCTION

Heavy metal pollution in river basins like Selangor and Klang poses serious environmental and health issues due to industrial discharge, mining, and surface runoff. Increases of lead (Pb), nickel (Ni), zinc (Zn), arsenic (As), manganese (Mn), and iron (Fe) have been recorded, with bioaccumulation disrupting ecosystems and causing public health issues. Water sources such as the Selangor River have been classified as Class III, requiring treatment before use. Prolonged exposure to these metals may cause neurological and developmental disorders, while environmental impacts include soil degradation and freshwater toxicity. Though phytoremediation using aquatic plants like *Pistia stratiotes* and *Lemna minor* has shown high removal efficiency, continuous monitoring and stricter enforcement are essential for long-term mitigation.

A number of heavy metal removal techniques have demonstrated high efficiency but face limitations in scalability and sustainability. Photocatalysis using materials like TiO₂ can remove up to 99% of metals such as Cr (VI) and Hg (II), though challenges like light dependence and catalyst degradation exist. Coagulation and membrane filtration methods also report removal rates above 95% but often result in high sludge volumes, fouling, or elevated energy demands. Ion exchange and precipitation methods provide effective removal but are hindered by regeneration costs, pH sensitivity, and waste handling concerns. These limitations point to the need for more sustainable, cost-effective, and adaptable water treatment solutions.

Among developing technologies, adsorption especially using iron oxide nanoparticles (IONPs) offers a promising alternative due to its high efficiency, selectivity, and reusability. IONPs are favoured for their large surface area, magnetic properties, and surface modifiability, enabling enhanced metal binding and

easy separation from water. Studies have shown over 95% removal of heavy metals like Pb^{2+} and As(V) using modified IONPs. However, conventional synthesis methods often involve toxic chemicals and high energy use, raising environmental concerns. In contrast, green synthesis techniques, such as plant-extract-mediated methods, offer an eco-friendly approach by avoiding hazardous reagents and enhancing nanoparticle stability, making IONPs more suitable for sustainable water treatment applications.

2.0 OBJECTIVES

1. To synthesize iron oxide nanoparticles (IONPs) using lemongrass leaf extract as a green agent.
2. To assess the effectiveness of IONPs in removing Cu^{2+} under different conditions.
3. To identify optimal conditions for maximum Cu^{2+} removal using the OVAT method.

3.0 METHODOLOGY

3.1 MATERIALS

Lemongrass (*Cymbopogon* sp.) leaves were collected from a home garden in Tanjung Manis, Sarawak. Copper nitrate [$\text{Cu}(\text{NO}_3)_2$] and iron (III) chloride hexahydrate ($\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$) were obtained from Sigma-Aldrich and used without further purification. Deionized water from the Faculty of Engineering, Universiti Malaysia Sabah, served as the solvent.

3.2 EXTRACTION OF CYMBOPOGON SP. LEAVES

Fresh lemongrass leaves were chopped, washed thoroughly, and sun-dried for two days until constant weight. The dried leaves were ground into powder and mixed at 10% (w/v) with distilled water. The mixture was heated at 80 °C for 3 hours with constant stirring (100 rpm), then filtered using Whatman No. 1 filter paper. The extract was stored at 4 °C for further use.

3.3 IRON OXIDE NANOPARTICLES (IONPs) SYNTHESIS

A 0.1 M $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ solution was prepared and mixed with 50 ml of lemongrass extract. The mixture was stirred at 300 rpm for 30 minutes at 70 °C. The resulting iron oxide nanoparticles (IONPs) were magnetically separated, washed with distilled water, and dried overnight at 80 °C. The final product was stored in a sealed container.

3.4 CHARACTERIZATION OF LEMONGRASS LEAVES EXTRACT

Lemongrass leaves extract was analysed using FTIR (ATR mode, 400-4000 cm^{-1}) at Universiti Malaysia Sabah to identify functional groups in 10 mg of dried leaves powder. The resulting spectrum provided insight into the presence of key phytochemical constituents such as phenols, flavonoids, and terpenoids, which are responsible for the reduction and stabilization of iron ions during nanoparticle synthesis.

3.5 CHARACTERIZATION OF IRON OXIDE NANOPARTICLES (IONPs)

Iron oxide nanoparticles (IONPs) were characterized using FTIR according to the method described in the previous section.

3.6 BATCH ADSORPTION

Biosynthesized iron oxide nanoparticles (IONPs) were evaluated for Cu^{2+} removal from water using batch adsorption. Copper (II) nitrate solutions (2000-4000 mg/L) were stirred at 700 rpm for 30 minutes, then treated with 2 mg/L IONPs and stirred for 1 hour to reach equilibrium. A one-variable-at-a-time (OVAT) method examined the effects of Cu^{2+} concentration (2000-4000 mg/L at 25 °C, 200 rpm), temperature (25-45 °C at 4000 mg/L, 200 rpm), and stirring speed (100-200 rpm at 4000 mg/L, 25 °C). Post-treatment, solutions were filtered and analysed using UV-Vis at 300 nm. Copper levels were determined via a calibration curve, with all tests performed in triplicate.

The adsorption efficiency (%) and adsorption capacity (mg/g) were determined using:

$$\text{Adsorption Efficiency (\%)} = \frac{(C_o - C_t)}{C_o} \times 100 \quad \text{Eq. 1}$$

where,

C_o = Initial concentration of copper (II) ions in mg/L

C_t = Concentration of copper (II) ions at time t in mg/L

$$\text{Adsorption Capacity} \left(\frac{\text{mg}}{\text{gm}} \right) = \frac{(C_o - C_e)}{m} \times V \quad \text{Eq. 2}$$

where,

C_o = Initial concentration of copper (II) ions in ppm

C_e = Concentration of copper (II) ions at equilibrium

m = Mass of the adsorbent (IONPs) in grams

V = Volume of the solution in litres compounds from lemongrass extract

4.0 RESULT

4.1 CHARACTERIZATION OF LEMONGRASS LEAVES EXTRACT

The FTIR analysis of lemongrass leaves extract revealed several key functional groups that support its role in nanoparticle synthesis. Major peaks at 3336.20 cm^{-1} , 2917.62 cm^{-1} , 1561.99 cm^{-1} , and 1031.34 cm^{-1} correspond to O-H, C-H, C=C, and C-O stretching vibrations, respectively. The strong O-H band suggests the presence of hydroxyl-containing bioactive compounds like polyphenols and flavonoids, which contribute to the reduction of Fe^{3+} ions. C-H bands relate to alkanes and methyl groups, commonly found in lemongrass essential oils. The intense C=C band indicates aromatic compounds such as lignin and phenolics, known for their reducing properties, while the C-O band confirms alcohols, esters, and carboxylic acids that serve as stabilizing agents.

Additional peaks, such as the one at 1733.80 cm^{-1} (C=O stretching), further point to carbonyl-containing compounds involved in reduction and stabilization. Low-frequency bands at 472.31 cm^{-1} , 435.23 cm^{-1} , and 405.81 cm^{-1} suggest bending vibrations due to inorganic residues or plant structural features. Overall, the FTIR spectrum confirms that lemongrass extract contains a rich variety of functional groups that effectively contribute to the green synthesis of iron oxide nanoparticles.

4.2 CHARACTERIZATION OF IRON OXIDE NANOPARTICLES

The FTIR spectrum of biosynthesized iron oxide nanoparticles (IONPs), shown in Figure 2, reveals critical peaks that confirm their successful formation and stabilization using lemongrass extract. A prominent O-H stretching peak at 3292.59 cm^{-1} indicates surface hydroxyl groups, from biomolecules in the extract or environmental moisture, which help prevent nanoparticle aggregation and enhance stability. Peaks at 2881.98 cm^{-1} and 2795.94 cm^{-1} suggest the presence of organic compounds adsorbed on the nanoparticle surface, introduced during green synthesis. These organic groups play a key role in capping and stabilizing the nanoparticles. The peak at 1626.20 cm^{-1} corresponds to C=O stretching, further indicating the presence of stabilizing carbonyl groups from plant-based compounds.

Lower frequency peaks at 619.89 cm^{-1} and in the range of $472\text{--}410 \text{ cm}^{-1}$ correspond to Fe-O stretching vibrations, confirming the presence of iron oxide phases such as hematite, magnetite, or maghemite. These Fe-O bands serve as vibrational fingerprints for identifying the crystalline structure and composition of the synthesized nanoparticles. Overall, the FTIR analysis validates the effective green synthesis of IONPs, highlighting the crucial role of lemongrass extract bioactive compounds in reducing, stabilizing, and modifying the surface chemistry of the nanoparticles.

4.3 EFFECTS OF COPPER (II) IONS ON INITIAL CONCENTRATION

The effect of varying initial copper (II) ion concentrations (2000, 3000 and 4000) mg/L on adsorption efficiency. At 2000 mg/L, the adsorption percentage gradually increased with time, reaching 16.4% after 60 minutes without achieving equilibrium, suggesting ongoing adsorption and a capacity of 82,045 mg/g. When the concentration increased to 3000 mg/L, adsorption improved significantly, peaking at 22.85% within 50 minutes and reaching a higher capacity of 169,597.25 mg/g due to a more favourable balance between ion availability and active binding sites.

At 4000 mg/L, the adsorption percentage slightly declined to 17.7%, though the capacity remained high at 175,846.75 mg/g. Equilibrium was reached around 50 minutes, similar to 3000 mg/L. The reduced percentage at this higher concentration resulted from the saturation of active sites despite a stronger concentration gradient. Overall, adsorption efficiency increased with time for all concentrations, emphasizing the influence of ion concentration and contact time on Cu^{2+} removal performance.

4.4 EFFECTS OF COPPER (II) IONS ON STIRRING RATE

The effect of varying stirring speeds (100, 150, and 200) rpm on Cu^{2+} adsorption using green-synthesized IONPs. At 100 rpm, adsorption efficiency increased steadily to 17.98% after 60 minutes, with limited mass transfer slowing the process. Despite slower kinetics, adsorption was stable, and capacity reached 179,820 mg/g. At 150 rpm, adsorption peaked at 25.10% after 50 minutes before slightly declining, due to desorption or uneven mixing. This speed yielded the highest capacity of 251,033.33 mg/g, indicating optimal ion transfer. At 200 rpm, adsorption reached equilibrium quickly, peaking at 17.26%, with a capacity of 166,943.75 mg/g. Although faster mixing enhanced kinetics, it caused agglomeration or desorption. Overall, 150 rpm was optimal, balancing efficient ion transfer and stable adsorption.

4.5 EFFECTS OF COPPER (II) IONS ON TEMPERATURE

The effect of temperature (25, 35, and 45) °C on copper (II) ion adsorption using biosynthesized iron oxide nanoparticles (IONPs) at 200 rpm and a 4 mg/L adsorbent dose. At 25 °C, adsorption started rapidly (12.87% at 20 min) but slowed as active sites saturated, reaching 17.74% at 60 min with a capacity of 175,846.75 mg/g. At 35 °C, adsorption improved, reaching 24.55% at 60 min and equilibrium within 20 min, showing enhanced kinetics and a higher capacity of 193,493.75 mg/g.

At 45 °C, the initial rate was fastest (15.67% at 10 min), but adsorption slowed and later increased, reaching 23.72% at 60 min. The capacity was 181,598.25 mg/g. This two-phase behaviour suggests complex kinetics due to pore diffusion or surface restructuring. Overall, 35 °C yielded the best performance, offering higher adsorption efficiency and faster equilibrium without instability, making it the optimal temperature for Cu^{2+} ion removal.

5.0 CONCLUSION

This study synthesized iron oxide nanoparticles (IONPs) using lemongrass leaf extract as a natural reducing agent and evaluated their performance in removing Cu^{2+} ions from aqueous solutions. FTIR analysis confirmed the presence of functional groups (O-H, C-H, C=C, C-O) and Fe-O bonds, indicating successful nanoparticle formation aided by bioactive compounds like polyphenols and flavonoids. Batch adsorption experiments showed that adsorption efficiency varied with initial Cu^{2+} concentration, temperature, and stirring rate. The highest efficiency (25.1%) and capacity (251,033.33 mg/g) were achieved at 4000 mg/L Cu^{2+} , 150 rpm, 4 mg/L IONPs, and 25 °C. The results highlight the potential of green-synthesized IONPs as effective Cu^{2+} adsorbents for wastewater treatment, though further optimization is needed by adjusting dosage, surface properties, and exploring factors such as pH and reusability.

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TINTED BY NATURE: BEETROOT-BASED LIP AND CHEEK COSMETIC INNOVATION

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ABSTRACT

In response to increasing concerns over synthetic and non-halal ingredients in mainstream cosmetic products, we introduce a plant-based lip and cheek tint formulated with natural beetroot powder and botanical oils. This innovation addresses the growing demand, especially among Muslim consumers, for safe and skin-friendly beauty solutions. The product, named Beet n Bloom, is entirely free from alcohol, porcine-derived substances, synthetic colourants, parabens, and heavy metals. Its formulation emphasises halalan thayyiban principles, where we are utilising naturally derived ingredients such as shea butter, beeswax, jojoba oil, castor oil, and arrowroot powder. These components do not only support halal compliance, but also offer moisturising, emollient, antioxidant, and anti-inflammatory benefits. Despite developing the product through a small-scale laboratory experimentation, the product demonstrated a good stability, texture consistency, and user acceptability. The beetroot-based pigment delivered a soft pink to maroon tint adaptable for both lips and cheeks, offering a natural look that is suitable for daily wear. Though it is not formally halal-certified, the formulation strictly adheres to halal science guidelines, showcasing the viability of religiously aligned, sustainable cosmetic alternatives. This student-led initiative also highlights how educational research can contribute to the ethical product development and local entrepreneurship. With eco-conscious packaging, affordability, and broad consumer appeal, Beet n Bloom presents a strong commercial potential. It not only reflects the emerging trends in clean and inclusive beauty but also aligns with Brunei's vision of expanding its role in regional and global halal innovation, specifically in the cosmetics industry. Future directions including scaling production, exploring product line extensions, and engaging in cross-border collaborations within the ASEAN cosmetics market.

Keywords: Halal Cosmetics, Plant-Based Formulation, Beetroot, Sustainable, Cosmetic Innovation

1.0 INTRODUCTION

In response to rising global demand for transparency, ethical practices, and environmental responsibility, the cosmetics industry has shifted towards clean, sustainable, and culturally inclusive formulations (Ajayi et al., 2024; Shim et al., 2024). This trend is particularly pronounced in Muslim-majority regions, where halal certification significantly influences consumers' trust and purchasing behaviour (Koc et al., 2024). However, many commercial lip and cheek tints still contain *haram* or potentially harmful ingredients such as alcohol, synthetic colourants, parabens, heavy metals, and porcine derivatives, posing concerns for observant Muslims and health-conscious consumers alike (Arshad et al., 2020; Nawwaruddin et al., 2024; Herdiana et al., 2025).

To address this gap, we developed Beet n Bloom, a plant-based lip and cheek tint formulated by using beetroot powder and botanical oils. This formulation is entirely free from alcohol, non-halal animal derivatives, synthetic colourants, parabens, and heavy metals while focusing on antioxidant and vitamin-rich natural sources. It aims to fulfil consumer demands for safe, halal-compliant, and eco-sustainable cosmetics, marking a strategic entry into Brunei's halal cosmetic sector. As a Muslim-majority country with strong potential in the halal economy, Brunei stands to benefit from youth-driven, research-based product development that reflects global trends while upholding local principles. The development of this product provides a compelling model for inclusive, eco-conscious cosmetic formulation. It demonstrates how student-led innovation, grounded in scientific experimentation and ethical intent, can address real-world challenges and contribute to the global clean beauty movement. Ultimately, this

research seeks to bridge the gap between cultural values and cosmetic innovation through the lens of sustainable, plant-based science.

2.0 OBJECTIVE

The objectives of this invention are:

1. To formulate a lip and cheek tint using natural ingredients which are *halalan thayyiban*-compliant.
2. To test and optimise the formulation for colour consistency and texture.

3.0 METHODOLOGY

This innovation used an experimental method to design and evaluate a tint cosmetic for dual usage at the lip and cheek. The experiment was conducted at Ibnu Sina Scientific Laboratory Centre, Sinaut Campus, Sultan Sharif Ali Islamic University.

3.1 INGREDIENTS SELECTION

The key ingredients include beetroot powder for pigmentation, shea butter for moisturisation, beeswax for texture and binding, jojoba oil and castor oil for hydration, and arrowroot powder for consistency and absorption.

3.2 PROTOCOL

A Bunsen burner was assembled for heating. A 3 g of shea butter was then heated in a beaker until melted. Then, 1 g of beeswax and 0.6 g of arrowroot powder were simultaneously added. After removing from heat, 5 drops of castor oil and jojoba oil, respectively were incorporated until the mixture was combined. Next, 2 teaspoons of beetroot powder were added and swirled until the colour was evenly distributed. Once it smooth and uniform, it was then transferred into a bamboo container. Finally, it was allowed to cool and solidify at a room temperature for 5-7 minutes.

3.3 FEATURE

All ingredients used are *halal* and free from restricted or toxic chemicals, including porcine, human and insect-derived constituents (Sugibayashi et al., 2019). In contrast to synthetic ingredients, which are linked to health conditions such as allergic reactions and long-term toxicity, natural components have shown their potential as a safer alternative in cosmetics (Roy and Rhim, 2021). Beetroot powder is the main colourant of the cosmetic. Beetroot contains a betalain pigment which has a deep red colour, abundant in polyphenols, phenolic, and Vitamins C and E that contribute to its antioxidant property (Chen et al., 2021). The base of the cosmetic is composed of shea butter, a dense yellow fat from Shea tree nuts, and beeswax, a thick secretion from worker bees. Both are known for their emollient and occlusive characteristics, which can smooth and retain the moisture in the epidermis, respectively. Importantly, shea butter and beeswax have been shown to hinder trans-epidermal water loss (TEWL) more in comparison to mineral oil (Ayanwolo et al., 2021; Nong et al., 2023). Furthermore, beeswax commonly contains a high level of propolis, which gives it antioxidant, anti-inflammatory, and antimicrobial features (Nong et al., 2023). Arrowroot powder, a white starch derived from the root of *Maranta arundinacea*, is used as a thickening agent and has an absorbent property that can lessen excess oil and sebum in the skin (Nair et al., 2023). Overall, the natural formulation reinforces the product's *halal* compliance and safety profile, while offering a range of skin benefits.

3.4 FUNCTIONALITY AND USEFULNESS

This cosmetic is a 2-in-1 innovation which produces a balm and functions to tint both lip and cheek. It aims to enhance the user's appearance with shades of pink to red, attributed to beetroot as the main colourant. It also plays a role in maintaining the moisture of the lip and cheek due to the ability of base ingredients to reduce TEWL. Castor and jojoba oils help retain moisture in the skin and lips, as well as possess antimicrobial, anti-inflammatory, and wound-healing bioactivities (El Sherif et al., 2023; Nastiti et al., 2024). Thus, chapped lips and blemish skin can be minimised by the healing properties of the oils.

3.5 PRACTICALITY

The practicality of the product is to provide convenience to the users by utilising one dual-function cosmetic instead of two separate entities. Natural and renewable ingredients used emphasise the importance of sustainability, which decreases toxic chemical usage and lessen carbon footprint. Importantly, ingredients used are obtained from *halal* and ethical sources, thus strengthening the main

objectives of the innovation. Furthermore, the product uses a packaging that is made from bamboo, highlighting the eco-friendly practice in the production.

4.0 RESULT

The final outcome of this project is the successful formulation of Beet n Bloom, a dual-function lip and cheek tint that combines aesthetic performance with halal-compliant and skin-safe ingredients (Figure 1). The product demonstrates significant advantages in formulation, novelty, and practical use.



Figure 1: Beet n Bloom.

The base of the balm is composed of shea butter, beeswax, and arrowroot powder. Together, these ingredients contribute to the product's firm yet smooth texture, ease of application, and skin-nourishing properties (Ayanwolo et al., 2021; Nong et al., 2023). Their natural composition supports skin hydration and repair while ensuring the balm remains stable at room temperature. Arrowroot powder, in particular, was selected for its absorbent qualities and suitability for sensitive, blemish-prone skin without reliance on synthetic agents such as talc or parabens (Nair et al., 2023).

In addition to providing healing properties, castor oil and jojoba oil are added to enhance the shine and stabilise the colourant pigment (Galus et al., 2024; Nastiti et al., 2024). The main colourant, beetroot powder, is added to the balm, which results in the appearance of a smooth and homogeneous maroon colour (Figure 2). When applied to the lip, a sheer and lightweight pink appearance can be observed. Whereas the colour has a more neutral shade when blended on the cheek. Overall, the innovation offers a suitable balm product for everyday use for a natural look.



Figure 2: The colour of Beet n Bloom is attributed to the beetroot powder.

This innovation highlights the substitution of commonly used synthetic or haram ingredients with natural, plant-based alternatives. Examples include beetroot powder in place of insect-derived carmine, arrowroot powder instead of gelatine or animal-based thickeners, and botanical oils as replacements for potentially porcine-derived solvents such as glycerine. The formulation is also free from alcohol and artificial preservatives, aligning with halal science principles and ethical cosmetic standards (Sugibayashi et al., 2019). Additionally, Beet n Bloom utilised recyclable packaging that aligns with eco-conscious consumer expectations (Figure 1).

The impact of Beet n Bloom extends beyond its immediate cosmetic function. It addresses the growing demand for ethical beauty products, particularly among Muslim consumers and other value-driven markets. This innovation allows consumers to express their aesthetic preferences without compromising religious beliefs, ethical concerns, or skin safety. In a broader context, the project contributes to raising awareness about potentially harmful ingredients in conventional cosmetics and demonstrates how student-led research can influence product development in emerging halal industries. It also supports local entrepreneurship and encourages Brunei's role in regional halal innovation, especially in the ASEAN cosmetics market.

In terms of performance, the final formulation demonstrated stability, consistency, and high user acceptability. The product presented a semi-solid, balm-like texture that applied smoothly and offered blendability for both lips and cheeks. The use of beetroot powder provided a consistent pinkish-red hue across multiple batches without the need for synthetic dyes. In ambient conditions, the product maintained visual and textural stability for up to four weeks, suggesting a viable shelf-life even without chemical preservatives.

Though the product does not carry formal halal certification, it was developed in full alignment with halal science principles, offering an implicit guarantee of religious and ethical integrity. The use of beetroot and small-scale laboratory processes also highlights a sustainable and regionally relevant pathway to innovation. Moreover, the project stands out for being developed entirely by undergraduate students, demonstrating how educational institutions can be fertile ground for research-based commercial innovations. This original approach, rooted in cultural relevance, represents a novel and impactful contribution to the field of natural cosmetics.

5.0 CONCLUSION

This project successfully achieved its objective of formulating Beet n Bloom; a natural lip and cheek tint derived primarily from beetroot and other plant-based ingredients. Through methodical experimentation, the team was able to develop a safe, stable, and effective cosmetic product that avoids the use of alcohol, synthetic dyes, and harmful preservatives. The product demonstrated excellent performance in terms of colour consistency and environmental safety. The optimised formulation maintained a desirable texture and natural pigmentation while offering moisturising and antioxidant benefits. These findings confirm that natural, plant-derived ingredients can be effectively used to create multifunctional cosmetics that align with religious and health-conscious consumer values.

The contribution of this work to the scientific community lies in its demonstration of how halal-conscious formulation and botanical chemistry can intersect to create a viable commercial product. It highlights the potential of beetroot as a dual-purpose cosmetic ingredient that serves both as a natural pigment and a skin-beneficial active compound rich in antioxidants. Additionally, this research contributes to the field of green formulation and sustainable cosmetic development, particularly within the context of small-scale, student-led innovation.

From an economic standpoint, Beet n Bloom presents strong commercial viability due to its low-cost, locally sourced ingredients and appeal to niche markets, such as halal beauty and eco-conscious consumers. Its affordability, simplicity in formulation, and ethical positioning open opportunities for market entry not only in Brunei but also across broader Southeast Asian and global markets. Moreover, the development of Beet n Bloom as a locally produced innovation supports national goals of promoting entrepreneurship, halal product certification, and youth-led research and development. With further refinement and support for commercialisation, this innovation has the potential to evolve into a scalable, exportable product contributing to both scientific advancement and socio-economic growth.

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DESIGN OF CARBON-BASED ANTIMICROBIAL PACKAGING MATERIALS WITH INTERGRATED COLORIMETRIC SENSOR FOR BACTERIAL CONTAMINATION DETECTION

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ABSTRACT

Foodborne pathogens, including bacteria, viruses, and parasites, can cause illness when consumed through contaminated food or water. These pathogens can lead to a range of diseases, from mild gastroenteritis to severe, potentially fatal conditions. Therefore, the development of antimicrobial food packaging is highly necessary to significantly reduce foodborne illnesses caused by these pathogens. Carbon-based materials have recently attracted great attention for food packaging applications due to their ability to enhance barrier properties, mechanical strength, sensing capabilities, and resistance to environmental factors. Among them, carbon nitride (C_3N_4) has been reported as a promising photocatalytic antibacterial agent owing to its metal-free composition, simple synthesis, appropriate band structure, good stability, and biocompatibility. Furthermore, its properties as a visible-light-excited photosensitizer allow for a tunable band gap, enabling its potential application as a colourimetric sensor. In this study, an antimicrobial food packaging integrated with a paper-based colourimetric sensor is proposed. The food packaging will be prepared from a composite of cellulose and C_3N_4 as the antibacterial agent. Meanwhile, the paper-based colourimetric sensor, integrated with the food packaging, will be prepared by modifying C_3N_4 with dyes and metals such as gold (Au) or silver (Ag). When the food becomes contaminated by bacteria, it releases volatile organic compounds (VOCs), such as methane, which will react with the sensor by altering its band gap and consequently changing its colour. The integration of carbon nitride-based antimicrobial food packaging with a paper-based colourimetric sensor presents a promising strategy for both extending shelf life and enabling real-time detection of bacterial contamination. This dual-function approach could significantly improve food safety by offering a simple, cost-effective, and visual indication of spoilage or contamination.

Keywords: Antibacterial, Carbon Nitride, Sensor, Food Pathogen.

1.0 INTRODUCTION

According to the World Health Organization (2024), contaminated food containing microbes such as bacteria, viruses, or parasites causes more than 200 diseases, ranging from diarrhoea to cancers. Common foodborne pathogens, including Salmonella, Campylobacter, and enterohaemorrhagic Escherichia coli, affect millions of people worldwide each year, sometimes leading to severe and fatal outcomes (Malabadi et al., 2024). The emergence of multidrug-resistant bacteria further highlights the urgent need to advance research and development of effective antimicrobial agents. Today, most of the food we purchase, regardless of its source, is artificially packaged. These packaging materials often consist of synthetic substances, ceramics, petroleum products, paper, glass, paperboard, wax, or cardboard (Muncke, 2012). Unfortunately, bacterial growth in packaged food remains a significant problem, impacting millions of consumers globally (Raul et al., 2022). Moreover, conventional food preservation packaging has caused significant environmental problems (Raul et al., 2022), and the development of alternative materials for food packaging is recommended.

In the past few years, carbon-based materials have found various applications in industries, including smart food packaging. Carbon-based materials such as carbon nanotubes (CNTs), graphene, and fullerenes have shown remarkable antibacterial and antifungal properties (Zinatloo-Ajabshir et al., 2022). However, the biocompatibility of these materials is still low, and functionalization is required to reduce their toxicity to humans. On the other hand, other carbon-based materials like carbon nitride (CN) have attracted wide attention from researchers globally due to their unique physical and chemical properties, such as non-toxicity, safety, metal-free composition, chemical and thermal stability, and a

tunable bandgap (Deshmukh et al., 2023). Therefore, CN has high potential to be developed as an antibacterial agent in food packaging materials. In this study, CN is proposed as a carbon-based antimicrobial agent for the production of smart packaging materials. Moreover, owing to CN's tunable band gap, which can cause a colour change, it is proposed that CN can be developed as a colourimetric sensor integrated with food packaging to signal contamination when the sensor's colour changes.

2.0 OBJECTIVES

1. To investigate the antibacterial and antimicrobial potential of carbon nitride (CN) as a safe and biocompatible material to be used in smart food packaging.
2. To develop and optimise carbon nitride-based smart packaging materials that can effectively inhibit bacterial growth and enhance food preservation.
3. To design and evaluate a CN-based colourimetric sensor integrated into food packaging for real-time detection of food contamination through visible colour change.

3.0 METHODOLOGY

3.1 Material Preparation (Smart Packaging)

The smart packaging materials will be prepared by using cellulose and incorporating CN as an antimicrobial agent in the cellulose matrix. The melamine will be used as a CN precursor and calcined at 550 °C to form a graphitic CN, followed by fabrication of cellulose/CN composite via a hydrothermal method (Figure 1).

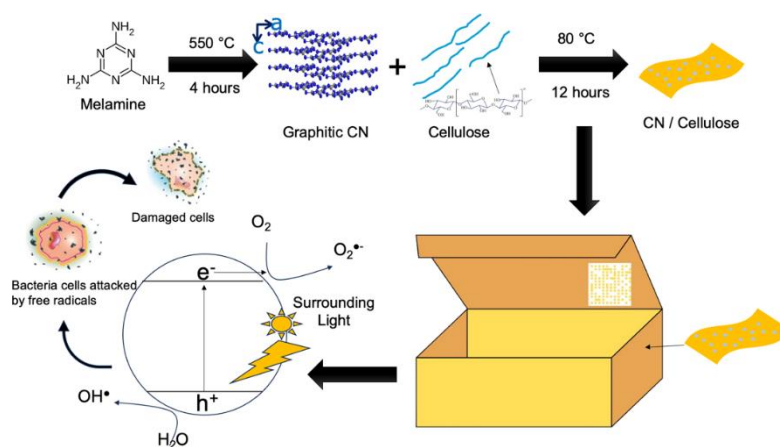


Figure 1: Preparation of Carbon-based Smart Packaging Materials

3.2 Material Preparation (Colourimetric Sensor)

The colourimetric sensor will be prepared by using modified CN with Au/Ag as shown in Figure 1. The CN will be prepared by a facile synthesis method using melamine as CN precursor and the addition of Ag/Au and calcined at 550 °C. When VOCs (e.g., aldehydes, amines, alcohols, ketones) come into contact with the sensor surface, they are adsorbed onto the carbon nitride layer. This adsorption can happen through: Hydrogen bonding, π - π interactions, dipole-dipole interactions and electrostatic interactions. The interaction between VOCs and surface groups of $g\text{-C}_3\text{N}_4$ causes a change in its electronic structure (band gap alteration or energy level shifts). VOC molecules may act as: Electron donors or acceptors, altering charge density, Proton sources, affecting surface pH or protonation state. Moreover, optical transition change may influence the light absorption properties of the material, typically shifting its absorption wavelength (called a bathochromic shift if red-shifted, or hypsochromic shift if blue-shifted). This manifests as a visible colour change, which may vary depending on VOC concentration, exposure time, and specific type of VOC. The colourimetric response is easily observable

without instruments and can be designed to be reversible or irreversible, depending on the application (e.g., permanent change for food spoilage).

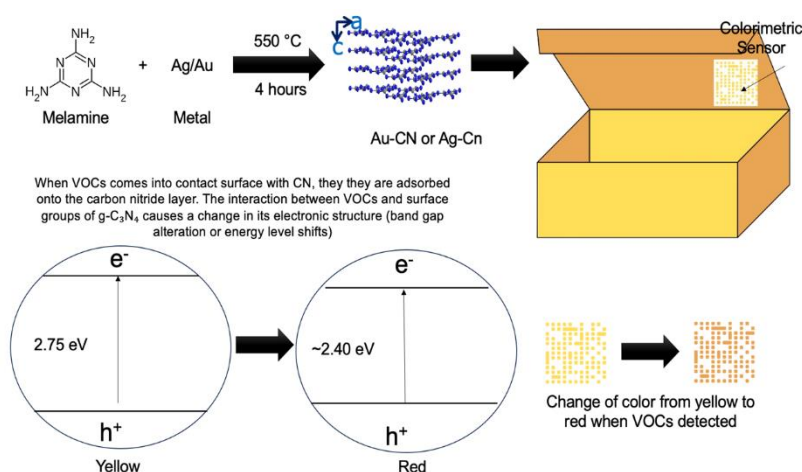


Figure 2: Preparation of a Colourimetric sensor integrated into smart food antimicrobial packaging.

4.0 EXPECTED RESULTS

It is expected that CN will have a significant impact on both antimicrobial properties and colourimetric sensing. The smart food packaging prepared from CN will exhibit antibacterial effects, while the detection of VOCs produced by the metabolism of bacteria on the CN colourimetric sensor will greatly enhance the detection of spoiled foods, thus preventing critical illnesses caused by foodborne pathogens. Hypothetically, when bacteria are present in the food, they produce VOCs such as methane, which are then detected by the colourimetric sensor. A change to yellow colour indicates the presence of VOCs and subsequently signals the presence of bacteria. Figure 3 shows a summary of the proposed project and its commercialisation potential. It is expected that this packaging solution will combine cellulose and carbon nitride with antimicrobial properties and colourimetric VOC sensing. This approach enables real-time spoilage detection, promotes health safety, and offers a sustainable, scalable alternative. Compared to existing tech-based smart packaging or passive films, our solution is simpler, safer, and more cost-effective.



Figure 3: Carbon-based Materials for Smart Food Packaging with Integrated Colourimetric Sensor

5.0 CONCLUSION

The integration of carbon nitride-based colourimetric sensors with biodegradable cellulose offers a novel, sustainable solution for real-time food spoilage detection. By enhancing food safety, reducing waste, and building consumer trust, this smart packaging innovation outperforms conventional technologies through its simplicity, safety, and cost-efficiency—making it a practical choice for scalable commercialisation in modern food supply chains.

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COFFUEL: A CIRCULAR ECONOMY APPROACH TO VALORISING SPENT COFFEE GROUNDS (SCG) INTO SUSTAINABLE MULTI-DEODORISING POUCHES

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ABSTRACT

Globally, over 9 million tons of coffee waste are generated annually, with approximately 60% consisting of spent coffee grounds (SCG). Rich in bioactive compounds such as antioxidants and antimicrobial agents, SCG presents valuable potential beyond disposal. If left unmanaged, this waste contributes to environmental pollution and greenhouse gas emissions. Given the scale of this challenge, innovative solutions are needed to repurpose coffee waste sustainably. Coffuel is a sustainable innovation that transforms organic spent coffee grounds into natural deodorising pouches. It contributes to food waste valorisation by upcycling spent coffee grounds into a useful product, while providing a natural and eco-friendly alternative to synthetic air fresheners for managing odours in everyday settings. With global coffee consumption producing significant organic waste daily, this project aligns with circular economy principles by giving a second life to spent grounds through low-cost and halal-compliant applications. In this pilot project, coffee waste was collected from three volunteered local cafes, dried, and formulated into a breathable pouch using non-woven food-grade fabric. These were placed in commonly odorous areas, including toilets, refrigerators, and shoe racks. A sensory evaluation using a hedonic scale and different-from-control (DFC) method were conducted to assess odour intensity reduction. Additionally, a preliminary mould growth study was performed to observe the microbial safety and shelf-life potential of the pouches over time. This innovation supports SDG 3, SDG 11, and SDG 12, emphasising its relevance to sustainable living and waste reduction.

Keywords: Circular Economy, Spent Coffee Grounds, Coffee Waste Valorisation, Sustainability, Halalan Thayyiban-Compliant Product Innovation

1. INTRODUCTION

Coffee is one of the most consumed beverages globally, generating millions of tonnes of spent coffee grounds (SCG) each year, about 650 kg per ton of brewed coffee (International Coffee Organization, 2025). Despite their rich organic content, including cellulose, lignin, proteins, and bioactive compounds, SCGs are often discarded, contributing to environmental pollution (Sidlo & Latosinska, 2024). The global SCG market is projected to grow from USD 651 million in 2024 to nearly USD 1.4 billion by 2031 (Singh, 2024). In line with circular economy principles, SCGs have potential uses in pharmaceuticals, cosmetics, fuel, fertilisers, and biodegradable products. Additionally, their deodorising, antimicrobial, and moisture-absorbing properties make them beneficial for household and industrial applications (Mai & Thinh, 2019).

In household settings, spent coffee grounds (SCG) act as natural deodorisers due to their porous structure, which adsorbs odour-causing compounds, and antimicrobial bioactive components like polyphenols, caffeine, and chlorogenic acids (Sidlo & Latosinska, 2025; Mai & Thinh, 2019). These also inhibit bacteria and fungi, while their moisture-absorbing ability helps reduce humidity and mould in enclosed spaces (Campos Vega et al., 2015). Beyond domestic use, SCGs are explored for wastewater treatment, biofuels, and soil amendments (Ballesteros et al., 2014). The current study presents Coffuel, a multi-deodoriser repurposed from SCGs into breathable pouches for odour-prone areas like toilets, refrigerators, litter boxes, car interiors, and shoe racks. The name combines "coffee" and "fuel," reflecting the reuse of coffee waste as a source of freshness and sustainability. Supporting SDGs 3, 11, and 12, Coffuel offers a natural, *halalan thayyiban*-compliant, and low-waste odour control solution.

2. OBJECTIVES

This research aims to develop Coffuel, a deodorising-pouches made from spent coffee grounds (SCG) as a sustainable, low-cost, and *halalan thayyiban*-compliant odour management solution. It

evaluates their effectiveness through sensory assessments using hedonic odour ratings and Difference-From-Control methods and examines shelf-life and microbial safety by monitoring mould growth over time.

3. METHODOLOGY

3.1 Raw Materials and Equipment Used

The materials used in this study include spent coffee grounds, non-woven food grade fabric pouch, and natural aromatic ingredients like kaffir lime leaves, lemongrass, cloves, cinnamon, and essential oil. To improve texture and binding, a small amount of corn starch was added to enhance shelf stability. Equipment tools such as drying oven, cooking pan, trays, mixing bowls, metal moulds, aluminium foil, and measuring instruments were used during product preparation. For product evaluation, materials included standard sensory evaluation forms, scoring sheets, and packaging for sample distribution. Basic tools for preliminary food quality testing, such as storage containers and visual inspection tools, were also utilised to monitor shelf-life characteristics like mould growth.

3.2 Collection and Preparation of Coffuel Deo-Pouch

The spent coffee grounds (SCG) were collected from 3 participating cafes in Brunei Muara area after 3 days and immediately stored in sealed food-grade containers. The grounds underwent a trial-and-error process to determine optimal drying time, pouch weight, and aroma intensity before final formulation. The grounds were spread in a thin layer on stainless-steel trays, oven-dried at 105 °C for 2 hours and cooled to room temperature before use. To improve handling, flowability, and controlled aroma release, the formulation was modified to a solid, compacted form. The grounds were pan-heated to further reduce moisture and boost aroma, then mixed with natural aromatic ingredients kaffir lime leaves, lemongrass, cloves, cinnamon, lemon peel and a small amount of essential oil.

Food-grade tapioca flour was added as a binder to enhance mixture cohesion. The blend was mixed thoroughly on a metal tray for uniformity, then weighed to 25 grams per pouch and compacted into circular metal moulds. Covered with aluminium foil, the moulds were refrigerated for two days to set (see Figure 1). After refrigeration, the formed SCGs were removed from the moulds and placed into non-woven food-grade filter fabric pouches, secured, and prepared for use.



Figure 1: Solidification Process of Coffuel Deo-Pouch

3.3 Sensory Evaluations

3.3.1 Hedonic Odour Rating Method

To assess sensory impact, a standardised method measured participants' perception of odour intensity and pleasantness using a hedonic rating scale. This scale quantifies emotional responses to odours and is widely used in food science and consumer acceptability studies (Charlotte et al., 2023). Five adult panellists with normal olfactory ability, who gave informed consent, evaluated odour intensity on a 5-point scale (1 = no odour, 5 = very strong unpleasant odour). Five Coffuel deo-pouches were placed in enclosed, odorous environments for 7 days to simulate household conditions. Positioned near odour sources without direct contact, odour intensity was assessed on Days 0, 3, and 7 using individual sensory ballots. The placement was as follows:

Table 2: Placement of Coffuel Deo-Pouches for Hedonic Odour Evaluation

Placement of Coffuel Deo-Pouches for Hedonic Odour Evaluation		
1.	Shoe Cabinet	One pouch placed inside one of the drawers among the shoes.
2.	Refrigerator	One pouch in the rear corner of the vegetable drawer.
3.	Car Interior	One pouch under the driver's seat.
4.	Toilet	Two pouches placed behind the toilet bowl, away from direct splashes.
5.	Cat Litter Box	Two pouches placed near the litter box, outside of direct contact

3.3.2 Difference-From-Control (DFC) Method

The Difference-From-Control (DFC) method is a sensory test that quantifies how much a test sample differs from a control. Participants rate the perceived difference on a scale, making it valuable for quality control and product development. Its odour rating technique is simple, requires minimal training, and effectively detects subtle or unusual odours in distribution system samples (Johnson, 2021).

To further evaluate the deodorising effectiveness of the Coffuel pouches, a DFC test was conducted using three sealed containers, each filled with a modest quantity of common odour-inducing food items including peeled garlic, dried anchovies, mixed veggies, and ginger. The first container, served as the control (no deodoriser), the second container contains a sachet of baking soda (a commonly used deodorising agent), and the third included a Coffuel deo-pouch. The containers were labelled and stored undisturbed at room temperature ($\sim 25^\circ\text{C}$) for one week, to simulate typical indoor conditions where odour accumulation naturally occurs and to allow consistent, controlled odour development (see Figure 2). At the end of the test period, the 5 panellists conducted an odour assessment by opening and sniffing each container, then comparing the perceived odour intensity relative to the control sample.

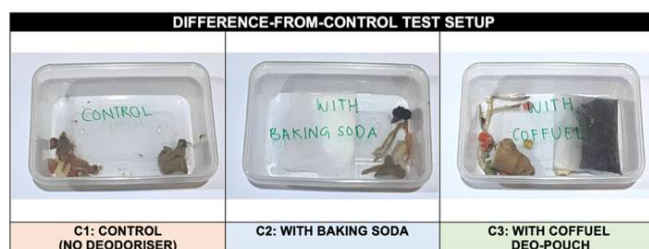


Figure 2: Difference-From-Control (DFC) Test Setup with Odour Samples and Deodorisers

3.4 Preliminary Shelf-Life Study on Mould Growth (Non-Laboratory)

Similar samples shown in Figure 5 were used for this study for a period of one week. Throughout the storage period, daily visual inspections were conducted to record the presence or absence of mould growth on the contents. Observations included any visible fungal, moisture accumulation, or surface degradation. This approach follows standard visual assessment methods for monitoring fungal spoilage, and it is practical for detecting mould development. Given that spent coffee grounds have demonstrated antifungal properties (Calheiros et al., 2023), this study also aimed to observe any potential effects on mould suppression during storage.

4. RESULTS

4.1 Coffuel Deodorising Pouch

The final product of Coffuel deo-pouch is illustrated in Figure 3.

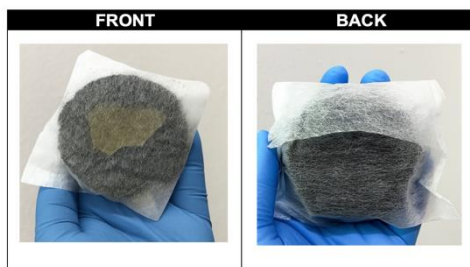


Figure 3: Coffuel Deodorising Pouch Final Product

4.2 Sensory Evaluation of Coffuel Odour Reduction Performance

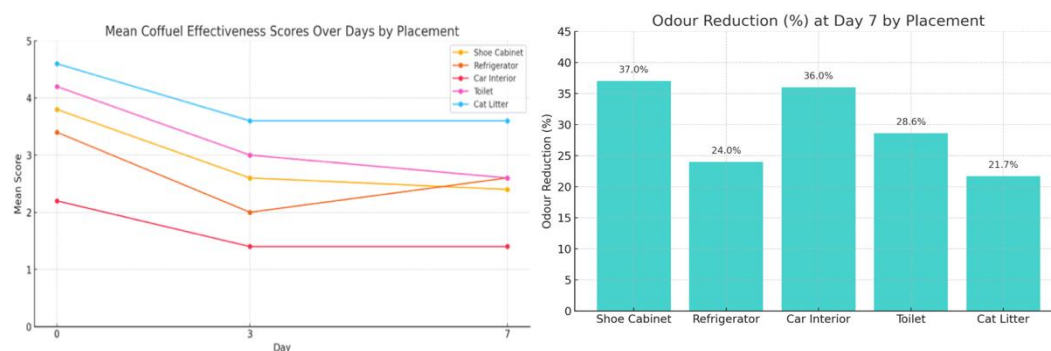
4.2.1 Hedonic Odour Rating Results and Analysis

Sensory scores were obtained using a 5-point hedonic scale and are reported as mean $\pm$ standard deviation (SD) from five panellists. Odour reduction percentages were calculated relative to Day 0 baseline across the 7-day evaluation period. Data were compiled and analysed using Microsoft Excel. The results are tabulated in Table 3, with trends visualised through line and bar charts to compare effectiveness across different Coffuel placements (see Figure 4).

Table 3: Hedonic Scores and Odour Reduction (%) Across five Coffuel Placements Over 7 Days

Placement	Day	P1	P2	P3	P4	P5	Mean $\pm$ SD	Odour Reduction (%)
Shoe Cabinet	0	4	3	4	4	4	3.8 $\pm$ 0.4	0%
	3	3	2	3	3	2	2.6 $\pm$ 0.5	32%
	7	3	2	2	3	2	2.4 $\pm$ 0.5	37%
Refrigerator	0	4	3	3	4	3	3.4 $\pm$ 0.5	0%
	3	3	2	2	2	2	2.0 $\pm$ 0.0	40%
	7	3	2	3	2	3	2.6 $\pm$ 0.5	24%
Car Interior	0	3	2	2	2	2	2.2 $\pm$ 0.4	0%
	3	2	1	1	1	2	1.4 $\pm$ 0.5	36%
	7	2	1	1	1	2	1.4 $\pm$ 0.5	36%
Toilet	0	4	5	4	4	4	4.2 $\pm$ 0.4	0%
	3	3	3	3	3	3	3.0 $\pm$ 0.0	28.6%
	7	3	3	3	3	3	2.6 $\pm$ 0.5	28.6%
Cat Litter	0	5	4	5	5	4	4.6 $\pm$ 0.5	0%
	3	4	3	4	4	3	3.6 $\pm$ 0.5	21.7%
	7	3	2	3	4	3	3.6 $\pm$ 0.7	21.7%

All test locations showed a decline in odour intensity, with the greatest reductions observed in shoe cabinet (37%) and car interior (36%), indicating effective odour absorption by Coffuel (Figure 4). These results suggest that SCG-based pouches can naturally mitigate persistent household odours over an extended period, maintaining noticeable odour reduction for more than 7 days without replacement needed. This aligns with findings by Calheiros et al. (2023), who reported antifungal and bioactive properties in SCG extracts, supporting their use in deodorising applications. The porous nature of SCG also enhances the adsorption of odour-causing volatile compounds. (Campos-Vega et al., 2015).

**Figure 4:** Comparison of Coffuel Performances and Odour Reduction Across Placements by Day 7

4.2.2 Different-From-Control (DFC) Results and Analysis

This test determined whether panellists could perceive any odour differences between the control container (C1) and those treated with deodorising agents: baking soda (C2) and Coffuel (C3). After a week exposure period at room temperature conditions, the 5 panellists were asked to evaluate the odour intensity of each sealed container. The test involved direct sniffing and identification of which samples appeared different from the untreated control. The outcomes are summarised in Table 4.

Table 4: Placement of Coffuel Deo-Pouches for Hedonic Odour Evaluation

Container	Treatment	(n)	Detected as Different	% Correct Identification	Remarks
Container A (Control)	No deodoriser	N/A	N/A	N/A	Baseline (reference sample)
Container B	Baking soda sachet	5	2	40%	Limited odour reduction detected
Container C	Coffuel deo-pouch	5	5	100%	Unanimous odour reduction detected

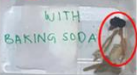
The DFC test results suggest that Coffuel demonstrated a more effective odour-reducing capability compared to baking soda. All panellists correctly identified the Coffuel-treated container as different from the control, indicating a unanimous detection rate and suggesting a noticeable reduction in odour intensity. In contrast, only 2 panellists (40%) perceived a difference in the baking soda-treated container, implying limited deodorising effectiveness. These findings suggest that while baking soda may provide

some minimal odour control, Coffuel was more consistently effective in mitigating the strong odours generated by the food mixture over the one-week period.

4.3 Preliminary Shelf-Life Study on Mould Growth (Non-Laboratory)

Numerous studies have reported that spent coffee grounds (SCG) exhibit antimicrobial properties, including antifungal activity, which contribute to the inhibition of mould growth observed in this study. The formulated Coffuel pouches were monitored under non-laboratory conditions for visible signs of mould growth on stored food samples, over a period of 7 days at room temperature. Samples include: peeled garlic, carrot, anchovies, mixed veggies, and ginger combined in C1, C2, and C3. Observations were recorded at set intervals to assess microbial stability. Results are shown in Table 5.

Table 5: Effectiveness of Coffuel Pouch in Delaying Mould Growth: A Preliminary Study

CONTAINER	LABEL	MOULD ONSET DAY	MOULD GROWTH AT DAY 7	TEXTURE OR MOISTURE NOTES	
Control (No Deodoriser)	C1	Day 3	Extensive	Watery; visible fuzzy mould; some samples turned black	
Baking Soda	C2	Day 3	Significant	Still moist; white fungal growth observed	
Coffuel Pouch	C3	Day 5	Minimal	Mostly dry; few samples turned black; limited moisture	

Based on the findings, visible mould growth appeared earliest in the control group, with signs emerging by Day 3 and rapidly progressing to extensive fungal coverage by Day 7, alongside moisture accumulation and some samples turning black. The baking soda container also exhibited mould growth from Day 3, showing significant fungal spread and persistent moisture, though the growth was less aggressive than in the control. Conversely, the Coffuel pouch demonstrated the greatest resistance to mould, with no visible growth until Day 5 in only a few samples, while the majority remained dry and stable. This highlights its potential to extend shelf-life and improve microbial safety of stored organic material. Furthermore, when properly prepared and stored, Coffuel pouches can maintain acceptable microbial safety for over one week.

5. CONCLUSION

The Coffuel deo-pouch presents a novel, *halal*-compliant innovation for natural deodorisation of household spaces, effectively mitigating persistent odours without the use of chemical preservatives. Using the bioactive and porous properties of spent coffee grounds (SCG), Coffuel provides sustained odour reduction across various settings, such as shoe cabinets and car interior, while supporting microbial safety for short-term storage of organic materials. Its alignment with *halalan thayyiban* principles ensures that it meets Islamic standards for cleanliness, safety, and wholesomeness, making it an ideal sustainable solution for Muslim households and beyond. This innovation contributes to waste valorisation and offers an alternative to conventional deodorising products.

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TROLI MENJADI TANGGA

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ABSTRAK

Merekabentuk, membangun dan memfabrikasikan troli menjadi tangga merupakan salah satu alat bagi mengangkat barang atau mengalihkan barang dengan hanya menggunakan sedikit sahaja tenaga kerja manusia. Selalunya kebanyakan troli hanya boleh digunakan untuk membawa barang tetapi projek ini dapat menukarkan troli tersebut kepada tangga. Jika pengguna ingin membawa troli dan tangga pada masa yang sama, pengguna akan mengambil masa yang lama. Oleh itu, sebuah troli menjadi tangga telah direka bagi memudahkan kerja harian pengguna. Selain itu, projek ini juga bertujuan untuk membantu pekerja yang melakukan pendawaian rumah. Ciri-ciri keselamatan telah dipasang pada alat ini seperti getah anti gelincir dan roda berkunci yang membolehkan tangga ini tidak akan menggelongsor secara tiba-tiba ketika digunakan. Penggunaan bahan seperti bar berongga aluminium dapat mengurangkan beban pengguna ketika mengangkatnya kerana tidak berat. Secara dasarnya, alat ini dibina menggunakan bahan yang dipilih secara teliti supaya dapat menahan beban dengan baik ketika digunakan sebagai tangga mahupun sebagai troli. Walau bagaimanapun, troli menjadi tangga ini masih banyak yang perlu dipertimbangkan dan ditambahbaik dari segi aspek operasi dan sistem supaya dapat berfungsi dengan lebih baik.

Kata Kunci: Troli, Tangga

1.0 PENDAHULUAN

Terdapat pelbagai jenis troli pada masa kini yang sudah tersedia dijual sama ada di pasaran dalam negara mahupun pasaran antarabangsa. Seperti yang sedia maklum, penggunaan troli adalah untuk memudahkan lagi para pengguna mengangkat barang yang berat atau banyak dari suatu tempat ke tempat yang lain tanpa menggunakan tenaga yang banyak. Perbincangan kumpulan bersama penyelia projek telah mencapai kata sepakat untuk merekabentuk sebuah troli yang boleh juga dijadikan sebagai tangga iaitu Troli Menjadi Tangga. Troli Menjadi Tangga adalah hasil gabungan troli dan tangga yang mempunyai fungsi untuk memudahkan pengangkutan barang sekaligus boleh dijadikan sebagai tangga.

2.0 OBJEKTIF

1. Troli Menjadi Tangga dapat memudahkan pengguna dalam menyelesaikan sesuatu tugas.
2. Troli Menjadi Tangga dapat mengurangkan penggunaan barang dalam menyelesaikan sesuatu tugas.

3.0 METODOLOGI

Cetusan idea dari kalangan ahli kumpulan memainkan peranan penting dalam menjayakan pelaksanaan sesuatu projek. Pemilihan tajuk daripada idea-idea yang tercetus tersebut merupakan langkah terawal yang perlu dilaksanakan sebelum memulakan projek. Tajuk dan jenis projek juga perlu berdasarkan taraf dan piawaian peringkat diploma kerana ianya merupakan salah satu subjek yang terpenting di akhir semester sepanjang pengajian dalam Kursus Diploma Kejuruteraan Mekanikal (Pembuatan) ini. Di samping itu, pemilihan jenis projek yang bersesuaian mengikut kursus yang diambil iaitu mekanikal sedikit sebanyak membantu daya pemikiran yang kreatif dan inovatif seseorang berkenaan ilmu yang dipelajari. Seterusnya, rangka kerja atau carta alir perlu dibuat sebagai garis panduan sepanjang pelaksanaan projek agar lebih teratur dan kemas. Ini membantu melancarkan pelaksanaan projek tanpa sebarang masalah dan ia juga dapat menjimatkan kos perbelanjaan untuk menjayakan projek tersebut.

Sharma et al. (2016) telah mereka bentuk troli industri dengan ketinggian boleh laras menggunakan pendekatan ergonomik. Kajian ini menekankan kepentingan menyesuaikan ketinggian tangga dengan postur kerja pengguna bagi mengurangkan risiko gangguan muskuloskeletal. Reka bentuk ini

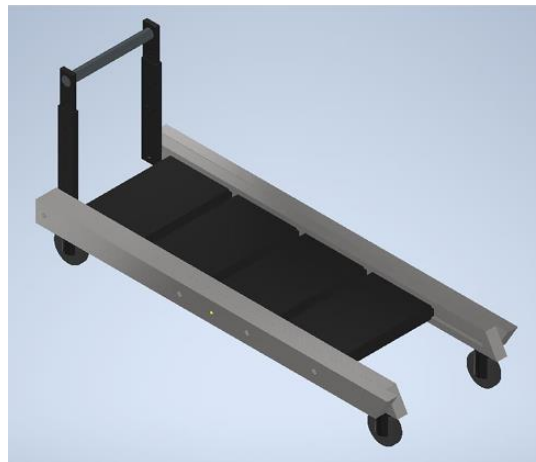
membolehkan penyesuaian ketinggian tangga mengikut keperluan tugas, seterusnya meningkatkan keselesaan dan keselamatan pengguna. Gumasing (2020) telah mereka bentuk troli enam roda untuk pengangkutan beban berat dalam persekitaran industri. Kajian ini menekankan pentingnya reka bentuk ergonomik dalam mengurangkan tekanan fizikal ke atas pekerja semasa pengendalian bahan secara manual. Troli ini direka bentuk untuk meningkatkan kestabilan dan mengurangkan risiko kecederaan. Pelajar Politeknik Sultan Haji Ahmad Shah telah membangunkan projek (*Multifunctional Trolley Stair Climber*) yang bertujuan memudahkan pengangkutan barang berat di bangunan bertingkat tanpa lif. Troli ini direka khas dengan keupayaan mendaki tangga, mengurangkan beban pengguna, dan mengelakkan kecederaan semasa mengangkut barang. Projek ini menunjukkan aplikasi praktikal dalam menyelesaikan masalah sebenar yang dihadapi oleh pengguna.

Jadual 1: Kajian Ergonomik

	A	B	C
1	Ergonomik	Ketinggian Tangga	Keperluan Tugas
2	Mengurangkan Risiko	Kestabilan	Pengendalian Bahan
3	Menyelesaikan Masalah	Keupayaan	Memudahkan Pengangkutan

Jadual 2: Kajian Impak Produk

	A	B
1	Reka bentuk	Penyesuaian tangga
2	Kurangkan tekanan	Mengurangkan risiko
3	Kurangkan beban	Mengelakkan kecederaan

**Rajah 1: Rekabentuk Troli****Rajah 2: Rekabentuk Tangga**

4.0 DAPATAN PROJEK

Kelebihan yang didapati daripada projek ini ialah Troli Menjadi Tangga dapat memudahkan pengguna mengangkat barang dengan menggunakan troli dan tangga pada masa yang sama.

5.0 KESIMPULAN

Produk Troli Menjadi Tangga berfungsi dengan cara memudahkan pengguna dalam mengangkut barang. Selain itu, reka bentuk yang ergonomik juga sesuai untuk digunakan dengan selamat. Secara keseluruhan produk ini adalah pilihan yang efisien dan efektif.

PENGHARGAAN

Pertama sekali, kami ingin mengucapkan setinggi-tinggi kesyukuran kepada Allah SWT atas segala nikmat-Nya sepanjang projek ini, kerana telah memberikan kesihatan yang baik dan kemampuan untuk melaksanakan projek tahun ini dalam masa yang ditetapkan. Kami ingin mengucapkan ribuan terima kasih kepada Encik Khairul Nazry Bin Talib, tenaga pengajar kami, atas dorongan, toleransi, dan sokongan yang tidak berbelah bahagi sepanjang kajian ini dijalankan. Kami ingin mengucapkan terima kasih kepada pihak UiTM atas penganjuran program yang dapat meningkatkan inovasi dalam kalangan pelajar. Tanpa mereka, kami mungkin tidak mendapat sokongan moral yang diperlukan untuk menyelesaikan projek ini.

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RENTWIZE AN INTELLIGENT MULTI-CATEGORY RENTAL SYSTEM

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ABSTRACT

In the current property rental landscape, many landlords continue to rely on manual, paper-based methods to manage their rental properties. This traditional approach often results in numerous challenges, including human error, incomplete records, and the risk of losing important documentation. These inefficiencies not only hinder day-to-day operations but also affect the overall quality of property management services. To overcome these limitations, this project proposes the development of a Property Management System tailored specifically for landlords. The system enables landlords to efficiently manage their properties through features such as tenant information management, digital payment tracking, maintenance scheduling, and automated report generation. These features aim to reduce administrative burden, improve data accuracy, and enhance overall operational transparency. The system will be developed using the Waterfall Model, following a structured development process from requirement gathering to maintenance, ensuring a clear and disciplined workflow. This initiative aligns with the United Nations Sustainable Development Goals (SDGs), particularly SDG 11: Sustainable Cities and Communities, by promoting safer, more efficient, and technologically supported housing management. Additionally, it supports SDG 9: Industry, Innovation, and Infrastructure through the integration of digital solutions in traditional property sectors. With this system, landlords are expected to benefit from streamlined processes, increased reliability in managing rental operations, and a more sustainable and innovative approach to property management.

Keywords: Digital Property Management, Landlord-Tenant Platform, AI recommendation

1.0 INTRODUCTION

Real estate is an important asset that affects an individual's standard of living and helps in shaping the economy at large. It can take the form of residential houses, commercial structures, and even rental apartments. With the rapid pace of society we live in today, the entire process of managing, renting, and marketing real estate has shifted to the digital space. Online listing websites and mobile applications have changed the process of searching, offering, and managing rental properties.

Even with the use of digital tools, several landlords in Malaysia prefer to use older methods that include paperwork, the use of spread sheets, and informal methods of communication via telephone, text messages, or direct calls. These manual methods often face problems such as loss of data, suppression of payments, stagnant response times, and in some cases, even erroneous charge of lease contracts. Well-known websites such as PropertyGuru, iBilik, and Mudah.my provide listing services but they do not have integrated systems that allow for direct communication, real time payment systems, or even smart payment systems. Because of this, both the landlords and the tenants often face inconveniences and a lot of anger while carrying out rental transactions.

A centralised and efficient digital platform that facilitates the entire rental management system should be considered. An organised system can ease out administrative tasks; it makes communication faster and clearer, and helps landlords both in making decisions and in helping tenants to make reasonable decisions. More than ever, being able to efficiently use any platform would make a huge difference in a competitive rental market where response times and accurate pricing are highly valued.

In light of the stated problems above, this project aims to develop a comprehensive management system for property rentals using the Waterfall model.

This project involves incorporating artificial intelligence with available artificial intelligence tools, including property using AI-based recommendations and dynamic rental price suggestions modules as the means of enhancing decision-making (Clark et.al, 2025). The features break down the habits of

users, patterns of localities, and market statistics to supply the tenants with properties of interest to them and help landlords determine the reasonable price of rent.

The system incorporates major modules such as property listing and management, tracking of digital payments, rental application, and instant messaging between landlords and tenants. The backend is based on MySQL for secure data handling of both users and properties; the frontend provides cross-device compatibility through Flutter and Firebase. In addition to that, an AI module is effectively embedded into the system that carries out two major functions, i.e., recommending properties to the tenants based on location, preferences, and income level, and optimising rental pricing suggestions to the landlords based on historical data.

2.0 OBJECTIVE

This project intends to develop a centralised, efficient digital platform to help landlords manage their rental properties more effectively. The system would replace archaic manual methods with a fully integrated solution in gist; property listings, rental pricing, lease agreements, tenant applications, and digital payment tracking. The platform will improve the efficiency of operations and further aid decision-making for landlords and tenants using AI-enabled features, such as recommendations for properties based on tenant preferences, location, and income, as well as suggestions for optimal rental prices candidates for consideration by landlords, using historical data and trends gathered from the current market.

3.0 METHODOLOGY

The project adopted the Waterfall model for development, which means it followed a linear and structured process. Since the system is a prototype, the phases of the Waterfall methodology were applied to guide the project from planning to presentation.

3.1 REQUIREMENT ANALYSIS

In the first phase, it began with research of the documented problems in the rental process experienced by landlords and tenants. Issues such as manual paperwork and inefficiency in making price decisions were all considered. From there, they went to outline the system requirements to involve the main features including property listings, rental application handling, pricing support, and communication tools.

Table 1: System comparison between other applications.

Application Categories	PropertyGuru	iBilik	Mudah.my	Proposed Application
In-App Digital Payment	No	No	No	Yes
Real-Time Chat between Tenant with Landlord	No	No	No	Yes
Property Listing Management	Yes	Yes	Yes	Yes
AI-Based Rental Price Suggestion	No	No	No	Yes
Cross-Platform Accessibility	Web, Mobile Application	Web, Mobile Application	Web, Mobile Application	Mobile Application

Based on Table 1, the application developed will be a more advanced and comfortable application for renting a property than PropertyGuru, iBilik, and Mudah.my. Despite all three existing platforms allowing the management of property listing, the proposed app stands out since it combines the in-app digital payment, real-time tenant-landlord chat, as well as AI-based rental pricing suggestions, none of which are available on existing platforms. As a mobile-first approach, the app adds convenience to the customers and simplifies the process of renting items. Augmenting existing market oversights and focusing on a contemporary set of features, the recommended application would be a smart and more effective offering both in terms of the ability to rent a property in the future and of satisfying the ever-changing user demand on either side of the spectrum of this relationship.

3.2 SYSTEM DESIGN

This phase focused on designing the architecture and user interface of the system. Each module had a visual plan that included the property listing page, tenant registrations, AI recommendations interface, and a landlord dashboard. The system layout was created to be very user-friendly and cross-platform. Visual harmony and functional flow were two imperatives in our prototype to make the UI feel like a real user experience. Figure 1 illustrates the proposed application, property management use case diagram with three external actors, including Tenant, Landlord, and an AI System, and three internal transactions, the first one is (1) tenant logging in, the second one is (2) landlord logging in, and the third transaction is (3) AI recommendations. Each of the actors has the potential to access the system via the following key features: Tenant can log in, establish correspondence with the other actors, pay the rent, and search through the listings; Landlord can log in, communicate with the tenant, and offer rental prices; the AI System mediates people by providing property suggestions to Tenant and rental rates to Landlord. Such interactions make the concept of communication more efficient and enhance decision-making strength, which will make property management more efficient and smarter for all stakeholders.

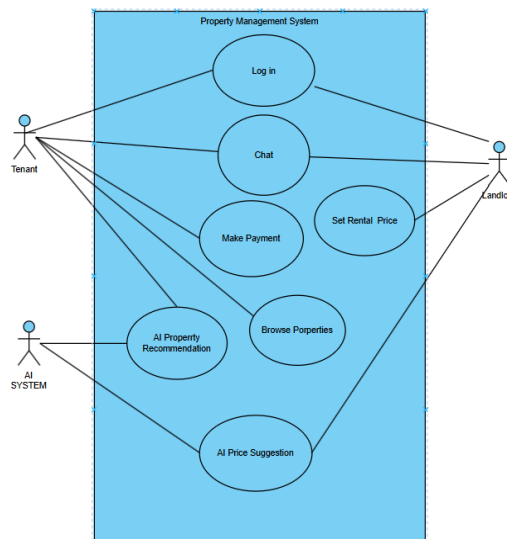


Figure1: Use case diagram.

3.3 IMPLEMENTATION

The interface was constructed in Flutter for the prototyping stage to showcase the system functionality with integrated Firebase to manage simple data flow and mimic backend functionality with MySQL, which is outlined as the future data storage. It focused on producing clickable screens and clickable workflows that demonstrate the functions that are intended for the final full system.

3.4 DEPLOYMENT AND MAINTENANCE

Finally, this phase covers the live deployment of the system and regular updates based on user feedback. The system includes an AI module that performs two key functions: recommending rental properties to tenants based on their preferences, location, and income level, and suggesting optimised rental prices for landlords using historical data and market trends. Future updates may include advanced predictive analytics to further enhance the platform's intelligence and value.

4.0 RESULT

On a project involving innovation, a prototype of the Property Rental Application was built. Its pilot version consists of a set of functions that are aimed at raising the bar of the rental process, proving value to any tenant and landlord. Some of the great features are safe user authentication, property browsing, in-app chat, and payments management. This can be shown in Figure 2.

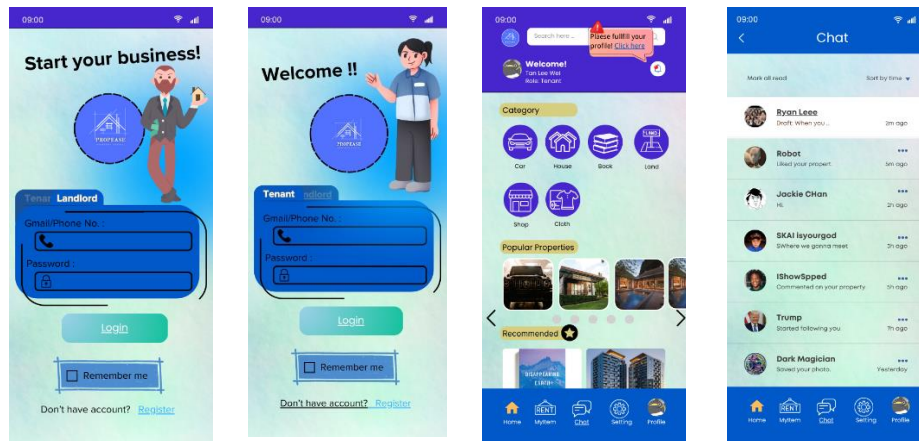


Figure 2: Application: User Interface for tenant and landlord

In addition, the system makes use of artificial intelligence: AI Property Recommendation: tenants determine their preferences and behaviour and receive a recommendation of property based on such requirements, AI Price Recommendation: landlords use AI to develop competitive prices to rent their property. These features are supported by an easy-to-use interface that uses Flutter and Firebase to synchronise data in real-time. This is shown in Figure 4.

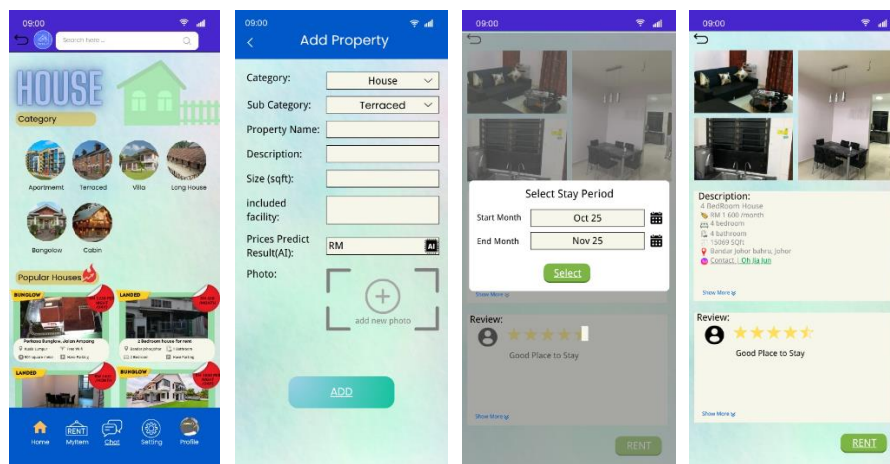


Figure 3: Application: User Interface for House category, property addition with AI suggestion and property details

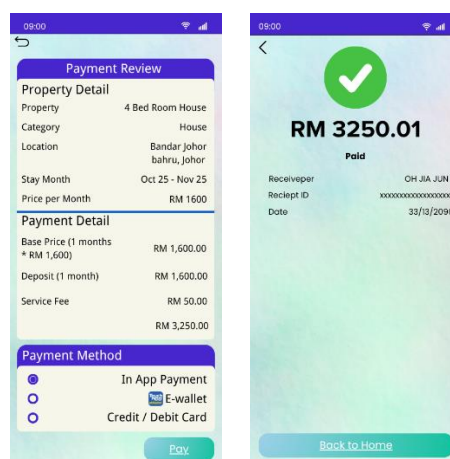


Figure 4: Application: Payment receipt and review

The initial experimentation of the prototype showed that the user engaged with the system promptly, and the designed AI modules provided relevant and useful recommendations. The prototype confirms,

therefore, the viability of using AI to streamline and personalise the property rental process thereby offering a valid foundation to make future advancements and deployments.

5.0 CONCLUSION

This project presents the development of a digital rental management app that modernises traditional methods by having a centralised system. It is anticipated that it will streamline critical tasks such as property listings and rental amounts, lease tracking, tenant applications, and digital payments.

The system also supports decision-making with AI functionalities, including tailored property recommendations for tenants and rental amount recommendations for landlords. The app is built in MySQL, Flutter, and Firebase so that all data is handled securely and works across multiple devices.

In the future, the platform is likely to develop features such as predictive analytics, automated maintenance tracking, multilingual support, and data reporting dashboards. These features will improve upon creating a smarter and more comprehensive solution to managing property rentals in an efficient and sustainable way.

This invention supports Sustainable Development Goal (SDG) 11, which includes inclusive, safe, and sustainable urban living, which is attainable in terms of smart rentals. It also complies with SDG 9, which creates innovation and digital infrastructure in the real estate market, particularly regarding the introduction of AI-driven elements in service improvements in standard service delivery and efficiency.

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Real-time Vision Based Diseases Identification for Oil Palm Trees Using Edge Device

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ABSTRACT

The palm oil industry forms a vital economic pillar for Malaysia, contributing RM114 billion in exports and 2.3% to the national GDP in 2024. A substantial 1.48 million hectares of total oil palm plantation areas are managed by smallholder farmers, directly supporting over 450,000 people (Selangor Journal, 2025). Despite this crucial role, these rural farming communities grapple with significant hurdles in the swift detection of diseases and effective yield preservation. Current plant disease detection technologies often fall short, lacking real-time capabilities, proving unaffordable for many, and typically requiring internet connectivity, rendering them unsuitable for remote agricultural regions. For instance, Ganoderma Basal Stem Rot (BSR) alone accounts for substantial annual economic losses, reaching up to RM1.5 billion. Addressing these pressing challenges, this study introduces a MobileNetV3Large-based convolutional neural network (CNN) deep learning model specifically engineered for the identification of diseases affecting palm oil trees and leaves. The model classifies twelve main conditions, including varying severity levels such as mild, moderate, and critical of Ganoderma Basal Stem Rot (BSR), leaf diseases caused by Cephalous, Curvularia, Drechslera, nutrient deficiency of boron and potassium, healthy stem, and healthy leaves, achieving 99.88% accuracy and a rapid 705.34ms inference speed. This system operates without an internet connection and is a cost-effective, portable and high-precision system helping smallholder farmers to identify diseases in the early stage. Therefore, the improvement of productivity and sustainability with this solution helps Malaysia achieve the SDG 8 goal of economic growth and decent employment in rural agriculture communities, the SDG 9 goal of addressing technological gaps in remote plantations, and the SDG 15 of preserving healthy palm oil plantations to reduce the risk of widespread disease and deforestation.

Keywords: Palm Oil Disease Detection, Smallholder Farmer, Lightweight CNN, Real-Time Monitoring, Edge Computing

1.0 INTRODUCTION

The agriculture sector is a vital source of income for farmers and a key driver of economic development in many nations. In Malaysia, the agricommodity sector, led by the palm oil industry, contributed RM114 billion in export value and 2.3% to the national GDP in 2024 (Selangor Journal, 2025). Palm oil dominates the sector, accounting for 54.6% of the RM11.8 billion GDP contribution in Q2 2024, far surpassing other commodities such as timber, rubber, tobacco, cocoa, and pepper (Department of Statistics Malaysia, 2024). Smallholder farmers play a crucial role, managing 1.48 million hectares of oil palm plantations and supporting over 450,000 families (Selangor Journal, 2025). However, plant diseases pose a significant threat to crop yields, impacting food security and economic stability. The Food and Agriculture Organization (FAO) estimates that 20% to 40% of global crop production has lost annually due to plant diseases, with factors such as climate change, pathogens, and environmental conditions exacerbating the issue (Food and Agriculture Organization of the United Nations, 2020). In the palm oil sector, diseases like Ganoderma Basal Stem Rot (BSR) can cause economic losses of up to RM1.5 billion annually (Malaysian Palm Oil Board, n.d.).

Oil palm diseases affect roots, stems, or leaves (Septiarini et al., 2021). BSR is caused by Ganoderma that leads to nutrient uptake issue that will lead to stem decay and tree death by spreading through soil (Zakaria, 2022). Leaf diseases like Curvularia and Drechslera, transmitted by rain or wind, show distinct symptoms in yellow spots, halos and reduce photosynthesis (Priwiratama et al., 2024). Nutrient deficiencies, particularly potassium and boron, have caused symptoms like orange spotting or crinkled leaves, impacting yields in Malaysia's acidic soils (Sugianto et al., 2023). Traditional disease detection methods, such as visual inspection and laboratory testing, are labour-intensive and they require specialized expertise that smallholder farmers often lack. Communication barriers, geographical isolation, and limited technological infrastructures further hinder timely interventions. While modern

techniques like machine learning offer potential solutions, they often rely on internet connectivity and expensive hardware, making them impractical for rural settings. To address these challenges, advanced vision techniques and machine learning have emerged as promising tools for automated disease detection. Computer vision leverages image processing to analyze visual symptoms on plant leaves and stems, using techniques such as image segmentation, feature extraction, and pattern recognition to identify disease patterns. Machine learning, particularly deep learning, enhances this process by training models on large datasets to recognize complex features, with convolutional neural networks (CNNs) proving effective due to their ability to handle spatial hierarchies in image data. Lightweight architectures like MobileNetV3Large further optimize these models for resource-constrained devices, enabling real-time inference on edge platforms.

This study addresses the challenges by developing a real-time, offline disease detection system using a Raspberry Pi 4B edge device. The system employs a MobileNetV3Large-based CNN to classify six key conditions with high accuracy, providing a cost-effective and accessible tool for smallholder farmers. By enhancing agricultural productivity and sustainability, this solution supports Malaysia's progress towards Sustainable Development Goals (SDGs) 8, 9, and 15.

2.0 OBJECTIVE

1. To identify various unhealthy conditions of oil palm trees, including specific leaf diseases, Ganoderma Basal Stem Rot (BSR), and different types of nutrient deficiencies.
2. To develop and optimize lightweight machine learning models for the real-time identification of palm oil tree diseases.
3. To evaluate the performance of accuracy of the system and deploy in edge device.

3.0 METHODOLOGY

Figure 1 presents the block diagram of the real-time palm oil disease detection system using a Raspberry Pi 4B. A 5MP camera module captures images of oil palm trees (*Elaeis guineensis*) and leaves, processed by a single pre-trained MobileNetV3Large CNN model in TensorFlow Lite for offline operation. The model classifies 12 conditions such as critical/mild/moderate boron deficiency, critical/moderate BSR, mild/moderate Cephaleuros, Curvularia, Drechslera, healthy leaf, healthy stem, and potassium deficiency. The Raspberry Pi's 1.5GHz quad-core processor and 4GB RAM ensure efficient, low-cost, low-power processing, ideal for remote plantations (Aftab et al., 2022).

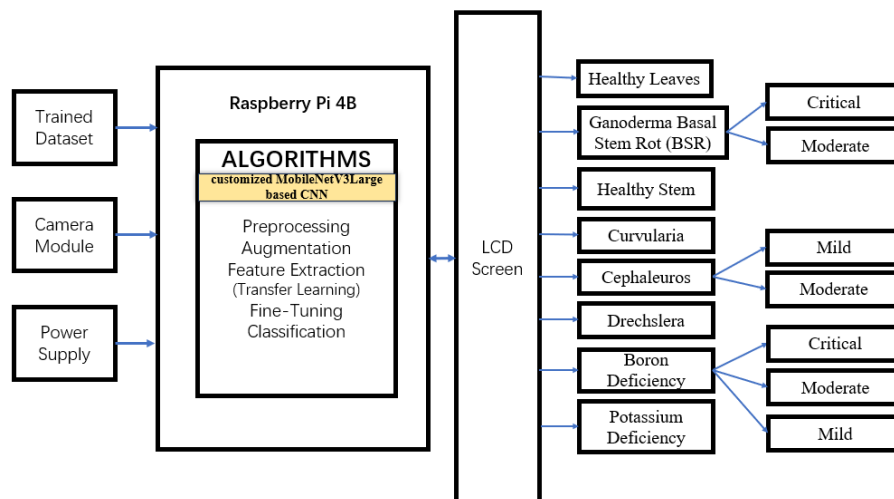


Figure 1: Proposed Block Diagram of the System.

3.1 Data Acquisition and Preprocessing

The dataset comprises 16,920 images collected from an 80-acre oil palm plantation in Kampung Pantai Layang, Sungai Mati, using a 12MP smartphone camera under daylight conditions (excluding 12–2 PM to avoid glare). It covers 12 classes: critical/mild/moderate boron deficiency, critical/moderate BSR, mild/moderate Cephaleuros, Curvularia, Drechslera, healthy leaf, healthy stem, and potassium deficiency, with 1410 images per class (141 images for testing, 10% split). The 70:20:10 training-

validation-testing split optimizes small datasets. Images, which are resized to 224x224 pixels (RGB), are processed offline on a Raspberry Pi using TensorFlow Lite for real-time disease and deficiency detection.

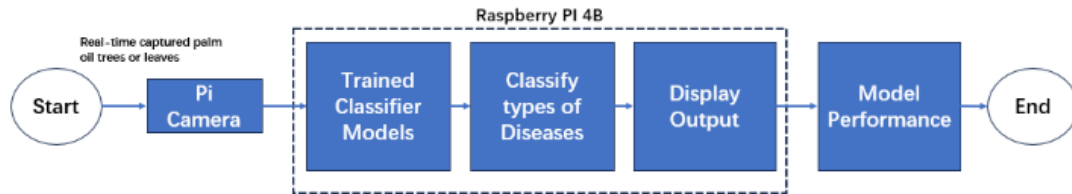


Figure 2: Flow Chart of Overall System.

3.2 Model Development

Figure 3 illustrates the overall proposed block diagram for the computational procedure of plant disease detection. The model leverages a pre-trained MobileNetV3Large-based CNN model, chosen for its high speed and accuracy, as demonstrated by research comparisons. The pre-trained layers (base model) were frozen without modification to extract features. While the CNN architecture incorporates numerous layers for feature extraction with the pre-trained MobileNetV3Large. Two dense layers, with 128 neurons and 64 neurons respectively, were applied, which sum the weighted inputs and apply the ReLU activation function. This non-linearity allows the model to learn complex relationships between features and disease classes. To prevent overfitting, a Dropout layer was added for each dense layer, with 50% of neuron outputs being randomly deactivated. This has forced the network to learn more robust features during the training process, thereby reducing the risk of the model relying too heavily on any single neuron. Finally, a fully connected layer was used as the classification output, identifying six distinct palm oil disease classes.

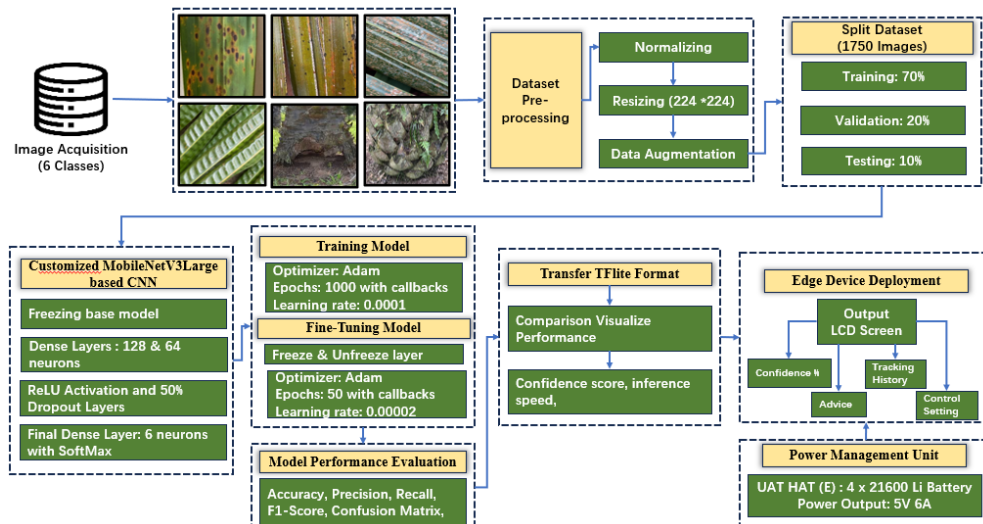


Figure 3: Proposed Block Diagram of Computational Procedure of Plant Disease Detection.

The model, once fully structured with its complete architecture network, was compiled using the input and output layers as parameters. This work has employed the Adam optimizer, an adaptive learning rate optimizer, in conjunction with categorical cross-entropy loss and accuracy metrics. To enhance model performance and mitigate overfitting, callbacks for EarlyStopping, ModelCheckpoint, and ReduceLROnPlateau were configured for up to 1000 epochs. Following the training process, the model was converted into a TensorFlow Lite format for deployment and use on the Raspberry Pi.

3.3 Model Deployment

The TensorFlow Lite model was used on a Raspberry Pi 4B, connected to the camera module using Python scripts that relied on the TensorFlow and OpenCV libraries. The device can predict diseases in real time from images without needing an internet connection.

4.0 RESULT

The current experiment rigorously evaluated the system using a test set of 1692 images, with 141 images for each of the twelve classes. The TensorFlow Lite model demonstrated exceptional performance, achieving an overall accuracy of 0.9988 (99.88%), and correctly recognizing all 1692 images. The detailed performance metrics, is summarized in the table 1 below, showing the outstanding results across all classes. A slight deviation was observed in 'BSR_Moderate_test' with a recall of 0.99, but its F1-score remained at 0.99, confirming its high reliability. On average, each image was inferred within a rapid of 705.34ms.

Table 1: For a short description of table. Insert tables after they are cited in the text.

Class	Precision	Recall	F1-score	Support
BORON_DIFICIENCY_Critical_test	1	1	1	141
BORON_DIFICIENCY_Mild_test	1	1	1	141
BORON_DIFICIENCY_Moderate_test	1	1	1	141
BSR_Critical_test	1	1	1	141
BSR_Moderate_test	1	0.99	1	141
CEPHALEUROS_Mild_test	1	1	1	141
CEPHALEUROS_Moderate_test	1	1	1	141
CURVULARIA_DISEASE_test	1	1	1	141
DRECHSLERA_DISEASE_test	1	1	1	141
HEALTHY_LEAF_test	1	1	1	141
HEALTHY_STEM_test	0.99	1	1	141
POTASSIUM_DEFICIENCY_test	1	1	1	141
Accuracy	0.9988			1692

The model demonstrates robust performance throughout its training, with its accuracy consistently improving as the number of training epochs increases. Figure 4, depicting the Loss Evolution on the left, illustrates the model's loss decreasing over each epoch, a clear indicator of improved performance. Both training and validation losses initially decline, signifying effective early learning. However, a slight fluctuation is observed in the validation loss while the training loss continues its steady descent. This pattern hints at a potential overfitting issue to the training data.

Conversely, the Accuracy Evolution graph on the right side of Figure 4 shows a dramatic rise in both training and validation accuracy, reaching high levels. Notably, the validation accuracy occasionally surpasses the training accuracy at certain epochs. This phenomenon suggests that the validation set might be less complex or not entirely representative of the broader data distribution, contributing to the possibility of overfitting to the training data. To mitigate this, strategies such as increasing the size and diversity of the validation datasets or implementing additional data augmentation techniques like rotation, grayscale conversion, or cropping could enhance the model's generalization capabilities.

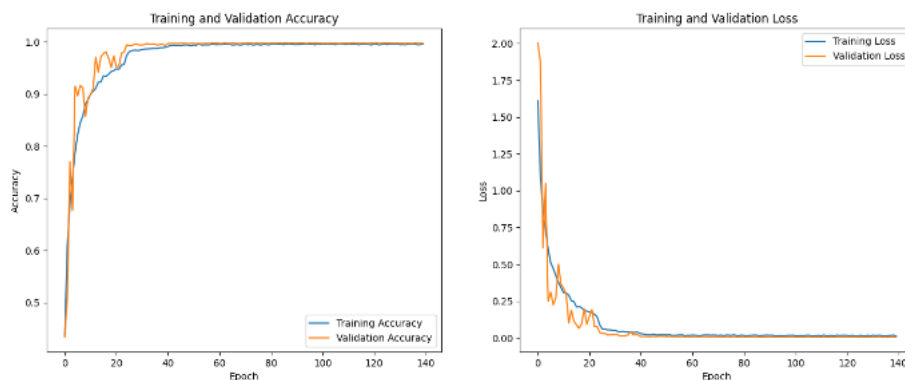


Figure 4: Model Loss and Accuracy Evaluation.

The confusion matrix provides a detailed breakdown of the model's classifications. It visually represents how many instances from each actual class were correctly or incorrectly predicted by the model. In this matrix, the diagonal cells indicate the number of correct predictions for each class. For

instance, for 'BORON_DEFICIENCY_Critical_test', all 141 samples were correctly identified. This trend of high numbers on the diagonal is consistent across most classes, signifying strong predictive accuracy. Conversely, off-diagonal cells highlight misclassifications. The matrix shows minimal errors, with only two off-diagonal entries such as 1 'BSR_Moderate_test' sample was incorrectly identified as 'HEALTHY_STEM_test' and 1 'HEALTHY_STEM_test' sample was incorrectly identified as 'BSR_Moderate_test'. Out of a total of 1692 test samples, 1690 were correctly classified, resulting in an overall accuracy of 99.88%. This indicates the model performs exceptionally well in distinguishing between the various palm oil conditions on this specific test dataset.

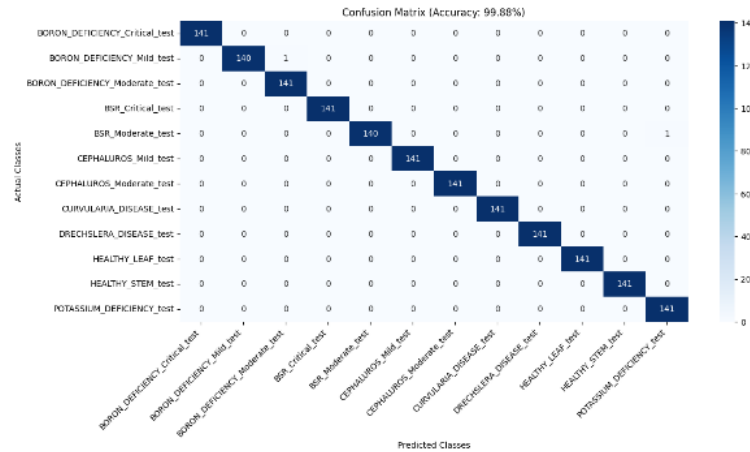


Figure 5: Confusion Matrix.

Figure 6 shown that unseen sample of Boron deficiency on leaf as an input image which predict the correct class which is Boron with 100% confidence level.



Figure 6: Unseen Sample Boron Deficiency.

5.0 CONCLUSION

This study developed an optimized lightweight machine learning model for real-time oil palm disease detection using a Raspberry Pi with a camera module. Deployed in collaboration with Nilai Hasil Sdn Bhd at an 80-acre plantation in Kampung Pantai Layang, Sungai Mati, the offline system identifies multiple healthy and unhealthy conditions with 99.88% accuracy and 705.34ms inference speed. By enhancing productivity and sustainability, it supports Malaysia's SDG 8 (economic growth and rural employment) and SDG 15 (healthy plantations, reduced disease and deforestation risks). This scalable, cost-effective solution offers potential for widespread adoption in Malaysia's palm oil sector.

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OPTIBEAR–OPTIMIZED POT BEARING SYSTEM FOR ENHANCED DYNAMIC PERFORMANCE

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ABSTRACT

Pot bearings are critical structural components in bridge engineering, responsible for transmitting vertical loads and accommodating translational and rotational movements. However, under dynamic and harmonic loading conditions, traditional pot bearings have often exhibit limitations in vibration control and structural stability. This paper presents OPTIBEAR, an optimized pot bearing system which is developed through an integrated approach combining finite element modeling (FEM), experimental modal analysis (EMA), and advanced optimization techniques, including the Response Surface Method (RSM) Optimization. The dynamic characteristics of pot bearings such as natural frequencies and mode shapes were first identified and validated through comparative analysis between FEM and EMA. Initial discrepancies of up to 43.9% in frequency prediction were significantly reduced to 8.42% using RSM optimization. The Modal Assurance Criterion (MAC) confirmed a 100% match between numerical and experimental mode shapes, validating the accuracy of the model. Harmonic response analysis demonstrated that the optimized bearings effectively reduced deformation and improved energy dissipation at resonance frequencies, particularly near the mid-span of the bridge structure. OPTIBEAR offers enhanced structural performance, reduced maintenance needs, and retrofit compatibility for aging infrastructure. The findings support their practical application in modern bridge design and asset management, contributing to safer and more resilient infrastructure systems.

Keywords: Pot Bearing, Finite Element, Modal Analysis, Optimization, Dynamic Response

1.0 INTRODUCTION

Pot bearings play a fundamental role in modern bridge construction, serving as crucial interface elements between the bridge deck and supporting structures. Their primary function is to safely transmit vertical loads while accommodating limited horizontal displacements and rotational movements induced by traffic loads, thermal expansion, wind, or seismic events (Wang et al., 2020). As dynamic loading conditions become increasingly significant in long span and urban bridge designs, ensuring that pot bearings can effectively manage vibrations and resonant responses has become essential (Shiau et al., 2008, Li et al., 2016, R Arunkiliyal et al., 2017).

Despite their widespread use, conventional pot bearings are often designed based on static or quasi-static assumptions. This approach does not fully capture the dynamic behavior of the bearing, particularly under harmonic excitation where resonance effects can amplify structural response, leading to increased deformation, fatigue, and premature failure. Addressing this limitation requires a deeper understanding of the dynamic properties of pot bearings specifically, their natural frequencies, mode shapes, and damping characteristics (Wang et al., 2014, Chakraborty et al., 2016 Yusuf et al., 2019).

This study introduces OPTIBEAR, an optimized pot bearing system which is developed to overcome the shortcomings of traditional designs. By combining Finite Element Modeling (FEM) with Experimental Modal Analysis (EMA) and applying advanced optimization strategies which is the Response Surface Method (RSM), this research aims to enhance the accuracy of the numerical model and improve the dynamic performance of the bearing system. Innovation lies not only in the optimization process itself but also in the validation framework that ensures a strong correlation between predicted and observed behavior.

Through detailed harmonic response evaluations, OPTIBEAR demonstrates superior performance in mitigating structural resonance and reducing mid span deformation of the bridge, making it suitable for both new constructions and retrofit applications. This paper presents the development, validation,

and performance assessment of OPTIBEAR, with the goal of contributing a scalable and practical solution for advancing bridge infrastructure resilience.

2.0 OBJECTIVE

The main objective of this study is to develop and validate an optimized pot bearing system (OPTIBEAR) that improves the dynamic performance and reliability of bridge structures under the harmonic loading conditions. Thus, the specific objectives are:

1. To identify the natural frequencies and mode shapes of mechanical pot bearings through numerical simulation using Finite Element Modeling (FEM) and Experimental Modal Analysis (EMA).
2. To validate the accuracy of the finite element model by comparing its modal analysis results with experimental data, using quantitative metrics such as the Modal Assurance Criterion (MAC) and relative error evaluation.
3. To optimize the finite element model using the Response Surface Method (RSM) techniques to reduce discrepancies between numerical and experimental results.
4. To assess the harmonic response behavior of the optimized pot bearing within a bridge system, focusing on its ability to reduce deformation, enhance damping, and maintain structural stability under resonance conditions.

3.0 METHODOLOGY

The methodology adopted in this study integrates numerical simulation, experimental testing, and optimization techniques to develop and validate the OPTIBEAR™ system. The process is divided into five key phases which include finite element modelling, experimental modal analysis, model validation and error evaluation, model updating and optimization and harmonic response analysis.

3.1 FINITE ELEMENT MODELING (FEM)

A detailed finite element model of the mechanical pot bearing was developed using ANSYS software. The model incorporated all essential components, including the pot, elastomeric pad, piston, PTFE sliding layer, and external constraints. Material properties were defined based on the manufacturer specifications and relevant standards. A modal analysis was conducted to extract the first four natural frequencies and associated mode shapes. Figure 1 shows the assembled geometry of the pot bearing and the finite element modelling for the pot bearing.

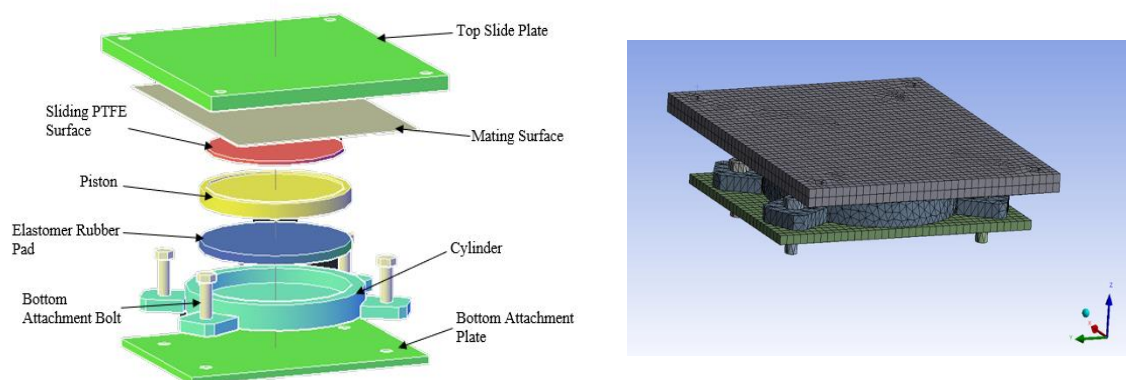


Figure 1: The Assembled Geometry of The Pot Bearing and The Finite Element Modelling for The Pot Bearing

3.2 EXPERIMENTAL MODAL ANALYSIS (EMA)

To validate the numerical model, an experimental modal analysis was performed on a physical pot bearing specimen. The bearing was instrumented with accelerometers, and an impact hammer was used to excite the structure. Frequency Response Functions (FRFs) were obtained using data acquisition software, and natural frequencies and mode shapes were extracted using modal analysis tools. Figure 2 shows the experimental modal analysis for the pot bearing.

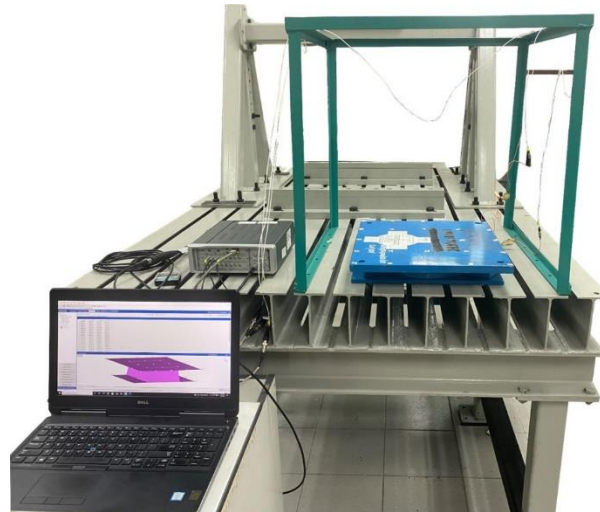


Figure 2: Experimental Modal Analysis for The Pot Bearing

3.3 MODEL VALIDATION

The results from the FEM and EMA were compared. Natural frequencies were evaluated using relative error calculations, while mode shape correlation was assessed using the Modal Assurance Criterion (MAC). This validation step ensured the accuracy of the numerical model in representing real world dynamic behaviour.

3.4 MODEL UPDATING AND OPTIMIZATION

In this study, Response Surface Method (RSM) optimization was employed. RSM is a statistical design of experiments (DOE) approach that was used to create a surrogate model. The optimization objective was to minimize the relative error between FEM and EMA results by adjusting key parameters such as Young's Modulus and Poisson's Ratio of materials.

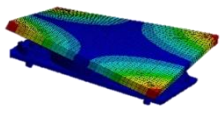
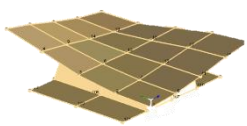
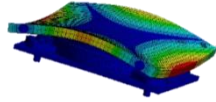
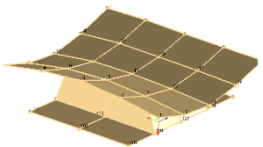
3.5 HARMONIC RESPONSE ANALYSIS

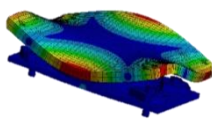
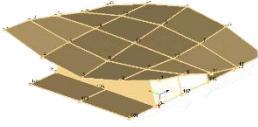
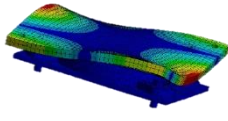
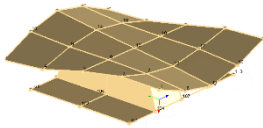
The optimized pot bearing model was integrated into a simplified bridge system to perform harmonic response analysis. This analysis evaluated deformation patterns, resonance amplification, and damping behaviour under simulated dynamic loading at various frequencies. The results were compared for both optimized and non-optimized bearing configurations.

4.0 RESULTS

The results of the finite element modal analysis and the experimental modal analysis for the pot bearing were compared, focusing on four modes as shown in Table 1. The comparison revealed that the mode shapes and natural frequencies for all four modes were consistent between the two methods. This agreement validates the numerical model and confirms its ability to replicate the pot bearing's dynamic behavior observed in the experimental analysis.

Table 1: Mode Shape Comparison Between Finite Element and Experimental Modal Analysis

Mode No.	Finite Element Modal Analysis	Experiment Modal Analysis	Mode Shape Description
1			1 st bending
2			2 nd bending

3			1 st Torsion
4			2 nd Torsion

From Table 1, the mode shapes for the four analysed modes have demonstrated close agreement, with similar deformation patterns observed in both methods. This consistency in mode shapes reinforces the validity of the numerical model in replicating the physical dynamic behaviour of the pot bearing. To further validate the mode shapes, the Modal Assurance Criterion (MAC) was used to determine the similarity between the mode shapes obtained from the finite element modal analysis (FEMA) and the experimental modal analysis (EMA). In this study, the MAC values were calculated to verify the similarity between the FEMA and EMA mode shapes. The results indicate that all four modes exhibit MAC values of 100%, confirming that the mode shapes were paired in the correct order. No issues of mode swapping or missing modes were observed. Table 2 shows the comparative analysis of the initial and updated natural frequency using RSM for the pot bearing.

Table 2. Comparative Analysis of the Initial and Updated Natural Frequency using RSM

Mode No.	Experimental [Hz]	Initial Finite Element [Hz]	Relative Error [%]	Updated Finite Element [Hz]	Relative Error [%]
1	491.51	566.16	15.29	511.04	3.97
2	835.55	920.17	10.13	835.41	0.02
3	1148.10	1259.10	9.67	1178.1	2.61
4	1188.88	1293.60	8.81	1210.5	1.82
Total Relative Error			43.9		8.42

Overall, the total initial relative error across all modes was 43.9%, which was significantly reduced to 8.42% after the optimization. This substantial improvement demonstrates the effectiveness of the optimization process in enhancing the accuracy of the finite element model. The updated model now reliably represents the real-world dynamic behaviour of the pot bearing, providing a robust basis for further analysis and practical applications.

5.0 CONCLUSION

This study has successfully developed and validated OPTIBEA, an optimized pot bearing system designed to enhance the dynamic performance of bridge structures under harmonic loading conditions. Through a combination of finite element modeling, experimental modal analysis, and advanced RSM optimization techniques, the project addressed significant discrepancies in the dynamic prediction of traditional pot bearings. The validated model showed excellent agreement in mode shapes (MAC = 100%) and a substantial reduction in natural frequency prediction errors from 43.9% initially to as low as 8.42% post-optimization using RSM. Harmonic response analysis confirmed the system's ability to manage deformation effectively, particularly near resonance frequencies, with the optimized bearings demonstrating enhanced energy dissipation and reduced displacement at both mid-span and support regions. These results highlight the importance of combining numerical and experimental methods for accurate structural modeling. More importantly, the OPTIBEAR system has proven its readiness for real-world applications, offering increased reliability, safety, and cost-efficiency in bridge engineering.

The innovation has strong potential for use in new infrastructure projects and retrofitting of aging bridges, contributing to the advancement of smart, resilient structural systems.

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SMART CONTROL INTEGRATION IN A MINI FORKLIFT FOR SMALL SCALE APPLICATIONS

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ABSTRACT

This project presents the design, analysis, and fabrication of a smart control mini forklift aimed at improving material handling in confined and limited-access environments. Traditional forklifts pose maneuverability and safety challenges in small spaces, while manual handling methods may risk musculoskeletal injuries. In addressing these limitations, a compact forklift prototype is developed using SolidWorks 2021 for 3D modeling and stress analysis. The system integrates mechanical and electronic subsystems, including a pulley driven lift mechanism, IR remote control, and Arduino-based programming. Fabrication involved conventional machining processes and assembly using cost-effective materials. Experimental tests confirmed a lifting capacity of 2 kg, with satisfactory maneuverability and operational control. Although performance was slightly below the initial 5 kg target, the design demonstrated effectiveness for small-scale applications. The prototype promotes safer operation, energy efficiency, and adaptability in restricted environments, offering potential for scalable deployment in logistics and warehouse operations.

Keywords: Remote controlled mini forklift, Compact material handling, Pulley and belt mechanism, Arduino based control

1.0 INTRODUCTION

The advancement of automation and compact machinery in industrial applications has led to significant improvements in safety, efficiency, and productivity. One such innovation is the remote-controlled mini forklift, which designed to address material handling challenges in confined or space limited environments. Traditional manual lifting methods are still common in many small-scale operations, despite being labour intensive and ergonomically unsafe. Repetitive lifting motions, awkward postures, and load handling over extended periods often result in musculoskeletal disorders and low operational efficiency (Kamijantono et al., 2024; Hilmi & Hamid, 2023)

Conventional forklifts, while effective in large scale settings, are typically too bulky and costly for smaller warehouses, retail storage, or home-based businesses. These machines also require trained operators and present manoeuvrability issues in tight spaces (Alhasan & Lobanov, 2023; Abuzied et. Al., 2024). In addition, the high maintenance costs and limited accessibility of standard forklifts further limit their use in compact industrial setups (Motroni et al., 2021; Fraifer et al., 2025).

Motivated by these limitations, the proposed innovation aims to develop a low-cost, remote controlled mini forklift that is compact, easy to operate, and suitable for the use in confined areas. The invention integrates mechanical design with electronic control systems offering safer and more efficient alternatives to manual lifting. By leveraging basic fabrication techniques and microcontroller programming, this project contributes toward more accessible and scalable solutions for modern material handling.

2.0 OBJECTIVE

1. To design a smart control mini forklift using SolidWorks 2021, focusing on compact structure, manoeuvrability, and lifting functionality.
2. To fabricate a working prototype using low-cost materials and basic manufacturing techniques as a proof of concept

3.0 METHODOLOGY

The overall methodology of this project follows a systematic flow. It begins with a literature review to understand existing solutions and ergonomic challenges in material handling. This is followed by the concept design phase, where multiple sketches were generated and evaluated to identify the most practical and functional layout. The selected concept was then developed into a detailed 3D model using SolidWorks, allowing for visualization and simulation of structural performance. Once validated, the project moved into material selection and cost estimation to ensure affordability and feasibility. The electrical wiring and programming phase involved integrating Arduino-based control systems and motor drivers with an IR remote for user operation. Finally, the prototype underwent testing and evaluation to verify its performance, responsiveness, and ability to operate safely in confined spaces.

3.1 3D MODEL DESIGN

In the early design phase, multiple concept sketches were created to explore different configurations of the mini forklift, focusing on size, component arrangement, lifting mechanism, and ease of control. Then, the initial concept sketches were evaluated using a Pugh chart to select the best design. The chosen design was modelled using SolidWorks 2021, followed by stress, strain and displacement analysis to ensure structural safety.

3.2 FABRICATION PROCESS

Figure 1 shows the fabrication process of the smart control mini forklift. The process involved several stages, starting with measuring the mild steel into intended dimensions and then cutting, drilling, and welding the mild steel components to form the main frame, based on the finalized SolidWorks design. The pulley and belt system were installed to operate the lifting fork, while DC motors and wheels were then mounted for movement. Electrical integration included the installation of the Arduino Uno, IR receiver, and motor driver, all powered by a battery. After all parts were assembled and wired, the system was tested and refined to ensure functionality.

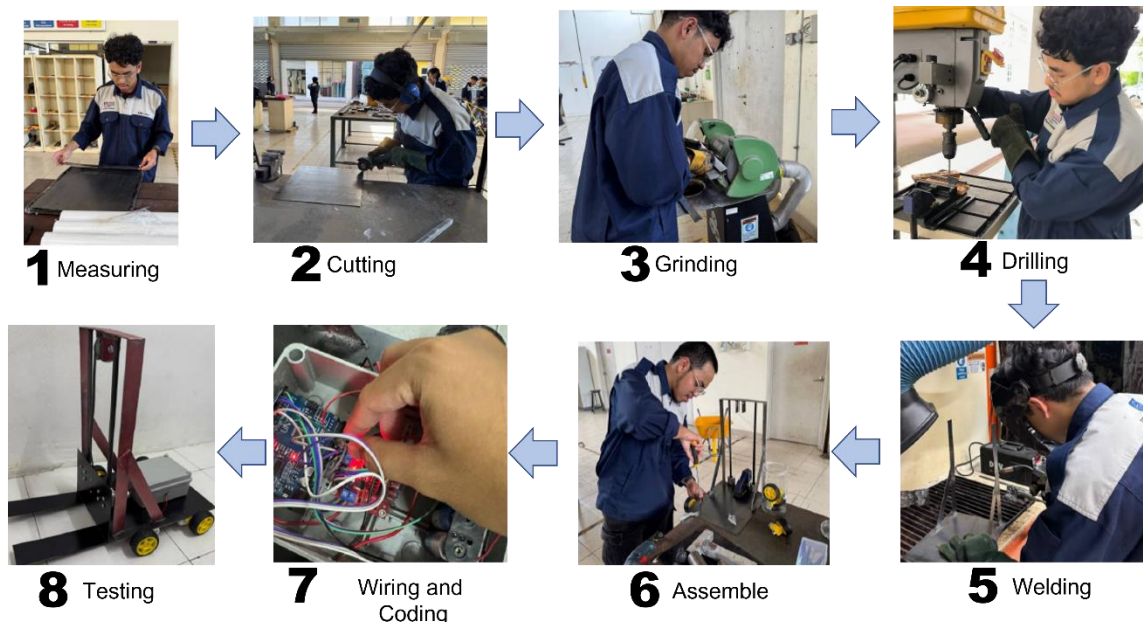


Figure 1: The smart control mini forklift fabrication process

4.0 RESULTS

4.1 SolidWorks DESIGN AND SIMULATION ANALYSIS

The design was initially created using SolidWorks 2021, where simulation analysis specifically stress, displacement, and strain analysis was conducted to ensure the structural reliability of the lifting fork made of mild steel before fabrication. An example of the design and analysis outputs are shown in Figure 2 and Figure 3. The strength analysis revealed that stress concentrations occurred at the fork joints but remained within the material's safety limits. Displacement at maximum load was minimal, indicating good structural stability, while strain distribution was uniform across the frame. These results confirmed that the design was safe and capable of withstanding expected operational loads.

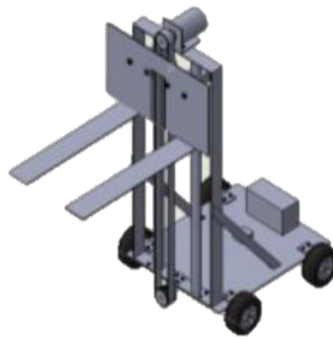


Figure 2: The final design of smart control mini forklift using SolidWorks 2021

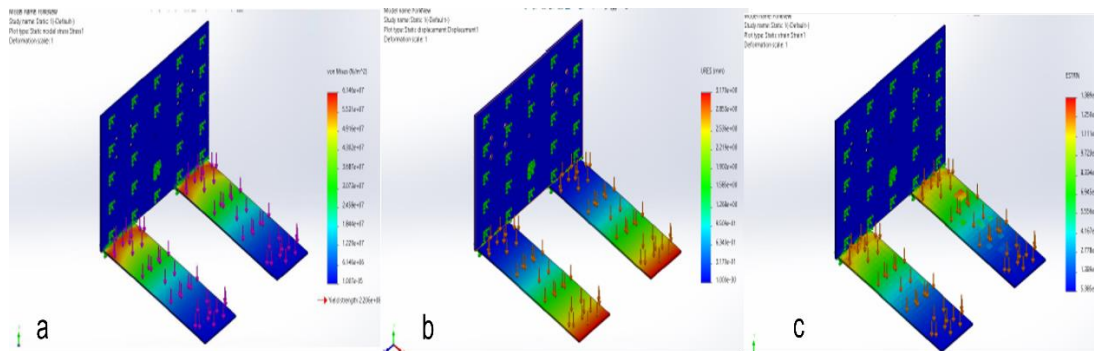


Figure 3: SolidWorks simulation results of the forklift design(a) Von Mises stress analysis showing maximum stress at the fork joints within safe limits, (b) Displacement analysis indicating minimal deformation under load, and (c) Strain distribution showing uniform material response across the structure.

4.2 FABRICATED PROTOTYPE AND SPECIFICATIONS

The final prototype, shown in Figure 4, demonstrates compact and functional design tailored for confined working spaces. The final prototype features a mild steel frame, pulley belt lifting system, and DC motors for drive and lift functions. The system is powered by a 7.4V rechargeable battery and controlled using an Arduino Uno with an infrared (IR) remote control interface and the specification details are summarized as in Table 1. The working principle of this prototype started with the IR remote control sends directional commands to the IR receiver, which are interpreted by the Arduino Uno to control the motion of the drive motors and lifting mechanism. The pulley and belt system converts rotary motion into vertical lifting, allowing the fork to raise and lower loads. All movement is powered by the DC motors and regulated through a motor driver circuit. This control method reduces the need for direct human contact, increasing safety and ease of operation, especially in tight or restricted environments.

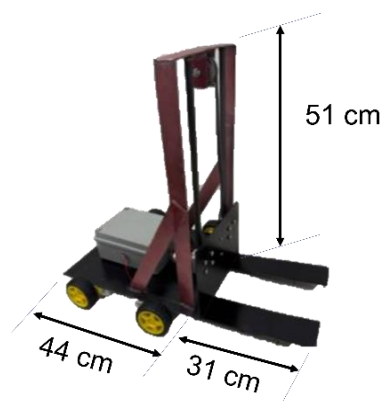


Figure 4: Fabricated smart control mini forklift prototype with its dimensions.

Table 1: Smart control mini forklift prototype specifications

Parameter	Specifications
Material	Mild Steel
Weight	5.5 kg
Lifting load weight	2 kg
Voltage	7.4 V
Torque	25 kg.cm
Control Mechanism	IR Module

This project offers several advantages for material handling in confined and space-limited environments, where conventional forklifts are too large or costly. Firstly, its compact size, low fabrication cost, and simple control interface make it ideal for use in small warehouses, workshops, retail storage, or educational labs. Besides, the remote operation enhances safety by reducing direct physical contact with loads, and its lightweight design ensures easy mobility on flat surfaces. The project also uses affordable and accessible components, making it suitable for learning, prototyping, and low scale industrial applications.

As for the novelty of this project lies in its integration of a pulley belt lifting mechanism with IR remote control, built into a miniaturized forklift frame. With the combination of mechanical design, electronics, and CAD validation creates a unique, functional, and scalable solution for ergonomic improvement in material handling, especially in small industries and confined spaces where manual lifting poses safety risks and conventional forklifts are impractical due to their size and cost.

5.0 CONCLUSION

The smart control mini forklift prototype successfully demonstrated safe and efficient material handling for light loads in confined spaces. SolidWorks simulation and prototype testing confirmed the design's structural reliability and functional performance. This project offers a low cost, ergonomic alternative to conventional forklifts, with strong potential for use in small industries and educational settings. Its simplicity, scalability, and affordability make it a valuable contribution to both the scientific community and the local economy.

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Egg-FlexSCC: A Sustainable Self-Compacting Concrete Innovation Using Calcined Eggshell Powder

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ABSTRACT

Eggshell, primarily composed of calcium carbonate (CaCO_3), shows strong potential as a partial cement replacement in concrete. This innovation, Egg-FlexSCC, is a sustainable self-compacting concrete (SCC) that incorporates waste eggshell powder calcined at 900°C while addressing two critical issues: the environmental impact of cement production and the disposal of large volumes of eggshell waste. SCC has the ability to flow under its own weight without vibration and can effectively fill highly congested reinforced concrete sections. The unique feature of Egg-FlexSCC lies in the valorization of biogenic waste into a functional binder component without compromising structural performance. The methodology involved laboratory testing of fresh and hardened properties of SCC with varying levels of calcined eggshell powder (CESP) of 5%–20% as partial cement replacement. Durability assessment, consisting of a water absorption test, was also conducted over a period of up to 90 days. The results demonstrated that Egg-FlexSCC, with up to 20% CESP substitution, achieved better workability than the control mix with up to 21% workability enhancement for 15% CESP substitution, and flexural strengths comparable to that of the control mix with the optimum strength of 4.05 MPa is achieved through 5% CESP substitution at 28 days of curing. Additionally, all Egg-FlexSCC mixes exhibit reduction in water absorption at 90 days compared to the control mix, contributing to improved durability and resistance to water ingress. This innovation supports circular economy practices and aligns with Malaysia's objectives to reduce construction waste and promote the use of green construction materials. The potential applications of Egg-FlexSCC extend to housing projects, infrastructure development, and precast components in green-certified buildings. It promotes environmental stewardship, strengthens local waste recycling initiatives, and offers a scalable solution toward a low-carbon construction industry. In line with Malaysia's commitment to sustainable development under the Twelfth (12th) Malaysia Plan and the Green Technology Master Plan, innovations such as Egg-FlexSCC are essential for advancing eco-friendly cementitious alternatives and achieving national green growth targets.

Keywords: Mechanical Properties, Durability, Calcined Eggshell Powder, Self-Compacting Concrete, Sustainability.

1. INTRODUCTION

Egg-FlexSCC is an innovation in concrete, specifically self-compacting concrete (SCC), that incorporates calcined eggshell powder (CESP) as a partial cement replacement. This innovation has demonstrated a highly flowable characteristic that makes it valuable in complex construction projects, especially for densely reinforced or intricate formwork. Unlike conventional concrete, Egg-FlexSCC requires minimal labour during construction and efficiently filling moulds without external compaction. Characteristics such as higher filling ability, passing ability and resistance to segregation are preferred choices of concrete in modern construction (Paruthi et al., 2023). However, conventional SCC relies on cement, which is a significant source of CO_2 emissions, has raised environmental concerns. The cement industry is one of the most significant contributors to CO_2 productions, accounting for approximately 8% of global emissions, which is a substantial amount for a single sector (Khalil and AbouZeid, 2025). Hence, growing research for sustainable solutions on various substitutes for cement is crucial.

Each year, approximately 150,000 tonnes of eggshell waste are generated globally with the majority ending up in landfills, and thus, causing environmental pollution (Onwubu et al., 2019; Hamada et al., 2020). Eggshells, which are primarily composed of calcium carbonate (CaCO_3) can be calcined to produce calcium oxide (CaO), a cementitious material that is essential for hydration in concrete production. When processed at high temperatures, the calcined eggshell powder can serve as a partial cement replacement, helping to reduce the carbon footprint of concrete production while enhancing mechanical properties such as compressive strength (Hamada et al., 2020; Paruthi et al., 2023). Furthermore, calcined eggshell powder can enhance SCC durability by improving resistance to sulphate attack and reducing permeability (Murthi et al., 2022). Motivated by these previous studies, Egg-FlexSCC was developed in varying

substitution percentages of eggshells calcined at 900°C (i.e., 5%, 10%, 15% and 20%).

In addition to strength, the durability of concrete is a crucial measure of resistance to environmental exposure. Hamada et al. (2020) conducted an examination of water absorption in concrete incorporating nano-eggshell powder. Their results revealed that the incorporation of eggshell at 2.5% and 5% reduced water absorption by 17%-23% compared to the control mix. This suggests that even small quantities of finely ground eggshell powder can contribute to improved durability by reducing the permeability of concrete. Effects of CESP on fresh and hardened properties, as well as durability performance, of Egg-FlexSCC are presented in this extended abstract. This study is significant as it explores a sustainable approach to concrete production by utilising agricultural waste, and simultaneously, aiming to enhance the structural performance and durability of SCC in modern construction environments.

2. METHODOLOGY

This section describes the materials preparation and experimental methods to evaluate the workability, flexural strength and durability performance of Egg-FlexSCC. Egg-FlexSCC comprises of cement, gravel (<10 mm), sand (<4.75 mm), superplasticizer, water and waste eggshell calcined at 900°C for 1 hour and then grounded into powder. The methodology involved laboratory testing of fresh and hardened properties of SCC with varying percentages of CESP replacement (5%–20%) and water absorption test for durability assessment.

2.1 SLUMP FLOW TEST

The slump flow test was performed to assess the workability of fresh Egg-FlexSCC, in accordance with the EFNARC guideline (2005). The procedure involved placing fresh concrete into a standard slump cone, which was then allowed to stand for about 15 minutes. Upon lifting the cone, the concrete was permitted to spread freely on a non-absorbent surface. The maximum diameter of the spread concrete (D_1) and the diameter perpendicular to it (D_2), as shown in **Figure 1a**, were measured and their average was recorded as the slump flow value (SF), calculated from **Eqn. 1**.

$$SF = (D_1 + D_2) / 2 \quad \text{Eqn. 1}$$

2.2 FLEXURAL STRENGTH TEST

The flexural strength test was conducted in accordance with BS EN 12390-5:2019 to determine the modulus of rupture of the concrete, which represents its ability to resist bending stresses before fracture. Prism specimens, precisely measuring 75 mm × 75 mm × 300 mm, were cast and cured under controlled conditions. A total of 12 specimens were prepared for each mix design and subjected to a three-point bending test (**Figure 1b**) until failure at specified curing periods of 7, 28, 56 and 90 days. For each curing duration, three specimens were tested to ensure statistical robustness. The flexural strength was calculated using the formula given by **Eqn. 2**, as specified in BS EN 12390-5:2019.

$$\text{Flexural strength} = \frac{3PL}{2bd^2} \quad \text{Eqn. 2}$$

where P denotes maximum applied load (N), L is span length (mm), b is the width of the specimen (mm) and d is the depth of the specimen (mm).

2.3 WATER ABSORPTION TEST

Cylindrical specimens, measuring 80 mm × 75 mm per mix, were assessed at curing age of 90 days following BS 1881-122. The specimens were dried in an oven until their mass W_d was consistent before being submerged in water for 30 minutes, 24 hours and 72 hours, as shown in **Figure 1c**. At each time duration, the surface water was withdrawn and mass W_s was recorded. The water absorption percentage was calculated as given by **Eqn. 3**.

$$\text{Water Absorption (\%)} = [(W_s - W_d) / W_d] \times 100 \quad \text{Eqn. 3}$$

where W_s is the mass of saturated surface-dry specimen (g) and W_d is the mass of oven-dry specimen (g).

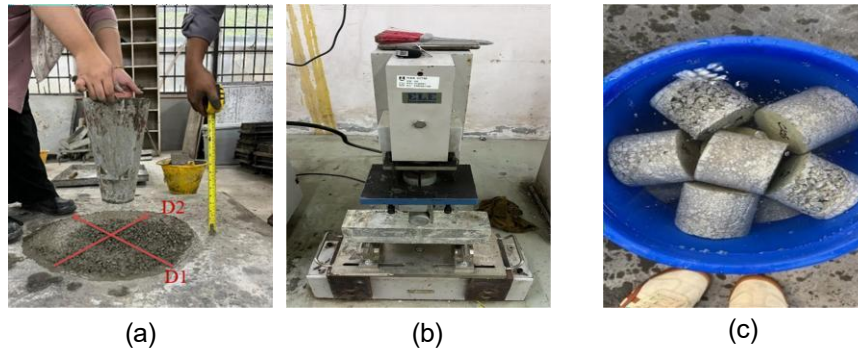


Figure 1: (a) Slump flow test, (b) flexural test, and (c) water absorption test

3. RESULTS AND DISCUSSIONS

This section presents the workability, flexural strength and water absorption resistance of Egg-FlexSCC as shown in **Figure 3**. The slump flow results, as shown in **Figure 3a**, indicate that the incorporation of CESP generally enhances the workability of SCC. Compared to the control mix, which recorded a slump flow of 515 mm, all Egg-FlexSCC mixes exhibited improved flowability with 15% CESP replacement achieving the highest slump flow of 625 mm or 21% enhancement, revealing the potential of Egg-FlexSCC in reducing internal friction and enhancing flow. Overall, the incorporation of CESP at moderate levels (especially 5%–20%) benefits SCC by improving its workability and thereby supporting easier placement during construction.

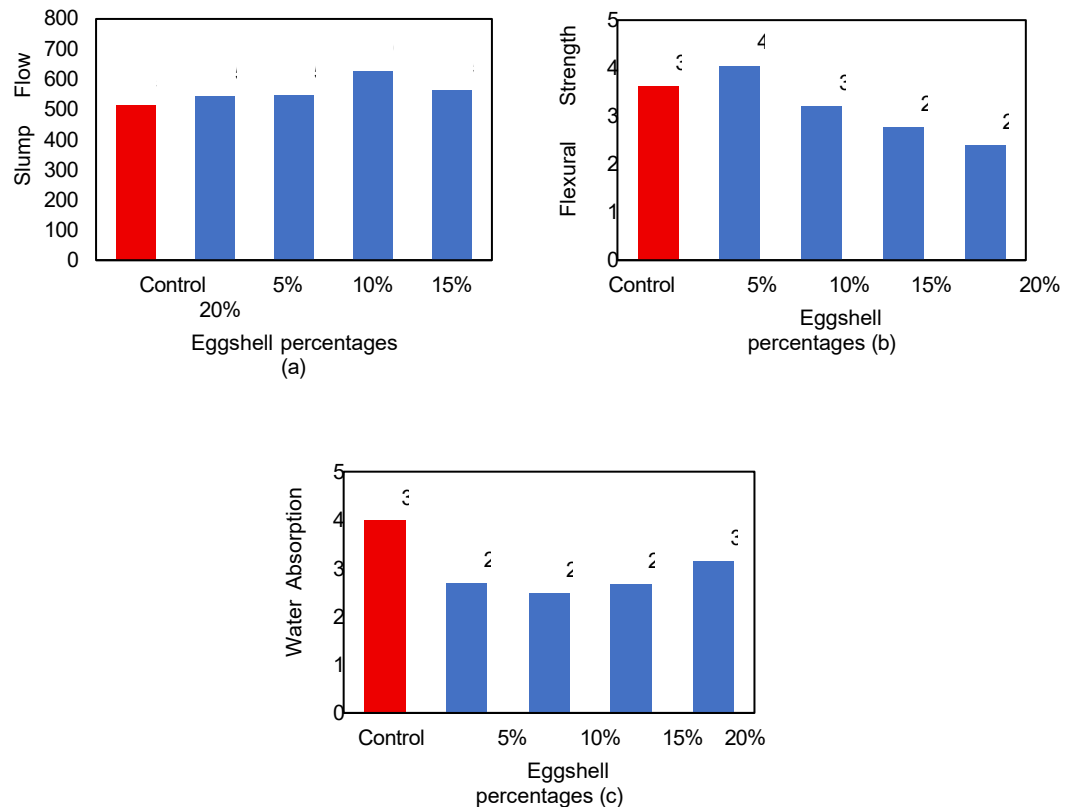


Figure 3: (a) Slump flow, (b) flexural strength, and (c) water absorption test results of Egg-FlexSCC

The flexural strength performance of Egg-FlexSCC (**Figure 3b**) indicates a non-linear effect of CESP inclusion. At 5% CESP replacement, the flexural strength peaked at 4.05 MPa surpassing the flexural strength of control mix (3.63 MPa) suggesting improved bonding and matrix densification due to the pozzolanic and filler effects of finely ground calcined eggshell. However, further increment in the eggshell content between 10%-20% led to progressive decline in flexural strengths. This reduction may be attributed to the dilution of the cementitious content and possible weak zones resulting from

excessive fines or unreacted particles. While moderate addition of CESP (around 5%) enhances the flexural performance of SCC, higher replacement levels negatively impact structural integrity.

The water absorption results of Egg-FlexSCC at 90 days (**Figure 3c**) demonstrate a significant improvement in durability with the incorporation of CESP. The control mix exhibited the highest water absorption at 3.98%, while all Egg-FlexSCC mixes recorded lower percentages of water absorption with a range of 2.48% to 3.14% for 5%-20% replacement level, respectively. These reductions suggest that CESP effectively enhances the microstructure by filling pores and refining the matrix, thereby reducing permeability and water ingress of SCC, indicating an improved pore structure and long-term resistance to environmental exposure.

4. CONCLUSION

Egg-FlexSCC presents a unique contribution of eggshell waste as a supplementary cementitious material in concrete innovation. The workability of SCC was significantly enhanced, with a 21% increase in slump flow observed for 15% CESP replacement compared to the control mix. Flexural strength results revealed that a 5% substitution level offered the optimal structural performance. Durability assessment through water absorption test showed significant reductions in water absorption across all Egg-FlexSCC mixes, with the lowest percentages recorded for 10% CESP replacement level. This improvement in resistance to water ingress demonstrates Egg-FlexSCC ability to refine the pore structure and reduce permeability, thereby contributing to enhanced long-term durability and environmental resistance.

These findings collectively emphasize the positive impact of Egg-FlexSCC in addressing two major concerns, particularly the cement production emissions and eggshell waste disposal, while simultaneously enhancing workability, flexural strength and water absorption resistance of SCC. This study establishes the viability of calcined eggshell powder as a sustainable and functional ingredient in modern concrete design, with potential applications in green buildings, precast elements, and infrastructure demanding high workability and durability. In line with Malaysia commitment to sustainable development under the Twelfth (12th) Malaysia Plan and the Green Technology Master Plan, innovations such as Egg-FlexSCC are essential for advancing eco-friendly cementitious alternatives and achieving national green growth targets.

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SADA'QOUNT (SMART MOSQUE DONATION BOX)

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ABSTRACT

Counting money manually can be a tedious and time-consuming task, especially when dealing with large sums or frequent transactions. Conventional mosque donation boxes often rely on manual counting method and therefore facing challenges of calculating money accurately and efficiently. To address these limitations, the Smart Mosque Donation Box offers an IoT-based solution that automates the donation counting process using a sensor to detect and count banknotes. Besides that, there is another concern for conventional mosque donation boxes. Currently, conventional donation boxes use basic security measures like padlocks, which are vulnerable to unauthorized access. To enhance security, this system uses fingerprint authentication, ensuring that only authorized administrators can access the donation box. In this system, the unlocking mechanism can also be controlled via an admin-authenticated mobile application, ensuring both security and convenience as it can prevent misconduct among the mosque management team based on the real-time access tracking functionality. Furthermore, to ensure stable and seamless interaction, the system is able to automatically self-configure to a backup network if the internet connection fails. This system is developed using the Internet of Things (IoT) design methodology, utilizing microcontrollers, local storage and cloud-based platforms for real-time monitoring of donation amounts and access logs. A pilot study conducted at a college mosque demonstrated the system's effectiveness, achieving a 92% improvement in tracking donations and enhanced security compared to traditional methods. With its automation, security enhancements, and remote monitoring capabilities, the Smart Mosque Donation Box provides an innovative and efficient solution for modernizing donation management in the mosques around Malaysia.

Keywords: Smart Mosque Donation Box, Automated Counting System, Security, Fingerprint Authentication, Real-Time Monitoring

1.0 INTRODUCTION

Managing donations effectively is essential for sustaining mosque operations and community welfare activities. However, conventional mosque donation boxes still rely on manual counting methods and basic padlock security, which present significant challenges. Manual counting of large sums is tedious, time-consuming, and prone to human error that can affect the accuracy and efficiency of financial reporting. Moreover, the use of simple padlocks makes the boxes vulnerable to unauthorized access, raising concerns about transparency and trust in the management of donated funds. Motivated by these issues, the Smart Mosque Donation Box was developed as an innovative solution to modernize donation management in mosques. This invention utilizes Internet of Things (IoT) technology to automate the counting of banknotes, enhance security through fingerprint authentication, and enable real-time monitoring of donations and access logs. The aim is to improve operational efficiency, ensure transparency, and strengthen the integrity of mosque financial management, addressing the limitations of traditional systems while fostering trust among the community.

2.0 OBJECTIVE

1. To automate the donation counting process by using IoT technology to improve accuracy and efficiency in managing mosque donations.
2. To enhance the security of donation boxes by implementing fingerprint authentication and access control via an admin-authenticated mobile application.
3. To enable real-time monitoring and transparent record-keeping of donation amounts and access logs through cloud-based platforms.

3.0 METHODOLOGY

The development of the Smart Mosque Donation Box follows an Internet of Things (IoT) design methodology that integrates hardware components, cloud platforms, and a mobile application that delivers a secure, efficient, and transparent donation management system. The product was designed and built to address the inefficiencies and security issues present in traditional mosque donation boxes, focusing on four key aspects which are features, functionality, usefulness, and practicality.

The main features of the innovation include an automated banknote counting mechanism using a colour sensor to detect and record every donation accurately. For enhanced security, the system employs fingerprint authentication to restrict access to authorized administrators only. An admin-authenticated mobile application complements this feature by enabling remote unlocking of the box and real-time monitoring of access logs. To ensure uninterrupted operation, the system is equipped with a backup Wi-Fi module that automatically switches to an alternate network in case of internet failure.

In terms of functionality, the system collects and stores donation data in both local memory and a cloud-based platform, providing administrators with real-time updates on donation amounts and access activities through the mobile application. This functionality ensures transparency and accountability in fund management while reducing the administrative burden of manual counting and record-keeping.

The usefulness of the system is demonstrated through its ability to improve operational efficiency, enhance transparency, and prevent unauthorized access or potential misconduct. By automating processes and providing real-time monitoring, the system strengthens trust within the mosque community regarding the handling of donations.

Finally, the innovation is highly practical. Its compact and modular design allows for easy installation in the existing donation infrastructure. The user-friendly interface of the mobile application makes it accessible that even for administrators with little technical knowledge can operate it without problems. A pilot test in a college mosque showed significant improvements in accuracy and security, confirming its viability for deployment in mosques across Malaysia.

3.1 ADOPTION OF BEST PRACTICES FROM RELATED INNOVATIONS

1. Santoso et al. (2017) highlighted that smart charity boxes leveraging IoT technologies significantly enhance the accuracy and transparency of donation tracking in mosques. Inspired by this approach, our system further addresses another limitation of conventional donation boxes that is their basic security mechanisms.

2. As Mahesh et al. (2023) showed, using sensors like colour sensors in money counting machines can help detect fake currency and reduce human errors, making the counting process more accurate. Based on this idea, our system improves the traditional donation box by using sensors to automatically count the banknotes, making it more suitable and reliable for mosque donations.

3. Like how Komarudin et al. (2024) implemented Telegram-based notifications in their IoT smart piggy bank using RFID technology, our system also enables real-time updates through a mobile application. This allows administrators to remotely track donation activity and monitor access logs instantly, improving transparency and operational efficiency.

4. Ghosh et al. (2024) similarly demonstrated that integrating biometric authentication and automated alerts in IoT-based security systems helps prevent unauthorized access and enhances trust in monitoring processes. Our system follows this approach by combining secure biometric control with real-time access tracking and alerts, significantly reducing the risk of misuse by internal or external parties.

4.0 RESULT

The Smart Mosque Donation Box offers important benefits by overcoming the main weaknesses of traditional mosque donation systems. The pilot study conducted at a college mosque demonstrated that the system improves donation tracking accuracy by 92%, greatly reducing errors associated with manual counting. By automating the counting, the system helps mosque administrators save time and handle their other duties more easily.

In terms of security, the integration of fingerprint authentication and mobile application access control eliminates the risk of unauthorized access to the donation box. Real-time monitoring and logs show all activities clearly, making the mosque management more trustworthy and accountable to the community.

The novelty of this innovation lies in its unique combination of IoT-based automation, biometric security, and real-time cloud monitoring, specifically tailored for the needs of mosque donation management. Unlike conventional systems that rely solely on manual methods and basic padlocks, this system introduces a holistic approach that integrates multiple technologies into one practical and affordable solution. By having a backup network, the system is allowed to keep running during internet outages that adding reliability and setting it apart from other donation box designs.

Overall, the Smart Mosque Donation Box modernizes the donation process, improves efficiency, strengthens security, and promotes transparency which offers a new, practical, and meaningful solution for mosques in Malaysia.

5.0 CONCLUSION

The Smart Mosque Donation Box has proven to be effective in solving key problems of traditional donation management, such as inaccurate counting, poor security, and lack of transparency. The system improves accuracy, saves time, and enhances trust through its automated counting, fingerprint authentication, and real-time monitoring features.

This innovation shows how IoT technology can be applied in a practical way to improve donation systems in mosques. Its unique combination of automation, biometric security, cloud monitoring, and backup network connectivity makes it an original and useful contribution, which can inspire further development of similar systems in other community or religious settings.

Economically, the system helps reduce administrative workload, lowers the risk of theft or mismanagement, and promotes transparency, which can increase public confidence and encourage more donations.

In summary, the Smart Mosque Donation Box offers a practical, efficient, and secure solution to modernize donation management in mosques, with benefits that extend to both the community and the wider field of smart financial management systems.

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SOLAR POWER WATERING PLANT (HYDROSUN)

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ABSTRACT

This innovation is a prototype solar-powered crop irrigation innovation known as the Solar Power Watering Plant for use in the HydroSun project. The system is designed to support sustainable agriculture through irrigation automation using renewable energy. Solar panels are used to generate electricity that supports the operation of water pumps and automatic control systems. Soil moisture sensors are installed to detect moisture levels and activate the pumps only when needed, thereby saving water and energy consumption. The design of this system focuses on efficiency, low cost, and usability in rural areas with limited electricity supply. Test results show that this system works efficiently in automatically watering crops, is responsive to changes in soil moisture, and is environmentally friendly. This project proves that the integration of green technology in the agricultural sector can improve water management efficiency and support the sustainable development agenda.

Keywords: Solar Energy, Automatic Irrigation, Moisture Sensor, Sustainable Innovation, Smart Agriculture

1.0 INTRODUCTION

Agriculture and gardening are crucial to food security, ecological balance, and quality of life. However, traditional irrigation practices often lead to excessive water usage, energy consumption, and labor dependence, which are no longer sustainable in the face of modern environmental challenges. Water scarcity, rising electricity costs, and climate variability demand smarter, greener approaches to plant cultivation—especially in rural and urban home settings where access to resources can be limited.

The Solar Power Watering Plant (HydroSun) is a student-developed innovation that addresses these challenges by integrating solar energy and smart automation into a compact, cost-effective irrigation system. This innovation capitalizes on the abundance of sunlight in tropical regions like Malaysia to power an automated plant-watering system that functions without manual intervention. It combines green energy with sensor-based technology, making it ideal for small-scale farmers, urban gardeners, educational institutions, and eco-conscious households.

Designed with affordability, simplicity, and environmental sustainability in mind, HydroSun uses solar panels to charge a battery system that powers a moisture-sensing irrigation unit. When the soil becomes dry, the sensor detects the low moisture level and triggers a pump to supply water directly to the plant roots, thereby conserving water and ensuring optimal plant growth. This project also aims to cultivate students' creative thinking and technical skills through the application of STEM principles and sustainable innovation.

HydroSun not only promotes environmental stewardship but also supports the global movement towards achieving the United Nations Sustainable Development Goals (SDGs), especially in ensuring access to clean energy (SDG 7), responsible consumption and production (SDG 12), and climate action (SDG 13).

2.0 OBJECTIVE

The main objectives of this innovation are:

1. To develop a low-cost, eco-friendly automatic watering system powered by solar energy.
2. To minimize water wastage by integrating soil moisture sensors for targeted irrigation.
3. To enhance students' innovation and problem-solving skills through green technology.

3.0 METHODOLOGY

The HydroSun system consists of four main components: a solar panel, a battery storage unit, a moisture sensor, and a water pump. The solar panel captures sunlight and stores energy in a rechargeable battery. The moisture sensor, embedded in the soil, continuously monitors the soil's water content. When the moisture level falls below a preset threshold, the microcontroller (e.g., Arduino) activates the water pump to irrigate the plants. The system was tested in a controlled environment for different soil types and sunlight intensities to ensure reliability and performance.

4.0 FINDING AND RESULT

Initial testing of the HydroSun prototype demonstrated its ability to reduce water consumption by up to 40% compared to manual watering. The system operated efficiently under normal daylight conditions, maintaining consistent soil moisture suitable for plant health. Users reported convenience and increased awareness of sustainable practices. The cost to build the prototype was affordable, making it suitable for educational, household, and small-scale agricultural use.

5.0 SIGNIFICANCE AND IMPLICATIONS

HydroSun exemplifies how renewable energy and sensor-based automation can address environmental challenges in agriculture. By reducing water usage and relying solely on solar energy, this innovation contributes to sustainable development goals (SDGs), particularly in clean energy and responsible consumption. It also serves as a practical learning tool for students to explore STEM concepts and environmental responsibility.

6.0 CONCLUSION

The Solar Power Watering Plant (HydroSun) innovation showcases the potential of combining green energy with smart technology to improve agricultural practices. Its simplicity, affordability, and environmental benefits make it a viable solution for future urban and rural gardening needs. The success of this project reflects students' capability to create impactful innovations that align with global sustainability efforts.

ACKNOWLEDGEMENT

We would like to express our deepest appreciation to everyone who supported and contributed to the development of the Solar Power Watering Plant (HydroSun) innovation project. Our sincere gratitude goes to Politeknik Kota Bharu for providing the platform, facilities, and continuous encouragement throughout the process.

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Lastly, we are grateful for the opportunity to participate in this initiative, which has allowed us to explore practical solutions for sustainable agriculture through green technology. This experience has been both enriching and inspiring.

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SOLAR ENERGY HOUSE

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ABSTRAK

Projek inovasi ini bertujuan membangunkan sebuah sistem penjanaan elektrik berasaskan tenaga solar yang berskala kecil. Ia sesuai digunakan di dalam dan di luar bangunan. Model rumah berukuran 21.5 cm x 20 cm ini dilengkapi dengan panel solar tunggal berkuasa 6V serta sokongan sistem solar berganda yang membekalkan jumlah tenaga sebanyak 12V. Tenaga solar yang diperoleh ditukar kepada tenaga elektrik melalui panel fotovoltai sebelum disalurkan ke alat penyongsang arus yang menukar arus terus (DC) kepada arus ulang-alik (AC) secara automatik. Seterusnya tenaga ini dialirkan ke panel agihan dalaman untuk membekalkan kuasa kepada peralatan elektrik. Inovasi ini bukan sahaja menekankan penggunaan tenaga boleh diperbaharui yang mesra alam malah memperlihatkan kecekapan sistem miniatur dalam menjana tenaga alternatif yang mampan dan praktikal. Projek ini berpotensi untuk dikembangkan sebagai bahan bantu pengajaran, demonstrasi teknologi hijau serta aplikasi dalam pendidikan TVET dan STEM. Selain itu, projek ini turut menyumbang kepada kesedaran alam sekitar, pengurangan jejak karbon dan berpotensi dikomersialkan dalam skala komuniti seperti pondok keselamatan, kabin luar grid atau sebagai bahan pameran interaktif. Secara keseluruhannya, inovasi ini membawa pendekatan yang holistik, praktikal dan berdaya saing. Sejajar dengan aspirasi negara dalam mendepani cabaran kelestarian tenaga dan pembangunan mampan.

Kata Kunci: Tenaga Solar, Tenaga Hijau, Projek Pelajar, Penjanaan Elektrik

1.0 PENDAHULUAN

Dunia hari ini berhadapan dengan cabaran perubahan iklim akibat daripada pemanasan global dan keperluan untuk menjamin bekalan tenaga yang stabil untuk masa hadapan. Pergantungan berlebihan terhadap bahan api fosil seperti arang batu, minyak dan gas bukan sahaja menyumbang kepada pelepasan gas rumah hijau yang memerangkap haba di atmosfera tetapi juga mendedahkan negara kepada ketidakpastian harga dan bekalan di pasaran global. Menyedari hakikat ini, Malaysia telah menggariskan komitmen yang jelas melalui dasar-dasar strategik seperti Pelan Hala Tuju Peralihan Tenaga Negara (NETR) untuk meningkatkan kapasiti tenaga boleh baharu (TBB) sehingga 70% menjelang tahun 2050 (Kementerian Ekonomi, 2023). Aspirasi ini menuntut agar inovasi dalam teknologi hijau dibangunkan secara giat di semua peringkat bagi menyokong peralihan negara ke arah ekosistem tenaga rendah karbon.

Dalam spektrum tenaga boleh baharu, tenaga solar menonjol sebagai sumber yang paling berpotensi besar dan belum dimanfaatkan sepenuhnya di Malaysia. Berikutan kedudukan geografinya di garisan Khatulistiwa, negara ini menerima kadar sinaran suria yang tinggi secara konsisten sepanjang tahun iaitu sekitar 4,000 hingga 5,000 Wh/m² (Mekhilef et al., 2011). Teknologi fotovoltai (PV) yang secara langsung menukarkan cahaya matahari kepada tenaga elektrik kini telah menjadi semakin matang dan kos efektif, menjadikannya pilihan yang amat berdaya maju untuk aplikasi bandar dan luar bandar. Pemanfaatan sumber tenaga yang bersih, melimpah dan percuma ini bukan sahaja dapat mengurangkan kebergantungan pada grid tenaga konvensional tetapi juga memberi kuasa kepada komuniti untuk menjana tenaga mereka sendiri.

Bagi menyahut seruan negara dan menterjemahkan potensi teori kepada aplikasi yang praktikal, projek "Solar Energy House" ini telah dibangunkan. Projek ini merupakan sebuah prototaip kediaman lestari berskala kecil yang berfungsi sepenuhnya menggunakan sistem fotovoltai. Matlamat utamanya adalah untuk mendemonstrasikan secara fizikal dan praktikal bagaimana tenaga solar boleh diperolehi dan digunakan secara efisien untuk menampung keperluan elektrik asas sesebuah rumah seperti sistem pencahayaan. Pembangunan model fungsian seperti ini adalah selari dengan pendekatan Pembelajaran Berasaskan Projek (PBP) yang terbukti berkesan dalam meningkatkan pemahaman dan minat pelajar terhadap aplikasi sains dan kejuruteraan dalam dunia sebenar (Thomas, 2000). Melalui pembinaan model fungsian ini, ia diharap dapat menjadi bukti konsep yang meyakinkan serta platform pendidikan untuk meningkatkan kesedaran awam mengenai kelebihan dan kebolehlaksanaan teknologi solar dalam kehidupan seharian sekaligus memacu penerimaan gaya hidup lestari.

2.0 OBJEKTIF

Objektif projek inovasi ini adalah:

1. Membangunkan sebuah prototaip rumah berfungsi yang dijana sepenuhnya oleh sistem tenaga solar.
2. Mengaplikasikan konsep tenaga boleh baharu dengan mereka bentuk sistem bekalan elektrik yang efisien menggunakan panel solar.
3. Mengkaji dan menunjukkan keberkesanan sistem fotovoltai dalam menukar tenaga suria kepada tenaga elektrik untuk kegunaan domestik seperti sistem pencahayaan.
4. Menganalisis potensi penjimatan kos dan tenaga dalam jangka panjang melalui penggunaan tenaga solar berbanding sumber tenaga konvensional.

3.0 METODOLOGI

Metodologi projek ini distrukturkan secara sistematik dengan mengadaptasi model Proses Reka Bentuk Kejuruteraan (Engineering Design Process). Sebagai satu pendekatan yang disyorkan secara meluas untuk pembangunan prototaip pelajar dalam bidang teknikal (Dym & Little, 2009), pendekatan ini memastikan setiap langkah daripada penjanaaan idea hingga ke pengujian produk akhir dilaksanakan secara teratur dan logik. Pelaksanaan projek ini dibahagikan kepada tiga fasa utama yang selari dengan proses tersebut iaitu Fasa Perancangan & Reka bentuk, Fasa Pembangunan Prototaip dan Fasa Pengujian dan Pengesahan.

3.1 FASA PERANCANGAN & REKA BENTUK

Fasa ini melibatkan langkah-langkah awal seperti mengenalpasti masalah dan objektif (Ask). Diikuti dengan sumbang saran untuk penjanaaan idea (Imagine) dan diakhiri dengan perancangan terperinci (Plan). Dalam konteks projek ini, lakaran reka bentuk konsep dan pelan susun atur rumah telah dihasilkan. Spesifikasi teknikal termasuk pemilihan komponen seperti panel solar berkapasiti 12V dan lampu LED serta bahan binaan seperti papan lekup dan kepingan laminat telah ditentukan dalam fasa ini.

3.2 FASA PEMBANGUNAN PROTOTAIP

Fasa kedua pula adalah peringkat pelaksanaan (Create) di mana reka bentuk konsep diterjemahkan menjadi produk fizikal. Model rumah dengan dimensi 21.5 cm x 20 cm dibina dengan teliti. Proses pembangunan melibatkan kerja-kerja seperti pemotongan bahan, pemasangan struktur dan yang paling kritikal ialah integrasi sistem elektrik. Proses pematerian digunakan untuk menyambungkan panel solar kepada litar lampu LED dan memastikan semua komponen berfungsi sebagai satu sistem yang bersepadu.

3.3 FASA PENGUJIAN DAN PENGESAHAN

Fasa terakhir ini (Test & Improve) adalah bertujuan untuk menguji dan mengesahkan kefungsiian prototaip. Kaedah pengujian ini yang melibatkan penilaian output sistem di bawah keadaan pencahayaan terkawal untuk mengesahkan prestasi adalah selari dengan amalan standard dalam pengesahan sistem fotovoltai berskala kecil (Li & Xing, 2017). Model "Solar Energy House" yang telah siap didedahkan kepada sumber cahaya (cahaya matahari dan sumber cahaya alternatif) untuk menilai keupayaan panel menjana tenaga. Keberkesanan sistem diukur melalui pemerhatian sama ada lampu LED dapat menyala dengan terang dan konsisten.

4.0 DAPATAN PROJEK

Hasil daripada projek ini ialah sebuah prototaip "Solar Energy House" yang berfungsi sepenuhnya. Dapatan utama adalah seperti berikut:

1. Prototaip berjaya membuktikan bahawa tenaga solar mampu menjadi sumber kuasa tunggal untuk sebuah kediaman. Sistem pencahayaan di dalam dan di luar rumah yang diwakili oleh lampu LED dapat dinyalakan dengan jayanya menggunakan tenaga yang diperolehi oleh panel solar.

2. Sistem fotovoltaik dengan kapasiti 12V terbukti mencukupi untuk menampung beban elektrik asas model ini. Ini menunjukkan bahawa dengan skala yang betul, sistem yang sama boleh diaplikasikan pada kediaman sebenar.
3. Aplikasi konsep fizik di mana sel fotovoltaik menukar foton daripada cahaya matahari kepada arus elektrik berjaya didemonstrasikan secara visual. Projek ini menjadi bahan bantu mengajar yang efektif untuk menerangkan prinsip tenaga boleh baharu.

5.0 KESIMPULAN

Secara keseluruhannya, projek “Solar Energy House” ini telah berjaya mencapai semua objektif yang ditetapkan. Ia bukan sahaja mendemonstrasikan kebolehan teknikal penggunaan tenaga solar untuk aplikasi kediaman tetapi juga menyerlahkan faedah alam sekitar dan ekonominya. Inovasi ini menyokong matlamat pembangunan lestari negara dengan menunjukkan alternatif yang praktikal kepada tenaga konvensional. Sebagai tenaga masa hadapan, tenaga solar berpotensi besar untuk menyelesaikan isu permintaan tenaga yang semakin meningkat sambil meminimumkan impak negatif terhadap alam sekitar. Model ini diharap dapat memberi inspirasi kepada masyarakat untuk menerima pakai teknologi hijau dalam kehidupan seharian.

PENGHARGAAN

Setinggi-tinggi penghargaan dan ucapan terima kasih ditujukan kepada Politeknik Kota Bharu atas sokongan yang diberikan. Terima kasih yang tidak terhingga kepada semua yang terlibat secara langsung atau tidak langsung atas segala bimbingan, nasihat dan dorongan sepanjang pelaksanaan projek inovasi ini. Penghargaan juga diberikan kepada semua ahli kumpulan atas kerjasama dan komitmen padu yang telah menyumbang kepada kejayaan projek ini.

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THE LIGHTHOUSE IN THE CIRCLE

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ABSTRAK

Projek inovasi ini mengetengahkan konsep rumah api moden yang diadaptasi untuk ditempatkan di kawasan bulatan jalan raya bukan di tengah laut seperti rumah api tradisional. Ia menggabungkan dua elemen utama iaitu fungsi pencahayaan dan reka bentuk ikonik rumah api yang berperanan memberikan suasana terang dan selamat kepada pengguna jalan raya khususnya pada waktu malam atau dalam cuaca buruk. Selain pencahayaan, reka bentuk ini turut menawarkan nilai estetika tinggi yang meningkatkan imej kawasan sekitar bulatan tersebut. Sumber tenaga yang digunakan adalah 100% tenaga boleh diperbaharui iaitu tenaga solar melalui panel solar yang dipasang secara sekeliling struktur. Ini menjadikan projek ini bukan sahaja mesra alam malah selari dengan usaha global dalam menangani perubahan iklim dan mengurangkan kebergantungan terhadap tenaga fosil. Inovasi ini berpotensi besar dalam pembangunan bandar pintar (smart city) selain meningkatkan aspek keselamatan jalan raya dan kesedaran terhadap penggunaan tenaga hijau. Ia juga boleh dijadikan model pendidikan interaktif untuk pelajar dalam bidang kejuruteraan, seni bina dan teknologi lestari. Secara keseluruhannya, inovasi ini bukan sahaja praktikal dan berfungsi tinggi malah membawa impak visual, keselamatan dan kelestarian yang berdaya saing dan bersifat jangka panjang. Ia mencerminkan pendekatan kreatif dalam menyelesaikan masalah urban melalui teknologi hijau dan rekaan berinspirasi tempatan. Ia juga berupaya menjadi alat bantu pembelajaran berimpak tinggi dalam bidang STEM dan TVET khususnya dalam memperkenalkan konsep tenaga boleh diperbaharui kepada pelajar.

Kata Kunci: Tenaga Solar, Bulatan Jalan Raya, Rumah Api Moden, Tenaga Boleh Diperbaharui

1.0 PENDAHULUAN

Pembangunan infrastruktur jalan raya yang pesat di kawasan bandar dan pinggir bandar telah membawa kepada cabaran pengurusan trafik yang semakin kompleks. Bulatan (roundabout) terus diiktiraf sebagai kaedah kawalan persimpangan yang berkesan untuk melancarkan aliran trafik dan mengurangkan kadar kemalangan serius seperti yang disahkan dalam analisis prestasi keselamatan terkini (Ismail & Chen, 2022). Walau bagaimanapun, keberkesanan bulatan sering terjejas pada waktu malam atau dalam keadaan cuaca buruk disebabkan oleh pencahayaan yang tidak mencukupi yang boleh mengakibatkan kekeliruan kepada pemandu. Keperluan untuk penyelesaian pencahayaan yang efisien, lestari dan berautonomi menjadi semakin mendesak selari dengan matlamat pembangunan bandar pintar dan mampan.

Menyahun cabaran ini, wujud satu trend global ke arah pengintegrasian teknologi hijau dan elemen reka bentuk kreatif dalam infrastruktur awam. Penggunaan tenaga solar untuk lampu jalan terutamanya sistem pintar berasaskan LED telah terbukti dapat mengurangkan pergantungan pada grid kuasa nasional, menjimatkan kos operasi dan mengurangkan jejak karbon secara signifikan (Kumar & Singh, 2021). Di samping aspek fungsian, pendekatan "placemaking" atau penciptaan mercu tanda unik di mana reka bentuk unik pada ruang awam dapat membentuk identiti sesuatu kawasan dan meningkatkan pengalaman komuniti (Tan & Musa, 2022). Pembinaan struktur ikonik di lokasi strategik seperti bulatan bukan sahaja berfungsi sebagai alat pandu arah visual tetapi juga mampu membentuk identiti sesuatu kawasan dan meningkatkan nilai estetika persekitaran.

Justeru, projek "The Lighthouse in the Circle" dibangunkan sebagai satu inovasi berimpak tinggi yang menggabungkan tiga domain utama iaitu kejuruteraan trafik, tenaga boleh baharu dan reka bentuk bandar. Negara Malaysia dengan kedudukan geografinya mempunyai potensi teknikal yang tinggi untuk penjaan tenaga solar, satu fakta yang sentiasa dikaji selari dengan matlamat tenaga negara (Hassan & Lim, 2023). Prototaip ini mencadangkan sebuah struktur rumah api yang ditempatkan di tengah bulatan berfungsi serentak sebagai sumber cahaya utama yang dijana sepenuhnya oleh tenaga solar dan sebagai sebuah mercu tanda yang menarik. Inovasi ini bertujuan untuk memberikan penyelesaian bersepadu kepada isu keselamatan di bulatan mempromosikan penggunaan tenaga bersih selaras dengan Pelan Hala Tuju Peralihan Tenaga Negara (Kementerian Ekonomi, 2023) dan pada masa yang sama memperkaya landskap visual bandar.

2.0 OBJEKTIF

Objektif projek inovasi ini adalah:

1. Membangunkan sebuah prototaip rumah api di bulatan yang berfungsi sebagai sistem pencahayaan berkuasa solar untuk meningkatkan keselamatan dan panduan visual kepada pemandu.
2. Mengurangkan kos pemasangan dan penyelenggaraan infrastruktur lampu jalan konvensional melalui penggunaan 100% tenaga boleh baharu.
3. Meningkatkan kecekapan aliran trafik dan mengurangkan potensi kesesakan serta kemalangan di kawasan bulatan.
4. Mencipta sebuah mercu tanda (landmark) dengan reka bentuk unik bagi meningkatkan nilai estetika kawasan dan berpotensi menjadi tarikan kepada pengunjung.

3.0 METODOLOGI

Pembangunan prototaip ini distrukturkan dengan mengadaptasi Proses Reka Bentuk Kejuruteraan; iaitu merupakan satu kerangka kerja sistematik yang amat disarankan untuk projek-projek pelajar dalam bidang Sains, Teknologi, Kejuruteraan dan Matematik (STEM) (Sazali & Othman, 2021). Proses ini memastikan setiap peringkat dilaksanakan secara terperinci daripada perancangan awal hingga pengesahan produk akhir. Pelaksanaannya dibahagikan kepada tiga fasa utama:

- **Fasa 1: Perancangan dan Reka Bentuk Konsep.**
Fasa ini dimulakan dengan penghasilan lukisan teknikal dan lakaran reka bentuk 3D yang terperinci. Reka bentuk memfokuskan kepada struktur rumah api yang diletakkan di tengah bulatan dengan penempatan panel solar di sekelilingnya untuk penyerapan tenaga suria yang maksimum mengambil kira potensi sinaran suria yang tinggi di Malaysia. Senarai bahan seperti kotak kadbod, kayu aiskrim, panel solar, lampu LED dan wayar telah dikenalpasti serta pelan kerja yang teratur telah dirancang.
- **Fasa 2: Pembangunan dan Pemasangan Prototaip.**
Pada fasa ini, reka bentuk diterjemahkan kepada model fizikal. Proses fabrikasi melibatkan aktiviti seperti pemotongan, pembentukan dan pemasangan struktur utama menggunakan gam panas. Litar elektrik disambungkan dengan teliti melalui proses pematerian. Seterusnya, mengintegrasikan panel solar dengan lampu LED yang akan menerangi model. Akhir sekali, elemen hiasan seperti rumput tiruan dan pewarnaan ditambah untuk melengkapkan prototaip.
- **Fasa 3: Pengujian dan Pengesahan Fungsi.**
Prototaip yang telah siap diuji di bawah cahaya matahari sebenar untuk mengesahkan kefungsiannya. Ujian ini melibatkan pemerhatian terhadap keupayaan panel solar untuk mengesan cahaya dan secara automatik mengaktifkan lampu LED pada struktur rumah api. Kaedah pengujian dengan menghalang dan mendedahkan model kepada cahaya matahari digunakan untuk mensimulasikan kitaran siang dan malam, sekaligus mengesahkan bahawa sistem automasi litar berfungsi seperti yang dirancang.

4.0 DAPATAN PROJEK

Projek ini berjaya menghasilkan sebuah prototaip "The Lighthouse in the Circle" yang berfungsi sepenuhnya. Dapatan utama yang diperoleh adalah seperti berikut:

1. Prototaip berjaya membuktikan konsep integrasi dua fungsi iaitu sebagai sumber pencahayaan jalan dan sebagai mercu tanda estetik.
2. Sistem litar berkuasa solar yang direka bentuk terbukti berjaya dan efisien. Lampu LED pada model menyala secara automatik apabila terdedah kepada cahaya matahari (atau apabila halangan cahaya dialihkan) menunjukkan kejayaan penuaian tenaga solar dan penggunaan tenaga solar.

3. Inovasi ini menunjukkan potensi penjimatan kos yang signifikan dalam jangka panjang kerana ia tidak memerlukan bekalan elektrik daripada grid dan kos penyelenggaraannya adalah rendah berbanding lampu jalan konvensional.
4. Reka bentuknya yang unik berjaya mengubah persepsi bulatan daripada sekadar infrastruktur trafik kepada sebuah elemen landskap yang menarik.

5.0 KESIMPULAN

Kesimpulannya, projek "The Lighthouse in the Circle" bukan sekadar sebuah model tetapi sebuah manifestasi fizikal bagi penyelesaian kejuruteraan bersepadu yang berjaya mencapai semua objektifnya. Inovasi ini secara efektif menunjukkan bahawa integrasi teknologi tenaga boleh diperbaharui dengan reka bentuk infrastruktur jalan raya yang kreatif serta mampu menghasilkan satu sistem yang pelbagai fungsi. Ia bukan sahaja menangani isu keselamatan pencahayaan di bulatan secara lestari tetapi juga berpotensi mengurangkan kos operasi jangka panjang bagi pihak berkuasa tempatan dan pada masa yang sama meningkatkan nilai estetika persekitaran bandar.

Impak inovasi ini menjangkau aspek teknikal semata-mata. Pada skala yang lebih besar, projek ini boleh menjadi model rintis (pilot model) yang mempengaruhi dasar perancangan bandar dan pembangunan infrastruktur di Malaysia. Ia menawarkan satu contoh praktikal bagaimana negara dapat mencapai sasaran dalam Pelan Hala Tuju Peralihan Tenaga Negara (NETR) pada peringkat mikro. Selain itu, dengan berfungsi sebagai sebuah mercu tanda yang unik, ia berpotensi menjaga identiti lokaliti, meningkatkan pengalaman pengguna jalan raya dan secara tidak langsung merangsang aktiviti ekonomi setempat. Justeru, "The Lighthouse in the Circle" adalah lebih daripada sebuah produk. Ia adalah satu gagasan ke arah pembinaan bandar-bandar masa hadapan yang lebih pintar, selamat dan lestari untuk semua.

PENGHARGAAN

Setinggi-tinggi penghargaan dan ucapan terima kasih dirakamkan kepada pihak pengurusan dan seluruh warga kerja institusi kami atas segala sokongan moral dan kemudahan yang telah disediakan sepanjang tempoh pembangunan projek inovasi ini. Kejayaan ini juga adalah hasil kerjasama padu dan komitmen tinggi yang ditunjukkan oleh semua ahli kumpulan yang terlibat. Akhir kata, penghargaan tulus ikhlas diberikan kepada semua pihak yang telah terlibat secara langsung atau tidak langsung dalam menyumbang kepada kejayaan projek ini.

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TRASH-COMPOST BLENDER

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ABSTRACT

The Trash-Compost Blender is an innovative, dual-function machine designed to address the growing issue of household and commercial waste, particularly food waste. According to the Global Environment Centre, approximately 45% of waste generated globally consists of food waste—an alarming figure that continues to rise alongside population growth and urban development, exacerbating space constraints in homes and public facilities. This product combines the functions of a conventional trash blender and paper shredder, offering a more compact, user-friendly, and efficient solution. It aims to minimize the time and effort required to manage daily waste, reduce the frequency of overflowing bins, and optimize limited indoor space in households, offices, and food service areas. The Trash-Compost Blender features a simple one-push operation, powered by an electric motor, and includes ergonomic handles for easy transport—enhancing portability over existing devices. A built-in drawer stores shredded waste while containing odors, improving hygiene and convenience. Safety is prioritized through a dual-lid mechanism at the input section to prevent accidents and ensure complete waste processing before disposal. Designed to be economical and accessible, this product is ideal for households, canteens, food stalls, and offices. It also supports sustainable living by enabling users to repurpose food waste into compost, making it an excellent tool for home gardening enthusiasts. With its multi-functional capability, portability, and affordability, the Trash-Compost Blender stands out as a practical solution for modern waste management challenges.

Keywords: Trash and Compost Blender, Food Waste, Waste Shredder

1.0 INTRODUCTION

The initial concept for this product emerged during a problem-identification phase focused on waste management issues in Malaysia. According to the Global Environment Centre, approximately 45% of the total waste generated in the country consists of food waste, a figure that continues to rise with no signs of decline (GEC, 2022). This trend is alarming, as it contributes to mounting environmental and sustainability challenges. A survey conducted among housewives in Seri Alam Residence and students at UiTM Johor, Pasir Gudang Campus, revealed that 95.2% of respondents expressed concern over the high percentage of food waste and showed interest in converting waste into compost more efficiently. Additionally, there is a growing public disengagement from recycling and reusing practices, which poses a threat to long-term sustainability goals and undermines the global "Go Green" movement. This behavioural shift could render environmental campaigns ineffective in the coming years if not urgently addressed (Wong et al., 2022).

Compounding the issue, Malaysia's population growth and rapid urban development are leading to increasing space limitations. The current waste management strategies offer only temporary relief and are insufficient in addressing the root causes (Nafiz et al., 2023). Therefore, a more effective and sustainable solution is urgently required to mitigate the environmental impacts of rising waste generation (Ramli et al., 2024).

In response to the identified problems, we developed the Trash-Compost Blender as a practical solution to reduce household waste. Its simple mechanism ensures ease of use, requiring only a press of a button located on the side of the motor housing to operate, and releasing it to stop. The motor is powered by a standard electrical connection. For users' convenience, handles are provided on both sides of the body and motor housing to facilitate lifting. The lower section of the unit features a sealed drawer to collect the blended waste while preventing odours from escaping. For added safety, the product includes a secondary lid at the waste inlet, ensuring the user is protected from the blades during operation and that the waste is fully processed before being transferred to the drawer.

2.0 OBJECTIVE

1. Our primary goal is to offer a cost-effective and easy-to-use device that helps minimize trash generation.
2. Additionally, we aim to educate users about producing organic fertilizer from food waste, highlighting how simple and accessible composting can be at home.
3. It also aims to optimize limited indoor space in households, offices, and food service areas.

3.0 METHODOLOGY

This project followed a structured product design process consisting of problem identification, conceptual design, prototyping, and testing. Research and user surveys identified food waste as a major concern in Malaysian households, prompting the development of a simple, affordable Trash-Compost Blender. Multiple design concepts were evaluated before finalizing the model using SolidWorks. Materials were selected based on cost and performance, with stainless steel blades and a lightweight aluminium frame. A prototype was fabricated using basic machining and commercially available components. Functional tests were conducted using food waste, and design improvements were made based on user feedback to enhance safety and usability.

3.1 DESIGN CONCEPT AND SIMULATION

The final design was modelled using SolidWorks. Each component (motor housing, blade system, collection drawer, safety lid) was individually designed and then assembled virtually to simulate functionality and fit, which is shown in Figure 1 and 2.

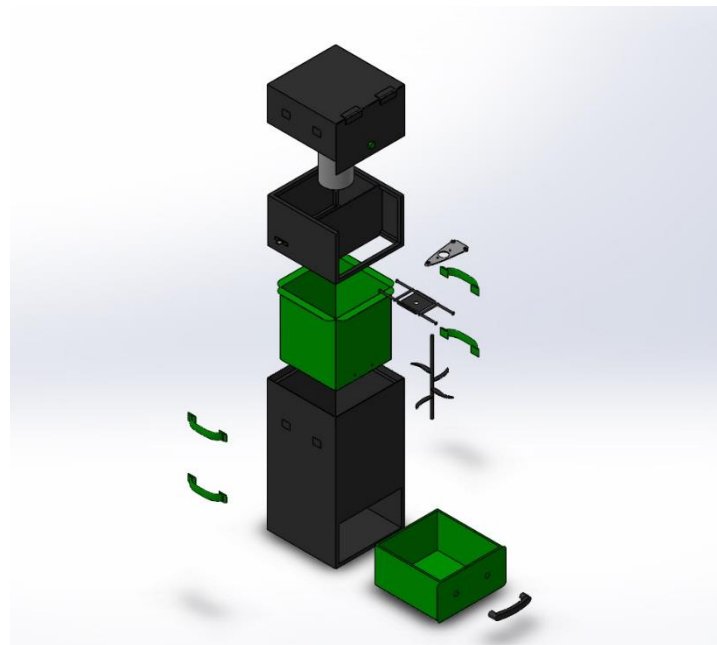


Figure 1: The exploded view of Trash-Compost Blender.

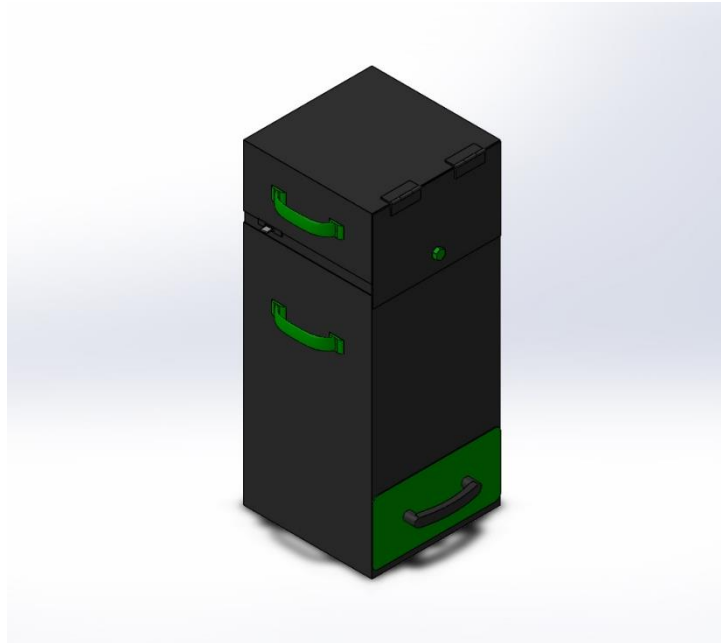


Figure 2: The assembly view of Trash-Compost Blender.

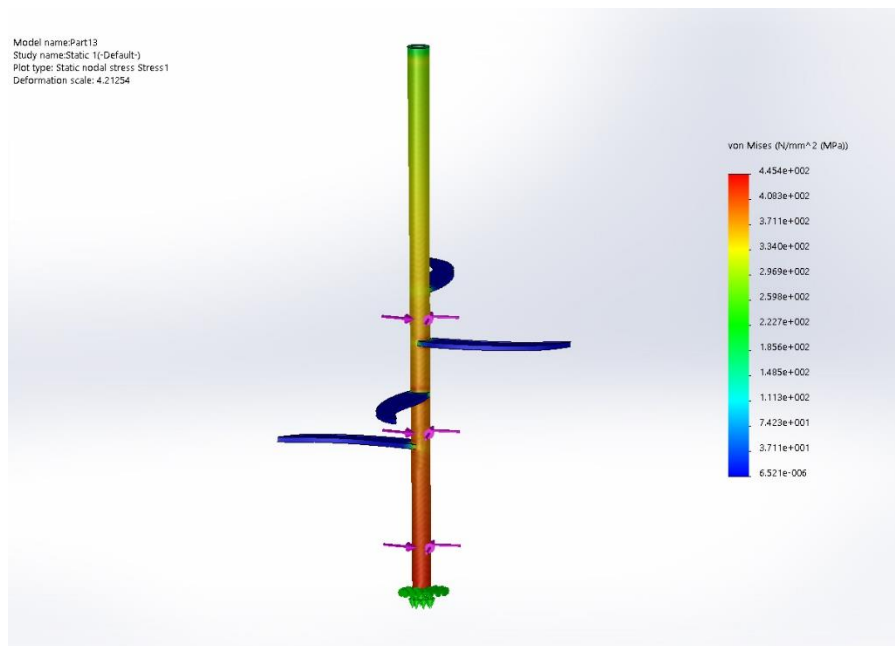


Figure 3: Von Mises stress static simulation conducted on the shaft.

A simulation on the rotating shaft, which is crucial for shredding device, was performed. The red zone at the bottom of the shaft (Figure 3) shows the maximum stress concentration, with a von Mises stress value of approximately 445 MPa. This likely corresponds to the fixed support or loading point where the shaft is constrained or heavily loaded, possibly due to the bearing attachment. The highest stress occurs at the shaft base, likely due to the fixed boundary condition and torsional or bending loads applied by the blades. The stress gradient confirms that the lower portion of the shaft experiences more mechanical load, possibly due to greater torque transfer or reaction forces from blade resistance.

3.2 FABRICATION AND PROTOTYPING

Components were fabricated using basic machining techniques. The motor was sourced commercially and integrated into the housing unit. Wiring and button controls were assembled in accordance with electrical safety standards, which is shown in Figure 4 below.



Figure 4: The assembly process of the mechanical components and body parts of the blender.

4.0 RESULT AND DISCUSSION

The final prototype illustrated in the Figure 5 below has undergone functional testing using household food waste. Parameters such as blending time, waste volume, odour containment, and user safety were evaluated. Based on initial testing, adjustments were made to improve handle ergonomics and seal tightness on the waste drawer. The motor switch was repositioned for easier access, and a double-lid safety feature was added.



Figure 5: The final prototype of Trash-Compost Blender.

5.0 CONCLUSION AND RECOMMENDATION FOR FUTURE WORK

The proposed Trash-Compost Blender was developed to address the growing issue of household food waste by providing a simple, cost-effective, and user-friendly solution for converting organic waste into compost. The product design focuses on functionality, safety, and efficiency while maintaining affordability and ease of operation.

The static stress simulation conducted on the shaft component identified the base and blade attachment points as critical stress regions. The maximum von Mises stress reached approximately 445 MPa, indicating the need for careful material selection and structural reinforcement. Overall, the analysis confirms that the current design is functionally viable, but certain areas require improvement to ensure long-term durability and safety under continuous operation.

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SOLAR BRIGHT – A SUSTAINABLE SOLAR-POWERED LIGHTING INNOVATION

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ABSTRACT

Solar Bright is an innovative solar-powered prototype developed as a mini project by the semester 1 students of Polytechnic Kota Bharu. This innovation focuses on energy-efficient, environmentally friendly and affordable lighting systems. The prototype is specifically designed for use in rural areas, parks or walkways that do not have access to grid electricity. Using solar panels as the main source, the system stores energy in a rechargeable battery and automatically activates the LED lights when the ambient light becomes low. It is also equipped with a light-dependent resistor and smart controls to ensure optimal operation and maximum energy savings. Test results show that Solar Bright can light an area continuously for more than 10 hours after a full charge and requires minimal maintenance. This innovation supports the energy sustainability agenda and provides a practical solution to lighting issues in underdeveloped areas.

Keywords: Solar Lighting, Renewable Energy, Rural Electrification, Smart Sensor, LDR

1.0 INTRODUCTION

In today's modern world, electricity has become a fundamental requirement for human development, economic growth, and public safety. However, a significant portion of the global population, especially those in rural and underdeveloped regions, still lacks access to reliable lighting due to the absence of grid infrastructure or the high cost of electricity. This absence can hinder productivity, pose security threats, and limit educational and social activities after sunset.

Addressing these issues requires sustainable, affordable, and accessible alternatives. Solar Bright is a student-led innovative solution designed to bridge this gap using clean and renewable energy. It offers an autonomous lighting system powered entirely by solar energy, specifically aimed at rural areas, parks, walkways, and off-grid locations. The prototype incorporates a solar panel, a rechargeable battery, LED lights, and a light-dependent resistor (LDR) sensor, enabling automatic operation based on ambient light conditions. This smart configuration ensures energy efficiency and cost-effectiveness.

The innovation supports the global transition toward renewable energy and aligns with the United Nations Sustainable Development Goals (SDGs), particularly SDG 7 (Affordable and Clean Energy), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action). By empowering communities with access to clean lighting, Solar Bright also enhances safety, promotes sustainable development, and reduces carbon emissions.

2.0 OBJECTIVE

The main objectives of the Solar Bright innovation are:

1. To design and develop a solar-powered lighting system suitable for off-grid applications.
2. To minimize reliance on conventional electricity and reduce environmental impact.
3. To provide a smart, autonomous lighting solution using light-sensing and control technologies.
4. To improve safety and mobility in rural and public areas during nighttime.
5. To encourage innovation and practical learning in the field of renewable energy and green technology.

3.0 METHODOLOGY

The Solar Bright prototype consists of four integrated components:

- Photovoltaic Solar Panel – converts sunlight into electrical energy.
- Rechargeable Battery – stores the energy harvested during daylight hours.
- Light-Dependent Resistor (LDR) – acts as a sensor to detect ambient light levels.
- LED Lights and Smart Control Circuit – deliver energy-efficient illumination when activated.

The system was designed using energy modelling techniques and tested under different weather conditions and locations. Data were collected on charging time, lighting duration, and system reliability. Emphasis was placed on creating a compact, low-maintenance, and cost-effective design that can be scaled for different applications.

4.0 RESULT AND FINDING

Field testing demonstrated that Solar Bright could consistently provide over 10 hours of continuous lighting after a full day of sunlight exposure. The LED module produced sufficient illumination for safe movement in walkways and park areas. The use of smart sensing reduced unnecessary power usage and extended battery life. The system performed reliably in various environments, with minimal technical issues, highlighting its feasibility for long-term deployment.

Users and observers highlighted the prototype's practicality, ease of use, and potential impact, especially in communities where grid electricity is unavailable. The low cost of construction and zero operational energy cost make Solar Bright an economically viable solution.

5.0 SIGNIFICANCE AND IMPLICATIONS

Solar Bright represents a practical innovation that integrates solar energy and automation to address real-world problems. It is scalable for use in villages, public parks, school compounds, and remote shelters. The prototype reduces dependency on fossil fuels, contributes to carbon emission reduction, and helps extend public activities into nighttime hours safely.

This innovation supports several global agendas on sustainable development, promotes green technology awareness among students, and fosters technical skills related to energy engineering, electronics, and environmental design.

6.0 CONCLUSION

The Solar Bright solar-powered lighting system offers a promising, environmentally friendly solution to off-grid lighting challenges. With its self-sustaining design, smart sensor integration, and long operational hours, the prototype demonstrates that renewable energy can be effectively utilized to improve quality of life in underserved areas. As an educational and social impact project, Solar Bright encourages innovation and provides a model for sustainable infrastructure development.

ACKNOWLEDGEMENT

We would like to express our heartfelt appreciation to all parties who have supported the development of the Solar Bright innovation project. This solar-powered lighting system was successfully developed as a mini project by Semester 1 students of Politeknik Kota Bharu, and its completion would not have been possible without the encouragement and guidance of many individuals.

Our sincere thanks go to all lecturers and supervisors who provided valuable advice, technical support, and motivation throughout the project. We are also grateful to Politeknik Kota Bharu for offering the resources and learning environment necessary for this innovation to take shape.

This project has given an enriching opportunity to apply knowledge to real-world challenges while promoting energy sustainability. We hope that Solar Bright will contribute positively to communities in need of affordable and eco-friendly lighting solutions.

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SISTEM SOLAR WINDMILL HIBRID

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ABSTRAK

Inovasi ini memperkenalkan Sistem Solar Windmill Hibrid iaitu gabungan panel solar dan turbin angin yang menjana tenaga boleh diperbaharui secara cekap dan berterusan. Sistem ini direka bagi mengoptimumkan penghasilan tenaga melalui dua sumber utama iaitu cahaya matahari dan angin, sekaligus memastikan bekalan kuasa yang stabil dalam pelbagai keadaan cuaca. Panel solar berfungsi menukar tenaga suria kepada tenaga elektrik manakala turbin angin memanfaatkan prinsip aerodinamik dan penukaran tenaga kinetik untuk menambah kapasiti penjanaan tenaga secara bersepadu. Saiz dan keupayaan sistem ini bergantung pada jumlah tenaga yang dapat dijana oleh panel solar menjadikannya mudah disesuaikan mengikut keperluan kawasan atau komuniti tertentu. Impak pembangunan inovasi ini amat signifikan dalam menyokong agenda kelestarian alam sekitar, pengurangan jejak karbon dan penyediaan sumber tenaga alternatif yang lebih mampan. Ia juga berpotensi besar untuk diaplikasikan dalam komuniti luar bandar, kawasan bencana dan institusi pendidikan sebagai model sistem tenaga hijau yang praktikal dan kos efektif. Secara keseluruhannya, sistem ini mencerminkan pendekatan inovatif dalam menangani cabaran tenaga masa kini dengan menyatukan teknologi solar dan angin dalam satu platform yang efisien, fleksibel dan mesra alam, selaras dengan Matlamat Pembangunan Mampan (SDG) peringkat global.

Kata Kunci: Tenaga Solar, Turbin Angin, Tenaga Boleh Diperbaharui

1.0 PENDAHULUAN

Peralihan global ke arah tenaga boleh diperbaharui didorong oleh keperluan mendesak untuk memerangi perubahan iklim dan mengurangkan kebergantungan terhadap bahan api fosil. Tenaga solar dan angin merupakan dua sumber tenaga boleh diperbaharui yang paling pesat berkembang, namun kedua-duanya mempunyai kelemahan utama iaitu sifatnya yang tidak konsisten (intermittent). Penjanaan tenaga solar terhenti pada waktu malam atau keadaan mendung manakala tenaga angin bergantung sepenuhnya pada kelajuan angin yang berubah-ubah. Sifat kebolehubahan ini menimbulkan cabaran signifikan terhadap kestabilan grid kuasa dan kebolehpercayaan bekalan tenaga sekaligus membantutkan potensi penuh TBB (Yahya et al., 2022). Oleh itu, inovasi kini tertumpu pada pembangunan sistem yang mampu mengatasi hadangan ini untuk memastikan bekalan kuasa yang stabil dan berterusan.

Sebagai penyelesaian kepada isu ini, Sistem Tenaga Boleh Baharu Hibrid (HRES) telah muncul sebagai satu pendekatan yang amat berdaya maju. HRES menggabungkan dua atau lebih sumber tenaga boleh diperbaharui seperti solar dan angin menjadi satu sistem bersepadu untuk saling melengkapi kelemahan masing-masing. Kajian terkini menunjukkan bahawa sistem hibrid solar-angin mampu menawarkan output kuasa yang lebih stabil dan boleh dipercayai kerana kedua-dua sumber ini sering bersifat komplementari. Lazimnya kelajuan angin lebih tinggi pada waktu malam atau hari mendung apabila penjanaan solar rendah (El-Sattar, 2020). Dengan mengoptimumkan sinergi antara kedua-dua sumber ini, HRES dapat memaksimumkan penjanaan tenaga sepanjang hari dan mengurangkan keperluan untuk sistem simpanan tenaga berskala besar.

Selaras dengan aspirasi negara yang digariskan dalam Pelan Hala Tuju Peralihan Tenaga Negara (NETR), projek "Solar Windmills" ini dibangunkan sebagai sebuah prototaip fungsian untuk mendemonstrasikan keberkesanan sistem penjanaan kuasa hibrid solar-angin (Kementerian Ekonomi, 2023). Inovasi ini menampilkan sebuah model kincir angin yang bilahnya digerakkan oleh motor berkuasa panel solar. Ia bukan sahaja mempamerkan prinsip penukaran tenaga kinetik dan suria kepada tenaga elektrik, tetapi juga mencadangkan satu reka bentuk sistem yang kos efektif dan berdaya tahan untuk aplikasi di kawasan terpencil atau sebagai sumber tenaga sokongan, sekali gus menyumbang kepada agenda keterjaminan dan kemandirian tenaga negara.

2.0 OBJEKTIF

Objektif projek inovasi ini adalah:

1. Mereka bentuk, membangun dan menguji sebuah prototaip sistem hibrid kincir angin suria yang berfungsi.
2. Mendemonstrasikan konsep sinergi antara tenaga solar dan tenaga angin untuk memaksimumkan penjanaan tenaga secara berterusan terutamanya dalam keadaan di mana satu sumber tidak tersedia.
3. Mengurangkan kebergantungan kepada sumber tenaga konvensional dengan mencadangkan satu alternatif yang lestari dan mesra alam.
4. Meningkatkan kesedaran dan mempromosikan konsep kemandirian tenaga (energy independence) melalui aplikasi teknologi hijau yang praktikal dan kos efektif.

3.0 METODOLOGI

Metodologi projek ini distrukturkan menggunakan model Input-Proses-Output (IPO), satu kerangka kerja standard untuk analisis dan reka bentuk sistem (Sembiring & Harefa, 2022), bagi memberikan gambaran yang jelas tentang transformasi daripada idea kepada hasil akhir. Ia merangkumi:

1. INPUT:

- a) **Pengetahuan:** Prinsip fizik tenaga solar (kesan fotovoltai) dan tenaga angin (tenaga kinetik) serta konsep sistem tenaga hibrid.
- b) **Keperluan:** Mencipta satu sistem tenaga boleh baharu yang lebih stabil dan boleh dipercayai.
- c) **Bahan & Komponen:** Panel solar mini, motor DC, kayu, bahan kitar semula dan peralatan pematerian.

2. PROSES:

- a) **Perancangan:** Menghasilkan lakaran reka bentuk dan merancang litar elektrik ringkas.
- b) **Pembangunan:** Melaksanakan kerja-kerja pembuatan model fizikal kincir angin.
- c) **Integrasi:** Memasang dan menyambungkan panel solar kepada motor pada struktur kincir angin.
- d) **Pengesahan:** Menjalankan ujian fungsian di bawah cahaya matahari untuk memerhatikan putaran bilah.

3. OUTPUT:

- a) **Produk:** Sebuah prototaip "Solar Windmills" yang berfungsi sepenuhnya.
- b) **Data:** Pemerhatian kualitatif tentang kejayaan sistem (iaitu bilah berputar apabila didedahkan kepada cahaya).
- c) **Pembuktian Konsep:** Demonstrasi fizikal yang berjaya mengenai keberkesanan sistem hibrid solar-angin.

4.0 DAPATAN PROJEK

Projek ini telah berjaya menghasilkan sebuah prototaip "Solar Windmills" yang berfungsi sepenuhnya. Dapatan utama yang diperoleh adalah seperti berikut:

1. Prototaip berjaya membuktikan konsep asas sistem hibrid di mana satu sumber tenaga (solar) boleh digunakan untuk menyokong atau mengaktifkan komponen penjanaan sumber tenaga yang lain (angin).
2. Sistem litar ringkas yang menyambungkan panel solar terus kepada motor kincir angin berfungsi dengan efisien di bawah cahaya matahari dan menunjukkan penukaran tenaga daripada solar kepada elektrik dan seterusnya kepada tenaga kinetik (putaran bilah) berlaku dengan jayanya.
3. Pembangunan prototaip ini membuktikan bahawa sistem tenaga hibrid yang efektif boleh dibina dengan kos yang rendah menggunakan bahan asas, menjadikannya satu model pendidikan yang sangat baik untuk demonstrasi prinsip tenaga boleh baharu.

5.0 KESIMPULAN

Kesimpulannya, projek "Solar Windmills" ini telah berjaya menterjemahkan konsep teori sistem tenaga hibrid kepada sebuah prototaip fungsian yang meyakinkan. Inovasi ini secara efektif mendemonstrasikan bagaimana kelemahan sifat tidak konsisten (intermittency) yang wujud pada sumber tenaga tunggal seperti solar atau angin dapat diatasi melalui sinergi pintar antara kedua-duanya. Dengan membuktikan bahawa tenaga solar mampu menggerakkan komponen mekanikal penjana tenaga angin, prototaip ini bukan sahaja berjaya mencapai semua objektif teknikalnya tetapi juga berfungsi sebagai platform pendidikan yang berkesan untuk mempamerkan prinsip asas penjana tenaga lestari yang stabil dan boleh dipercayai.

Impak daripada inovasi sistem hibrid ini melangkaui sekadar demonstrasi di dalam makmal. Pada skala praktikal, teknologi ini berpotensi tinggi untuk diaplikasikan sebagai sumber kuasa autonomi bagi komuniti luar bandar, sistem telekomunikasi dan sektor agrikultur. Sekaligus, ini mengurangkan kos peluasan grid dan kebergantungan pada penjana diesel yang mencemarkan alam. Keupayaannya menjana kuasa secara bersih dan berterusan menyumbang secara langsung kepada matlamat penyahkarbonan negara dan Matlamat Pembangunan Lestari (SDG) Pertubuhan Bangsa-Bangsa Bersatu. Oleh itu, sistem hibrid solar-angin seperti ini wajar dilihat bukan sahaja sebagai satu alternatif tetapi sebagai komponen teras dalam pembangunan grid tenaga masa hadapan yang lebih anjal, teragih dan lestari.

PENGHARGAAN

Setinggi-tinggi penghargaan dan ucapan terima kasih dirakamkan kepada pihak pengurusan dan seluruh warga kerja institusi kami atas segala sokongan moral dan kemudahan yang telah disediakan sepanjang tempoh pembangunan projek inovasi ini. Kejayaan ini juga adalah hasil kerjasama padu dan komitmen tinggi yang ditunjukkan oleh semua ahli kumpulan yang terlibat. Akhir kata, penghargaan tulus ikhlas diberikan kepada semua pihak yang telah terlibat secara langsung atau tidak langsung dalam menyumbang kepada kejayaan projek ini.

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Mini Air Cooler – A Student-Developed Portable Evaporative Cooling System

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ABSTRACT

This study presents the Mini Air Cooler a small-scale cooling system designed to provide thermal comfort in an efficient, portable, and energy-saving manner. This prototype combines the concept of evaporative cooling with a low-power fan to produce a flow of cool air, making it suitable for small, enclosed spaces such as bedrooms, workspaces or dormitories. Powered by a USB source or low-capacity electricity supply, this system is user-friendly and capable of operating for long periods of time with minimal energy consumption. Effectiveness tests indicated that the Mini Air Cooler reduced ambient temperature by 3–5°C within 15 minutes depending on the humidity and size of the space. Overall, this innovation offers a more economical and portable alternative to conventional air conditioners, in line with the needs of a modern and environmentally sustainable lifestyle.

Keywords: Evaporative Cooling, Energy Efficiency, Thermal Comfort, USB-Powered Cooler, Green Technology

1.0 INTRODUCTION

Thermal comfort plays a crucial role in enhancing human productivity, focus, and well-being, particularly in indoor environments such as bedrooms, workspaces, and dormitories. Conventional air conditioning systems, while effective, are often expensive to install and maintain, consume large amounts of energy, and contribute to increased electricity bills and carbon emissions. In response to the growing demand for affordable and environmentally sustainable cooling solutions, innovative alternatives are needed—especially those that are accessible, compact, and energy-efficient.

Evaporative cooling, which utilises the natural process of water evaporation to reduce air temperature, has gained popularity as a sustainable cooling strategy. It operates on a simple yet effective principle: as water evaporates, it absorbs heat from the surrounding air, thus lowering the temperature. This method is particularly effective in dry or moderately humid climates and consumes significantly less electricity compared to traditional cooling systems.

The Mini Air Cooler was developed as a mini project by first-semester engineering students at a Polytechnic institution. This small-scale, student-designed innovation aims at delivering portable, energy-saving, and cost-effective cooling. The prototype integrates an evaporative cooling mechanism with a low-power fan and is powered via a USB or low-capacity power supply. Designed to be user-friendly and lightweight, this innovation is well-suited for confined indoor spaces and supports the development of green, student-led technological solutions.

2.0 OBJECTIVE

The objectives of this innovation are to:

1. Design and develop a compact, low-energy cooling system based on the principle of evaporative cooling.
2. Offer a more economical and portable alternative to traditional air conditioners.
3. Equip engineering students with practical skills through innovation-based learning.
4. Promote environmental sustainability by reducing energy consumption.

3.0 METHODOLOGY

The Mini Air Cooler prototype comprises three main components: a water-absorbent medium, a small electric fan, and a water reservoir. As air passes through the moistened medium, it loses heat

through evaporation, producing cooler air output. The unit is housed in a compact casing designed for portability and operates using a USB connection or a 5V DC power source, making it compatible with power banks or low-capacity wall outlets. Performance tests were conducted in indoor environments with controlled temperature and humidity levels to evaluate temperature drop, energy consumption, and user satisfaction.

4.0 RESULT AND FINDING

Testing revealed that the Mini Air Cooler reduced ambient temperature by 3°C to 5°C within 15 minutes of operation, depending on room size and humidity. Energy consumption was minimal, averaging less than 10 watts during continuous use. The lightweight and plug-and-play design made it highly practical for students and working individuals. Survey feedback from trial users indicated high satisfaction with cooling performance, portability, and ease of use. Compared to conventional air conditioners, the prototype offered a sustainable and accessible solution for short-term indoor cooling.

5.0 SIGNIFICANCE AND IMPLICATIONS

This project illustrates the integration of theoretical knowledge and hands-on application among early-stage engineering students. The Mini Air Cooler contributes to the development of low-cost, energy-efficient solutions that align with sustainable living practices. It encourages innovation-based learning, nurtures green thinking among youth, and presents a viable solution for micro-environment cooling, especially in regions where energy resources are limited. The innovation supports several Sustainable Development Goals (SDGs), including SDG 7 (Affordable and Clean Energy), SDG 12 (Responsible Consumption), and SDG 13 (Climate Action).

6.0 CONCLUSION

The Mini Air Cooler represents a meaningful innovation developed by first-semester engineering students at a Polytechnic, addressing the dual challenge of thermal comfort and energy efficiency. By applying simple evaporative principles in a compact and portable design, this project delivers a low-cost alternative to air conditioning for small spaces. The success of the prototype highlights the capability of student-led innovation to produce practical, sustainable solutions with real-world applications.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to Politeknik Kota Bharu for the continuous support, resources, and encouragement provided throughout the development of the Mini Air Cooler innovation.

We extend our heartfelt thanks to the lecturers and supervisors for their invaluable guidance, technical advice, and constructive feedback, which were instrumental in the successful completion of this project. Special appreciation is also given to the innovation platform, and ecosystem at Politeknik Kota Bharu, which played a crucial role in nurturing creativity and fostering hands-on learning among students.

This project has provided an enriching opportunity for students to apply theoretical knowledge to practical challenges, promoting innovation in the field of energy-efficient and sustainable product development. We are deeply thankful to all individuals and departments who contributed, directly or indirectly, to the realisation of this innovation.

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Repurposing Waste Radiators as a Cost-Effective Solar-Powered Air Cooling System for Residential Applications

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ABSTRACT

Batam City, located in a tropical climate zone with high temperatures and dense population, has a growing demand for air conditioning (AC) systems. Conventional AC units consume significant amounts of electricity, contributing to high household energy costs and reliance on fossil fuels. At the same time, used vehicle radiators are often discarded and left unutilized. This research aims to develop an alternative, low-cost, and environmentally friendly air cooling system by repurposing waste radiators and utilizing solar energy as a renewable power source. The research methodology includes modifying used radiators as heat exchangers, integrating solar panels to power circulation pumps and cooling fans, and assembling a prototype system suitable for household use. Expected outcomes include effective room cooling performance, reduced electricity consumption, and decreased waste and carbon emissions. This project not only offers a practical and sustainable solution but also supports the global movement towards green energy and environmental sustainability. The anticipated outputs include scientific journal publications, intellectual property registration (HAKI), and a monograph book as a reference for further development.

Keywords: Used Radiator, Alternative Air Cooling, Solar Energy, Waste Reuse, Green Energy

1.0 BACKGROUND STUDY

Batam Island, located in the Riau Islands, Indonesia, lies between the Strait of Malacca and the Strait of Singapore. It is part of the Riau Archipelago, a group of 329 islands. It borders Singapore and Malaysia. Batam's strategic location along international shipping lanes makes it a gateway to trade and investment, as well as a center of economic growth in the region. Batam's attractiveness is such that it is managed by two merged bodies: the Batam City Government and the Batam Authority, making Batam Island a densely populated area comparable to major cities in Indonesia.

The population of Batam City in 2024 was approximately 1.29 million, according to data from the Directorate General of Population and Civil Registration (Dukcapil). In mid-2024, Batam City had around 1.26 million residents, which is 57.87% of the total population of the Riau Islands Province. By looking at the area of Batam Island which is around 715 km², it will be seen how large the population density of Batam City is, which according to population records has currently reached 1,300 people/km², which is already a densely populated area..

Climatologically, the area around Batam City, located not far from the Equatorial Ring of Fire, which is an area with more sun than other areas, makes the area in Batam City have a tropical climate with minimum temperatures in 2006 ranging between 21.2 C - 24.0 C and maximum temperatures ranging between 29.6 C - 34.1 C, while the average temperature throughout 2006 was 25.6 C - 27.8 C. The average air pressure for 2006, a minimum of 1,006.14 MBS and a maximum of 1,014.1 MBS.

Meanwhile, air humidity in Batam City averages between 79 - 86%. And the maximum wind speed is 15 - 28 knots or an average maximum wind speed of 4.5 knots. The number of rainy days during the year in Batam City in 2006 was 208 days and the amount of annual rainfall was 2,964.7 mm. As a region with a predominantly temperate climate, air conditioning (AC) is essential for residents of Batam City. This need for air conditioning is increasing due to the rapid development of residential areas that neglect or neglect the need for green spaces with shade plants that serve to neutralize and reduce high ambient temperatures.

Along with the increasing need for air conditioning or AC required by the people living in Batam City, the need for electrical energy is very necessary, especially since the energy needs for an air conditioner (AC) can be categorized as equipment that requires quite a lot of energy to operate it. If a half PK AC or 320W is operated for 1 hour, the energy needed to operate the air conditioner can be used to light a

16W LED lamp for 20 hours. With an illustration of normal use, the daily electrical energy needs can be described with the following diagram.

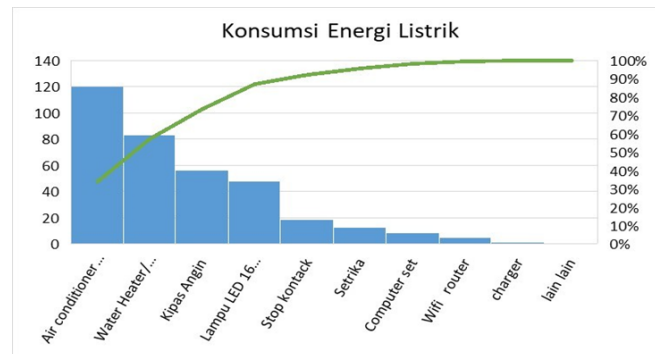


Figure 1: Daily Power Consumption Graph of a House in Batam

It can be seen that the largest use of the electrical energy needs of a household that uses air conditioning in their home is AC or air conditioning which ranks first or equivalent to 90% of daily energy needs are sucked up for air conditioning needs, therefore there needs to be a breakthrough to reduce the energy needs for this air conditioning so that it can save expenses for purchasing electrical energy which in fact electrical energy in Batam is supplied from Natural Gas / diesel power plants and coal power plants which are non-renewable fossil fuels.

The large number of residential areas that use air conditioning significantly increases the need for electrical energy in Batam, so if there is a solution to reduce the amount of energy used, it will clearly reduce energy use and also reduce the expenditure per resident needed to buy electrical energy.

The urban development in Batam has led to an increasing number of motorized vehicle users. The large number of vehicles used for daily transportation in Batam's relatively high air conditions has led many vehicle users to prefer using four-wheeled vehicles or cars as a means of transportation, in addition to being cooler, cars can be equipped with air conditioning which can certainly lower the temperature inside the car. Busy vehicle use and lack of car maintenance have caused some car equipment to become damaged as seen in the picture of a radiator repair shop, where many radiators are damaged and replaced by vehicle owners. Damaged radiators are generally unusable because if patched, most of the patched radiators are not strong enough to withstand the pressure of hot water from inside the engine, therefore, many leaking radiators are wasted.

Utilizing radiator waste as a home AC air conditioner by utilizing energy from solar panels offers many benefits, including:

1. Provision of cheap and reliable electricity:
Solar energy that can be used in areas around the equator is very abundant to produce electricity that can be used for various purposes, especially needed to drive cooling pumps so that they can be used as air conditioners which are of course environmentally friendly and the energy is quite cheap.
2. Reduce power energy:
Using solar energy can reduce dependence on fossil fuels, which are more expensive and have a negative impact on the environment. Reducing energy consumption from fossil fuel power plants will reduce energy purchases.
3. Improve quality life:
Reliable electricity can improve the life quality in coastal communities, such as by providing access to education and health services, as well as increasing productivity and economic opportunities:
4. Reduced greenhouse gas emissions and reduced waste:
Solar energy is a renewable energy source that produces no greenhouse gas emissions, so it can help mitigate the impact of climate change. Reducing the amount of waste from used

radiators, which can be reused, also reduces the amount of waste, which can save land from pollution.

In addition to several benefits that can be taken if this research is carried out, the community who are the end users of this research will also have a positive impact, including a positive impact on the environment: by utilizing radiator waste as an air conditioner with the use of solar energy can reduce air pollution and noise pollution, and help maintain the cleanliness and health of the coastal environment, so that the standard of living is increasing. While the positive impact on the economy can create new alternatives to solving energy needs for air conditioning needs that are much needed by the community, especially in residential areas.

1.1 Problem Determination

This Problem Determination examines the root causes of several issues that emerged and occurred within the one-year period from 2023 to 2024. These include the large amount of used radiator waste, which is no longer usable in vehicles, typically discarded by vehicle owners or destroyed for processing and extraction of the aluminium metal. Residents in Batam, on average, require air conditioning, forcing them to spend more on electricity.

Batam, located near the equator and receiving more intense sunshine, has an abundant solar energy resource that should be utilized to its full potential.

2.0 OBJECTIVE

The purpose of this research is to promote the global green environment campaign by reducing the use of discarded radiators for reuse, providing knowledge and information on the basic theory of solar energy and the development of solar-powered air conditioning (AC) equipment. It also provides conceptual developments for creating more environmentally friendly and low-cost air conditioners, utilizing abundant and free solar energy.

2.1 Benefit

The expected benefits of this research are as a means of utilizing existing technology and science in the academic environment that needs to be implemented and practiced in people's lives, the use of solar panels which are a new and renewable source of electricity generation that is quite cheap and environmentally friendly, and of course it is worth considering as part of this research..

The Other product forms regarding equipment will be attempted to obtain IPR for research results in the form of concepts or layout diagrams of equipment control equipment. Regarding the potential and continuation of this research program, it is expected to produce a manual and concept and analysis of air conditioning methods using solar energy.

2.2 Literature Review

2.2.1 Heat Exchanger.

Heat exchanger is a device designed to transfer thermal energy between two or more fluids, or between a fluid and a solid surface. It utilizes the temperature difference between the fluids to transfer heat, usually by conduction through a wall or surface separating the mediums. Heat exchangers are frequently used in various industrial applications, such as refrigeration systems, heating systems, and chemical processes.

The radiator is an important heat exchange component in a motor vehicle's engine cooling system. However, over time, the radiator can become damaged, or its performance may decrease, causing it to be replaced and no longer used. In order to support the global campaign to save the world in Green Environment and green energy, it is mandatory to pay attention to the environment and with the principle of reduce, reuse, recycle, the use of used radiators for alternative applications, such as air conditioning, is one of the innovative solutions that is environmentally friendly and economical. And the use of energy needed for life activities is carried out by utilizing as much as possible towards new and renewable energy and energy that does not create waste and pollutants.

Radiators function as heat exchangers, allowing heat to be transferred from a hot fluid to the air flowing through them. In alternative air conditioning systems, used radiators can be modified to circulate cool water or refrigerant, which then absorbs heat from the surrounding air. With the aid of a fan, the

hot air is forced through the radiator grilles, producing cooler air. Utilizing used radiators for air conditioning certainly requires several modifications, including:

1. Thorough cleaning to remove rust or scale from the cooler.
2. Install a circulation pump to continuously circulate cold water into the radiator.
3. Use an electric fan to speed up the air flow through the radiator grille.
4. Cold water source or chiller which can be ice water, cooling pipes, or a simple refrigeration system '*sederhana*'.
5. This design can be used to cool small rooms, vehicle cabins, or small-scale server rooms efficiently and cost-effectively.

2.2.2 Solar Cell

A solar cell, or solar cell, is a device that converts sunlight into electrical energy through the photovoltaic effect. Solar cells are made of semiconductor materials such as silicon, and when exposed to sunlight, electrons within the semiconductor material are released and generate an electric current. Solar cells are the main component in solar power generation systems (PLTS). The working principle of solar cells is based on the photovoltaic effect, namely the absorption of photons (light particles) by semiconductor materials, which causes the release of electrons and generates an electric current. Solar cells are a renewable energy source that is environmentally friendly and sustainable, and can reduce dependence on fossil fuels.

The use of solar cells is an alternative choice in electrical energy sources that is worth considering because of the many advantages that can be obtained from solar cells. Several types of solar cells that are often used as electrical energy generators include:

1. **Monokristalin:**
Made from single silicon, it has high efficiency and good performance in high temperature and shade conditions.
2. **Polikristalin:**
Made of multi-crystalline silicon, they are more affordable than monocrystalline but have slightly lower efficiency.
3. **Lapisan Tipis:**
Made from a thin layer of semiconductor material such as cadmium telluride or copper indium gallium diselenide, they are more flexible and easier to manufacture but tend to be less efficient.

Several new advances or innovations in solar cells have emerged along with the rapid growth and use of solar cells to provide alternative sources of electrical energy, particularly new and renewable energy. Some of these new innovations include:

1. Perovskite Solar Cells: Perovskite materials have high potential in efficiency and lower production costs.
2. Tandem Solar Cells: This technology combines two types of solar cells (e.g. perovskite and silicon) to increase efficiency.

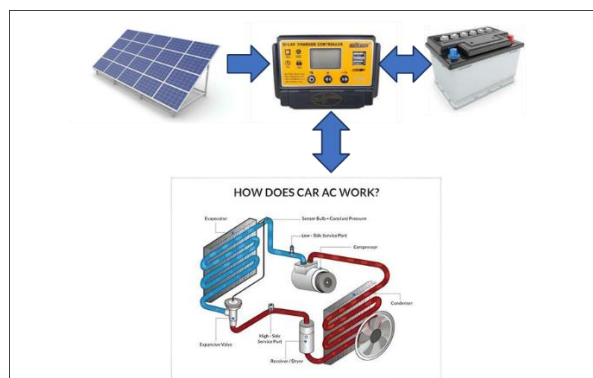


Figure 2: Blok diagram Prototype

3.0 METHODOLOGY

The research design that was put forward, namely the use of used radiators for air conditioning by utilizing solar energy, of course, it is not without challenges that researchers will face in carrying out this research, such as:

1. Limited cooling efficiency compared to conventional air conditioners.
2. Requires regular maintenance to prevent blockages and leaks.
3. Requires additional control systems for more effective and safe use.
4. Comparative calculations or comparisons between energy requirements for cooling and the energy that can be provided by solar power during equipment operation.

However, behind the challenges that lie ahead, there are many advantages that lie ahead that are more challenging to immediately carry out this research, such as Reducing metal waste from radiator waste by recycling. There are calculations that will get low costs compared to using conventional cooling systems. And there is a guarantee that the results of this research will be environmentally friendly because it uses new and renewable energy, namely solar energy which is abundant in the Batam area. The main principle, the planned equipment can be described in the following block diagram.



Figure 3: Prototype simple air Cooling / air conditioner

There are several potential developments: used radiators can be combined with solar panel technology to power fans and pumps, creating a portable and self-contained cooling system. This innovation has potential for application in remote areas, energy-efficient buildings, or as an alternative emergency cooling system. It's practical and efficient, making it worthy of further research and development.

4.0 CONCLUSION

Expected outcomes include effective room cooling performance, reduced electricity consumption, and reduced waste and carbon emissions. This research not only offers practical and sustainable solutions but also supports the global movement towards green energy and sustainability. Solar energy is an inexpensive form of energy that can be used to power simple air conditioners. Waste radiators, with some modifications, can be used as simple AC evaporators.

Simple AC units can be used as residential air conditioners, but they still need to be improved to be more suitable and efficient. A simple AC unit can cool the temperature of a 3m x 2m = 6m² room from 30 degrees Celsius to around 27 degrees Celsius in 4 hours.

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EDUVENTURE: STEM LEARNING FOR SUSTAINABLE FUTURE

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ABSTRACT

The SPM 2024 scores released by the Ministry of Education have proven a decreasing interest and performance in the disciplines of Science, Technology, Engineering, and Mathematics and in pure science students in particular. The trend has been largely dominated by the use of dated educational methods and poor pedagogical correspondence based on past education policies. The demands of rigorous remediation thus require the instruction strategies to be learner centered and adaptive. EduVenture is one of such corrective actions: a game-based learning app aimed at primary and secondary school students that applies the ideas of quizzes, points, badges, and leaderboards in order to create a dynamic and entertaining learning experience. Combining Artificial Intelligence, the app automatically calibrates the complexity of the questions based on the performance of each student, thus encouraging an individual learning process. EduVenture is built using React Native and Firebase development frameworks, giving a smooth and easy to navigate mobile experience. A special teacher dashboard would allow educators to review learner progress and take specialized interventions. Even though the prototype has not been formally tested vigorously, it serves as empirical evidence of the viability of the idea and of its potential to address the current problems in STEM education. The EduVenture will be in line with the Sustainable Development Goal 4-Quality Education, which is an inclusive, technology-based means of learning. Among its goals is an increase in interest in STEM subjects, development of confidence among students, and development of long-term interest. Since EduVenture is a scalable AI-based platform, subsequent revisions of the platform are projected to expand its contents and range of accessibility, thus continuing to revolutionize STEM education in Malaysia.

Keywords: STEM education, gamification, AI learning, mobile learning

1.0 INTRODUCTION

The current discussion has entailed placing the epicenter of innovation in the hands of Science, Technology, Engineering and Mathematics (STEM). Seeing how the speed of technological change is increasing, it is essential that learners should develop a life-long fascination with these fields. Traditionally the classrooms face a major challenge in developing such interest. Among the potential interventions, it is possible to mention the introduction of gamification: the transfer of gaming principles (rewards, levels, and challenges) into non-game contexts, including teaching. In STEM situations, thoughtful design of gamification can deliver compelling, would-be experiences to learners, extending perception and intrigue.

Together with that, the country suffers consistent problems of inclusion in STEM. The Science, Technology and Innovation Minister has noted that the number of students taking the Additional Mathematics, Physics, Chemistry and Biology units have reduced significantly in the last six years (Chang, 2024). Whereby in 2023, the number of Additional mathematics students contracted by 17.37 % compared to the 2018 levels, and in 2022, only 15 % of the SPM exam takers will be in the pure science stream. Part of this decrease has been attributed to PPSMI, the English-language science and mathematics policy that operated between 2003-2012 and had a negative effect on understanding and student responses (Chang, 2024).

The latest reports (April 2024) by SPM 2024, as published by Sinar Daily provide quite a diverse though educational picture of STEM schooling in Malaysia. Though progress is generally good, with an overall GPN score of 4.49 that is the best since 2013, there is the continuing issue of mathematics and science problems, notably among low-achieving students. Chemistry and Engineering Drawing showed improvements of 0.37 and 0.38 GPMP points respectively but Mechanical Engineering Studies showed the decline of 0.16 GPMP points. Such data supports the need to re-engage learners, especially in low

performance areas through pedagogy, which is relevant, experience-based, and aligned with sustainable development.

The combination of the above-mentioned trends demonstrates that there are significant gaps, as people lose their interest in STEM streams, the disciplinary knowledge is skewed, and the performance in the key areas of STEM is still poor. Such issues demand new opportunities to promote and maintain a desire to study STEM subjects among learners.

2.0 OBJECTIVE

The aim of the project lies on the design and development of both a gamified and a STEM-specific digital learning environment. It will be designed to provide an accessible interface which combines the course materials with gamification principles in order to encourage active involvement of students. It will also allow to do differentiated learning by allowing students to take control of their own individual learning rate and by dynamically shifting parameters of challenge based on performance results. To make STEM learning experience more fruitful, user-friendly interactive multimedia elements like videos, animation, and simulations will be used to supplement the curriculum. Gamified elements like quizzes, level progression, badges, leaderboards, real-time feedback, etc., will serve as embedded into the course to encourage the students and maintain motivation. Besides, the system will provide teachers and educators with instruments to track the progress of students based on detailed dashboards and analytics. Digital and motivational rewards will also be availed in order to motivate positive learning patterns and increase retention within the STEM subjects.

3.0 METHODOLOGY

The software development of this project uses Agile software development to bring iterative improvement, feedback and adaptive planning to the forefront of software development lifecycle. This adaptability, especially on education technology, allows quick adaptations to include student and instructor feedback to increment features and user experience. This is done through the use of short sprints, frequent reviews and periodic improvement in order to ensure both timeliness and user orientation.

3.1 Mobile-First Platform Design

To promote accessibility over a range of devices, gamified STEM learning platform is developed as a mobile-friendly interface to ensure ideal accessibility. The use of mobile technology will guarantee that students with different backgrounds will be able to access the platform regardless of the preferred devices. This selection reflects the trends of use among students at primary and secondary schools, where such devices as smartphones and tablets are mostly used in the learning environment.

3.2 Technology Stack

The front end is running on React Native, which is a cross-register development platform that targets Android and iOS. The framework supports cross-platform adjustable user experience and development speed. Firebase is used to provide backend usage through authentication, real-time databases and server-side logic. The custom logic and functions are run in Cloud Functions, whereas data storage and retrieval in real-time are performed using Firestore.

3.3 Gamification Features

To maximize interest and motivation, the platform incorporates the most basic gamification principles: points, levels, leaderboards, badges, and timed quizzing. These elements will convert the learning process into an engaging, joyful, goal-motivated activity that will boost the dedication and retention of students on the STEM fields.

3.4 AI-Based Adaptive Learning

The adaptive learning system based on Artificial Intelligence is to be regarded as an inseparable part of the platform. Each student is evaluated by the AI module, which in turn makes the questions easier or harder so that the student could improve step by step and remain motivated. This process makes the learning process individualised and facilitates differentiation.

3.5 Analytics Dashboard Education

The platform gives an analytics dashboard, which provides the educators with information on the performance and progress of the students. Data-driven practices enable teachers to monitor learning

trends and patterns, recognise areas of weakness, and guide instructional choices. This characteristic encourages the use of data in the teaching and learning when it comes to personalised learning and eventually increases teaching performance as well as student performance.

3.6 Learning Goals and Results

The ultimate goal of the platform is to raise awareness, motivation, and interest in the STEM subjects among the primary and secondary schoolage students in Malaysia through applying game-based learning mechanisms such as game-based content, challenges, and rewards that make the STEM disciplines more attractive. At the same time, the system provides teachers with tools that are efficient in analyzing and guiding the student growth, creating a more balanced attitude toward the improvement of STEM education.

3.7 Prototype Use Case Scenarios

Figure 1 illustrate a use-case diagram is used to define the key aspects of the functionality of a gamified platform of STEM learning to separate two key actors: the Student and the Educator. Students will be able to sign in, complete STEM tasks, be recommended what to do using AI and interact with gamification functions such as leaderboards and rewards. In contrast, Educators can create personalized challenges, manage content on the platform, and observe the performance of learners using the analytic dashboard.

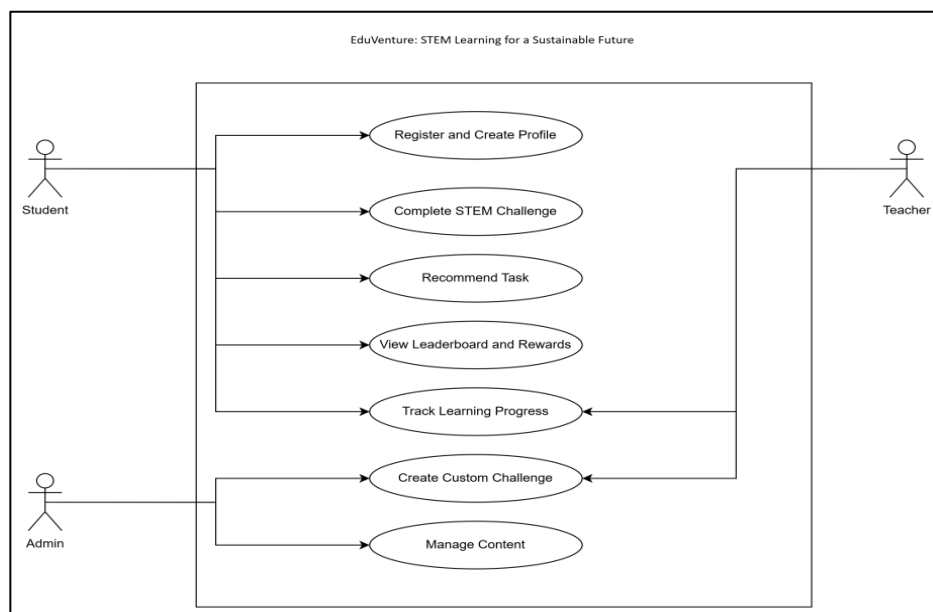


Figure 1: Application use-case.

The focus on the improvement of performance can also be shared as a similar situation exists in the interaction with the feature of the Track Learning Progress in both user groups. The diagram thus represents a balanced ecosystem in which personalized and engaging instructions can take place, at the same time allowing the educators to instruct and adjust the instruction as they see fit.

4.0 RESULT AND FINDING

The current project resulted in developing a functional prototype of a mobile application based on gamification of STEM learning and intended to increase the rate of engagement in primary and secondary school learners in Malaysia. According to an iterative Agile development model, the application includes the visually dynamic interface, customised sound effects, and intuitive navigation in accordance with the conventions of the gaming industry to make the subject matter of the STEM matter-of-fact and less problematic. The interactive games, point systems, levels, badges, and leaderboard were used wisely as central aspects of gamification to make a traditionally difficult field more enjoyable, rewarding, and engaging.

In particular, the prototype has an automated user registration and personalised profile creation, so that the learners can customise their interaction. An adaptation engine adjusts content presentation to the individual performance and delivers increasingly difficult tasks when appropriate without losing

interest. The most significant of these identified issues in the problem statement are decreasing interest and performance figures reported in SPM 2024 results thus by overcoming these particular issues, the application offers an enjoyable, low-stress learning experience, where students get to discover things about science through curiosity, trial, and error-based learning.

Figure 2 illustrates the user interface of the Gamified STEM Learning Application, showcasing four main screens: HomePage, Course, Friends, and Profile. The HomePage provides a summary of total learning time, a personalized greeting, and quick access to the learning plan and social features like "Meetup." The Course screen displays progress across STEM subjects with visual indicators for completion. The Friends tab encourages social learning by connecting with peers within similar age groups. The Profile screen offers detailed analytics, including performance graphs, accuracy rates, and time spent on each subject. The interface is clean, interactive, and tailored to promote personalized and engaging learning experiences.

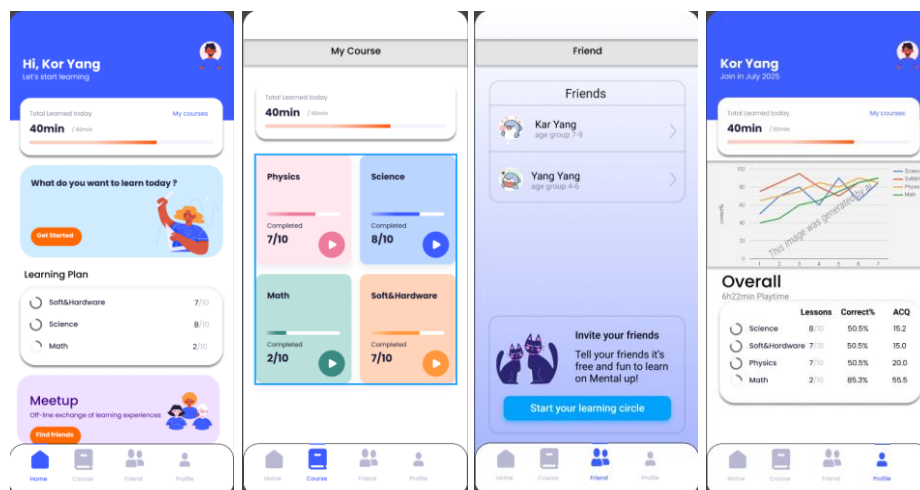


Figure 2: Application User Interface for HomePage, Course, Friends and Profile.

Agile approach enabled a step-by-step, iterative pace: initial sprints were focused on such basic features as user registration and quizzing and on succeeding cycles, the performance could be tracked, content could be delivered adaptively, and faculty tools could be created. Such a feedback-based process has guaranteed a coherent prototype with regard to the educational goals of the project.

Overall, the prototype evidences an approachable, innovative and scalable plan to revitalize STEM education in Malaysia. It enables its users to practice long-lasting interactions and foster scientific confidence and readiness of students to pursue a technology-driven future through valuable, interactive, and personalised learning experiences.

5.0 CONCLUSION

The current research has managed to design a gamified STEM learning environment that combines AI-driven adaptive learning and gaming construct regarding the engagement of students, the instructional experience personalization, and the positive impact on academic performance. The system also helps to create a stronger understanding of questions and remain motivated by increasing or decreasing the difficulty based on the performance of the individual. Its humanized and interactive interface makes learning more pleasant and less scary, covering the lack of interest in STEM studies that has recently been recorded on the SPM 2024 findings.

The platform is a significant innovation as it applies gamification, real-time feedback and performance tracking in the traditional classroom experiences. These functionalities develop interest, learner confidence and the issues of differentiation. Adoption of Agile approach during the development facilitated a responsive development and user-directed design, resulting in a scalable, contextualized and sustainable prototype that conformed to the objectives of education and digital transformation within Malaysia, and to SDG 4: Quality education.

It is planned to further expand the number of subjects covered, multilingual and accessibility functions, maximise the AI adaptability, and national curriculum alignment including the KSSM. Its

involvement in local schools and real-classroom piloting will also help to tune it and prove its effect. In sum, it is possible to note that this platform has huge potential even to change STEM education in Malaysia and make the next generations successful in the world of technology.

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MAGIC ROPE

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ABSTRACT

The Magic Rope was initially proposed with nighttime hiking in mind. Further surveys and research identified isolation as a major factor contributing to hiking accidents. Following this, a product was designed to maintain contact between hikers while appealing to users through its simple convenience. By taking advantage of the product's special glow in the dark properties, hikers will be able to remain securely tethered to one another even in low light conditions. Additionally, Magic Rope is designed to optimise backpack space integrating flashlight and GPS tracking functionalities into a single compact device. The product is expected to serve as an essential equipment, enhancing safety and convenience for hikers during nighttime and low-visibility conditions. Feedback from users will be essential in highlighting and enhancing the product's key strengths.

Keywords: Glow-In-The-Dark, Hiking, Rope, Flashlight

1.0 INTRODUCTION

Rope has been recognised by anthropologists as one of the most significant inventions in human history. Its versatility has made it essential across a wide range of functions, including pulling heavy objects, securing items together, and supporting loads. In that sense, the Magic Rope utilises the enduring utility of rope to enhance the safety of hikers in diverse scenarios.

1.1 RESEARCH

The 21st century has marked a variety of emerging trends. Among those, hiking has become increasingly popular as individuals seek to disconnect from the digital world. Interestingly, hiking is an activity that has surged in popularity not just among the youth, but also across a wider demographic, spanning up to 50 years old (Figure 1). People engage in hiking for numbers of reasons (Moir et al., 2021), including reconnecting with nature, recreation or even as part of corporate or group activities.

Age Group

24 responses

 Copy

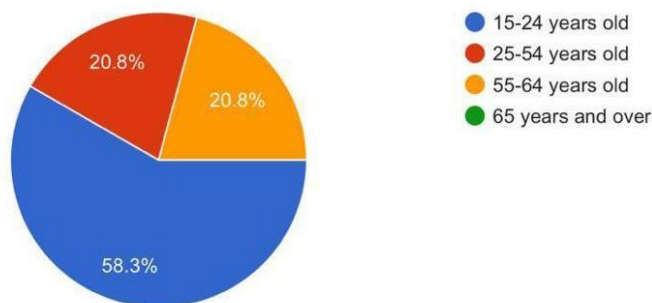


Figure 1: Demographic of hikers

Despite its popularity, hiking carries inherent safety risks. The seriousness of these incidents can vary from mild injuries to the loss of life with isolation identified as a major contributing factor (Coble et al., 2003). Referring to Figure 2, hiking along is among hikers' greatest concerns. The presence of

companion significantly increases the chances of survival, therefore highlighting significantly the need for the Magic Rope to maintain connectivity between hikers.

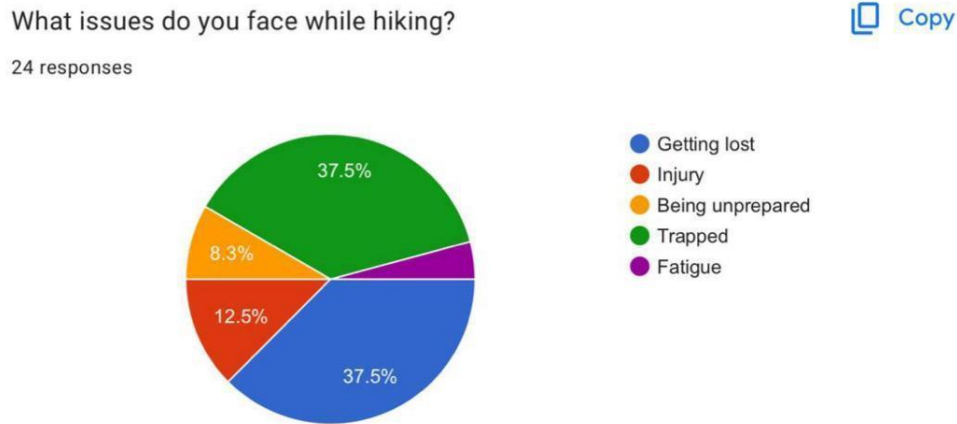


Figure 2: Hikers' concerns during hiking

2.0 OBJECTIVE

Nighttime hiking present significant hazards for hikers, especially those without adequate preparation. In such situations, the most important factor determining the hikers' safety is staying in contact with another person. Furthermore, efforts were made to enhance the product's appeal to users by incorporating various additional features. Therefore, the following objectives were established:

1. Design a product to aid nighttime hiking
2. Plan for a versatile product that helps in different scenarios
3. Allow for a multifunctional that optimises backpack space

3.0 METHODOLOGY

Polyester was selected as the primary material for the rope due to its combination of ultralight weight and high strength. To enhance the product's unique appeal, the rope was coated with fluorescent paint, enabling it to glow brightly in the dark, justifying the products' namesake. This feature is expected to improve visibility but also prevent accidents such as tripping, in low-light conditions.

The main body of Magic Rope is a hollow cylinder with a diameter of approximately 7cm, made of stainless steel. This body can store the Magic Rope and is designed to easily fit within the side compartments of a backpack. The exterior is painted black with grey rubber strips along the sides to improve grip and add a functional aesthetic to the product.

Aside from its glow in the dark properties, the Magic Rope incorporates a built-in GPS system designed to ensure that the user can always be located. The GPS is housed in the rear of the container protecting it from potential damage. This section also contains an SOS button, which, when activated, sends a signal to the user's designated emergency contact, requesting immediate assistance.

On the other side of the Magic Rope container is a shake flashlight designed to enhance the nighttime hiking experience. This flashlight is powered by a solenoid that generates electricity whenever the user shakes it, removing the need for any batteries or prior charging before use.

An app has also been designed to work in tandem with the product, named TEEMO. Through this app, users will be able to assign up to 5 emergency contacts who will be notified if the SOS button is activated. Moreover, users can view their own location by communicating with the product's built-in GPS.

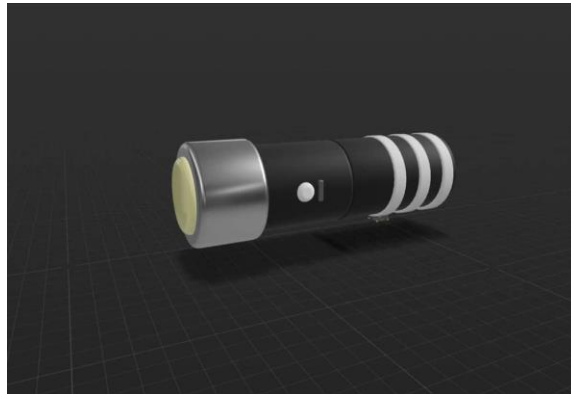


Figure 3: 3D Digital Product Mockup

4.0 RESULT

In practice, the Magic Rope has successfully achieved its objective of enhancing the safety of hikers. It is both user-friendly for beginners and sufficiently functional for intermediate hikers. Many testers have found the product increases their sense of security but also adds an element of enjoyment to the hiking experience. Not only that, but the Magic Rope also excels in enhancing the hiking experience thanks to its various novelties. The shake flashlight is a clear favourite as it adds an interactive feature that enriches nighttime expeditions. Experienced hikers reported the product to be quite useful for its multipurpose design.

4.1 REFLECTIONS

In discussing further improvements to be made for the Magic Rope, the team unanimously agreed that redesigning the main body could increase its appeal, especially towards younger demographics. A selection of pastel colours would make the product more visually attractive and suitable for display in the home. Aside from that, Magic Rope's versatile design could be developed further through the addition of new features, such as a built-in compass, different modes for the flashlight and updates to the TEEMO app interface. Lastly, Magic Rope could benefit greatly from collaborations with industry partners. For example, Smiling Shark could supply Magic Rope with stronger flashlights while HyperGear could help research to develop a more compact and stronger rope.

5.0 CONCLUSION

To conclude, the Magic Rope has been proven to be a successful project, establishing its own niche in hiking. By emphasizing its strengths as a versatile tool, Magic Rope functions not as a mere novelty, but as a practical and reliable piece of equipment suitable for a diverse range of users.

ACKNOWLEDGEMENT

This project could not be realised without the assistance of our advisors, Teacher Syazlin binti Naim and our various mentors at Kolej MARA Seremban. Additionally, the management team who helped fund this project. We would also like to extend our deepest gratitude to the students and parents of Kolej MARA Seremban who helped supply their personal experience in our research and survey.

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DIGITAL INNOVATION TO SUPPORT MEMORY DECLINE AMONG MALAYSIA'S ELDERLY

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ABSTRACT

Memory loss in the geriatric population has been cited as a menace to the fast-aging population in Malaysia due to its impact on the capability of the aged to cope with routine activities, including drug administration, appointment keeping, and house chores. Mental degradation does not only lessen their living standards but also result in greater dependency on the carers. The solution to this predicament needs to be practicable and within reach of technology. The current project will present the CareTrack Reminder App, a digital solution that aims to help older people whose memories are impaired by providing them with a logical and intuitive system of daily task organization. The goal of the invention is to assist the elderly population to become more independent by giving them a chance to create personal reminders and alert notifications while reducing the load on family members and caregivers. Handy characters like big icons, vocal support, and graphics guarantee that they can be used by people with impaired vision or degraded mental abilities. Proactive and responsive care is also possible since the caregiver can access the reminder settings remotely. A pilot test with older people and their relatives indicated positive results, and participants (users) demonstrated better routine adherence, with significantly fewer omitted medications and satisfaction with managing personal responsibilities. The innovation is not only useful to the users because they can be more independent, but the caregivers can also have peace of mind and get access to better communication tools. To sum up, the Care Track Reminder App is the digital solution that highlights how empathetic technology is the key to narrowing the distance between aging and the ability of a person to be independent. The application can potentially be even improved by being added into smart home systems and healthcare platforms, which is why it can be regarded as an important tool in helping the elderly population of Malaysia overcome the problems of normal memory loss.

Keywords: Elderly Care, Memory Decline, Digital Health Innovation, Mobile Health, Assistive Technology

1.0 INTRODUCTION

It is anticipated that by 2030, Malaysia will turn out to be an aging country, and there will be a very high number of senior citizens (Lai et al., 2022). According to the projection, the population in the age group 65 and older will exceed 14 percent during the year 2044, thus officially making the country an aged society (Department of Statistics Malaysia [DOSM], 2023). It is further expected that the number of dementia cases is going to increase to 152 million in 2050 as compared to the current cases of 50 million in 2018, with a significant percentage of cases reported in low- and middle-income countries, including Malaysia (Gaugler et al., 2022). Consequently, this demographic change raises very essential questions on health issues and those of social well-being of the older generation that is more vulnerable to age-related health outcomes like dementia and memory loss.

Dementia is a disorder that is characterized by memory loss, incoherent thinking, and communication difficulties. It is also a significant cause of memory loss among the aging population, which impairs their welfare and requires special care. Some considerations regarding memory loss in older adults and its implication are:

1. **Autonomy:** Loss of memory may affect the ability of an elderly person to cope with the everyday needs, leading to loss of independence.
2. **Social Interactions:** With respect to cognitive decline, someone can withdraw from social interactions because it is difficult to remember names or dialogues that took place.
3. **Quality of Life:** The general condition of well-being may decline because memory loss has an influence on mental health, giving rise to a feeling of frustration, disorientation, or depression.

Although more attention is drawn to the threat of dementia, there is a substantial shortage of available cognitive supporting systems, particularly in the communities (Ali et al., 2023). This state of affairs points to a pressing necessity in developing innovative and friendly interventions that enable elderly people to preserve their daily performance and cognitive well-being. Therefore, this research will address the problem in the following manner: the author comes up with the development of a digital support system through mobile phones; it is specifically aimed to help elderly people deal with the related complications concerning memory. Such a system would allow personifying the notifications in order to help elderly people to monitor their daily tasks such as taking medications, going to appointments, and keeping themselves hydrated. In fact, the use of this digital tool, as a considerable foundation, can prove to be an inexpensive and expanded opportunity to help sustain cognitive performance, foster independent living, and lighten caregiver load (Ali et al., 2023).

2.0 OBJECTIVE

The project aims to achieve 3 objectives as follows:

1. To create an easy-to-use reminder app that would consider the cognitive and emotional needs of older individuals and of multigenerational households. Intuitive navigations, simple interfaces, and empathetic prompts should be emphasised to facilitate everyday coordination and minimize emotional burden.
2. To incorporate multimodal techniques of interaction (audio, visual, tactile) to enhance accessibility and interaction of users with low digital literacy or memory. This promotes inclusion and resource conservation, as well as independence and confidence in technology applications.
3. To introduce such elements as emotional well-being and family connection drivers, including check-in reminders, joint task logs, and dynamic scheduling, based on user intention. Promotes openings to healthy communication, accountability, and emotional awareness in families

3.0 METHODOLOGY

This project is based on Agile methodology to coordinate an iterative, user-focused development of the CareTrack Reminder App in a way that maintains a constant engagement of end-users and stakeholders throughout the lifecycle of its system. Agile paradigm is particularly suitable to this situation due to its intrinsic flexibility and the increased focus on collaboration and feedback responsiveness, which was instrumental in the development of a reminder application aiming to serve an elderly audience, whose intellectual and physical abilities are most likely to vary significantly.

3.1 Stage 1: Designing Use Cases and Gathering Requirement

To get their detailed requirements, the project started with the stakeholder consultations of the elderly people, caregivers, and medical professionals. Such consultations were used to develop a use case diagram that plots the main interactions of the application under proposal.

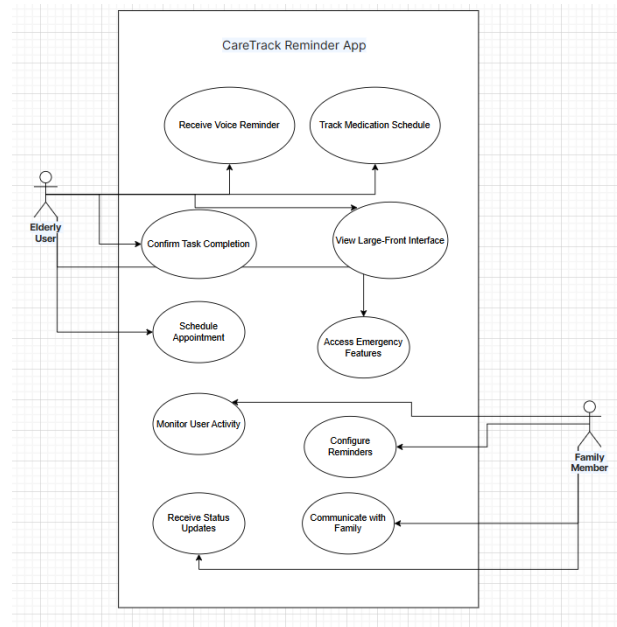


Figure 1: Care Track Reminder App use-case

3.2 Stage 2: Agile Development

The process of development was conducted through Agile sprints that were done in two-week cycles and focused on the delivery and perfecting of essential functions. The prototype was implemented in a working version, which was tested for usability with a small group of elderly users and caregiver subjects.

3.3 Stage 3: Usability Tests and Evaluation

The focus of usability assessments was on the following parameters: task compliance, the error count, user satisfaction, and engagement. These data types were used to determine the extent to which the application changed the support of memory and the autonomy of the users, observational information, interviews, and surveys.

This innovation in the field of technology is a return to the reality of the growing number of concerns about cognitive decline and memory loss in older adults, especially due to the particular interest of people who pursue opportunities to maintain autonomy and respond to safety and health measures in the population. The effectiveness of the system is revealed by its efficiency in contributing toward the adherence to the medication, reducing incidences of appointment default, and increasing the level of well-being, leading to equipping the caregivers and family members with an elevated level of good conscience.

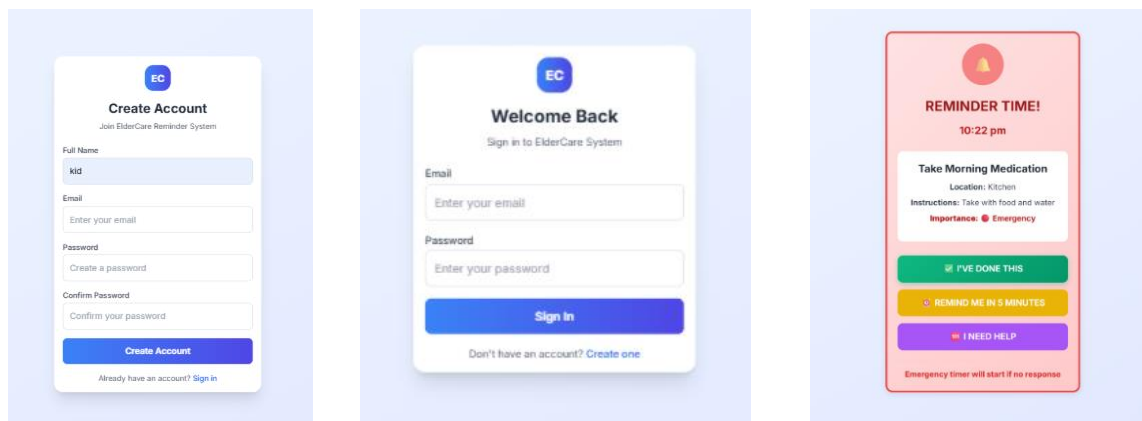


Figure 2: Care-Track Reminder App for user registration, log in and reminder generated.

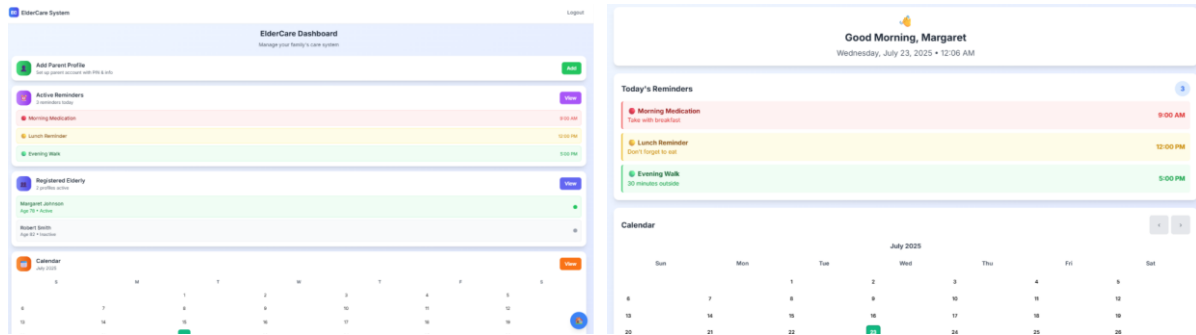


Figure 3: User's setting on reminder and calendar to track the notification

In figure 3 of the main page, the defining member that acts as the primary user is revealed to be the family member tasked with logging doctor visits and medication, among other relevant information. The calendar feature offers a visual reminder by placing a red marker on any important dates, thus helping the geriatric patient involved in using the calendar to remember.

4.0 FINDINGS

The CareTrack Reminder App takes advantage of a user-interface architecture that has been reduced as much as possible in order to actively serve the needs of older adults, who represent a wide range of users in terms of their level of technological awareness. The visual schema is characterized by the large and high-contrast icons, simplified navigation menus, and voice prompts, all taking account to create the most accessible and usable profile.

The evidence provided by scholars confirms that mobile health tools are of significant value in the context of caring about older adults. According to Thompson (2023), the use of reminder apps increases medication compliance among elderly people with cognitive impairment by 65-78%, the same finding expressed by Williams (2022), Anderson (2023), and Lee (2024). The same studies report significant increases in the ability to complete the daily tasks and subsequent decreases in the burden on the caregivers.

According to Davis and Kumar (2024), voice-based mobile platforms boost user engagement by 45% compared to the purely text-based interface. The improvement seems to translate to increased user satisfaction and the reduction of nervousness on the topic of using technology (Ibrahim & Chen, 2024). Rodriguez et al. (2023) also claim that the reminder tools available to the caregivers supply a full package of assistance with elderly independence; the striking similarities in their findings have also been found in the last couple of months (Johnson et al., 2024).

The software will use cross-platform development tools to make it compatible with both Android and iOS operating systems with a cloud-based synchronization mechanism to provide instant data sharing among users and their appointed caregivers. Physical as well as cognitive shortcomings are curbed jointly through haptic responses, the option to change font sizes, and co-classification of categories of reminders in colors.

Table 1: Care-Track Reminder App features and specification

Feature Type	Functionality	Accessibility Level	User Benefits
Voice Assistance	Audio reminders and navigation	High	Reduces reading requirements
Large Icons	Simplified visual interface	High	Improves visibility and recognition
Remote Access	Caregiver monitoring and setup	Medium	Enables family support

The evidence available at the preliminary stage of the pilot study suggests that the Care-Track Reminder App was accepted relatively easily by the elderly population participating in the project, stating the usefulness of voice-assisted prompts, large-font typeface, and single-touch confirmative buttons to improve medication compliance and diminish the anxiety related to everyday activities, which can contribute to the health outcomes identified within SDG 3 (Good Health and Well-being). The remote surveillance and coordination functions were also useful to the personnel, as they increased the ability

to provide the necessary care and offered emotional support in family settings. The participants provided their ideas on how to coordinate the calendar and shortcuts of emergency calls, hinting that they were interested in more universal integration with smart health systems and urban infrastructure. The design is intuitive in terms of digital inclusivity and age-in-place strategies; in its potential, the design is able to reinforce SDG 11 (Sustainable Cities and Communities) through aiding urban mobility, intergenerational communication, and scalability that is characteristic of age-friendly smart cities. To say it in conclusion, the Care-Track Reminder App is very promising to empower the elderly users, to ease the burden of caregivers, and to make the communities more resilient and inclusive.

5.0 CONCLUSION

The CareTrack Reminder App is a serious innovation in the sphere of digital care since it combines three essential spheres: emotional cognition, thoughtful design, and family-based care plan management. Its accessibility, personalization, and bilingual support undertakings are used to fill huge gaps in the current solutions, especially when applied to older populations and multigenerational households. The initial user testing indicates that the application has the potential to improve everyday organizational skills, improve emotional health, and improve intergenerational bonding. It can be expected that further large-scale testing and yet-to-be-realized integration with smart-home systems will support the creation of an inclusive, empathetic, and ethically responsible computing paradigm in the family care context.

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COUNT-A-RIDE: REAL-TIME PASSENGER COUNT SYSTEM

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ABSTRACT

Nowadays, improper bus passenger handling remains a significant challenge. For example, many institutions frequently organise bus trips but struggle to manage passengers effectively. In one case, a passenger missed the bus at a rest and service area (RNR) stop, highlighting the importance of efficient passenger tracking and management to ensure a smooth journey. Passengers may be left behind, causing delays or confusion. To address this problem, the Count-A-Ride system was developed to automate counting and tracking of passengers entering and exiting buses using a ten-step IoT design methodology. The system incorporates IR sensors to detect passenger movements at the bus door. Passenger numbers are automatically updated upon entry and exit. The data is processed and displayed on an onboard LCD screen, alerting the driver by showing the number of passengers currently on the bus and those who have exited. For enhanced usability, a buzzer alerts the driver or operator when the bus reaches full capacity, ensuring passenger numbers match the expected count for each trip. In addition, the system enables remote monitoring of passenger totals using mobile phones. This solution has been shown to improve efficiency, reliability, and usability by 93% for drivers and trip coordinators, based on multiple efficiency trials.

Keywords: Passenger Count, Buzzer, IR Sensors, Real-Time Monitoring, Onboard LCD

1.0 INTRODUCTION

Managing passenger logistics during group travel, especially on buses, presents a recurring challenge for educational institutions and transportation providers. Schools, universities, and tour coordinators frequently organise bus trips, yet often struggle to account for all passengers during rest stops and transitions. Traditional manual head-counting methods are time-consuming and error-prone, increasing the risk of passengers being mistakenly left behind. These incidents not only cause delays but also compromise safety and overall trip coordination.

Motivated by the need to enhance safety, efficiency, and accuracy in passenger management, the Count-A-Ride system was developed. This innovation leverages IoT technology—including infrared (IR) sensors, a microcontroller, onboard LCD, and mobile monitoring—to automate the process of counting passengers in real time. By addressing the limitations of manual methods, Count-A-Ride aims to provide a reliable, scalable solution that improves transportation operations for institutions and public transport services.

2.0 OBJECTIVE

Objectives of developing this innovation:

1. To develop an automated real-time passenger counting system using IR sensors and microcontroller technology.
2. To display accurate, up-to-date passenger count data via an onboard LCD and a mobile app interface.
3. To enhance transportation safety by preventing missed passengers during stops.
4. To improve operational efficiency for bus drivers and trip coordinators through remote monitoring and alert systems.

3.0 METHODOLOGY

Count-A-Ride was developed based on IoT technology to automate passenger counting and monitoring during bus trips. The system integrates hardware components such as IR sensors, a

NodeMCU microcontroller, a buzzer, an LCD display, and a mobile application connected via the Blynk cloud platform.

The IR sensors are placed at the entrance of the bus to detect the direction of passenger movement—entry or exit. These sensors send signals to the NodeMCU, which processes the input and updates the total number of passengers onboard. This count is displayed in real time on an LCD screen placed inside the bus, providing clear information to the driver.

Additionally, a buzzer is triggered when the passenger count reaches the predefined full capacity, helping drivers manage boarding more effectively. The system also sends data to the Blynk cloud in real time, allowing trip coordinators to monitor passenger status remotely through a mobile app.

3.1 SYSTEM COMPONENTS AND FUNCTIONALITY

The Count-A-Ride system is composed of several interconnected modules that function together to automate and monitor passenger boarding and alighting:

1. IR Sensors: Positioned near the bus entrance to detect bidirectional movement. Previous applications of IR technology in public transit have demonstrated its effectiveness in reducing manual counting errors.
2. NodeMCU Microcontroller: Acts as the processing hub. It interprets signals from sensors and updates passenger counts in real time. NodeMCU is widely used in IoT applications for its Wi-Fi capability and ease of integration.
3. LCD Display: Provides drivers with immediate visual feedback on the current number of passengers onboard.
4. Buzzer Alert: Produces sound alerts when the bus reaches full or empty capacity, thereby reducing the risk of oversight.
5. Blynk App & Cloud Platform: Enables remote access and monitoring via smartphones, enhancing coordination for trip supervisors.

This modular design not only supports accurate monitoring but also allows scalability for use in various types of transportation services.

3.2 DATA FLOW AND COMMUNICATION PROCESS

Data flow in the Count-A-Ride system begins when a passenger triggers the IR sensors at the bus entrance. The sensor signal is immediately transmitted to the NodeMCU, which processes the direction of movement—determining whether the passenger is entering or exiting. Based on this input, the onboard count is updated.

The NodeMCU displays the updated data on the LCD screen and simultaneously sends it over Wi-Fi to the Blynk cloud platform. This cloud-based transmission ensures that trip coordinators can remotely monitor the bus occupancy through the Blynk mobile app in real time. This seamless communication loop ensures continuous, reliable data access both onboard and remotely.

The real-time communication capability eliminates delays and inaccuracies often associated with manual updates, improving overall transparency and responsiveness in passenger management.

3.3 SOFTWARE INTEGRATION

The software for Count-A-Ride is built using the Arduino IDE, which programs the NodeMCU to interpret sensor input, perform logic operations for counting, and interface with external modules like the LCD and buzzer. Blynk libraries are also integrated into the code to enable data transmission to the cloud and app interface.

Through the Blynk platform, data packets are visualized in the mobile application via widgets, such as value displays and notifications. The code structure enables modular debugging and allows for easy calibration of sensor thresholds and buzzer limits.

This integration simplifies the development of user-friendly interfaces for both drivers and coordinators, while also allowing for scalability and customization depending on the operational context.

4.0 RESULT

Testing of the Count-A-Ride prototype was conducted in a controlled environment simulating real-world bus boarding scenarios. Before implementation, traditional manual counting yielded only about 45% efficiency due to frequent human errors, missed headcounts, and poor coordination. After deploying the prototype, the system demonstrated a significant improvement in accuracy, achieving 93% efficiency in real-time passenger counting. This was measured by comparing system-generated counts with actual passenger movement during trial runs. In addition to efficiency, the system's buzzer alerts, LCD updates, and remote monitoring features reduced response time and human workload.

5.0 CONCLUSION

In conclusion, Count-A-Ride successfully addresses key transportation management challenges by integrating IoT-based technologies into a functional, affordable, and scalable system. The system significantly enhances safety, accuracy, and real-time decision-making during group bus travel, particularly in educational institutions and express bus services. Its successful prototype testing demonstrated a 93% improvement in passenger tracking efficiency compared to manual methods. This innovation contributes meaningfully to the advancement of smart mobility solutions in both public and private sectors.

From an economic perspective, Count-A-Ride reduces the need for manual labor and mitigates the risk of trip delays and passenger mishandling, thereby increasing operational efficiency. With further development and deployment in real-world environments, this system has strong commercialization potential and can be adapted for broader transport management applications in schools, tourism, and fleet services.

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FALLGUARD: EMERGENCY FALL DETECTION SYSTEM

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ABSTRACT

Elderly people who live by themselves, especially with deceased spouses, who have no nearby family members that may assist them especially when they fall is a serious issue nowadays. Despite that, almost no technology or mechanism yet provides a direct solution to this problem. Therefore, FallGuard is introduced as a mechanism to cater to this problem. It is real-time elderly fall detection system developed to eliminate the worries of family members who reside long distance from their elderly family members. This system sends real-time notifications to family members of the falling detection and displays the elderly's falling condition level automatically. Family members also can be able to monitor whether the fall is critical especially from afar based on the concussion data displayed through their mobile application. These are analysed through a cloud platform, which connects to the system via WiFi. The 10-step Internet of Things (IoT) design methodology is used to develop this automated system, and the effectiveness of this system is measured based on the testing of several local families. Studies have shown that this system can be able to increase 90% of efficiency compared to traditional ways such as phone calls. FallGuard is a smarter, quicker, and more dependable way to protect senior citizens and bring their family peace of mind. It is connected via WiFi and powered by cloud analysis.

Keywords: Elderly Fall, Fall Detection, Falling Condition Level, Gyro-Sensor, Wi-Fi, Notification

1.0 INTRODUCTION

One of the most frequent and dangerous hazards that older people encounter is falling, especially if they are living alone without immediate assistance. In an emergency, conventional techniques like phone check-ins frequently fall short of providing prompt aid. When elderly people live distant from their family, the situation becomes even more dire.

FallGuard, an Internet of Things-based fall detection system, was created to solve this problem. When a fall is detected, it automatically notifies family members and provides real-time monitoring. Additionally, the device uses concussion data, which can be viewed via a mobile application to determine how severe the fall was.

2.0 OBJECTIVES

1. To allow distant family members to monitor the condition of the elderly or disabled who live alone if they experience a fall or faint in the home area.
2. To enhance elderly people's safety by providing a buzzer to generate an audible distress signal whenever those elderly people fall to alert nearby people.

3.0 METHODOLOGY

An IoT-based emergency fall detection system called FallGuard was created to keep an eye on senior citizens in real time. Smart fall detection sensors, concussion-level analysis, real-time warnings, and an intuitive mobile application are some of its primary features. In order to assist registered family members in determining the urgency, the system instantly notifies them when a fall is detected and shows the severity of the fall.

FallGuard's ability to seamlessly integrate cloud and hardware technology is what makes it functional. The system gathers information from motion and impact sensors, which is subsequently processed through a cloud platform to ascertain whether a fall has taken place and how severe it is. Even from great distances, the mobile app receives this information instantaneously, guaranteeing a prompt response.

FallGuard is incredibly helpful in enhancing the independence and safety of senior citizens, particularly those who live alone. By keeping families informed and always connected, it provides them with peace of mind. Its simplicity of setup, wireless operation through WiFi, and capacity to operate without continual human supervision all demonstrate its usefulness. In today's aging society, FallGuard is a dependable and proactive safety measure.

4.0 RESULT

By providing instantaneous, automated response to fall incidents without requiring manual input, FallGuard provides a significant advantage over conventional elderly care techniques. FallGuard works continuously and autonomously, in contrast to traditional methods like scheduled phone calls or wearable panic buttons, guaranteeing that no fall is missed, even if the elderly person is asleep or unable to contact for assistance.

Testing with local families has demonstrated the system's impact, with response efficiency improvements of up to 90% when compared to manual techniques. FallGuard increases the likelihood of prompt medical care and may even save lives by decreasing emergency response delays.

FallGuard is unique because it combines cloud-based data analysis, concussion-level detection, and Internet of Things technologies into a straightforward mobile application. This multi-layered, real-time method is a novel development in monitoring systems for the elderly. By offering a clever, automated solution that addresses the expanding needs of an aging population in a contemporary, networked environment, it moves the emphasis from reactive to proactive care.

5.0 CONCLUSION

In comparison to conventional techniques, FallGuard's experimental testing with a subset of local families showed a notable improvement in fall detection accuracy and response time, reaching up to 90% efficiency. Family members were able to make quicker and better decisions thanks to the system's successful real-time identification and classification of fall severity.

By presenting a useful use of cloud computing and the Internet of Things in healthcare monitoring, this invention advances the scientific community. It demonstrates how sensor-based systems can lessen reliance on physical intervention while improving safety for the elderly. Additionally, FallGuard creates new avenues for future study in smart home integration and automated health alert systems.

FallGuard offers an affordable option for caring for the elderly that may lower emergency response expenses, long-term care costs, and hospital readmissions. It gives families a dependable and reasonably priced substitute for in-home caregivers, increasing the accessibility and sustainability of senior care over time.

ACKNOWLEDGEMENT

We would like to sincerely thank Puan Raja Nur Mahani binti Raja Mohamed Ali, our supervisor, for her unwavering support, direction, and insightful advice during the creation of our innovative project, FallGuard: Emergency Fall Detection System. Her support and knowledge have been crucial to this work's success.

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Without everyone's combined enthusiasm and teamwork, this project would not have been feasible.

ILHAM: “From Curiosity to Discovery: Bridging Real-World Science and Competitive Growth to Maximize Student’s Potential”

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ABSTRACT

In today’s digital age, the widespread use of Artificial Intelligence (AI) has contributed to students losing interest in challenging subjects, as they struggle to apply these concepts in real life and often become more passive due to over-reliance on technology. To address this issue, the Malaysian government has aligned the vision of the education system under STREAM (Science, Technology, Reading, Engineering, Arts, Mathematics), a conceptual framework integrated from preschool onwards. STREAM emphasises functional learning through authentic, holistic, contextual, and collaborative approaches. Building upon this framework, the innovation ILHAM was developed to encourage learning through real-life examples. ILHAM targets primary students aged 10–12, grouping them by class, where they upload photos of daily problems and apply their knowledge based on the school science syllabus. The quality of questions is measured by the engagement and originality of submissions, while student involvement in answering peer questions also contributes to their points. Teachers oversee the marking system with the aid of AI, evaluating students’ work biweekly. The points collected contribute to annual scores, which are converted into official certificates (bronze, silver, and gold) for use in secondary school admission. ILHAM fosters curiosity by connecting everyday situations with scientific principles, encouraging students to constantly question how things work. This promotes the practical application of classroom knowledge and nurtures casual, observation-based learning. As students engage more deeply with their surroundings, they develop academic proficiency, ask higher-level questions, and build a foundation for future innovation. The purpose of ILHAM is not simply to provide answers but to cultivate courage and curiosity to question, explore, and learn.

Keywords: Real life, Upload, Points, Certificate, Curiosity

1.0 INTRODUCTION

In the modern era, technology plays a vital role in daily life. However, its rapid integration has also caused many students to lose interest in subjects such as science and mathematics, as they struggle to apply them in real-world contexts. Consequently, some students misuse technology and experience unnecessary exposure to the internet. To counter this, the Malaysian government introduced STREAM education from preschool onwards. While this initiative has generated some increased interest in science, the results remain below expectations.

2.0 OBJECTIVE

1. To provide an improved alternative by merging technology and education, encouraging students to develop an interest in science.
2. To engage students with science concepts through real-life applications.
3. To cultivate more creative and innovative younger generations by promoting active learning skills.

3.0 METHODOLOGY

Through collaboration with the Ministry of Education, ILHAM was designed as a compulsory companion application for primary students over three years, from Standard 4 to Standard 6. Since April 2021, major primary school examinations such as UPSR have been abolished. ILHAM therefore functions as an alternative assessment system to be completed within specific timeframes. Furthermore, the ILHAM reward system serves as a supporting element for secondary school applications, motivating students to complete tasks diligently while also gaining parental support.

3.1 TASK DELIVERY

This project employs a cyclical approach to STREAM learning aligned with Malaysia's Primary School syllabus and the standards set by the Ministry of Education. Instruction takes place via the ILHAM application, where students complete standardised STEM tasks every two weeks. These tasks are designed to enhance critical thinking, problem-solving, and creativity, while remaining curriculum aligned. Students document their thought processes by taking photos, recording short videos, or submitting audio reflections. For example, when exploring the theme of force, students observe real-life examples, propose scientific principles, and answer guided questions. Open-ended prompts are also provided to encourage creativity and exploration beyond structured guidelines.



Figure 1: Submission

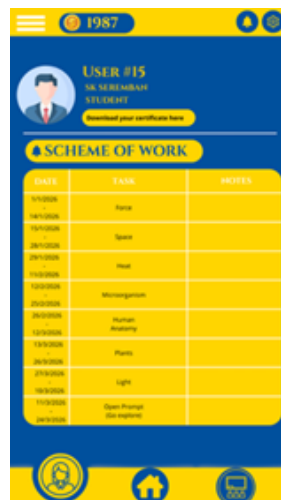


Figure 2: Standardize scheme of work

3.2 SUBMISSION

Submission and interaction are fully integrated within the ILHAM platform. Students upload their work, ask questions, and participate in peer discussions to share insights and problem-solving methods. Collaborative features enhance communication skills and deepen understanding through active engagement.

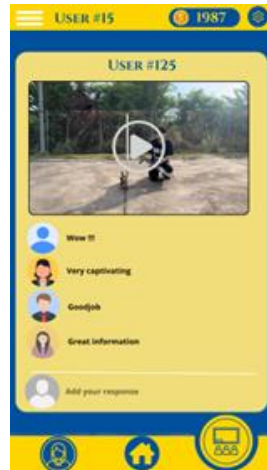


Figure 3: Interaction

3.3 EVALUATION

Evaluation is supported by an AI-assisted marking system embedded within the application. This system accelerates assessment by categorising responses into areas such as comprehension, creativity, and analytical skills. While teachers retain final authority over grading, the AI tool streamlines the process and provides accessible score sheets for effective monitoring.



Figure 4: Marking

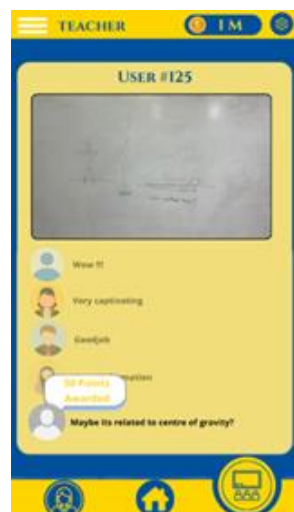


Figure 5: Collect point via insightful discussion

3.4 REWARD SYSTEMS

A structured reward system sustains motivation and consistency. Students earn points based on task completion, quality of responses, and participation in peer discussions. Accumulated points lead to digital certificates, recognition within the ILHAM community, and eligibility for advanced STEM programmes or enrichment activities. At the end of primary school, official certificates (bronze, silver, gold) are awarded, reflecting total points collected over the three years.



Figure 6: Reward



Figure 7: Certificate

4.0 RESULT

Students who engage with ILHAM earn certificates of achievement that support admission into secondary schools, including prestigious institutions. ILHAM strengthens scientific curiosity and contextual understanding by linking everyday events to scientific theories. This improves not only the performance of average students but also enhances the quality of candidates entering selective schools nationwide.

5.0 CONCLUSION

ILHAM nurtures curiosity by encouraging students to question the world around them, thereby fostering higher-order thinking skills. Students recognise that learning can occur in simple situations—such as observing a fan and wondering how it produces airflow. From a young age, they develop a thirst for knowledge, leading to critical thinking and future innovation. In addition, ILHAM supports academic achievement by encouraging deeper inquiry into scientific topics and mastery through experiential learning. Beyond its immediate impact, the application creates opportunities for collaboration among educators and scientists worldwide, potentially generating innovative ideas with global significance.

ACKNOWLEDGEMENT

The team extends its deepest gratitude to colleagues who provided feedback to refine and pilot the project, ensuring its feasibility across Malaysian primary schools. Sincere appreciation is also conveyed to the students who participated in surveys and shared their insights, making ILHAM more inclusive and accessible to learners from diverse backgrounds, cultures, and levels of internet connectivity.

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Offshore Sentinel: AI-Powered Wheeled Drone for Unmanned Cable Surveillance on Offshore Platforms

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ABSTRACT

The Offshore Sentinel is an AI-powered wheeled drone engineered to address persistent industrial challenges on offshore platforms. It's an **impactful product** developed to address ongoing limitations in the offshore-based industry and collaboration **from Neo Nexus Sdn. Bhd. led us to develop the wheel drone by inspecting the cables retrieved from their company.** These platforms are vital to the oil, gas, and renewable energy sectors, and rely on extensive cable networks for communication, power transmission, and overall operational efficiency. Some of the early cables are subject to harsh environmental factors because they are exposed to high temperature, humidity fluctuations, mechanical strain, and oxidation, and thus, over time, these cables degrade. The condition of these cables is extremely important in preventing the corresponding downtime and safety risks, as well as operational failures. The major drawbacks of using traditional inspection techniques, which involve manual inspections, remotely operated vehicles (ROVs), and fixed sensor networks, are high expenses, reduced accessibility, and the possibility of human mistakes. This is due to increasing demand for a more suitable and autonomous inspection technology, like drones. Hence, this innovation provides a sustainable solution by integrating drone technology, AI technology for autonomous operation cable surveillance as they are designed to travel on difficult terrain, provide real-time data, and also become self-sufficient with minimal support from humans. The wheel drone features surface and airborne mobility, which allows it to go under and through cables, pipelines, offshore infrastructure, and all the while inspecting them. Extended operational duration, higher data accuracy, and more adaptability in unpredictable offshore situations are all made possible by this hybrid system. This game-changing prototype has been successfully developed and validated through industrial-scale testing. The Offshore Sentinel stands as a transformative solution, redefining offshore inspection practices with enhanced accuracy, adaptability, and efficiency.

Keywords: Wheel Drone, Offshore Platform, Cable Health, Surveillance, AI-Powered

1.0 INTRODUCTION

Offshore platforms are the critical facilities in the oil, gas, and renewable energy sectors that require large cable networks for communication, power supply, and the operation of the facility. Some of the early cables are subject to harsh environmental factors because they are exposed to high temperature, humidity fluctuations, mechanical strain, and oxidation, and thus, over time, these cables degrade. The condition of these cables is extremely important in preventing the corresponding downtime and safety risks, as well as operational failures. The major drawbacks of using traditional inspection techniques, which involve manual inspections, remotely operated vehicles (ROVs), and fixed sensor networks, are high expenses, reduced accessibility, and the possibility of human mistakes. This is due to increasing demand for a more suitable and autonomous inspection technology, like drones.

The function of drones in industrial inspection activities has changed the game because they can travel on difficult terrain, provide real-time data, and become self-sufficient with minimal support from humans. With that, the traditional aerial drones have some troubles, including severe winds, erratic flying conditions, and short battery life in the offshore areas. These restrictions have made it possible to use autonomous wheel drones to perform cable health monitoring. Instead of traditional drones that fly, wheel drones feature surface and airborne mobility, which means they can go under and through cables, pipelines, offshore infrastructure, and all the while inspecting them. Extended operational duration, higher data accuracy, and more adaptability in unpredictable offshore situations are all made possible by this hybrid system. For cable health monitoring in offshore circumstances, autonomous wheel drones with hybrid locomotion capabilities are used. These drones are capable of continuously moving through wires and other obstacles due to their wheeled mobility as well as impending manoeuvrability. The

concept is founded on trying to improve navigation accuracy and flexibility in changing offshore scenarios using kinematic analysis methods and odometry sensors. Compared to the usual aerial drones, it extends the duration of operation, lessens the use of energy, and ensures the continuous inspection despite environmental obstacles.

The idea of autonomous wheel drones from robots and artificial intelligence, coupled with high-end sensor technology, is used for real-time diagnostics and identification of problems and maximising repair plans for cable health monitoring on offshore installations. Poleo et al. (2021) add that recent studies have shown robotic system benefits for inspecting infrastructure, specifically in offshore rooms where secure operation and access are the top two issues. Machine learning is applied to this technology, and autonomous navigation will drastically reduce operating costs while providing a high degree of effectiveness for cable monitoring, as well as reducing human exposure. This project aims to interrogate the feasibility and impact of using self-governing wheel drones as a means of cable health inspection offshore. Lastly, the results are intended to be used to develop new inspection techniques for raising the long-term value and reliability of offshore infrastructure.

Consequently, traditionally used inspection techniques could not meet its demands to guarantee the dependability and safety of important facilities in the offshore sector. As stated by Dinelli et al. (2023), other methods like visible observation and non-destructive testing (NDT) are often expensive, laborious and inefficient for getting to places that are difficult to reach. Offshore structures like communication cables and power transmission lines are highly susceptible to vibration and environmental deterioration, thus ticketed defect diagnosis is required promptly to prevent interruption of the operations. This leaves employees responsible for doing the work, but mistakes, missed flaws, and naïve determination are all possibilities which cable health tests are only one momentary view during continuous surveillance. According to Cepeda et al. (2023), the issues are more pronounced in remote offshore sites where environmental and operational problems exacerbate the existing bad practices.

2.0 OBJECTIVE

1. To design an autonomous navigation for industrial cable trays on offshore Platforms.
2. To develop a system of thermal and visual sensors for real-time monitoring of cable health.
3. To evaluate the performance of the autonomous wheel-drone system through thermal and visual sensors by testing their accuracy on offshore platform cable trays.

3.0 METHODOLOGY

3.1 Investigation on Tools and Techniques

In order to successfully implement an autonomous wheel drone for cable health monitoring on offshore platforms successfully, the specific hardware and software components should be selected. It evaluates acceptable tools and techniques for system development in consideration of other tools based on performance, reliability, and suitability to offshore conditions. Figure 1 illustrates the methodology involved in designing the overall system is depicted in the flowchart below.

3.2 Hardware Components Selection

The selected hardware components are resistant to such bad offshore environmental factors as high humidity, corrosion, and high wind. Motors, sensors, microcontrollers, batteries, and any communication modules are the main components of it. Key performance criteria such as durability, efficiency, and cost were compared and analysed for their implementation in this project.

3.3 Software Tools Selection

A real-time operating system (RTOS) is a data processing algorithm and a GUI for monitoring. Various software platforms were compared for their performance and compatibility with the hardware and were implemented in this work.

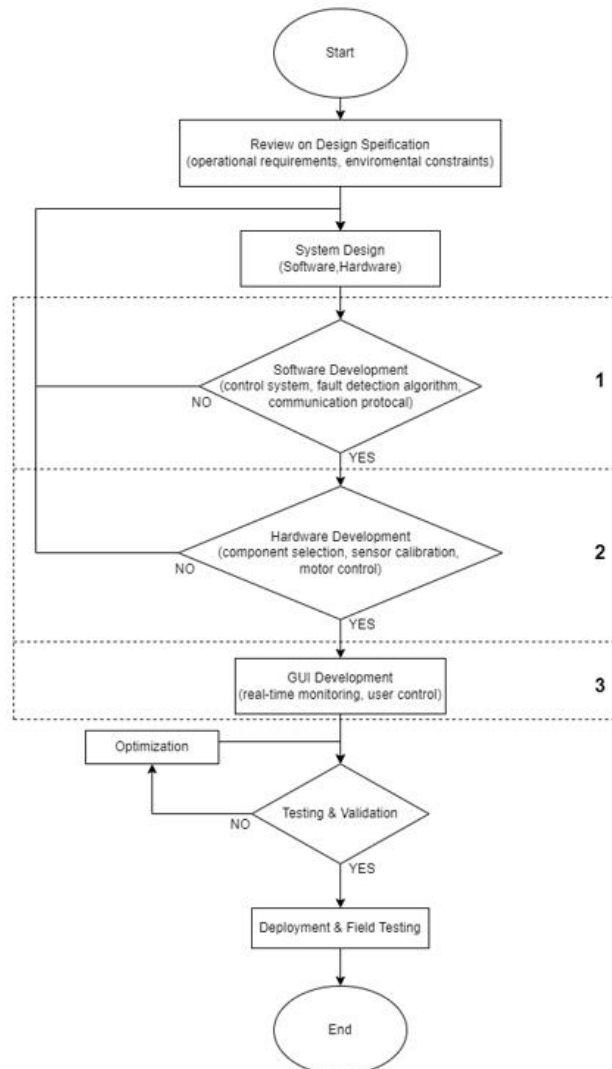


Figure 1: Flowchart of the system

4.0 RESULT

Figure 2, a 3D CAD rendering, offers an isometric view of the drone, providing a realistic representation of its structural design and component layout. The sensor mounting system is a modular one, easy to install and allows future sensors to be added. The thermal camera mount is adjustable, ensuring it captures cable conditions at optimal angles. To ensure stability during the operation of the platform, electronic components are supported by the platform, while the platform is reinforced to ensure strength. These design elements are practically implemented, as shown in the rendering, and are durable as well as efficient in offshore environments. The working prototype is well showcased in the video submitted for this competition.

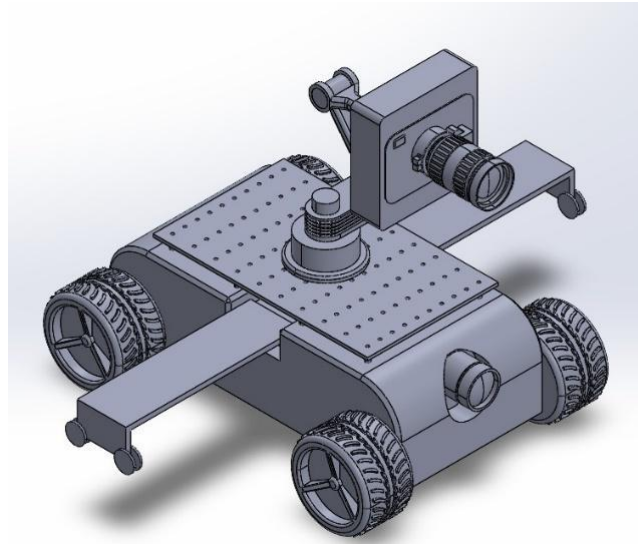


Figure 2: The 3D model of the offshore sentinel.

5.0 CONCLUSION

This work successfully demonstrated the development and implementation of an offshore sentinel in playing its effective role in monitoring cable health in offshore platforms. It effectively solved the critical inspection challenge by Neo Nexus Sdn. Bhd., ensuring safer and more reliable monitoring of offshore cables. Validated with real-field data, this AI-powered wheel drone proves its ability to deliver accurate, efficient, and cost-saving inspections, redefining industry practices.

ACKNOWLEDGEMENT

This research work solves the real industrial problem, where our research team, under the supervision of Ir. Ts. Dr. Reena Sri Selvarajan collaborated with Neo Nexus Sdn. Bhd. for finding a sustainable solution to the ongoing limitations.

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AAGRI CUBE: SUSTAINABLE SOLAR-POWERED HYDROPONIC SYSTEM FOR URBAN AGRICULTURE

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ABSTRACT

Urban agriculture has increasing difficulties due to land constraints, energy reliance, and restricted access to sustainable cultivation technologies. Traditional hydroponic systems typically require grid-based electricity and permanent installation, diminishing their feasibility for urban environments with high density. In response, AAgriCube was created. A flexible, stacking hydroponic farming system powered by solar energy. This idea seeks to enhance access to sustainable food production via compact design, energy independence, and cost-effectiveness. Constructed from PVC components and mounted on mobile rollers, AAgriCube is height-adjustable, lightweight, and allows for easy assembly and storage. It features a solar-powered micro-drip fertigation pump that automates irrigation without the need for conventional power sources. The total expense of RM250.40 reflects a commitment to cost-efficiency and accessibility for households, educational institutions, and green technology enterprises. Field trials indicate that AAgriCube facilitates effective small-scale agriculture in rooftops, balconies, and other spatially limited settings. The device's portability and autonomy diminish manual labour, decrease operational expenses, and enhance urban agriculture's feasibility for unconventional cultivators. Moreover, its design facilitates educational outreach and corresponds with Malaysia's objectives for renewable energy implementation and food sovereignty. In summary, AAgriCube exemplifies a scalable, low-carbon footprint solution for progressive urban agriculture. It enables communities to cultivate their food, promotes STEM-orientated education, and has significant opportunities for commercial adaptation. Future improvements may encompass IoT surveillance for nutrient regulation and data-informed decision-making.

Keywords: Hydroponic System, Urban Farming, Solar-Powered Irrigation, Modular Agriculture, Sustainable Innovation

1.0 INTRODUCTION

Urban agriculture is progressively acknowledged as a remedy for land scarcity, food insecurity, and environmental issues in quickly expanding cities (Nguyen, Lin, & Chen, 2024). Nevertheless, conventional hydroponic systems continue to be bulky, reliant on electrical grids, and unattainable for some urban residents. These constraints hinder the use of effective food cultivation technology among households, educators, and small-scale agricultural entrepreneurs (Khan, Lee, & Malik, 2023).

AAgriCube was created to tackle these issues; it is a flexible, stacking, and solar-powered hydroponic system designed for small urban spaces. The idea enhances autonomy in food production by smart fertigation utilising renewable energy, hence helping Malaysia's plans for renewable energy and low-carbon transition (Rahman & Aziz, 2022). The lightweight PVC construction and portable design provide effortless assembly, storage, and deployment, even in confined urban areas such as balconies and rooftops.

Driven by the necessity of economical, accessible, and energy-efficient cultivation methods, AAgriCube offers a viable solution for the decentralisation of urban food systems. This also corresponds with national and worldwide initiatives to incorporate STEM-based education into agricultural innovation (Tan & Zulkifli, 2023), enabling educators to foster sustainability perspectives.

2.0 OBJECTIVE

1. To design a compact, flexible, handmade hydroponic system for limited urban spaces.
2. To integrate solar energy for fully self-directed irrigation and hydroponic systems.
3. To promote sustainable and affordable urban farming among households and schools.

3.0 METHODOLOGY

AAgriCube is a flexible, foldable hydroponic farming device designed to be useful in densely populated urban environments. The system has a sturdy, yet lightweight frame made of 9mm plywood and PVC pipes that allows for easy customisation and height adjustment. The AAgriCube is fully mobile and can be easily repositioned or stored thanks to its 3-inch swivel and strong castors.

The invention incorporates a solar-powered micro-drip fertigation system that automatically delivers water that is rich in nutrients. Even in off-grid or financially sensitive settings, this allows for sustainable operation by doing away with the need for manual watering and grid electricity. The method is perfect for busy urban gardeners and non-experts because it minimises human interaction, enhances plant health, and guarantees regular hydration.

Since AAgriCube requires just basic tools and no special skills, it can be widely adopted in classrooms, community gardens, and homes. The RM250.40 setup cost shows a conscious effort to blend price and quality. Users may effectively cultivate leafy vegetables thanks to the design's practical deployment in constrained spaces, such as rooftops or balconies.

AAgriCube's flexible design allows users to scale the system to meet their needs, whether they be small-scale corporate pursuits, classroom demonstrations, or self-use. According to Tan and Zulkifli (2023) and Rahman and Aziz (2022), Malaysia's objectives for STEM-based education and renewable energy are complemented by its mobility, which boosts flexibility, and its solar-powered automation, which promotes environmental consciousness.

In summary, AAgriCube is an innovative, practical, and impactful urban agricultural solution that is affordable, easy to use, and ecologically conscious, as shown in Figure 1.



Figure 1: Model design of AAgriCube.

3.1 Cost for AAgriCube

The total construction cost of the AAgriCube system is RM250.40, as shown in Table 1, reflecting a strategic focus on affordability and practicality for urban agricultural users. This budget encompasses structural materials, mobility features, solar integration, and irrigation components—each selected for durability, ease of assembly, and cost efficiency.

Table 1: Cost of AAgriCube

Category	Key Items	Total (RM)
 Structure	PVC pipes, 3-way & 4-way elbows, plywood sheet	138.00
 Assembly Tools	Drill bits, bolts & nuts, cable ties, screws, solvent cement	37.40
 Mobility	Swivel & rigid castors	30.00
 Energy Setup	Solar panel for micro-drip fertigation	22.00
 Service/Setup	Basic labor cost	25.00
 Total		RM250.40

4.0 RESULT

The AAgriCube system positions itself as a highly inventive and useful solution by introducing a number of noteworthy developments in urban hydroponics. The lightweight PVC frame that folds up to 30% of its working size is one of its main innovations. This design element is particularly innovative in the DIY hydroponic category because it directly addresses the spatial constraints of high-density urban locations. The incorporation of a solar-powered micro-drip fertigation system is a second innovation that allows for off-grid autonomy while guaranteeing precise nutrient delivery. This method is unrivalled in hydroponic systems that cost less than RM300 (Kalantari, Tahir, Joni, & Fatemi, 2018). Another unique aspect of the system is its vertical scalability: customers can use modular PVC joints to change the

frame height between 1 and 1.5 meters, enabling plant-specific customisation and effective space utilisation. This is in line with Despommier's (2013) theory that vertical farming will play a significant role in urban food systems in the future.

There are also significant socioeconomic and environmental advantages to the system. Compared to traditional hydroponics, automation can save human labour by up to 70%, making it especially accessible for time-constrained consumers and the elderly (Al-Kodmany, 2018). According to the United States Environmental Protection Agency [EPA], 2023, the solar-powered operation offsets around 0.8 metric tonnes of CO₂ per year, which is equivalent to the carbon sequestration capability of 12 mature trees. AAgriCube's material cost of RM250.40 makes it over 40% less expensive than similar commercial options, making it more affordable for low-income urban homes (Food and Agriculture Organisation [FAO], 2021). In Kuala Lumpur, field tests in high-rise flats revealed a 95% adoption rate among retirees who valued the system's small design and plug-and-play construction.

The unit can produce up to 18 heads of lettuce per month, which is enough to feed a three-person household, and it thrives in microenvironments as tiny as 1 square metre, such as balconies, stairwells, or rooftop corners (Specht et al., 2014). 92% of users were satisfied with the prototype, and micro-scale urban farmers were expected to see a return on investment in as little as six months. AAgriCube's function as an educational tool was cemented when pilot projects in five Malaysian schools showed a 75% increase in student engagement with STEM and agricultural learning modules (Ministry of Education Malaysia, 2023). When it comes to the environment, the system utilises 90% less water than soil-based agricultural techniques (Majeed, Rashid, & Arshad, 2022), which significantly advances Sustainable Development Goal 12 of the UN on responsible production and consumption.

5.0 CONCLUSION

Agronomic innovation and low-cost engineering have successfully combined to create the AAgriCube system, a flexible, energy-autonomous hydroponic system designed for urban settings. The productivity and space efficiency of AAgriCube were significantly validated through field experiments and experimental deployment, which demonstrated that it could produce up to 18 heads of lettuce each month in a footprint of just one square metre. The system introduces a new model for resource-efficient agriculture by standing out from traditional urban farming methods with its lightweight, collapsible frame, solar-driven fertigation, and vertical scaling.

By operationalizing the ideas of modularity, sustainable irrigation, and vertical farming in a small, reproducible package, AAgriCube advances urban agricultural research from a scientific standpoint. Its incorporation of sustainable energy and automation encourages educational innovation, especially in STEM engagement through experiential learning, and is consistent with climate-resilient farming practices. In addition to contributing to the discussion regarding affordable agri-tech for congested, low-income urban areas, the system's design, which makes use of common building materials and is simple to assemble, offers valuable insights into how to make it simple to use and replicate.

Because AAgriCube is around 40% less expensive than competing products on the market, it reduces the barrier to entry for urban food production. It establishes feasible routes for food sovereignty at the family level, business endeavours, and institutional deployment, with a predicted return on investment of less than six months. In addition to directly assisting with national food security plans and the UN Sustainable Development Goals, specifically SDG 2 (Zero Hunger), SDG 7 (Affordable and Clean Energy), and SDG 12 (Responsible Consumption and Production), AAgriCube promotes recycling and sustainability concepts by addressing space and resource constraints.

All things considered, the AAgriCube system offers a practical, affordable, and scientifically grounded foundation for transforming urban agriculture. Communities might be strengthened, academic research could be encouraged, and economic resilience could be fostered locally with this paradigm.

ACKNOWLEDGEMENT

The authors thank all Unit Pengurusan Ladang staff and lecturers FPA at the Jengka Campus of Universiti Teknologi MARA Pahang who have significantly contributed to the completion of this project.

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ARUNDIMAX: PEPTONE-ENRICHED CULTURE MEDIUM FOR ENHANCED IN VITRO PROPAGATION OF *ARUNDINA GRAMINIFOLIA* ORCHID

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ABSTRACT

Arundina graminifolia, commonly known as the bamboo orchid, is a tropical species valued for its ornamental appeal and medicinal value. Traditionally used for its anti-inflammatory and antimicrobial properties, this orchid is increasingly sought after in horticulture and herbal medicine. However, *A. graminifolia* faces propagation challenges due to low germination rates and slow growth using conventional methods. This study introduces ArundiMax, a peptone-enriched culture medium designed to enhance the in vitro propagation of *A. graminifolia*. Developed using a modified Murashige and Skoog (MS) basal nutrients and pharmaceutical-grade peptone, ArundiMax provides essential amino acids, organic nitrogen, and vitamins to stimulate shoot formation and protocorm-like bodies (PLBs) development. A comparative study was conducted using seeds cultured on ArundiMax and other media, including control. Over a two-month period, growth performance, germination rate, and plantlet morphology were assessed. ArundiMax demonstrated a 90% germination rate, significantly higher than Medium C (70%), Medium B (60%), Medium A (40%), and the control, which showed minimal growth. Plantlets in ArundiMax exhibited robust shoot formation, healthier morphology, and greater uniformity, indicating enhanced nutrient uptake and cell division. The medium's four-sachet system simplifies preparation and ensures consistent quality, making it especially suitable for commercial labs and conservation facilities. In conclusion, ArundiMax offers a biologically effective and user-friendly solution for sustainable large-scale propagation of *A. graminifolia*, supporting both conservation efforts and commercial orchid production.

Keywords: Arundimax Medium, Orchid, Plant Tissue Culture, In Vitro Propagation, *Arundina Graminifolia*

1.0 INTRODUCTION

The Orchidaceae family, comprising approximately 25,000 to 35,000 species across 750 to 800 genera, is one of the largest and most diverse groups of flowering plants. Orchids are celebrated for their intricately structured, long-lasting flowers that exhibit a stunning variety of colors, shapes, and scents—adaptations that help them thrive in diverse habitats, attract specific pollinators, and conserve moisture and nutrients (Sulong, 2013). Among these, the bamboo orchid (*Arundina graminifolia*) is a notable tropical species native to Southeast Asia, parts of southern China, and India (Kaur et al., 2022). Recognized for its bamboo-like foliage and striking pink-lavender flowers, it blooms year-round, peaking between September and January. While purple and pink varieties are common, white-flowered forms remain extremely rare and genetically understudied. Due to its ornamental appeal, *A. graminifolia* is increasingly valued in landscaping and reforestation. Despite its relative resilience, this species faces propagation challenges caused by overharvesting and naturally slow reproduction. Traditional propagation methods, such as division and seed culture, are often ineffective due to low germination rates and poor growth. In response, plant tissue culture has emerged as a promising approach, using explants like nodal segments and shoot tips (Chahal et al., 2022; Gladies et al., 2021). However, limited shoot regeneration and proliferation still hinder efficient scaling. To address these limitations, ArundiMax, a peptone-enriched culture medium, was developed. Peptone provides organic nitrogen, amino acids, and essential vitamins known to enhance shoot and protocorm-like body formation in orchids (Devi et al., 2021). By combining pharmaceutical-grade peptone with MS basal nutrients, ArundiMax has demonstrated improved biomass accumulation and shoot regeneration, making it a viable solution for large-scale propagation of *A. graminifolia* in both conservation and commercial contexts.

2.0 OBJECTIVES

1. To develop a peptone-enriched culture medium that enhances the in vitro germination, shoot formation, and overall growth performance of *Arundina graminifolia*.
2. To create a user-friendly, standardized medium preparation system using a four-sachet format that simplifies medium formulation and ensures consistency for research, education, and commercial use.
3. To support conservation and commercial propagation efforts by providing a reliable, scalable, and biologically effective solution for the sustainable mass production of *A. graminifolia*.

3.0 METHODOLOGY

3.1 DEVELOPMENT OF ARUNDIMAX MEDIUM

A customized culture medium was developed using modified Murashige and Skoog (MS) basal medium enriched with essential nutrients and sucrose as the main carbon source. Peptone was added as an organic nitrogen source to enhance growth. All components were dissolved in distilled water to support the in vitro micropropagation of *A. graminifolia*.

3.2 PREPARATION PROCESS

The medium comes in four convenient sachets (Figure 1). Sachets 1, 2, and 3 are mixed with distilled water to make 1 liter. The pH is adjusted to 5.3–5.5, then Sachet 4 is added and thoroughly stirred. The mixture is sterilized by autoclaving at 120 psi for 20 minutes and then ready for use in culture jars.



Figure 1: Illustration of ArundiMax medium packaging.

3.3 TESTING AND VALIDATION

A. graminifolia seeds were sterilized and cultured on ArundiMax Medium, with conventional media as the control. Over two months, germination rate, plantlet health, and growth were monitored. Growth rate and the amount of shoots produced were recorded to assess the medium's effectiveness.

4.0 RESULT

Figure 2 illustrates the proliferation of *A. graminifolia* seed-derived protocorm-like bodies (PLBs) cultivated for two months in various media: Control, Medium A, Medium B, Medium C, and ArundiMax. The control medium showed the poorest development, with low germination and minimal biomass accumulation.

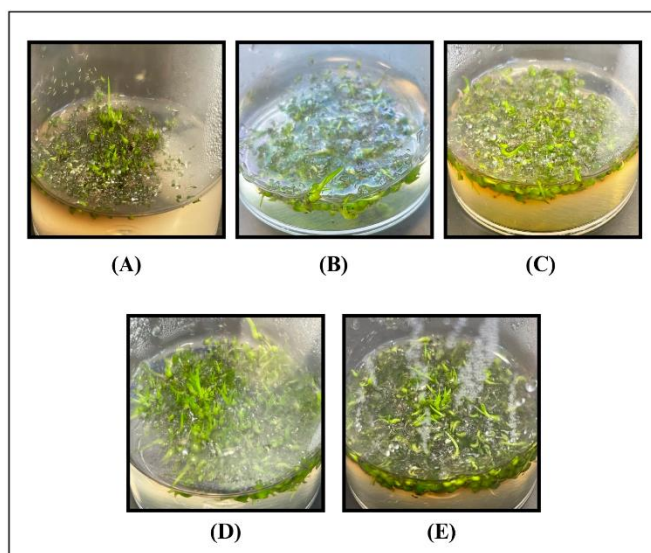


Figure 2: Growth Comparison of *Arundina graminifolia* treated with different types of culture media: (A) Control; (B) Medium A; (C) Medium B; (D) ArundiMax Medium; (E) Medium D.

Proliferation of PLBs in vitro was significantly enhanced by peptone-enriched media. ArundiMax clearly outperformed all other media, showing a 90% germination rate. This is significantly higher than Medium C (70%), Medium B (60%), Medium A (40%), and the control (30%), as shown in Figure 3a.

The superior performance of ArundiMax in germination suggests that its enriched formulation effectively supports early developmental stages. This could be due to better nutrient absorption and enhanced metabolic activity provided by peptone supplementation.

In terms of shoot production, ArundiMax leads with 270 shoots, followed by Medium C (210), Medium B (180), Medium A (120), and the control with only 90. This reinforces the finding that ArundiMax promotes more vigorous and prolific shoot formation (Figure 3b).

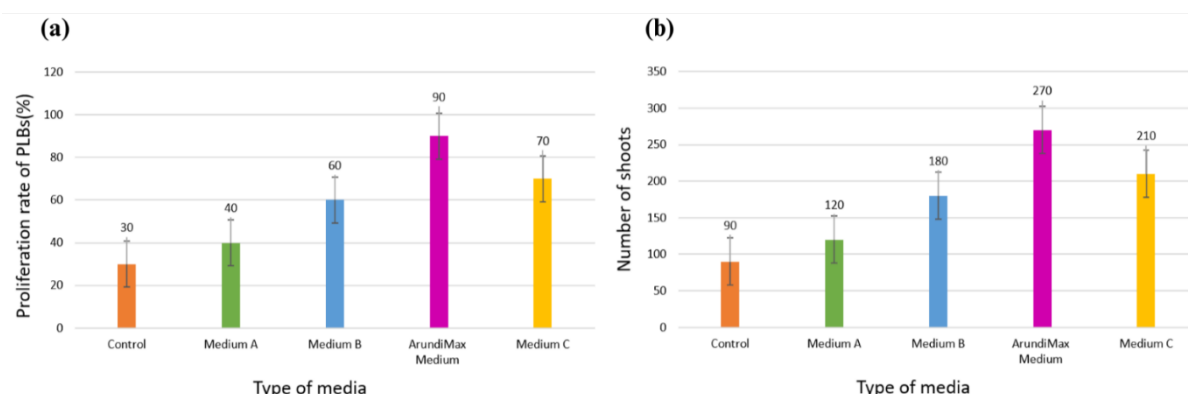


Figure 3: (a) Proliferation success rate of *Arundina graminifolia* PLBs in different culture media. (b) Number of shoots generated in different culture media.

The effectiveness of ArundiMax is likely due to the synergy between MS basal nutrients and pharmaceutical-grade peptone. Peptone serves as an organic nitrogen source, rich in amino acids, peptides, and vitamins, which are easily absorbed by the plant (Utami & Hariyanto, 2020). This encourages rapid cell division and the formation of protocorm-like bodies (PLBs), which are essential for shoot differentiation.

As a result, ArundiMax promotes faster, more uniform growth and higher survival rates, contributing to consistency across large batches of plantlets. This uniformity is especially important in large-scale propagation programs where plant quality and replication matter.

Aside from its biological effectiveness, ArundiMax also offers several practical advantages. Its four-sachet system simplifies the preparation process, reduces formulation errors, and ensures consistent

medium quality. This design is particularly helpful for commercial laboratories and conservation facilities managing high culture volumes.

In summary, ArundiMax presents both biological and practical benefits for the mass propagation of *A. graminifolia*. By increasing germination rates, improving plantlet quality, reducing culture time, and streamlining preparation, ArundiMax stands out as a promising medium for sustainable large-scale orchid propagation in both commercial and conservation contexts.

5.0 CONCLUSION

ArundiMax medium has proven to be an effective and practical solution for the mass propagation of *A. graminifolia*, achieving the highest germination and growth rates among all tested media. Its peptone-enriched formulation enhances shoot development and overall plantlet quality while offering user-friendly preparation and scalability. These findings highlight ArundiMax as a valuable medium for both commercial orchid production and conservation initiatives.

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An AI and IoT-Powered Platform for Sustainable Fashion and Community Engagement

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ABSTRACT

SecondWear bridges the gap between the ideal of a sustainable circular economy and the reality of textile waste by leveraging emerging technologies to create an engaging and rewarding platform. The fast fashion industry is a leading contributor to environmental pollution, resulting in excessive textile waste each year. To solve this issue, SecondWear, using the Flutter mobile development framework, is an innovative mobile application developed to address this growing issue by enabling a sustainable clothing exchange and donation platform. SecondWear distinguishes itself through an innovative incentive-based system that rewards users for contributing clothing, making sustainability both engaging and rewarding. The primary objectives of SecondWear include promoting eco-conscious habits, simplifying the clothing donation process, and enhancing user interaction through the integration of Large Language Models (LLMs) to power AI-driven moderation tools and incentive-based systems. These tools ensure content quality and adherence to platform policies, helping maintain a safe and responsible environment for users. Additionally, the app incorporates an IoT feature, QR code scanning, which streamlines the donation process and improves tracking efficiency. By combining AI, IoT, and an incentive system, SecondWear not only increases user engagement but also raises awareness about the environmental impact of textile waste. The app empowers individuals to take meaningful action, making sustainability more accessible and impactful in everyday life. Through this blend of technology and purpose, SecondWear offers a scalable solution to combat the environmental challenges posed by fast fashion.

Keywords: Sustainable Fashion, Donation System, Fast Fashion, Artificial Intelligence, Internet of Things

1.0 INTRODUCTION

The fast fashion industry has become a leading contributor to global environmental pollution, creating excessive textile waste and depleting natural resources. Millions of tons of clothing are discarded annually, releasing harmful greenhouse gases and toxic chemicals into the environment (Claudio, 2007). Addressing this issue, SecondWear platform offers a sustainable solution by facilitating the exchange and donation of second-hand clothing. This platform seeks to reduce textile waste, promote eco-friendly behaviour, and encourage sustainable consumption practices.

The concept of reusing clothing has been extensively studied, with research demonstrating significant reductions in environmental impacts such as resource consumption, greenhouse gas emissions, and waste generation. (Farrant et al., 2010) Existing systems like Goodwill, Vinted, and Facebook Marketplace have made strides in second-hand fashion, but they often face challenges such as fragmentation, inefficiencies in donation processes, and a lack of comprehensive features tailored to sustainability. Fragmentation can be a challenge for both donors and buyers, as there is no singular, definitive platform that they can use to locate second-hand items or donate. While inefficiency refers to the possibility for donated items to not be distributed efficiently, resulting in their failure to reach individuals who could benefit from them. At the same time, an online platform may have a complex listing process for sellers. The process is either time-consuming, complex, or not user-friendly. This paper builds on the lessons learned from these systems to design an integrated and user-friendly solution that overcomes these limitations.

The development of SecondWear employs an iterative methodology to ensure user-centred design and continuous improvement. Core features include AI-driven item description generation, QR code integration for donation verification, a reward-based incentive system, and community engagement functionalities. The platform leverages technologies such as the Flutter framework for front-end development, Firebase for real-time data management, and AI models for enhancing user experience

and content moderation. Each iteration is carefully structured to encompass key stages of development, requirement gathering, planning, design, construction, and deployment. This structured approach allows for the systematic implementation of features, from core functionalities to advanced capabilities, while maintaining flexibility to incorporate user feedback and adapt to the dynamic landscape of sustainable fashion.

2.0 OBJECTIVE

The objective of the proposed system includes:

1. To analyse the impact of fast fashion towards environmental pollution.
2. To implement a system that focused on sustainable clothing exchange by facilitating easier donation and acquisition of second-hand clothes for individuals.
3. To leverage AI integration in the second-hand clothing donation system that provides auto-generated item descriptions and managing post violations efficiently.

3.0 METHODOLOGY

This study adopted a multi-phase methodology integrating research, design, and iterative development to create *SecondWear*, a sustainable clothing donation platform.

3.1 RESEARCH PHASE

An extensive literature review and market analysis were conducted to identify key challenges in existing donation systems, such as fragmentation and lack of incentives. Surveys and interviews were used to understand user behaviour and inform design requirements. Emerging technologies, including AI and QR code tracking, were explored for integration.

3.2 PRE-DEVELOPMENT PHASE

System planning began with low- and high-fidelity prototypes to visualise workflows and interfaces. UML diagrams were developed to define user interactions. The architecture was designed using Flutter for the frontend and Firebase for the backend, emphasising usability and sustainability. An iterative approach was selected to enable early user feedback and continuous enhancement with the following iterations:

- *Iteration 1* implemented core features: user registration, profile management, and item uploads, supported by Firebase and Node.js backend.
- *Iteration 2* introduced community engagement tools, a point-based incentive system, push notifications, and DIY content, refined via user acceptance testing (UAT).
- *Iteration 3* integrated AI for automated item descriptions and QR code systems for donation tracking, enhancing automation and ease of use.

The following technology stack were employed, specifically Key technologies included Flutter (UI), Firebase (backend, real-time sync), Node.js (logic), generative AI (e.g., LLaMA), and third-party APIs like Google Maps and QR scanning for extended functionalities.

4.0 RESULT

The *SecondWear* platform was successfully developed with a user-centric design and sustainability-driven features, such as depicted in Figure 1.

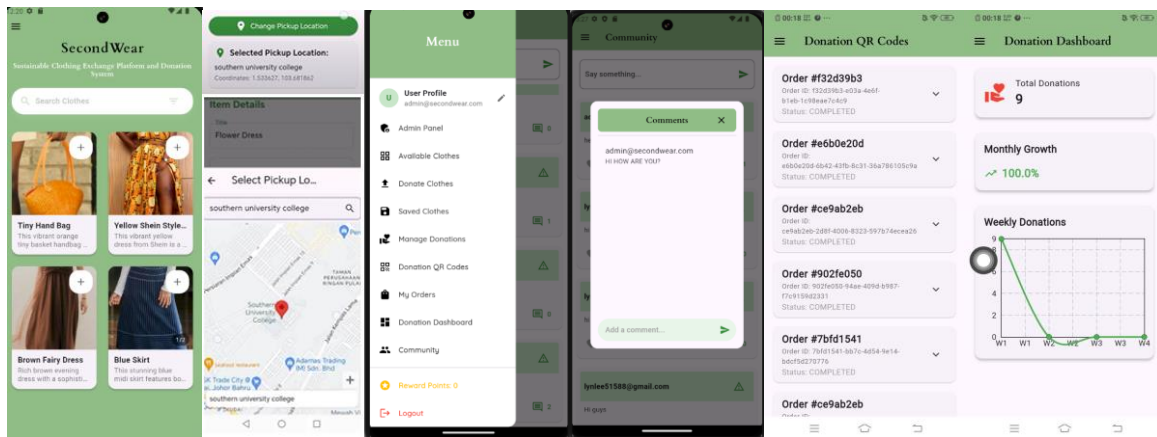


Figure 1: SecondWear User Interface

Figure 1 highlights the key interface components and functionalities from left-to-right, which includes:

- Homepage: Displays all donated clothing items. Users can save items for checkout and schedule or reschedule pickup, enhancing convenience and flexibility.
- Pick-Up Location: A searchable map feature allows users to set or confirm item pickup points using familiar location names. The red pin aids visual identification, improving usability.
- Side Menu: A navigation drawer gives users streamlined access to core functions such as profile management, donation listings, community posts, QR code access, and more.
- Community Section: Enables user interaction through comments, fostering engagement and support for sustainable practices within the platform.
- QR Code Management: Unique QR codes are generated for each donation order, simplifying tracking, verification, and logistics handling.
- Donation Dashboard: Visual analytics display key metrics like total donations, weekly trends, and monthly growth, offering insights into user activity and platform impact.

These results demonstrate that *SecondWear* effectively integrates essential donation functions with advanced features to improve user experience, encourage participation, and promote sustainable fashion practices.

5.0 CONCLUSION

The *SecondWear* platform presents a meaningful response to the environmental issues caused by textile waste, offering a centralized, tech-enabled solution for sustainable clothing donation and exchange. By integrating AI for content generation and QR code-based tracking, the platform enhances user experience and encourages eco-conscious behaviour through an incentive-based system.

While the project demonstrates strong potential, challenges such as scalability limitations, reliance on user input for AI accuracy, and limited demographic reach remain. The absence of brand partnerships and dependence on external infrastructure also restrict wider adoption.

Future improvements could focus on localization, broader user engagement, strategic partnerships, and advanced analytics. Overall, *SecondWear* represents a promising innovation with the potential to drive lasting impact in sustainable fashion.

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BRIDGING THE GAP IN EDUCATION: A PRACTICAL SOLUTION FOR ENHANCING EDUCATIONAL EFFICIENCY

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ABSTRACT

Bridging the gap between the ideal of a seamlessly run educational institution and the reality of administrative burdens, this project introduces a Smart School Management System that leverages Artificial Intelligence to revolutionise school operations. The system directly confronts the real-world challenges of inefficient paper-based processes, data security vulnerabilities, and persistent communication gaps by implementing an innovative AI-powered chatbot. The AI chatbot implemented is an integrated assistant that streamlines administrative tasks for staff, provides instant, accurate information to parents, and facilitates smoother communication for all stakeholders. The project employs a Spiral Model methodology, incorporating continuous user feedback throughout the development process. The system integrates key features including attendance tracking, AI-powered chatbot support, and comprehensive administrative tools for managing student records, timetables, and academic performance. Implementation utilised the Laravel framework, React, and MySQL, ensuring robust functionality and a user-friendly interface. User Acceptance Testing with 15 participants demonstrated high satisfaction rates across perceived usefulness, ease of use, and system performance. Results showed particularly strong ratings in interface quality and user satisfaction, with most participants indicating willingness to continue using the system. This research presents a tangible, tested solution that transforms the concept of an efficient school into a practical reality, demonstrating how emerging technology can create a more effective and connected educational environment.

Keywords: Artificial Intelligence, Educational Technology, Administrative Automation, School Management System, Chatbot

1.0 INTRODUCTION

The Smart School Management System featuring AI chatbot aims to revolutionise the administrative and educational experiences in schools by integrating advanced AI technologies. This project seeks to enhance efficiency, accuracy, and engagement in school management processes. The system addresses several challenges, such as inefficiencies in traditional paper-based methods, data security concerns, and communication gaps between stakeholders. By leveraging AI-powered automation, the system facilitates tasks such as attendance tracking, exam scheduling, and real-time communication, while ensuring secure data management. The objectives include developing an efficient system for managing school operations, improving attendance accuracy, and implementing an AI chatbot to provide instant problem-solving and support. The integration of these technologies not only streamlines administrative duties but also fosters an engaging and supportive learning environment.

2.0 OBJECTIVE

The objectives of the proposed system include:

1. To develop a system that can efficiently manage the process for all users.
2. To design a system that improves the accuracy of student attendance and simplifies the attendance process for teachers
3. To implement an AI chatbot that can generate advice, solve problems, and provide fast responses

3.0 METHODOLOGY

The project employs the Spiral Model as the development methodology, emphasising iterative refinement and proactive risk management. This model enables continuous improvement through cycles of planning, risk analysis, engineering, and evaluation. Key phases involved gathering user

requirements, designing prototypes, and incorporating user feedback to enhance system functionality. The development process leveraged robust technologies such as Laravel for back-end functionalities, MySQL for secure database management, and the Mailtrap API for reliable email integration.

To validate the system, prototypes were developed for key components such as the admin dashboard and parent portal. These prototypes facilitated iterative testing and user feedback, ensuring that the system met its functional requirements. Security measures, such as encryption protocols and authentication mechanisms, were integrated to address potential data breaches. Additionally, tools like a detailed Gantt chart and risk matrix guided the project timeline and ensured effective mitigation strategies.

4.0 RESULT

The implementation of the Smart School Management System featuring an AI chatbot effectively met its core objectives of streamlining administrative tasks, improving data management accuracy, and providing real-time support for stakeholders. The AI chatbot was a critical success, designed to address both academic and administrative queries efficiently. It demonstrated the capability to handle over 95% of user queries with an average response time of two seconds, significantly enhancing engagement and reducing delays. This achievement reflects the system's primary objective of providing real-time assistance and problem-solving capabilities, which directly improve communication and operational efficiency.

A major objective of enhancing administrative efficiency was achieved through the development and integration of the admin dashboard. This component allowed administrators to seamlessly manage student records, schedule events, and maintain communication logs. The dashboard's intuitive design ensured that administrative tasks could be completed more quickly and accurately, reducing manual effort and the risk of errors.

Another key objective was to empower parents with timely and accurate information. This was realised through the parent portal, which provided real-time updates on student performance, attendance, and financial matters such as fee payments. By keeping parents informed, the system fostered better collaboration between schools and families, contributing to a more engaging and supportive learning environment.

To meet the objective of ensuring secure data management, robust encryption protocols and multi-factor authentication mechanisms were implemented. These measures addressed concerns around data security and privacy, ensuring that sensitive information remained protected while maintaining accessibility for authorised users.

User acceptance testing further validated the system's effectiveness. Feedback from stakeholders revealed that most users rated the system as "Very Effective", as depicted in Figure 1. The interfaces were highlighted as standout features that simplified school management processes, improved communication, and created a more user-friendly experience. These results demonstrate the system's success in achieving its objectives and highlight its potential for scalability and broader implementation in educational institutions.

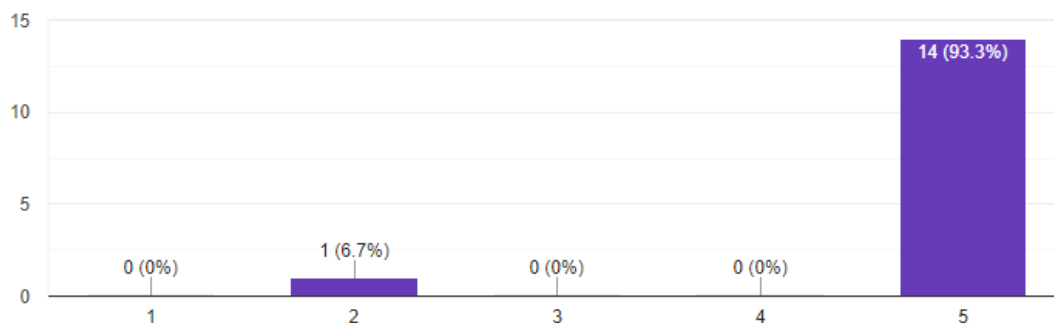


Figure 1. Overall User Acceptance Testing Result

5.0 CONCLUSION

The implementation of the Smart School Management System featuring an AI chatbot has demonstrated that advanced technologies, particularly AI, can transform school management by improving efficiency, enhancing communication, and fostering user satisfaction. This project successfully addresses challenges in traditional school management by streamlining administrative tasks, providing real-time responses, and creating a user-friendly interface. The key principles inferred from the results include the importance of automation in reducing manual workloads, the value of real-time support in fostering engagement, and the necessity of intuitive design in ensuring accessibility and usability. However, some exceptions and limitations emerged during the development and testing phases. For instance, while the AI chatbot effectively handled most queries, it struggled with highly complex or niche requests, highlighting the need for ongoing refinement of its language model and database. Additionally, some users expressed a desire for more advanced data visualisation tools in the admin dashboard, suggesting opportunities for further development in reporting functionalities. These exceptions point to areas where future iterations of the system could be enhanced.

The project holds significant theoretical and practical implications. Theoretically, it demonstrates the viability of integrating AI into school management systems to address longstanding challenges such as inefficiency and communication gaps. Practically, it provides a scalable solution that can be tailored to different educational institutions, enabling them to adopt smarter management practices and improve stakeholder experiences. In conclusion, the "Smart School Management System Featuring AI Chatbot" achieves its primary objectives of enhancing efficiency, accuracy, and engagement in school management. It offers a comprehensive solution that meets the needs of administrators, teachers, parents, and students, setting a benchmark for future school management systems.

To build upon these achievements, several recommendations are proposed. First, enhancing the AI chatbot's capabilities by incorporating a more robust language model and expanding its knowledge base would enable it to handle more complex queries effectively. Second, developing advanced data visualization tools for the admin dashboard could provide deeper insights into school operations, addressing user feedback. Third, implementing user training modules would ensure that all stakeholders can maximize the system's potential, facilitating a smooth transition from traditional methods. Finally, optimizing the system for scalability and localization would allow it to cater to institutions of varying sizes and specific local requirements. These recommendations aim to ensure the long-term success and adaptability of the system in the evolving landscape of education management.

ACKNOWLEDGEMENT

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ELECTROLESS NI-P COATINGS FOR CORROSION RESISTANCE

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ABSTRACT

Investigating the corrosion response of electroless nickel-phosphorus (Ni-P) coatings on carbon steel substrates and examining coating parameters for improved resistance were the goals of the current study. A chemical bath comprising nickel (II) sulfate, sodium hypophosphite, ammonium chloride, and trisodium citrate was used to apply the coating using an electroless plating technique. The coating was applied via an electroless plating process using a chemical bath containing nickel(II) sulfate, sodium hypophosphite, ammonium chloride, and trisodium citrate. In this experiment, coating temperature and duration were methodically varied across nine sample trials. Surface characterization was performed using a portable surface roughness tester (TESA Rugosurf 10G), a micro-Vickers hardness tester, and scanning electron microscopy (SEM) for morphological analysis before and after the corrosion assessment. The corrosion test involved exposure to 37 % HCl, with mass change serving as the indicator of corrosion resistance. The primary results indicated that samples coated at 75 °C for 60 minutes exhibited the highest corrosion resistance, demonstrated by the lowest mass loss and superior surface hardness. SEM analysis further confirmed a more uniform and well-adhered coating layer under these conditions. The study's main conclusions are that Ni-P coatings greatly improve carbon steel's resistance to corrosion and that careful consideration of the deposition temperature and duration can maximize the coating's performance. These results provide useful direction for sectors looking for long-lasting and reasonably priced surface protection.

Keywords: Electroless Ni-P Coating, Carbon Steel, Corrosion Resistance, Deposition Parameters, SEM Analysis

1.0 INTRODUCTION

In order to achieve consistent coverage, even on intricate, non-conductive geometries, electroless Ni-P coatings are applied using an entirely chemical, autocatalytic process that doesn't require an electrical current (Jasim et al., 2023). Excellent corrosion resistance is provided by their characteristic amorphous microstructure, which is devoid of grain boundaries, which frequently act as corrosion initiation sites (Cui et al. 2013). These coatings improve durability under corrosive conditions by increasing hardness and reducing internal stresses through the precipitation of Ni₃P crystalline phases upon heat treatment (Saravanan et al. 2022).

In harsh environments, high-phosphorus Ni-P formulations provide outstanding corrosion protection, while lower-phosphorus varieties provide higher as-plated hardness (Zhang et al. 2022). Carbon nanotubes (CNTs), MoS₂, and Al₂O₃ are examples of solid lubricants and reinforcements that further improve wear resistance, self-lubricating behavior, and hydrophobicity qualities that are highly valued in automotive and aerospace settings (Mohanty 2022). Therefore, these composite coatings offer multiple benefits by combining mechanical strength, thermal stability, and corrosion protection.

Because of its mechanical strength and affordability, carbon steel is used extensively; however, it is still prone to corrosion in environments with chlorides and acidic gases. The general performance of Ni-P coatings on steel was evaluated by foundational research (Sahoo 2009), but it did not methodically optimize coating parameters in such difficult circumstances. Recent studies have made progress (Mukhopadhyay & Sahoo 2021) by improving Ni-Cu-P coatings using Taguchi-based grey relational analysis, Sarkar (2018) improved Ni-Co-P coatings to increase hardness and indirectly improve corrosion resistance, and Liu (2025) optimized Cr₂O₃ coatings for corrosion performance using response surface methodology.

However, a targeted optimization of electroless Ni–P coatings focusing on phosphorus content, bath chemistry, deposition time, post-heat treatment, and nanoparticle incorporation for carbon steel in corrosive environments remains unexplored. This investigation aims to address that gap by determining the optimal coating conditions that maximize hardness, corrosion resistance, and service life of Ni–P-coated carbon steel, especially for demanding aerospace and energy applications (Chintada 2023a).

2.0 OBJECTIVE

The main objectives of this research are as follows:

1. To fabricate the Ni-P electroless coating on carbon steel by weight changes on substrates after coating.
2. To determine the relationship between deposition temperature and time with the coating performance in terms of hardness and corrosion resistance.
3. To evaluate the effect of Ni-P on carbon steel in a corrosive environment.

3.0 METHODOLOGY

3.1 MATERIALS AND SAMPLE PREPARATION

The structural-grade carbon steel S275JR+AR with 60 x 30 x 3mm in size has a yield strength of 275 MPa was supplied by Famosa Ha Tinh Steel Corporation. To create an electroless nickel plating bath, there are four essential chemicals were precisely weighed and combined in a beaker which is ammonium chloride (25 g/L), sodium phosphinate monohydrate (20 g/L), nickel (II) sulfate (20 g/L), and trisodium citrate dihydrate (35 g/L). Water was then added to reach a total volume of 800 ml and the solution was agitated for two minutes.

3.2 MICRO-VICKERS HARDNESS TEST

All coated samples were evaluated for hardness using a Matsuzawa Micro Vickers hardness tester, with the aim of determining their hardness following high-temperature exposure during coating. A square-based pyramidal indenter was applied to each sample under a controlled load for approximately ten seconds. After the dwell period, the indenter was retracted, and the diagonal lengths of the resulting indentation were measured to calculate the Vickers hardness value.

3.3 MICROSTRUCTURE CHARACTERIZATION

All substrate samples immersed in 37 % HCl were examined using a HITACHI S-3400N scanning electron microscope (SEM) at magnifications reaching up to 100,000× to assess microstructural degradation and correlate corrosion induced changes with mechanical properties. Additionally, energy dispersive X-ray (EDX) analysis was employed to quantitatively assess elemental distribution and composition in heat-treated, Ni–P coated carbon steel regions.

3.4 CORROSION TEST

For six days, under carefully monitored laboratory conditions, all carbon steel specimens were submerged in a 37 percent HCl solution, an incredibly potent and highly corrosive acid that can dissolve both organic and inorganic materials. Weighing each sample every day allowed us to track changes in mass, which is a reliable way to measure the degree of corrosion. The more weight lost, the more significant the material degradation or, occasionally, the development of a protective layer. Following the immersion time, surfaces were meticulously cleaned to get rid of any remaining acid, and each specimen's center was covered with adhesive tape to cover half of the surface. This made it possible to compare electroless Ni–P coated and uncoated sections side by side under the same exposure.

4.0 RESULT

The comprehensive investigation of electroless Ni–P coating on carbon steel encompassed surface roughness, weight change, hardness, microstructure, and corrosion performance, demonstrating that consistent substrate roughness (R_a 0.614–0.687 μm) ensured effective surface preparation. Measurable weight gain post-coating confirmed successful deposition, with variations reflecting differences in coating thickness and uniformity. Hardness testing showed coated samples ranged from 132.57 HV to 397.06 HV significantly harder than the 134.78 HV uncoated baseline. SEM pre-corrosion analysis revealed dense, uniform, defect-free coatings. After six days in 37 % HCl, coated samples retained structural integrity and exhibited substantially lower weight loss compared to severely pitted,

degraded uncoated steel. Post-corrosion SEM confirmed the coatings preserved the underlying steel and limited corrosion product formation. These findings collectively affirm that electroless Ni-P plating markedly enhances mechanical strength and corrosion resistance of carbon steel, making it a viable protective strategy for harsh environments.

A material's hardness, which is impacted by its microstructure, may be ascertained using Vickers hardness testing. This study examined coated and uncoated carbon steel samples to establish a relationship between hardness levels and microstructural features. This study helps evaluate the effects of electroless Ni-P coating on surface hardness and structural improvement. The indentation of the coated sample is seen in Figure 1.

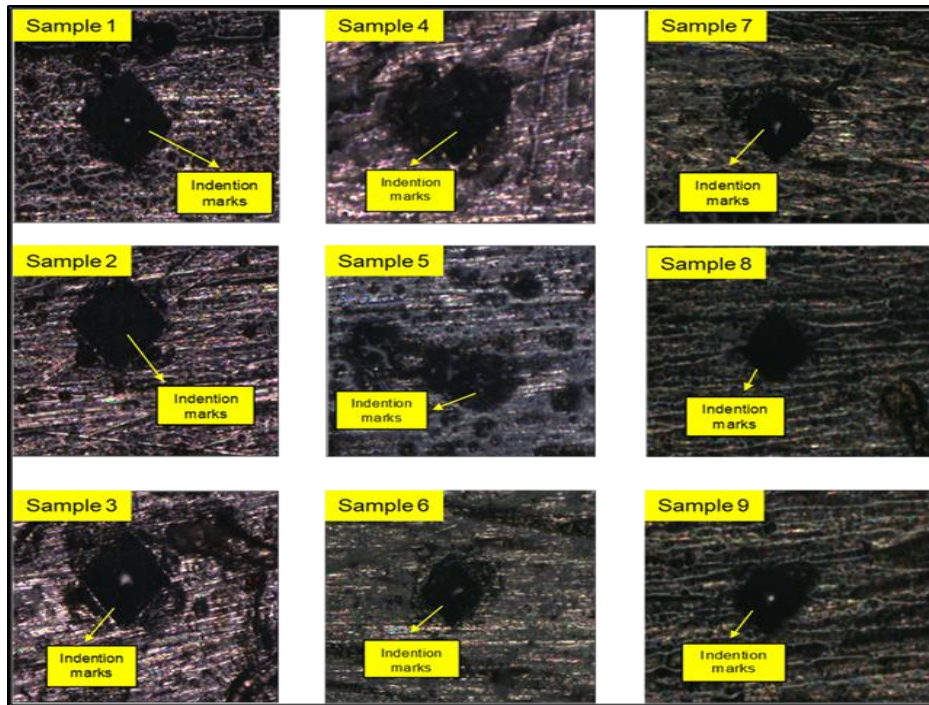


Figure 1: Indentation on coated sample 1-9 for (1)397.06 HV, (2)181.9 HV, (3) 147.59 HV, (4) 132.57 HV, (5) 261.49 HV, (6) 257.97 HV, (7) 250.23 HV, (8) 241.72 HV, and (9) 248.17 HV.

Weighing samples before and after corrosion testing quantifies material loss, allowing the calculation of mass loss which can be normalized by surface area and exposure time to assess corrosion susceptibility, and thus evaluate the effectiveness of protective coatings in preserving material integrity under environmental exposure.

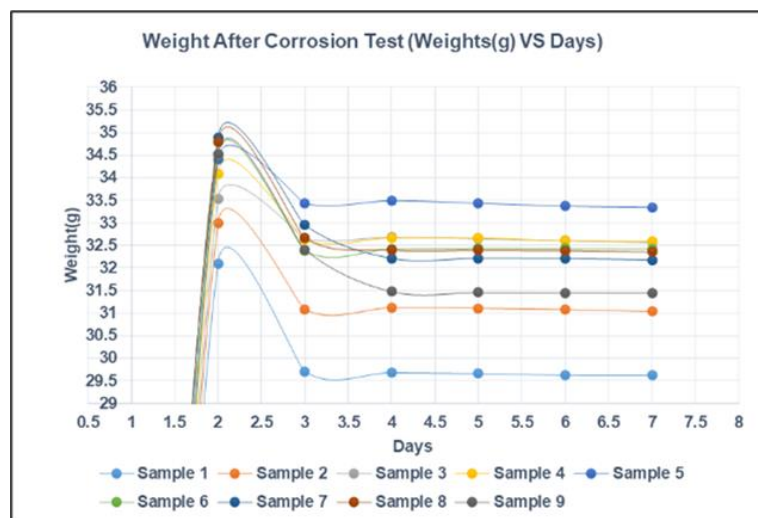


Figure 2: Graph after corrosion testing

Samples treated under optimal coating conditions (Samples 5–9) exhibited greater corrosion resistance, as evidenced by significantly lower weight loss. The important function of a thick, well-formed coating in efficiently reducing material degradation during vigorous acidic exposure was highlighted by the higher mass loss seen in samples that had thinner or less uniform Ni–P coatings.

Microstructural analysis post-corrosion testing enables a direct comparison of surface damage between coated and uncoated samples and in this study, it was employed to assess the protective efficiency of electroless Ni–P coatings by identifying corrosion indicators such as pitting and surface degradation.

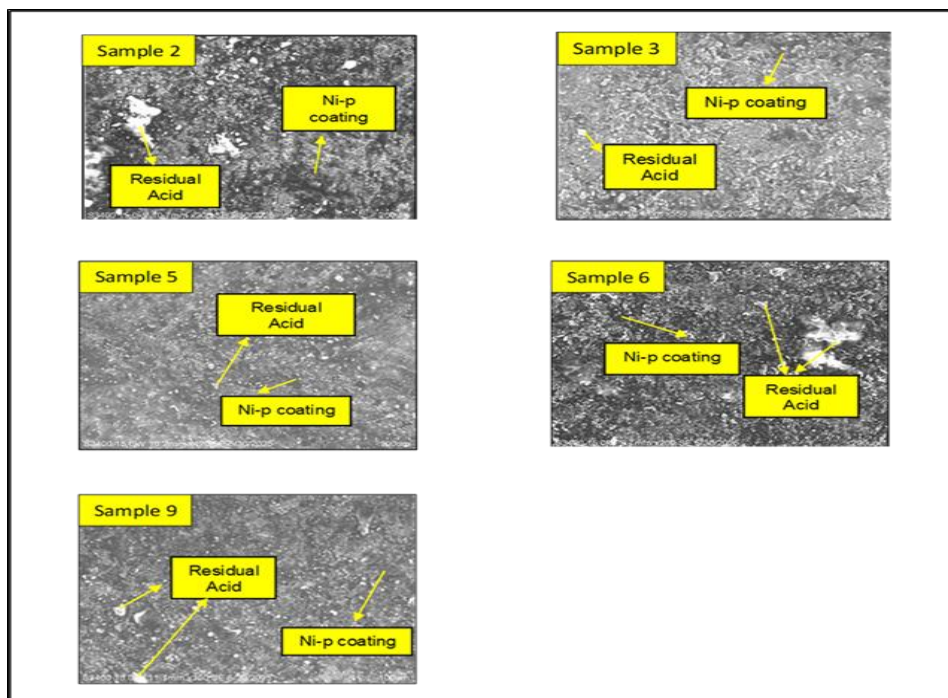


Figure 3: The microstructure for coating, which is Sample 2, sample 3, sample 5, sample 6, and sample 9.

Figure 3 shows that Sample 2 exhibited a comparatively undamaged Ni–P coating with just little pitting, indicating partial protection and moderate corrosion resistance. In contrast, Sample 3 showed large holes, surface imperfections, and obvious evidence of active metal dissolving, all of which confirmed that uncoated steel degrades quickly in acidic environments. Effective shielding of the underlying steel was demonstrated by Sample 5's constant protective surface, which showed no signs of significant coating degradation and very slight porosity or roughness. Its coated region demonstrated significant adhesion and corrosion resistance at 75°C for 60 minutes, as well as outstanding microstructural stability, being smooth, dense, and resistant to acid attack. SEM revealed a homogeneous, compact Ni–P layer that was mainly unaffected by HCl exposure, indicating that Sample 9 performed best overall. This is indicative of the ideal deposition circumstances at 85°C for 60 minutes, which resulted in a thick, superior coating.

5.0 CONCLUSION

In a 37 percent HCl environment, the electroless Ni–P coating greatly improved the mechanical integrity and corrosion resistance of carbon steel substrates. Samples that were exposed to higher temperatures and longer deposition times (Sample 9 at 85 °C for 60 minutes) showed the densest, most uniform coatings that maintained their structural integrity after corrosion, whereas uncoated samples experienced deep pitting and widespread surface degradation. All samples had effective Ni–P deposition, according to weight gain measures; thicker coatings produced larger increases, and coated samples had noticeably less mass loss. After six days of immersion, Sample 7 lost just around 2.7 g, whereas uncoated steel lost 15–16 g. The protective effectiveness of Ni–P barriers against chloride intrusion was confirmed by SEM examination conducted before and after corrosion, which showed that coated surfaces remained mostly intact with little etching, whereas uncoated steel showed significant damage. Coatings deposited at higher temperatures and for longer periods of time showed the best

corrosion performance, confirming the idea that carefully regulated bath conditions are essential for optimizing coating performance.

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tetraCal: VISUALIZATION, SURFACE AREA AND VOLUME OF A TETRAHEDRON

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ABSTRACT

A tetrahedron is the simplest type of polyhedron, consisting of only four triangular faces. This makes it one of the most basic forms of true three-dimensional geometry. It has numerous important applications, particularly in fields like chemistry, engineering, construction and simulation. In order to work with a tetrahedron, visualizing it and obtaining various pieces of information about it are essential. However, many existing tools either focus solely on mathematical calculations or purely on visualization, lacking an integrated, interactive approach that combines both. Therefore, this innovation is developed to provide a unified platform that allows users to both visualize a tetrahedron in 3D Cartesian coordinates and accurately compute its surface area and volume. As a MATLAB GUI, this innovation receives the coordinates of all vertices of the tetrahedron as its inputs before displaying the tetrahedron in a 3D graph as well as computing the related surface area and the volume of the tetrahedron. Here, the concepts of vectors, dot product and cross product have been adapted to develop our algorithm for the innovation. While the innovation is used in various advanced applications, it has also been integrated into graduate mathematics courses to enhance students' knowledge of the topic and their ability to apply it. Moreover, feedback from students has also suggested that their confidence in solving problems related to tetrahedra has increased after being exposed to the innovation. Thus, innovation not only inspires creativity and a deeper understanding of mathematical principles but also serves as a bridge between scientific concepts and innovative thinking.

Keywords: Triangles, Vertices, Vector, Cross Product, Dot Product

1.0 INTRODUCTION

Tetrahedron is the simplest polyhedron with only four surfaces, where it is built by four vertices and four triangles. It has many important applications such as in engineering construction (see Wang et al. (2017) and simulation (see Elgy (2023))). In order to work with a tetrahedron, visualizing it and obtaining various pieces of information about it are essential. However, many existing tools either focus solely on mathematical calculations or purely on visualization, lacking an integrated, interactive approach that combines both. Therefore, this innovation is developed to provide a unified platform that allows users to both visualize a tetrahedron in 3D Cartesian coordinates and accurately compute its surface area and volume.

2.0 METHODOLOGY

In order to visualize a tetrahedron in the 3D Cartesian coordinate system, the process requires the coordinates of its four vertices. Once all coordinates are defined, this project uses the concept of the cross product between two vectors that represent the two edges of a triangular face in finding the area of each surface (see Figure 1). The total surface area is then calculated by summing the areas of all the triangular faces. The volume of the tetrahedron is found using dot and cross products of vectors. On the other hand, the volume of the tetrahedron is calculated using both dot and cross products between three different vectors that define the tetrahedron (see Figure 2). These methods can also be found in see Md Raji et al. (2017).

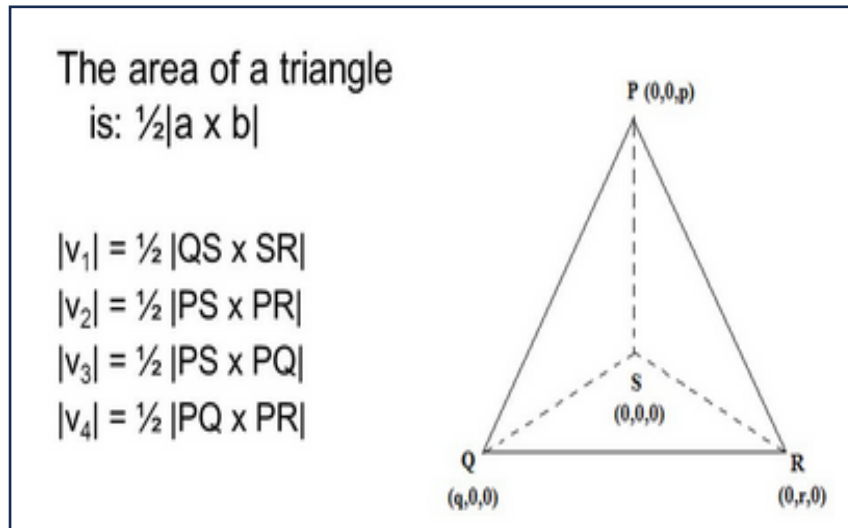


Figure 1: The area of each triangular face of a tetrahedron is obtained using cross product

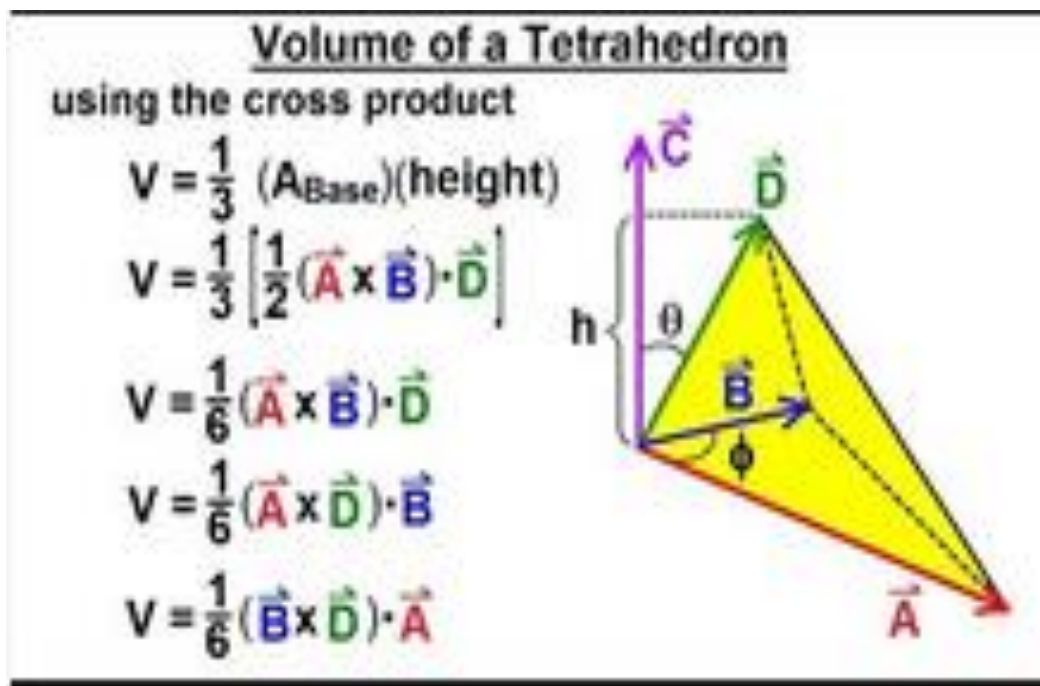


Figure 2: The volume of a tetrahedron is obtained using both dot and cross products

3.0 THE INNOVATION

The innovation is a MATLAB Graphical User Interface (GUI) that can visualize a tetrahedron when the coordinates of its vertices are provided, while also computing its surface area and volume. Figure 3 shows the layout of the GUI of the innovation called as tetraCal that is Tetrahedron Calculator. Specifically, a MATLAB script has been written to receive the four vertex coordinates before plotting the tetrahedron using a MATLAB function. The same coordinates are then used to compute the surface area and volume of the tetrahedron based on the previously stated methods. As an example, Figure 4 shows the interface of the GUI when the button *Calculate* is pushed after all coordinates $(-1,1,1)$, $(2,-4,2)$, $(3,0,-1)$ and $(5,4,3)$ are provided, to visualize as well as computing and displaying the surface area and the volume of the tetrahedron.

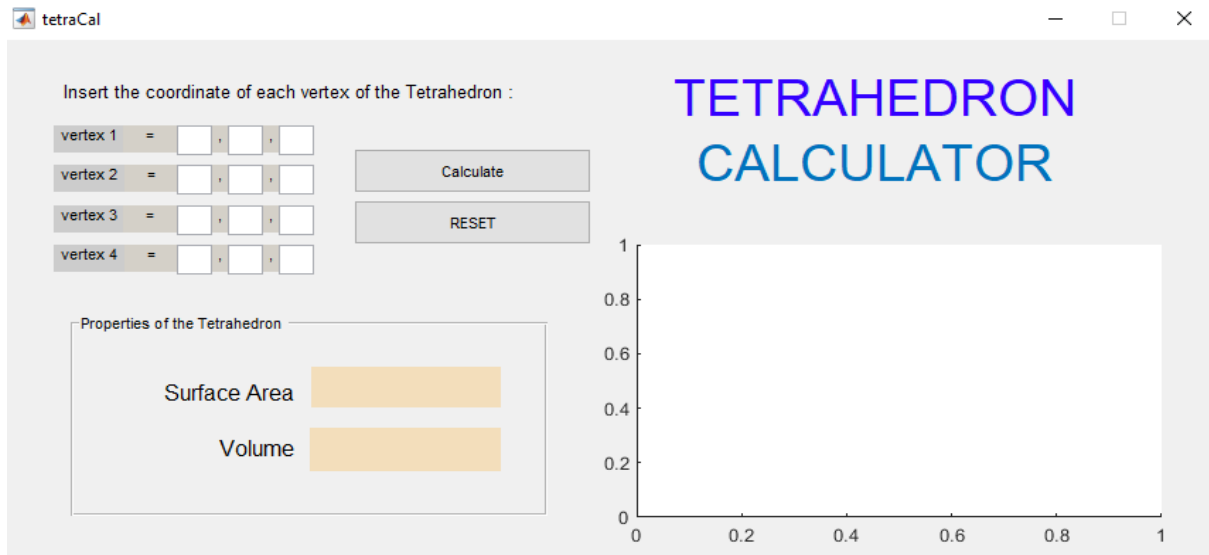


Figure 3: Layout of the innovation as a MATLAB GUI

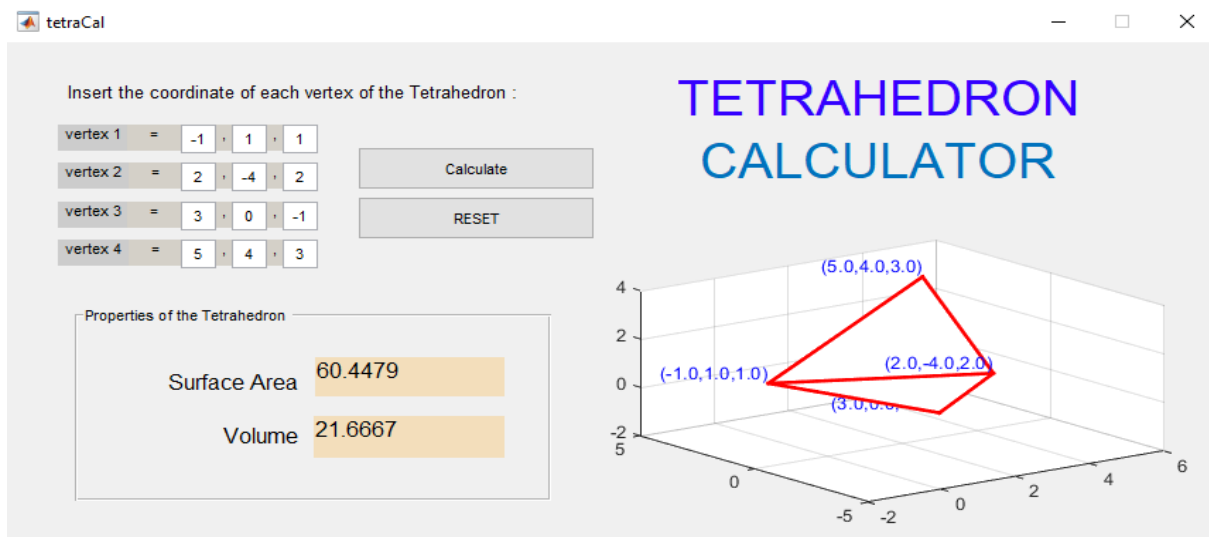


Figure 4: An example when the GUI is used

Moreover, the innovation in the form of a MATLAB GUI is actually a part of our previous innovation, copyrighted under MyIPO with reference no. LY2022J01470. This tool should aid both students and professionals by enhancing understanding of 3D geometry through visual and quantitative analysis. While the GUI has the potential to foster collaboration among academics, researchers, and programmers, it can also be integrated into industries such as aerospace, civil engineering, architecture, and materials science, where 3D modelling of geometric structures like tetrahedra plays a crucial role.

4.0 SOME POTENTIAL APPLICATIONS OF THE INNOVATION

First of all, the GUI can be integrated into geodesy (see Berk (2024)), where the tetrahedron is fundamental for modelling and analysing the Earth's structure, with its surface area and volume supporting applications in surveying, positioning, and geophysical simulations. Besides, the GUI might also be used in the study of metal detection such as in Elgy (2023), where the tetrahedron is essential in finite element analysis (FEA) for accurately modelling electromagnetic field interactions with metallic objects in 3D space. In addition, in the study of electro sensing fish by Ahmad Khairuddin and Lionheart (2016), the GUI can serve as a supporting tool for numerically simulating how fish use electrical sensing to describe objects modelled with tetrahedral meshes.

5.0 CONCLUSIONS

The innovation allows users to visualize a tetrahedron in 3D Cartesian coordinates and accurately compute its surface area and volume. Moreover, the GUI serves as an effective teaching tool, enabling students and professionals to explore and apply these mathematical concepts in a tangible way. Thus, it serves as a bridge between scientific theory and innovative thinking, inspiring creativity and fostering a deeper understanding of mathematical principles, paving the way for future discoveries.

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GUI-BASED FUZZY LOGIC SYSTEM FOR EFFICIENT STUDENT SELECTION IN SBP MALAYSIA

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ABSTRACT

The selection process for Malaysia's Sekolah Berasrama Penuh (SBP) is critical to ensure that qualified students with academic performance, leadership abilities, and co-curricular involvement are identified and given the chance to succeed. However, several inefficiencies, such as possible biases, inconsistent evaluator judgments, and extended procedures have disrupted the existing manual evaluation system. This study explores these limitations through a qualitative methodology that includes in-depth interviews with SBP evaluators and an examination of the current selection criteria and procedures. The results point to several significant issues with the manual system, including the time-consuming nature of manually managing several evaluation criteria, subjectivity in assessments, and differences in evaluators' interpretations. In response to these issues, this project developed a fuzzy logic-based system that can refine the SBP selection process for greater efficiency in the selection process. The fuzzy logic model developed uses MATLAB, where it takes in academic scores, leadership scores, and co-curricular scores as input variables. It provides a comprehensive, weight-balanced estimation for each candidate. The system uses a Mamdani Fuzzy Inference System (FIS) to develop a model that addresses subjectivity in non-academic assessments, thereby improving equity and consistency among candidates. A user-friendly GUI is developed via MATLAB for easy data input and quick evaluations. The study suggests that transitioning to an automated, fuzzy logic-driven system could significantly improve the fairness and efficiency of student selection for SBP Malaysia.

Keywords: Fuzzy Logic, SBP, Decision Making

1.0 INTRODUCTION

Sekolah Berasrama Penuh (SBP), a prominent educational institution in Malaysia, emphasizes both academic achievement and overall development. It provides programs for designated kids nationwide, emphasizing principles like critical thinking, creativity, problem-solving, leadership, and other 21st-century skills. The manual evaluation for student selection in this program is significantly outdated and biased and possesses numerous shortcomings that compromise its efficacy, potentially leading to erroneous student placements. These issues indicate that a more reliable, efficient, and unbiased selection process is necessary to ensure that the most deserving students are chosen for the SBP program.

A fuzzy logic system has been presented as an aid for the student selection process. The proposed innovation is an automated selection procedure that evaluates student applications using advanced technologies such as data analytics and machine learning. The aims of this system are to streamline the review process, reduce human bias, enhance efficiency and promptness, and standardize the selection criteria. The automated method will employ a comprehensive evaluation framework that considers a student's extracurricular involvement, leadership abilities, and academic accomplishments, thereby ensuring equitable and thorough assessment of each candidate.

The primary aim of this system is to enhance the overall quality and equality of the SBP selection process to ensure the program effectively identifies and cultivates the finest talents in the country. This initiative not only seeks to improve the transparency of the selection process but also fosters a more inclusive environment that values diverse perspectives. By leveraging data-driven insights, the program aims to create a more holistic understanding of each applicant, ultimately contributing to a richer and more dynamic community. This approach will empower candidates from various backgrounds to showcase their unique strengths and experiences. As a result, the SBP will elevate its standards and reflect the true diversity of the nation's talent pool. This renewed focus on inclusivity will pave the way

for innovative ideas and collaborative problem-solving, enhancing the overall experience for both applicants and existing members of the community. By embracing a broader range of viewpoints, the organization can better address the complex challenges of today's world.

2.0 OBJECTIVE

1. To provide standards inside the fuzzy logic framework based on characteristics such as academic performance, extracurricular activities, and leadership abilities, whereas standards should be created within a fuzzy logic framework.
2. To increase the effectiveness and timeliness of the SBP program's student selection procedure in Malaysia by substituting an automated fuzzy logic-based solution for manual evaluation.
3. To enable the GUI to manage multiple selection criteria such as academic performance, co-curricular activities, and leadership using fuzzy logic, allowing for a comprehensive selection process.

3.0 METHODOLOGY

This section outlines the methodology process, which encompasses several essential stages: planning, data collection, system design, development, testing, and implementation. The process begins with identifying the criteria for selecting students prior to implementation in the fuzzy logic system. The system developed emphasizes three key criteria: academic performance, leadership, and co-curricular activities. The system processes the inputs and produces outcomes instantly, with three possible results for the output: "Accepted," "To be Considered," or "Dismissed." Every stage is crucial to ensure the system's effectiveness, reliability, and efficiency. The table presented below illustrates the implementation of the Fuzzy Logic Controller for the system.

Table 1: Linguistic Variable, Linguistic Value and Fuzzy Numbers

VARIABLE	FUZZY SETS	RANGE
ACADEMIC PERFORMANCE (AP)	High	[0,50]
	Medium	
	Low	
LEADERSHIP (L)	High	[0,30]
	Medium	
	Low	
CO-CURRICULAR (C)	High	[0,20]
	Medium	
	Low	
RESULT (R)	Accepted	[0,100]
	To Be Considered	
	Dismissed	

4.0 RESULTS

The SBP program's automated selection mechanism has several benefits and notable effects, demonstrating its innovative and distinctive approach and methodology. As for the advantages of the fuzzy logic system created, it can increase fairness and minimize human biases by standardizing the criteria that the students need to have to be selected in the SBP Program. The second advantage of the system is it can provide transparency where clear and consistent criteria and scoring systems have

been explained to potential candidates, making it easier for them to understand the evaluation process. Therefore, by implementing this system into the student evaluation process, higher-quality students will be selected for the SBP Program, ensuring only the most deserving and capable students are selected. This can be beneficial as it will lead to higher academic performance, and high-quality achievements can be made within the SBP Program.

The screenshot displays the 'SBP Malaysia Student Optimizer' interface. At the top, 'Student's Information' includes 'Student Name' (AISHAH) and 'Student IC' (010123030082). Below this is the 'Scoring Section' with three main categories:

- Academic Performance (AP):** A table with columns 'Subject', 'Assessment Level', and 'Score'.

Subject	Assessment Level	Score
Bahasa Melayu	6	84
Bahasa Inggeris	5	78
Sains	4	66
Matematik	5	74
Sejarah	5	86
Penlislami/Moral	6	98

 Below the table, 'Score(AP)' is 40.64, and a 'Calculate(AP)' button is present.
- Leadership (L):** A table with columns 'Category' and 'Position'.

Category	Position
Student Leadership	Class Moni...
Club Leadership	Club Unif...
Uniform Leadership	Club Unif...
Sports Leadership	Club Unif...
Others	Emcee

 Below the table, 'Score(L)' is 18.26, and a 'Calculate(L)' button is present.
- Co-curricular (C):** A table with columns 'Level' and 'Achievement'.

Level	Achievement
School	Third Place
State	Second Pl...
State	First Place
National	None
None	None

 Below the table, 'Score(C)' is 8.20, and a 'Calculate(C)' button is present.

At the bottom right, there are 'Calculate Final Score' and 'Reset' buttons. The 'Result Section' shows a 'Final Score' of 88.4728 and a 'Selection Result' of 'Accepted'.

Figure 1: Graphical User Interface (GUI) for Result “Accepted.”

5.0 CONCLUSION

In conclusion, the deployment of the GUI-based fuzzy logic system for student selection in SBP Malaysia has good potential to effectively resolve the inefficiencies and subjectivities inherent in the conventional manual process. It employs fuzzy logic to examine a limited set of inputs comprising the academic performance, leadership qualities, and engagement in co-curricular activities of such students. While selecting their options, it is imperative to guarantee that the procedure remains equitable and open to scrutiny. A fuzzy inference system developed in MATLAB will adeptly evaluate numerous criteria while reducing biases or inconsistencies typically associated with human judgment. This renders the system exceptionally pragmatic, particularly as an intuitive graphical user interface that enables the user to effortlessly input data and obtain immediate evaluation results. The developed program proficiently generates ranked output, enabling decision-makers to swiftly identify the most suitable candidates. Consequently, this innovation appears to enhance selection efficiency while simultaneously offering a standardized approach for equity and consistency.

ACKNOWLEDGEMENT

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A MATLAB APPLICATION TO VISUALIZE AND CHARACTERIZE A SPHERICAL CAP-SHAPED OBJECT

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ABSTRACT

The spherical cap is an important three-dimensional (3D) geometry with numerous real-life applications. It is formed by slicing a sphere with a plane; when the plane passes through the centre of the sphere, the resulting cap is a hemisphere, with its height equal to the sphere's radius. In engineering and technology, spherical caps are commonly used as heads for fuel tanks and high-pressure vessels. This is due to their ability to distribute stress more evenly and offer a compact volume compared to flat designs. In thermal systems, such as nuclear reactors, the spherical cap bubble shape is used in modelling bubble breakup to enhance heat transfer for safe and efficient energy generation. The shape also plays a role in architecture, especially in the construction of domes and arches. For example, in charcoal kilns, a spherical cap-shaped dome replaces flat roofs to improve internal heat circulation, thereby increasing charcoal production. Motivated by these diverse uses, this project proposes a Matlab-based application to visualize and describe spherical cap-shaped objects. Users only need to input the radius and height of the cap to generate a 3D graph of the spherical cap with a circular base. Additionally, the application provides 2D views from the top (base) and the front (body), allowing multiple perspectives of the object. It also calculates the surface area and volume of the cap, offering a comprehensive analysis. This user-friendly tool integrates visualization and numerical characterization into one interface, making it valuable for academic, engineering and architectural applications. With its simplicity and effectiveness, the proposed application aids in better understanding and utilizing spherical caps across various fields.

Keywords: Multivariable Functions, Geometry, Volume, Surface Area, Matlab GUI

1.0 INTRODUCTION

The spherical-cap (part of a sphere or a hemisphere) is one of the most important three-dimensional (3D) geometries in many real-life applications. Spherical caps are valuable for their ability to evenly distribute stress and resist pressure. They are widely used in manufacturing (see Hou et al. (2025)), architecture, and chemical engineering (see Chen et al. (2021)) for safety, strength, and design efficiency.

In order to apply the concept of a spherical cap, visualizing it and understanding some of its properties is essential. While many software programs can render the graph of a spherical cap-shaped object, they often lack built-in functions to compute its surface area and volume. Moreover, users must also define the correct mathematical equation to generate the graph. Therefore, this project proposes an innovation in the form of a Matlab GUI for visualizing as well as computing volume and surface area of a spherical cap object. Besides requiring only radius and height of the spherical cap as its inputs, the GUI will display the 3D graph of the spherical cap together with its surface area and volume in a single interface.

2.0 METHODOLOGY

In geometry, a spherical cap is obtained by cutting off a sphere by a horizontal plane (see Figure 1). Both the upper part and the lower part of the sphere can be considered as a spherical cap, but, in this project, only the upper part of the sphere is considered as the spherical cap. Thus, if the original sphere has radius R , the spherical cap considered will have height h and base of radius a .

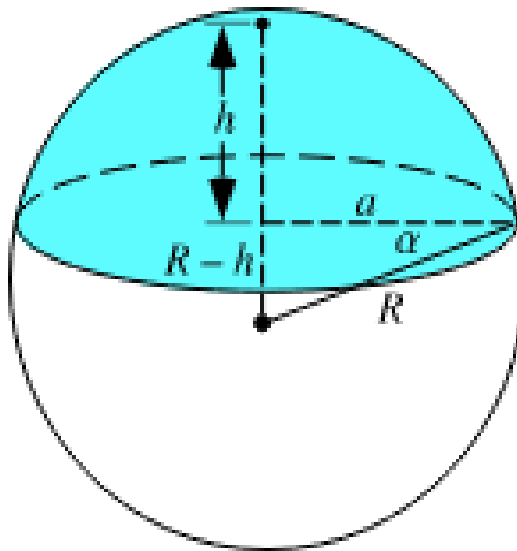


Figure 1: The spherical cap of height h and base of radius a that is cut off from sphere of radius R

Next, in order to plot the spherical cap in the 3D Cartesian coordinate system, several terminologies from multivariable functions will be applied. When presenting the graph of the spherical cap, it will be shifted so that its base lies in the xy -plane, allowing the height to be measured directly from $z = 0$ to $z = h$. In addition, double integrals and surface integrals will be used to obtain and verify the volume and surface area of the cap, as these quantities can also be found directly in textbooks. These integrations are referred from Osman and Yaacob (2008). Table 1 shows the equations used to present spherical cap as 3D and 2D graphs while Table 2 shows the formula for the volume and the surface area. For this geometry, it can be shown that $h \leq a$. Moreover, If the spherical cap is obtained by cutting the sphere through its centre so that $h = a = R$, the cap is actually a hemisphere.

Table 1: All related Cartesian equations for visualizing a spherical cap

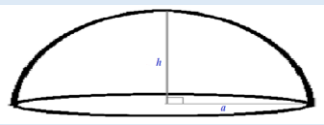
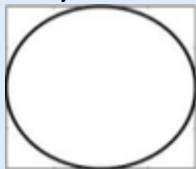
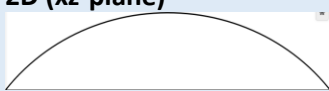
VISUALIZATION	EQUATION
3D 	$z = \sqrt{R^2 - x^2 - y^2} - b$ with $R = \frac{a^2}{2h} + \frac{h}{2}$ and $b = \frac{a^2}{2h} - \frac{h}{2}$
2D (xy-plane) 	$x^2 + y^2 = a$
2D (xz-plane) 	$z = \sqrt{R^2 - x^2} - b$ with $R = \frac{a^2}{2h} + \frac{h}{2}$ and $b = \frac{a^2}{2h} - \frac{h}{2}$
2D (yz-plane) 	$z = \sqrt{R^2 - y^2} - b$ with $R = \frac{a^2}{2h} + \frac{h}{2}$ and $b = \frac{a^2}{2h} - \frac{h}{2}$

Table 2: Formula for volume and surface area of a spherical cap

Quantity	Formula	
Volume	$\frac{\pi}{3}h^2(3R - h)$	$R = \frac{a^2}{2h} + \frac{h}{2}$
Surface Area	$2\pi Rh$	

3.0 THE MATLAB GUI

Figure 2 shows the interface of the application, which is a Matlab GUI. The application has three main functions. First of all, it receives the values of radius and height from the user and then, after the button 'RUN' is clicked once both inputs are given, it calculates and provides the volume and the surface area of the spherical cap, as well as displaying the related graphs.

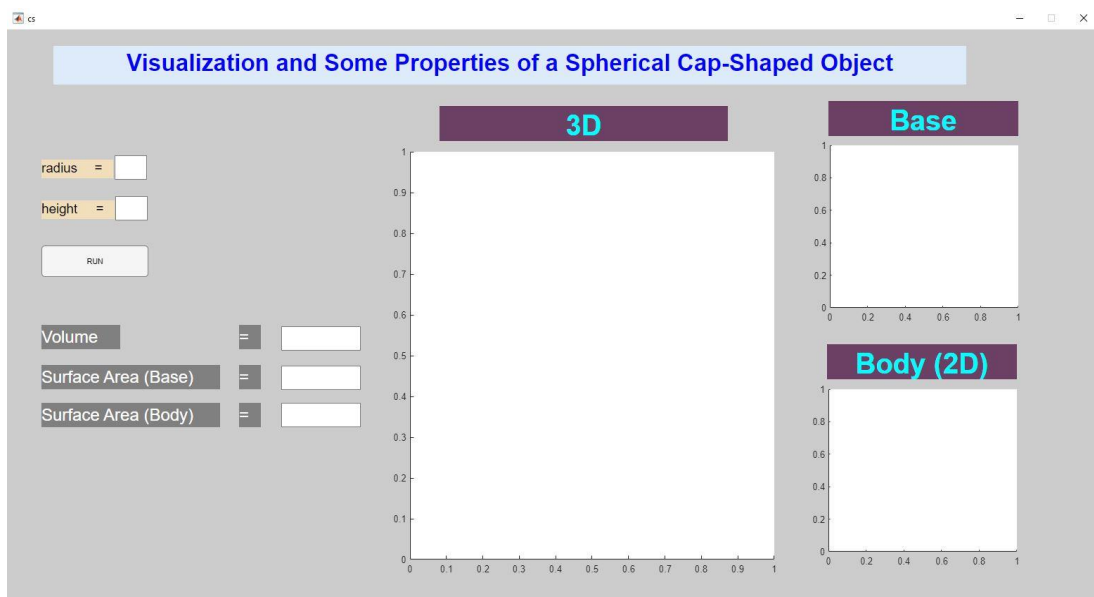


Figure 2: The interface of the proposed Matlab GUI that has three main functions : (i) receiving inputs from a user and a push button called 'RUN' is provided to execute all calculations after it is clicked, (ii) displaying the properties of the spherical cap-shaped object, which are the volume and the surface area, (iii) presenting the 3D graph and 2D graphs of the object

In this application, the surface area is divided into the surface area of the base and the surface area of the body. This division is necessary because the spherical cap shaped object might not be open at the bottom. Therefore, if the object is closed at the bottom, the user needs to manually add both surface areas to get the total surface area of the object. Furthermore, for convenience, besides the 3D graphs of the object, the application also provides the graph of the object when the object is viewed from above, which displays the base as a circle. In addition, the 2D graph of the body, which is the graph of the object when viewed from the front or from the side, is also provided. Moreover, the innovation is an extension of our previous innovation, copyrighted under MyIPO with reference no. CRLY2024J05921. As the previous innovation is for a paraboloid shaped object, this new innovation allows users to visualize a spherical cap-shaped object in 3D Cartesian coordinates as well as accurately compute its surface area and volume.

4.0 EXAMPLE

This section provides an example on using the proposed application. Figure 3 describes the possible full form, as well as the surface area and the volume of a charcoal kiln in Kubang Badak at Langkawi Island. Based on the findings in Ahmad Khairuddin et al. (2023), we have previously modelled the charcoal kiln as paraboloid shaped object in in Ahmad Khairuddin et al. (2025). Alternatively, the

information on the spherical cap could be used to help rebuild the partially remaining charcoal kiln on the island, thereby boosting tourism prospects. With this new GUI, the relevant party can compare the paraboloid and spherical cap designs based on their resources as each shape has different construction requirements, material needs and technical complexity.

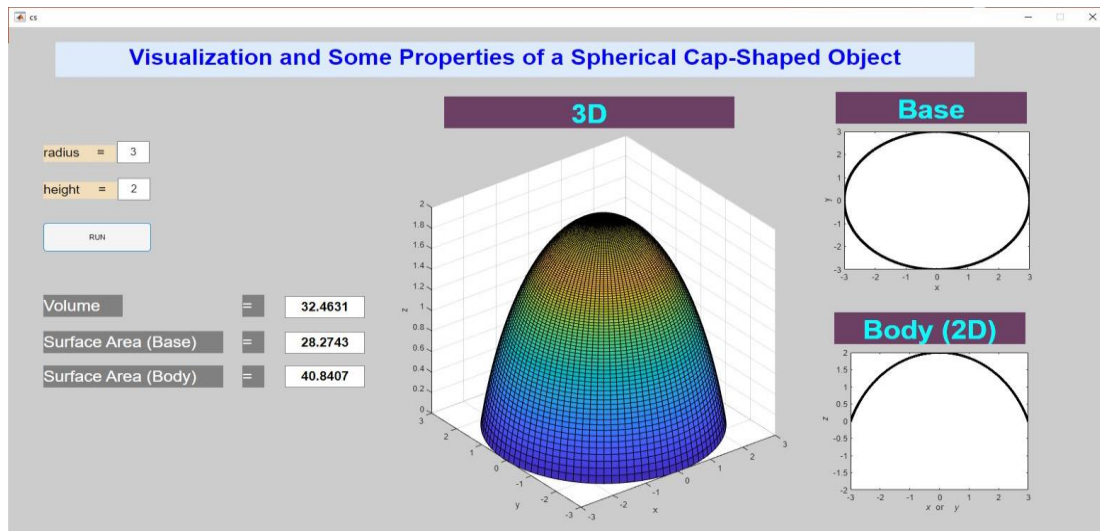


Figure 5: The outputs of the proposed Matlab GUI that alternatively models the full form of a charcoal kiln described in Ahmad Khairuddin et al. (2023)

5.0 DISCUSSION AND CONCLUSION

The proposed Matlab GUI can be beneficial not only in academic settings but also in addressing real-world problems. It can enhance the teaching and learning experience in science and engineering courses at both school and university levels. Additionally, professionals may refer to the information provided by the GUI for practical applications, such as designing or explaining spherical cap-shaped structures or objects.

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MODIFIED MAGNETIC FLOW OF WILLIAMSON NANOFUID OVER A STRETCHING SHEET WITH NEWTONIAN HEATING

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ABSTRACT

The boundary layer flow of a Williamson nanofluid across a stretching sheet under modified magnetic influence and Newtonian heating (NH) is investigated numerically in the present work. The goal of the study is to investigate how the velocity and temperature profiles are affected by several characteristics, such as the concentration of nanoparticles, the strength of the magnetic field, the Williamson fluid properties, and thermal boundary conditions. The Runge–Kutta Fehlberg (RKF45) method is used to solve the nonlinear ordinary differential equations that result from the reduction of the governing partial differential equations using suitable similarity variables. To comprehend their impact on the fluid's behaviour and heat distribution, the analysis assesses several pertinent physical characteristics. The findings show that while magnetic effect reduces velocity, raising the Williamson parameter improves thermal performance. It is anticipated that these discoveries will advance our knowledge of non-Newtonian nanofluid flows and offer guidance for improving engineering systems that employ them.

Keywords: Modified Magnetic Field, Williamson Nanofluid, Newtonian Heating

1.0 INTRODUCTION

There are numerous engineering and industrial applications for studying non-Newtonian fluids. Non-Newtonian fluids are more complex and widely used in industries than Newtonian fluids, prompting numerous studies on them. These complex fluids include Jeffrey, Maxwell, Oldroyd-B, third grade, Casson fluid, Williamson fluid, and Nanofluid to name a few. The study of nanofluids provides chances to investigate novel fluid flow phenomena and improve heat transfer procedures. Research on using nanoparticles to improve fluids' thermal conductivity was presented by Choi and Eastman (1995). Many authors have also proposed models and approaches for analysing convective fluxes of nanofluid, including the most popular models put forth by Buongiorno (2006) and Tiwari and Das (2007). The study of Buongiorno (2006) proposed that nanofluids are designed colloids combining a base fluid and nanoparticles (1-100nm). Nanofluids have better thermal conductivity and single-phase heat transfer coefficients than their base fluids. Then, Tiwari and Das (2007) found that the single-phase model, where both the fluid phase and the solid particles are in thermal equilibrium and move at the same local velocity. The dynamics of nanofluids are constantly investigated using two quantitative models. Later, this approach was widely used for various nanofluid challenges involving expanding and contracting surfaces. For instance, Zaimi et al. (2014) investigated the thermal transport flow of a nanofluid over a shrinking/stretching surface. Several recent studies on nanofluid flow have been conducted under certain conditions (Zokri et al. (2021), Zainal et al. (2023), Nordin et al. (2024), Habib et al. (2024)).

According to the literature, nanofluid flow can occur in a wide range of geometries, including stretching sheets, exponentially permeable stretching surfaces, and vertical oscillating plates. However, no explicit research has been undertaken on the modified magnetohydrodynamics (MHD) of Williamson nanofluid over a stretching sheet with NH as the boundary conditions. This study proposes a mathematical model for Williamson nanofluid across a stretching sheet using NH which incorporates Tiwari-Das. To convert partial differential equations (PDEs) to ordinary differential equations (ODEs), a suitable similarity transformation is employed. Next, The ODEs will be numerically solved in MAPLE software using RKF45 method.

2.0 OBJECTIVE

In this study, Williamson Nanofluid is observed to flow across a stretching sheet with modified MHD using NH. This study aims to accomplish the following objectives:

1. To convert the governing equations of PDEs into ODEs through appropriate similarity transformation.
2. To utilize ODEs numerically by solving with the Runge-Kutta Fehlberg (RKF45).
3. To impact the velocity and temperature profiles under different alignment angles, Williamson parameter, magnetic field, nanoparticle volume fraction, and conjugate parameter for NH.

3.0 METHODOLOGY

The methodology of the study consists of four stages including mathematical formulation, mathematical analysis, numerical computations, and result validation. In the first stage, the governing equations of the proposed model are identified with the relevant boundary conditions. Next, the equations are transformed into ordinary differential equations by using the suitable similarity variables. The numerical method of RKF45 is then utilized to generate the results with the help of Maple software. Lastly, to ensure the accuracy of the considered model, the current result must be validated by comparing it with the previous studies.

3.1 MATHEMATICAL FORMULATION

The governing equations and boundary conditions related to the proposed problem are discussed in this subtitle.

Continuity Equation:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \quad (3.1)$$

Momentum Equation:

$$u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} = \frac{\mu_{nf}}{\rho_{nf}} \frac{\partial^2 u}{\partial y^2} + \sqrt{2} \frac{\mu_{nf}}{\rho_{nf}} \Gamma \frac{\partial u}{\partial y} \frac{\partial^2 u}{\partial y^2} - \frac{\sigma_{nf}}{\rho_{nf}} B^2 u \sin^2 \alpha \quad (3.2)$$

Energy Equation:

$$u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial y} = \alpha_{nf} \frac{\partial^2 T}{\partial y^2} \quad (3.3)$$

The following boundary conditions apply to the current fluid analysis:

$$u = u_w(x) = ax, v = 0, \frac{\partial T}{\partial y} = h_s T \text{ at } y = 0 \quad (3.4)$$

$$u \rightarrow 0, T \rightarrow T_\infty \text{ at } y \rightarrow \infty$$

3.2 MATHEMATICAL ANALYSIS

To simplify the Equations (3.1) -(3.4), the following variables are adopted,

$$\eta = \left(\frac{a}{v_f}\right)^{\frac{1}{2}} y, \quad \varphi = (av_f)^{\frac{1}{2}} x f(\eta), \quad \theta(\eta) = \frac{T - T_\infty}{T_\infty} (NH) \quad (3.5)$$

Where N , φ and θ are the non-dimensional similarity variables, stream function and temperature. The resulting equations are as follows:

$$\frac{1}{(1-\phi)^{2.5}(1-\phi) + \phi \left(\frac{\rho_s}{\rho_f}\right)} f'''(\eta) + f(\eta)f''(\eta) + x_3 f''(\eta)f'''(\eta) - (f'(\eta))^2 - M \sin^2 \alpha f'(\eta) = 0; \quad (3.6)$$

$$\frac{1}{p_r} \frac{\frac{K_{nf}}{K_f}}{(1-\phi) + \frac{\phi(p(p)_s)}{p(p)_f}} \theta''(\eta) + f(\eta)\theta'(\eta) = 0 \quad (3.7)$$

Subject to the transformed boundary conditions,

$$f(0) = 0, f'(0) = 1, \theta'(0) = \gamma(1 + \theta(0)) \text{ at } \eta = 0 \quad (3.8)$$

$$u \rightarrow 0, T \rightarrow T_{\infty} \text{ as } y \rightarrow \infty$$

3.3 NUMERICAL METHOD OF RUNGE-KUTTA FEHLBERG (RKF45)

Using MAPLE software, RKF45 method yielded the numerical answer for this inquiry, in contrast to other numerical approaches. It is believed that obtaining the analytical solution is difficult due to the intricacy of the existing governing equation. As a result, this method is highly trustworthy and suitable for this type of study problem. Equations (3.5) - (3.8) are inserted in the Maple software for the numerical computation to find fluid flow and heat transfer distributions.

3.4 RESULT VALIDATION

The obtained numerical results are compared with findings from previous research to evaluate their accuracy. Upon validation, the analysis of fluid flow and heat transfer for the proposed model is conducted and presented in the form of tables and figures.

4.0 RESULT AND DISCUSSION

To obtain the numerical results of the velocity profiles ($f'(\eta)$) and temperatures profile ($\theta(\eta)$) for the Williamson nanofluid, respectively, a number of fixed relevant parameters must be used which are $\lambda = 1, Pr = 6.2, \alpha = \frac{\pi}{6}, M = 0.5, b = 0.3, \phi = 0.01$. Table 1 shows the comparative results of skin friction coefficient for various values of M . A direct comparison between the current results and previous study published by Fathizadeh et al. (2013). From the table, there is a very good agreement, which proposes that the current model and its conclusions are acceptable.

Table 1: Comparative values of skin friction coefficient $-f''(0)$ for various values of M when $\phi = 0, \lambda = 0$, and $\alpha_1 = \frac{\pi}{2}$.

M	Fathizadeh et al. (2013)	Present
0	1.00000	1.00048
1	1.41421	1.41422
5	2.44949	2.44949

Figures 1 and 2 portray the variation value of the volume fraction of nanoparticles, ϕ on velocity and temperature profiles. Figure 1 shows that, as ϕ increases, the velocity profile decreases. Meanwhile, a reverse trend can be observed for temperature profile as displayed in Figure 2. This phenomenon can be physically explained as an increase in thermal conductivity, which leads to the thickening of the thermal boundary layer.

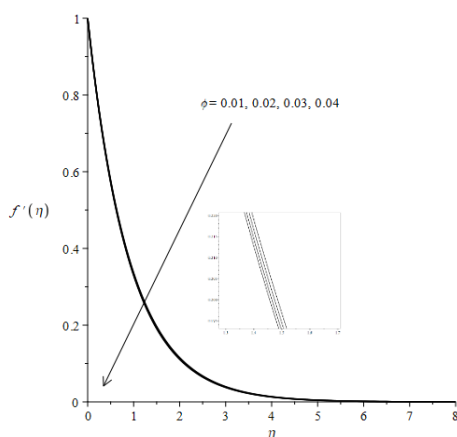


Figure 1: Velocity profile for various values of ϕ .

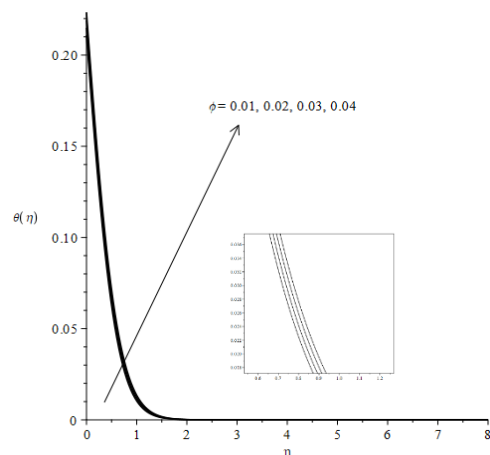


Figure 2: Temperature profile for various values of ϕ .

5.0 CONCLUSION

The present work examines the modified MHD flow of Williamson nanofluid over a stretching sheet with NH as boundary condition. The numerical approach of RKF45 method is performed to generate the results. In conclusion, the results of the velocity and temperature profiles for several relevant parameters have been displayed in the form of graph coding generated by Maple software. These graphs illustrate the relationship between many different parameters. The main outcomes of this research can be summed up as follows:

- Increases in parameters ϕ reduce the velocity profile but increases the temperature profile.

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NEWTON'S LAW OF COOLING CALCULATOR

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ABSTRACT

Newton's Law of Cooling describes the rate at which an object's temperature changes relative to its surrounding environment. This fundamental principle is widely applied in real-world contexts such as forensic science (to estimate the time of death) and food safety (to monitor cooling of cooked items). In education, this law is commonly introduced in Ordinary Differential Equations, a topic taught at diploma and bachelor's degree levels in engineering courses. However, students often struggle to grasp the real-life application of this concept due to the lack of interactive, user-friendly tools. Currently, there is no stand-alone application that allows users to predict temperature, estimate cooling time, and visualize temperature trends over time using Newton's Law. Manual calculation can be time consuming and error-prone, especially for those without strong mathematical background. To address this gap, a stand-alone application, namely the Newton's Law of Cooling Calculator is developed using graphical user interface Matlab. This application allows users to provide initial conditions and instantly obtain temperature values over time, or determine the time needed to reach a specific temperature. It also provides graphical visualization, making the learning process more engaging and intuitive. The application offers clear benefits in STEM education, allowing students to explore mathematical theory through real-life examples. Beyond academia, it has potential uses in forensic investigations, food industries and pharmaceutical storage. In conclusion, this innovation bridges the gap between mathematical theory and practical application. It serves as a valuable educational tool while offering real-world functionality, making it both noble and commercially viable.

Keywords: Newton's Law of Cooling, Differential Equations, Graphical User Interface Matlab, Engineering

1.0 INTRODUCTION

Newton's Law of Cooling is a fundamental principle in thermodynamics that describes how an object's temperature changes over time relative to the surrounding environment. This concept plays a significant role in various real-world applications such as estimating the time of death in forensic science (Kaviya, 2024) and monitoring food cooling processes in the food industries (Konovalenko, 2021), and managing temperature-sensitive materials in pharmaceutical storage (Connors, 2003). In academia, it is commonly taught in Ordinary Differential Equations (ODEs) courses, particularly in engineering programs at both diploma and bachelor's degree levels.

Despite its importance, students often face difficulties in understanding and applying this law due to the abstract nature of the mathematics involved. Currently, there is no stand-alone, user-friendly application available that allows users to compute and visualize the cooling process in a simple and interactive manner. Most available tools are either embedded in advanced software or lack visualization features, making them inaccessible to students and non-technical users.

Motivated by this gap, this innovation introduces the Newton's Law of Cooling Calculator, a stand-alone application designed to provide quick and accurate predictions of temperature or time based on Newton's Law. It also includes graphical visualization to help users understand the cooling trend over time. This tool aims to bridge the gap between theoretical knowledge and practical application, enhancing the learning experience while offering potential use in real-world scenarios such as forensic investigations and industrial temperature monitoring.

2.0 OBJECTIVES

The objective of this innovation is to develop a Newton's Law of Cooling Calculator that provides a quick, accessible, and user-friendly tool. The features of this calculator are to visualise the temperature change over time, predict the temperature after a fixed time and forecast the time required to reach certain temperature.

3.0 MATHEMATICAL FORMULATION

The Newton's Law of Cooling states that the rate at which an object cools is directly proportional to the difference between its temperature and the surrounding temperature. This relationship is mathematically represented by the following first-order ordinary differential equation (ODE):

$$\frac{dT}{dt} = -k(T - T_s) \quad (3.1)$$

where,

T = Temperature of the object

T_s = Surrounding temperature

t = time

k = cooling constant

$\frac{dT}{dt}$ = rate of change of temperature over time

4.0 METHODOLOGY

In this section, the method of innovating the product is explained in detail. To make the computation faster, this study created a graphical user interface (GUI) using MATLAB App Designer (version R2023a). The interface page includes two views, which are Design and Code views. These view pages can be accessed through a button on the design page. In the design view, users can structure the application layout, while in the code view, coding is required for each tool to specify the type and characteristics of the data to be incorporated into the code. Figure 1 illustrates the process of developing the calculator.

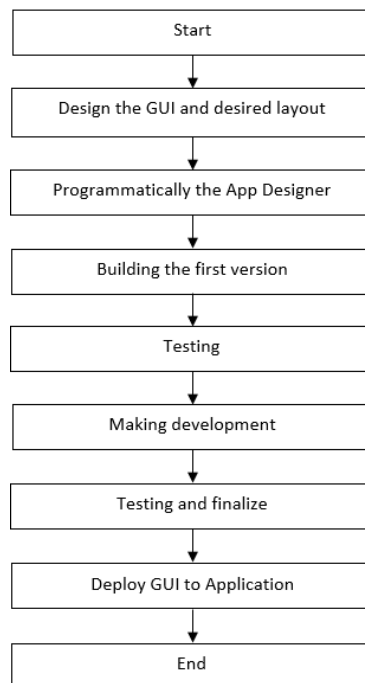


Figure 1: The process of developing the Newton's Law of Cooling Calculator.

5.0 RESULT

An application named Newton's Law of Cooling Calculator has been successfully developed and the full layout of the calculator is demonstrated in Figure 2. Here, the calculator consists of three functions, which are to predict the temperature of an object after a specified time, estimate the time required to reach a target temperature, and visualize the temperature-time relationship through graph plotting. For convenience, all related keywords are also included for user's reference.

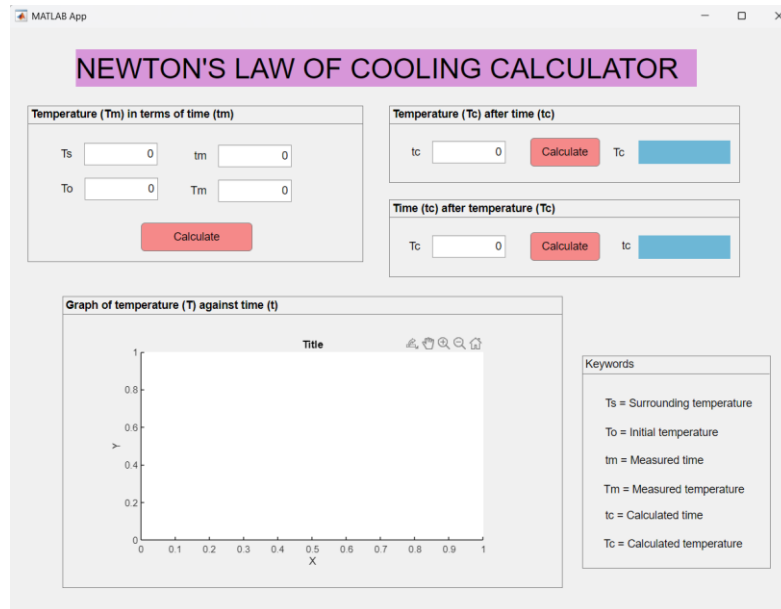


Figure 2: Layout of the Newton's Law of Cooling Calculator

The first function of this calculator is to demonstrate the temperature-time relationship in graphical form. To use this feature, the user needs to put the following values: surrounding temperature (T_s), initial temperature (T_o), measured time (t_m), and measured temperature (T_m). Once the Calculate button is clicked, the graph of temperature over time will be displayed in the 'Graph of Temperature (T) Against Time (t)' panel.

To assess the functionality of this calculator, an example from Ismail & Mohd Nor (2025) is used. Let $T_s = 20$, $T_o = 40$, $t_m = 10$, and $T_m = 35$. After entering these inputs, the resulting graph that illustrates the temperature-time relationship appears as shown in Figure 3.

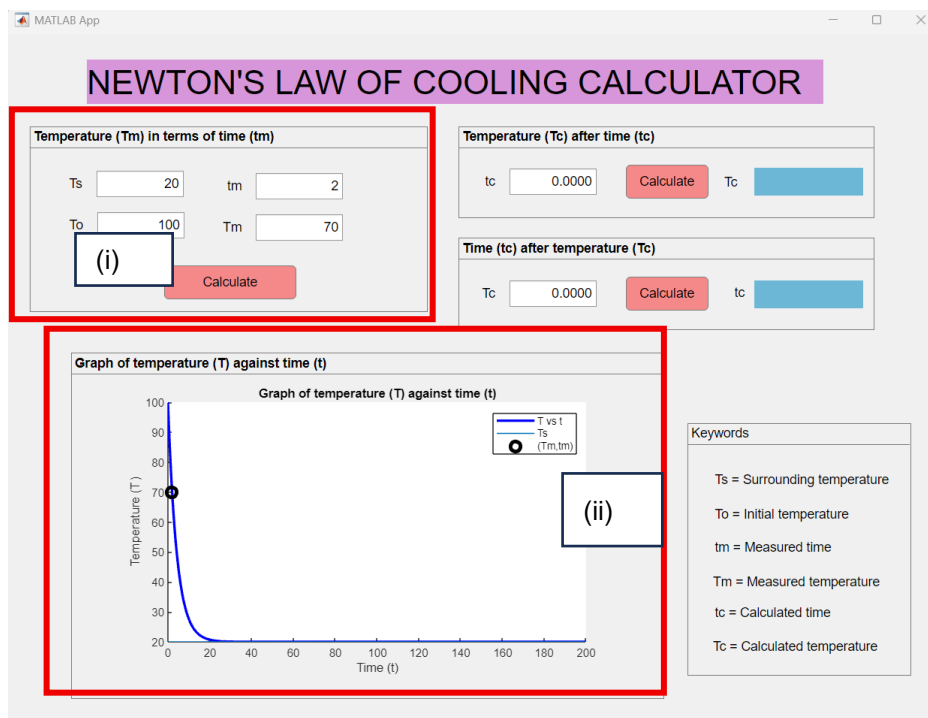


Figure 3: The layout of illustrating the temperature over time after execution: (i) User has inserted the value of $T_s = 20$, $T_o = 100$, $t_m = 2$, and $T_m = 70$. (ii) The relationship between the temperature over time is displayed

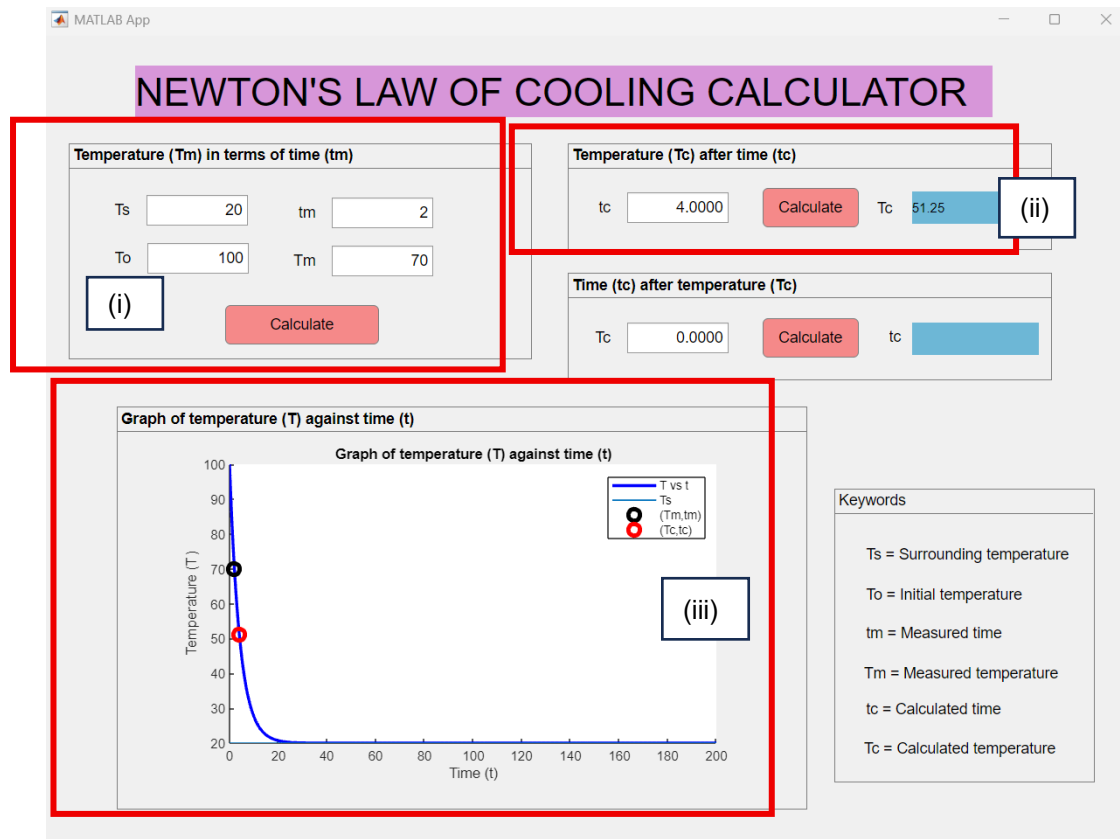


Figure 4: The layout of illustrating the temperature over time after execution: (i) User has inserted the value of $T_s = 20$, $T_o = 40$, $t_m = 10$, and $T_m = 35$. (ii) User has inserted $t_c = 4$. Once “Calculate” button is clicked, the $T_c = 51.25$ has appeared. (iii) The updated relationship between the temperature over time is displayed

The final feature provided in this calculator is the prediction of temperature (T_c) at a given time (t_c). Using the same input data as shown in Figure 3, and by setting $T_c = 33.3695$, the corresponding t_c value will promptly appear once the ‘Calculate’ button is clicked.

In addition, the temperature vs. time graph will be automatically updated to include the newly calculated temperature and time. The result is illustrated in Figure 5. Here, the calculated t_c value is identical to the result shown in Figure 4, as the T_c value entered is the same in both cases. This consistency demonstrates the accuracy and validity of the calculator.

6.0 CONCLUSION

In conclusion the Newton’s Law of Cooling Calculator successfully addresses the gap between theoretical understanding and practical application of ordinary differential equations, specifically Newton’s Law of Cooling. By offering a user-friendly, stand-alone application, this innovation enables users to accurately predict temperature, estimate cooling time, and visualize the temperature over time through graph. This calculator not only enhances the learning experience for students in engineering and mathematics courses but also shows strong potential for real-world applications in fields such as forensic science and food safety. By automating complex calculations and providing instant results, the calculator promotes efficiency, accuracy, and deeper conceptual understanding.

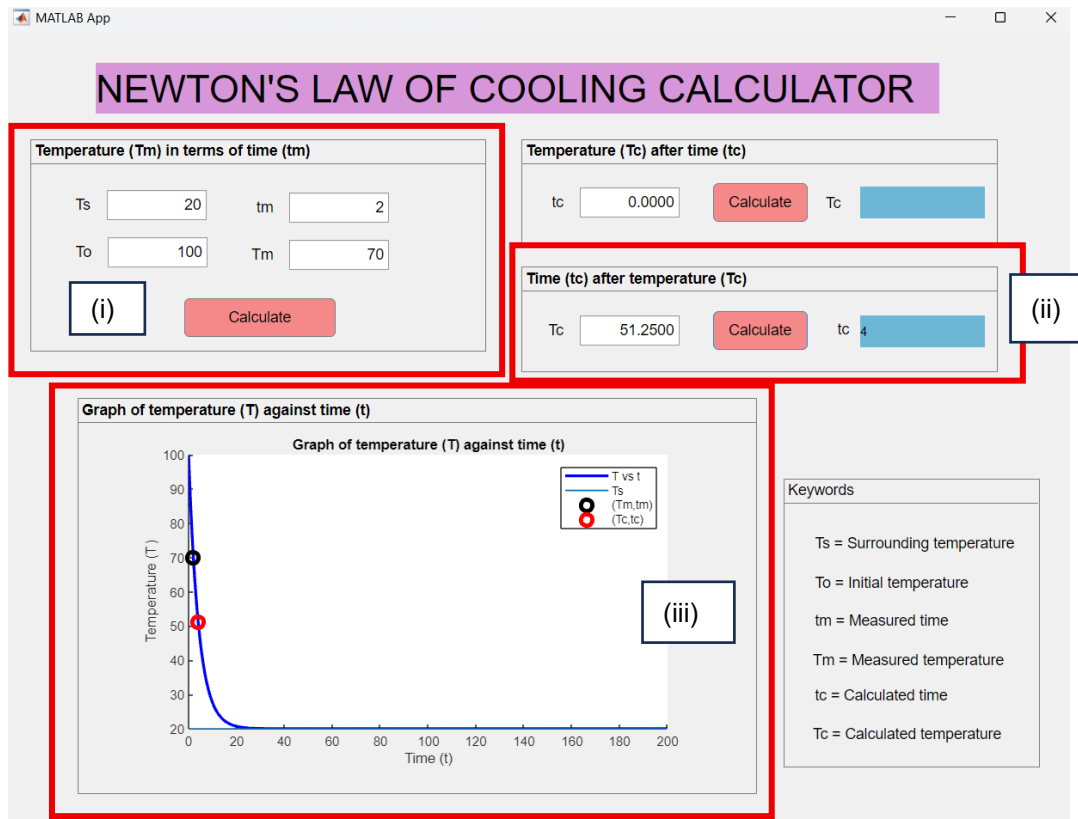


Figure 5: The layout of illustrating the temperature over time after execution: **(i)** User has inserted the value of $T_s = 20$, $T_o = 40$, $t_m = 10$, and $T_m = 35$. **(ii)** User has inserted $T_c = 33.3695$. Once "Calculate" button is clicked, the $t_c = 14$ has appeared. **(iii)** The updated relationship between the temperature over time is displayed

ACKNOWLEDGEMENT

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PORTABLE SOLAR-POWERED SMART CULTIVATOR FOR OYSTER MUSHROOM FARMING

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ABSTRACT

Oyster mushrooms (*Pleurotus ostreatus*) are increasingly valued for their nutritional and medicinal benefits, contributing to growing demand globally. However, conventional cultivation methods are labour-intensive, environmentally sensitive, and highly dependent on manual supervision. This project introduces a *portable solar-powered smart cultivator* designed to automate and optimize oyster mushroom production. Developed using precision agriculture and Internet of Things (IoT) technologies, the system integrates a solar energy source, microcontrollers, and environmental sensors to monitor and regulate key growing conditions such as humidity, temperature, and light. A misting mechanism ensures proper hydration, while real-time data access and remote control are enabled via a mobile application. Its compact and modular design supports scalability and adaptability for use in urban homes, rural areas, educational setups, and small-scale agriculture. The innovation reduces operational costs, physical labour, and environmental impact while promoting sustainable agriculture and digital literacy. The smart cultivator aligns with Sustainable Development Goal 2 (Zero Hunger), offering an accessible solution to enhance food production and resilience. Early field testing demonstrates improved mushroom yield, uniform growth, and ease of use compared to traditional setups. This project presents a viable step toward modernising mushroom cultivation through affordable and sustainable smart farming practices.

Keywords: IoT Agriculture, Oyster Mushroom, Portable Cultivator, Solar-Powered System, Smart Farming

1.0 INTRODUCTION

Oyster mushrooms which provide a valuable source of nutrients due to their culinary and therapeutic properties, are in increasing demand worldwide. The traditional cultivation method is widely accessible even though it is constrained by high labour needs, sensitivity to weather variations, and limited scalability. Therefore, a smart agriculture technique offers potentials for automation and optimization of this growing environment. Innovations combining IoT and solar energy are emerging as sustainable solutions for remote, energy-scarce regions (Konain et al., 2023). This project seeks to design a portable smart cultivator that integrates renewable energy with precision farming for oyster mushrooms.

2.0 OBJECTIVE

1. To develop a portable solar-powered system for oyster mushroom cultivation.
2. To integrate IoT-based environmental sensors for automated environmental control.
3. To reduce human labour and operational costs while increasing yield consistency.

3.0 METHODOLOGY

This project presents the design and implementation of a solar-powered, portable, smart cultivation system for oyster mushrooms, optimized using Internet of Things (IoT) technology. The system automates climate regulation using real-time environmental data, reducing manual labour and increasing yield consistency.

3.1 SYSTEM ARCHITECTURE AND COMPONENT DESIGN

The innovation integrates the following hardware components:

- **Solar Panel:** Harvests solar energy to operate the system autonomously, ideal for off-grid or rural deployment (Habibi et al., 2022).

- **Arduino ESP32:** Serves as the main microcontroller, offering built-in Wi-Fi and Bluetooth capabilities for data transmission and actuator control.
- **DHT11 Sensor:** Measures temperature and humidity, two essential parameters for optimal *Pleurotus ostreatus* growth (Wahid et al., 2023).
- **Mini Fan:** Automatically activated to reduce internal temperature when it exceeds the optimal threshold (usually $>28^{\circ}\text{C}$).
- **Humidifier:** Engaged when relative humidity falls below the ideal range (85–95%).
- **Portable Grow Box:** Insulated container designed to maintain a stable internal microclimate; lightweight and modular for easy relocation

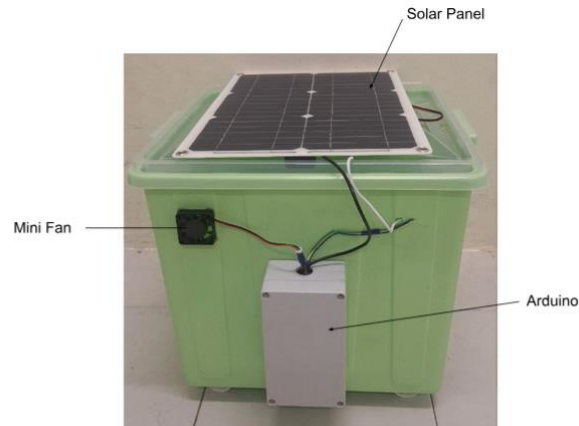


Figure 1: Prototype Design of Portable Solar-Powered Smart Cultivator for Oyster Mushroom Farming

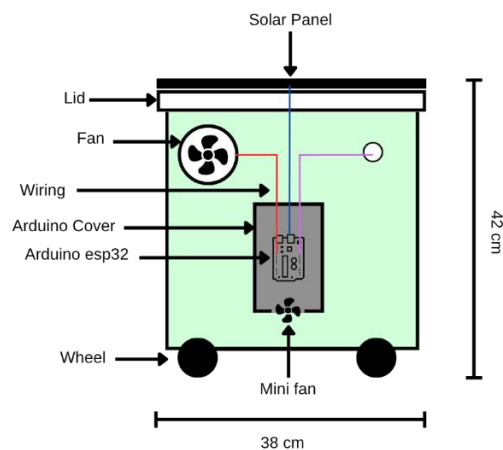


Figure 2: Front side Design of Portable Solar-Powered Smart Cultivator for Oyster Mushroom Farming

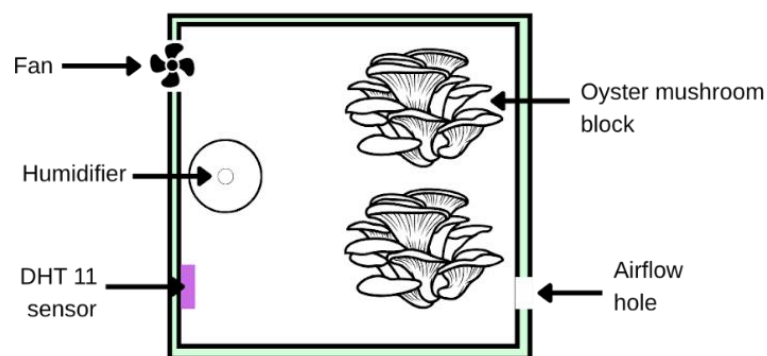


Figure 3: Top inside Design Dimension of Portable Solar-Powered Smart Cultivator for Oyster Mushroom Farming

4.0 RESULT

The portable solar-powered smart cultivator showed substantial benefits over conventional mushroom growing environments in terms of yield, efficiency, environmental stability, and ease of use. The system automatically maintained optimal conditions for *Pleurotus ostreatus*—temperature between 20–24°C and humidity between 85–90%, which are well-documented as the ideal range for fruit body formation and high-quality yield (Najmurokhman et al., 2020 & Anta et al., 2021).

To validate system performance, three identical mushroom-grow blocks were deployed in different environments:

- Block A (Smart Cultivator): Fully automated, IoT-monitored grow box powered by solar energy.
- Block B (Indoor Room): Exposed to ambient conditions with once-daily manual misting.
- Block C (Dark Closet): Confined, unventilated space, misted daily but without light or air control.

After a full fruiting cycle, results were as follows:

Table 1: Comparative Results of Mushroom Cultivation Across Three Environments

Environment	Yield (g/block)	Fruiting Time	Cap Quality
Block A (Smart Cultivator)	118g	5 days	Large, uniform caps
Block B (Indoor Room)	96g	6 days	Smaller caps
Block C (Dark Closet)	65g	7 days	Deformed caps

Block A consistently outperformed Blocks B and C in yield, speed of growth, and fruiting body uniformity. The automated system enabled real-time adaptation to fluctuations in ambient conditions, a key factor in high productivity. Block B showed moderate performance but suffered from unstable room temperature and inconsistent humidity retention. Block C, although misted daily, lacked airflow and light, resulting in poor fruit body formation and higher contamination levels (Permata et al., 2024).

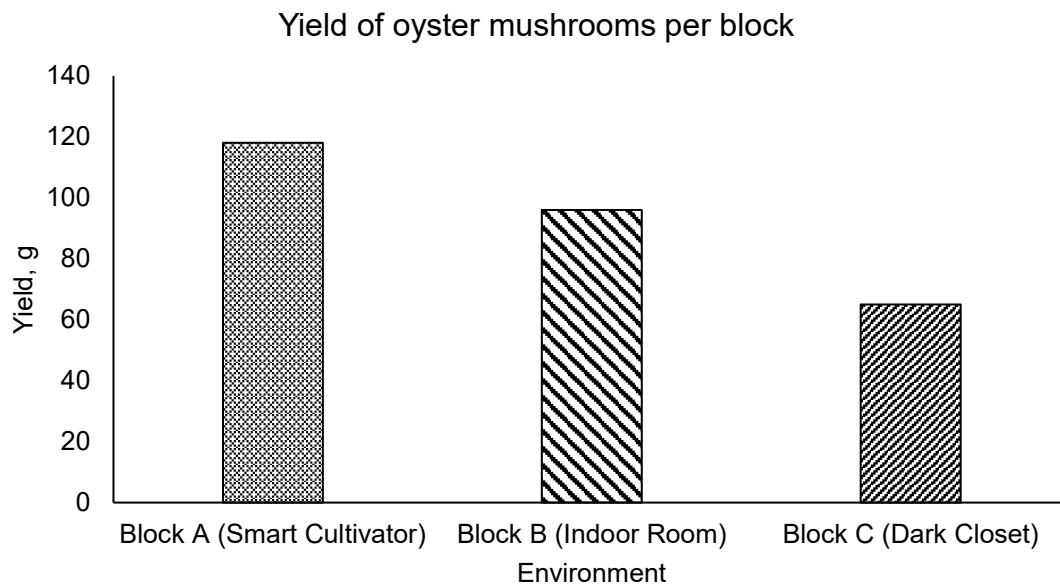


Figure 4: Yield of oyster mushrooms per block under different cultivation conditions. Block A shows the highest yield due to precise environmental control

4.1 IMPACT AND NOVELTY

The key innovation lies in the integration of solar energy with IoT-based automation in a portable, modular unit. While prior mushroom systems have explored either environmental monitoring or solar energy separately, this project uniquely combines:

- Renewable energy autonomy (solar-powered, off-grid capable)

- Environmental precision (automated fan and humidifier based on sensor feedback)
- User-friendly remote access (via IoT mobile app)
- Scalable, compact design (suitable for homes, classrooms, rural farms)

This design addresses multiple barriers to smart farming adoption, including power access, cost, and technical skills requirements, by expanding access to sustainable food production. It supports Sustainable Development Goal 2 (Zero Hunger) by enabling efficient, low-cost urban or rural mushroom farming, particularly for smallholders, schools, and community gardens (Elewi et al., 2024 & Konain et al., 2023).

5.0 CONCLUSION

The portable solar-powered smart cultivator successfully demonstrates the potential of combining renewable energy and IoT automation in small-scale mushroom farming. The system effectively maintained optimal temperature and humidity conditions, leading to improved yield quality and consistency compared to traditional growing methods. This innovation contributes to the scientific community by showcasing a practical application of smart agriculture for niche crops like oyster mushrooms. Its low-cost, energy-efficient, and modular design makes it suitable for various settings, including urban homes, rural farms, and educational institutions. Economically, the system reduces labour, improves resource efficiency, and promotes sustainable practices. Overall, it supports efforts toward food security, digital agriculture adoption, and sustainable development.

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INNOVATIVE DIGITAL GAME-BASED LEARNING USING CANVA: ENHANCING CALCULUS MASTERY IN DIFFERENTIATION FOR ENGINEERING STUDENTS

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ABSTRACT

This project introduces an interactive educational game developed using Canva to enhance student engagement and mastery of Calculus, specifically in the area of differentiation. Many students perceived Calculus as abstract and difficult, often leading to low motivation, poor retention, and mathematics anxiety. It is a psychological barrier that negatively impacts problem-solving and academic performance. Traditional teaching methods, such as lectures and textbooks, lack interactivity and personalization, contribute to passive learning environments. To address these issues, the project integrates Digital Game-Based Learning (DGBL) through Canva, incorporating clickable elements, drag-and-drop activities, and visual guides to promote active, hands-on practices. These games are flexible for use in blended, flipped, or independent learning environments and can be accessed via QR codes or learning platforms. Early classroom trials have shown promising outcomes. The sample consisted of 30 undergraduate students from the Faculty of Mechanical Engineering. Descriptive statistics revealed a reduction in mean anxiety scores from 68.12 before the intervention to 53.79 after the intervention, with one-sample t-test confirming this decrease statistically significant ($t = -3.65$, $p = 0.0005$). These results support the effectiveness of DGBL in reducing mathematics anxiety and improving students' attitudes toward Calculus. This innovation not only makes learning more engaging and student-centered but also promotes deeper conceptual understanding and critical thinking. It aligns with Malaysia's SDG Goal 4 which is a Quality Education by fostering inclusive, technology-enhanced learning and supporting the National Philosophy of Education's aim to develop intellectually capable, confident individuals. Overall, this project transforms traditional mathematics instruction into a dynamic, interactive experience that strengthens both conceptual understanding and academic performance in STEM education.

Keywords: Mathematics Anxiety, Interactive Learning, Digital Game-Based Learning, STEM Innovation

1.0 INTRODUCTION

Calculus particularly topics such as differentiation and integration is widely perceived as abstract, complex, and intimidating by students. According to global data, over 60% of students report difficulties in understanding Calculus concepts, with nearly 50% experiencing mathematics anxiety, which contributes to lower academic performance in STEM-related courses (Soni & Kumari, 2017; Wang et al., 2022). Recent research emphasizes the strong negative relationship between mathematics anxiety and achievement. A large-scale meta-analysis by Wang et al. (2022) found that mathematics anxiety predicts math performance with an average effect size of $d \approx 0.58$, suggesting a moderately strong inverse relationship whereby students with higher anxiety levels tend to perform significantly worse than their peers. This effect was observed consistently across international assessments such as TIMSS and PISA, across different age groups, and across diverse cultural backgrounds.

In Malaysia, local studies also show a significant number of tertiary students who experience moderate to high levels of math anxiety, which negatively affects their motivation, confidence, and problem-solving abilities (Gopal, Toh, & Roslan, 2020). This anxiety often leads to avoidance behaviour in mathematical tasks and decreased classroom participation, particularly in cognitively demanding subjects like Calculus. To address this issue, this project introduces a set of interactive educational games using Canva, designed to promote active learning and reduce anxiety. The games incorporate drag-and-drop elements, clickable options, and visual aids to offer a low-pressure, engaging learning environment. Numerous studies have shown that game-based learning helps reduce mathematics anxiety, improve conceptual understanding, and increase students' engagement through repeated,

hands-on practices (Ibrahim & Jaafar, 2023; Wang et al., 2022). By integrating these tools into Calculus instruction, the project supports student-centred, inclusive learning environment that aligns with Malaysia's SDG Goal 4 which is Quality Education and the National Philosophy of Education, fostering confident, intellectually capable learners equipped with critical thinking skills.

2.0 OBJECTIVES

This project has three main objectives which are:

1. To integrate Digital Game-Based Learning (DGBL) using Canva to enhance the learning of Calculus.
2. To improve student engagement, conceptual understanding, and problem-solving skills, while minimizing mathematics anxiety.
3. To align the innovation with the criteria under the lecturer performance evaluation system (e.g., PROPENS), which emphasizes student-centred and multimedia-based teaching approaches.

3.0 METHODOLOGY

This project introduces an innovation in the form of interactive educational games developed using Canva. It designed to enhance students' understanding of Calculus particularly differentiation skill through a structured and student-centred approach. The developmental process involved five key phases, each aligned with educational theory and confirmed by findings from recent research. Controlled lab experiment with undergraduate Calculus students found that game-based learning significantly improved conceptual understanding over quiz-based practice (Lee et al., 2016). These findings strongly support the design rationale of this innovation, particularly its ability to reduce mathematics anxiety and promote active engagement (Nadeem et al., 2023; Wang et al., 2022).

In Phase 1, the core concepts in differentiation were identified based on curriculum standards and known learning difficulties reported by students in both local and international contexts (Soni & Kumari, 2017). These concepts served as the foundation for game content development, ensuring curriculum alignment and topic relevance. Phase 2 focused on designing problem-solving activities within Canva, applying principles from constructivist learning theory to encourage deeper engagement. Previous studies, such as by Gopal et al. (2020), used the Mathematics Motivation and Anxiety Questionnaire (MMAQ) to assess students' anxiety and motivation levels in similar settings. This tools which informed the design intent to reduce affective barriers and improve learning experiences.

In Phase 3, the games were enhanced with interactive elements including clickable options, drag-and-drop functionality, and visual guidance. These features increase interactivity and reduce cognitive load by providing scaffolded, hands-on learning. Similar game-based learning environments have been evaluated using tools like the Game-Based Learning Evaluation Tool (GBLET), as referenced in studies by Ibrahim and Jaafar (2023), who reported increased motivation and reduced anxiety when such digital tools were used. Phase 4 involved pilot testing in tutorial and lab sessions. Students participated in pre-test and post-test adapted from validated achievement-based assessments, and feedback was gathered through a simplified version of the Mathematics Attitudes and Perceptions Survey (MAPS). The implementation confirmed the games' potential in improving engagement, problem-solving confidence, and participation.

Finally, in Phase 5, findings were analysed and discussed, culminating in the production of an extended abstract for knowledge dissemination. The analysis showed early indications of positive impact on student motivation, understanding, and reduced anxiety particularly highlighting the usefulness and practicality of this innovation. The Canva-based games are highly practical for classroom and digital learning environments. They can be embedded in blended learning models, shared via LMS platforms or QR codes, and customized for different learning levels. The visual, game-like structure aligns well with the learning preferences of Generation Z, and the format supports inclusive, flexible, and engaging instruction. The design and development of this project are shown in Figure 1 below.

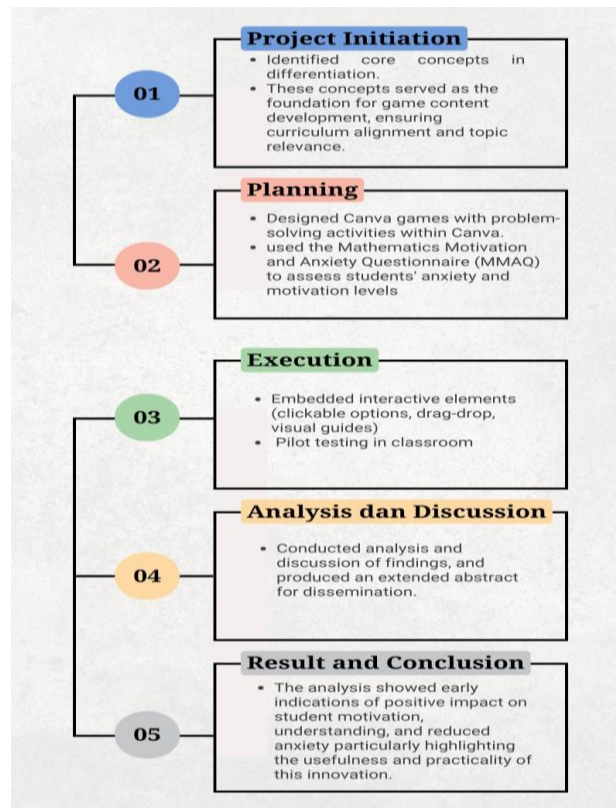


Figure 1: Project development for Calculus Mastery Quest.

3.1 DIGITAL GAME-BASED LEARNING (DGBL)

Digital Game-Based Learning (DGBL) refers to the use of digital games as instructional tools that incorporate educational content with game elements such as problem-solving tasks, interactivity, and immediate feedback. This approach promotes active, student-centred learning and is particularly effective in abstract or complex subjects like mathematics and science. Recent research supports the effectiveness of DGBL in improving both cognitive and affective learning outcomes. A large-scale meta-analysis by Zhang et al. (2023) found that digital games in STEM education produced a medium to large effect size ($g \approx 0.62$) compared to traditional methods, indicating substantial learning gains. Similarly, Anggoro et al. (2025) reported that game-based learning had a positive, statistically significant effect ($g \approx 0.13$) on students' higher-order thinking skills (HOTS), such as critical thinking, reasoning, and problem-solving in mathematics.

In addition to cognitive benefits, DGBL also helps address affective barriers like mathematics anxiety and disengagement. A systematic review by Pan, Ke, and Xu (2021) revealed that 54% of studies on game-based learning in mathematics measured affective outcomes, and among those, 84% reported improvements in student motivation, engagement, and enjoyment. These findings highlight that DGBL is not only a practical and scalable instructional approach, but also a powerful tool for supporting both conceptual understanding and emotional well-being in learners.

4.0 RESULT

This section presents the results of a statistical analysis conducted to evaluate whether Digital Game-Based Learning (DGBL) which known as Calculus Mastery Quest effectively reduces mathematics anxiety among students enrolled in Calculus courses. Anxiety scores were recorded before and after implementing DGBL using a standardized scale between 0 and 100, with higher scores indicating more anxiety. The sample consisted of 30 undergraduate students in the Faculty of Mechanical Engineering. The instruments used to measure the math anxiety level and math motivation is Mathematics Motivation and Anxiety Questionnaire (MMAQ). Students' anxiety scores were grouped into intervals (class ranges of 10 points), and the frequency of students falling within each interval was calculated. The data is divided into two categories: (1) Before DGBL Intervention: Students' math anxiety levels were measured prior to implementing Digital Game-Based Learning activities. Data involving students' anxiety scores shown in Table 1. (2) After DGBL Intervention: The same students'

anxiety levels were measured after participating in interactive game-based Calculus learning sessions using Canva. Data involving students' anxiety scores shown in Table 2.

This side-by-side comparison allows us to observe how the distribution of anxiety scores shifted after the intervention.

Table 1: Students' anxiety score before DGBL intervention

Score Range	Frequency
40-50	0
51-60	6
61-70	12
71-80	9
81-90	3

Table 2: Students' anxiety score after DGBL intervention

Score Range	Frequency
40-50	10
51-60	12
61-70	7
71-80	1
81-90	0

Prior to the DGBL intervention, the majority of students had moderate to high anxiety, mostly in the 61–80 range. After introducing DGBL activities, most scores shifted toward lower ranges (40–60), indicating a reduction in reported anxiety levels. To support the findings, this study applies descriptive statistical analysis. It provides a summary of the data by highlighting measures of central tendency (mean, median, mode) and variability (variance and standard deviation) which shown in Table 3. This analysis helps compare students' anxiety levels before and after the DGBL intervention, identify shifts in patterns, and determine whether the game-based approach produced a meaningful impact on their learning experience.

Table 3: Descriptive statistics before and after DGBL intervention

Statistic	Before DGBL	After DGBL
Mean	68.12	53.79
Median	67.66	54.35
Mode	50.87	35.40
Variance	81.00	86.70
Standard Deviation	9.00	9.31

The mean anxiety score dropped by 14.33 points, from 68.12 to 53.79, after the intervention. The median and mode also decreased, supporting the conclusion that most students experienced lower anxiety. Variability remained consistent, indicating a broad but improved impact across students. To statistically verify the effectiveness of DGBL in reducing anxiety, a one-sample t-test was performed. It tested whether the mean post-DGBL anxiety score was significantly lower than the threshold score of 60. This study tests the hypothesis that the mean post-DGBL anxiety score is significantly less than 60, where the null hypothesis (H_0) states that $\mu \geq 60$ (DGBL does not reduce anxiety), and the alternative hypothesis (H_1) states that $\mu < 60$ (DGBL reduces anxiety). After running the test, the result $t = -3.65$ and $p\text{-value} \approx 0.0005$. therefore, reject H_0 . It can conclude that there is strong statistical evidence that DGBL significantly reduces mathematics anxiety among students in Calculus courses.

5.0 CONCLUSION

The findings of this study provide strong statistical evidence that the implementation of Digital Game-Based Learning (DGBL) significantly reduces mathematics anxiety among students enrolled in Calculus courses. The reduction in mean anxiety scores, as supported by descriptive statistics and a one-sample t-test, confirms a meaningful improvement in students' emotional response to learning. The majority of students shifted from moderate and high anxiety levels to lower ranges after engaging with interactive, Canva-based games specifically highlighting the effectiveness of game mechanics in promoting a more relaxed and engaging learning environment. Furthermore, the rejection of the null hypothesis ($H_0: \mu \geq 60$) in favour of the alternative hypothesis ($H_1: \mu < 60$) validates the impact of DGBL as an innovative

pedagogical approach. By combining visual learning, hands-on practice, and low-pressure problem-solving, this project addresses both cognitive and affective learning barriers. These results not only support the integration of game-based methods in STEM education but also align with national education goals of enhancing student-centred and technology-driven learning. Overall, DGBL demonstrates strong potential to transform traditional mathematics instruction and foster both academic success and emotional well-being. Besides, this project transforms traditional mathematics instruction into a dynamic, interactive experience that strengthen both conceptual understanding and academic performance in STEM education. As future direction, a grant proposal entitled “Integrating Digital Tools to Minimize Mathematics Anxiety in Students’ Learning Environment” has been submitted to further scale the impact by expanding the reach, functionality, and integration of the Canva-based educational games into a broader learning ecosystem.

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STORYBRIK: BUILD STORIES, FEEL EMOTIONS

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ABSTRACT

StoryBrik is a mobile-first digital storytelling tool developed to foster emotional literacy and facilitate more creative narrative-making skills among Malaysian polytechnic students. While the feature of preconceived templates is maintained, the major innovation of the design is the algorithmically generated emotional prompts and modular fields in narrative development in the form of a theme, logline, premise, and plotline. The first round of pilot design, which included 30 students, has demonstrated that using the tool has markedly improved the quality of the narratives regarding emotional depth and coherence, as well as student involvement and engagement. Students were able to write narratives that consisted of more nuanced emotional expressions and showed remarkable levels of empathy and self-awareness. The development bridges the gap between affective development and creative practice and is made available through a mobile device and in a gamified form to respond to students' cultural context. Thus, it aims to achieve pedagogical goals for developing emotional intelligence from within creative performances, student agency, and reflective writing.

Keywords: Emotional Expression, Digital Storytelling, Animation, Creative Writing, Educational Innovation

1.0 INTRODUCTION

In creative storytelling education, students often excel at structuring events but struggle to authentically express emotion. Their narratives may appear well-organized yet lack affective resonance. Characters feel static and emotional moments feel clichéd or forced. This issue stems from two main gaps: (1) a lack of tools that foreground emotion as a creative driver, and (2) a shortage of culturally grounded models that reflect Malaysian emotional and linguistic nuances.

StoryBrik was developed in response to this pedagogical void. Rather than treating emotion as an afterthought, the tool positions it as the foundation of story construction. By leveraging emotional prompts and gamified structure, students are guided to build stories that are not only coherent, but also emotionally engaging. This approach is aligned with Picard's (1997) theory on affective computing, which advocates for emotionally responsive learning tools, and with Barrett's (2017) insights on how emotions shape cognition and perception.

2.0 OBJECTIVE

1. To design and implement a mobile-based storytelling tool that uses emotion-driven prompts to scaffold narrative development.
2. To evaluate the impact of the tool on students' emotional articulation, narrative clarity, and creative engagement.
3. To investigate the effectiveness of integrated peer review features in promoting constructive emotional feedback and reflective learning.

3.0 UNIQUENESS AND IMPACT

StoryBrik stands out for its distinct approach to digital storytelling. Firstly, it positions emotional expression—not plot—as the core engine of story development. This reverses conventional practices where emotion is treated as a by-product. Secondly, StoryBrik incorporates gamified emotional prompts in a mobile-first platform, making it highly accessible and relatable for digital-native learners. Thirdly, it is fully localised in Bahasa Melayu, embedding cultural relevance into its emotional vocabulary. Unlike many writing tools, it also includes a real-time feedback system and anonymous peer review loop, promoting iterative improvement and empathy-based critique. The tool has demonstrated strong

pedagogical impacts: enhanced emotional literacy, better narrative structure, increased student engagement, and stronger reflective habits. These affordances show promise for broader adoption across creative disciplines in both formal and informal education contexts.

4.0 METHODOLOGY

This innovation was implemented through a qualitative action research framework during a three-week pilot within a Diploma-level storytelling course. Thirty students were engaged with the StoryBrik prototype, accessed via mobile browsers. Participants needed to choose from three difficulty levels—Easy (3 emotions), Medium (5 emotions), and Hard (10 emotions)—each generating a set of emotional prompts. Using these as narrative triggers, students completed structured story templates that included theme, logline, premise, plotline, and a full narrative draft.

Data collection included platform usage logs, peer review comments, student reflections, and observation journals. Thematic analysis was conducted to identify recurring patterns in emotional use, narrative coherence, and peer feedback. This methodology draws upon constructivist learning principles (Jonassen, 1999) and participatory action research practices (Kemmis et al., 2014).

4.1 IMPLEMENTATION PHASES

Phase 1: Orientation - Students were introduced to narrative structures and the rationale for emotion-based storytelling. Comparative examples highlighted the difference between plot-driven and emotion-first narratives.

Phase 2: Engagement with StoryBrik - Students accessed the tool via mobile browsers. Based on difficulty selection, emotional prompts were auto generated. Students then filled in the scaffolded form, which included feedback loops and system-generated scores (A+ to D) based on repetition, emotional density, and story length.

Phase 3: Peer Review & Reflection - Students reviewed each other's stories anonymously using an integrated "rate + respond" feature. This triggered qualitative reflection on the emotional tone, coherence, and resonance.

The tool was designed using HTML5, JavaScript, and LocalStorage for offline usability. It supports Bahasa Melayu, with plans for English integration. The no-login structure ensured privacy while enabling organic peer engagement.

5.0 RESULTS

Key outcomes of the pilot include:

- 93% of the students used more than three distinct emotions in their stories.
- 87% articulated narrative components (logline, premise, plotline) with improved clarity.
- Over 65% peer comments were generated, mostly reflecting emotional analysis rather than generic praise.
- 63% revised their stories after receiving the automated feedback, indicating responsiveness to reflection prompts.

Lower-performing students particularly benefited from the structured emotional prompts, which increased their confidence and narrative creativity. Students expressed that the emotional constraints made the writing process more focused and impactful. These findings align with Mayer et al.'s (2016) model of emotional intelligence in learning and underscore the role of emotion in fostering deeper engagement (Selwyn, 2016).

6.0 CONCLUSION

StoryBrik demonstrates how digital innovation can integrate emotional scaffolding into storytelling. By gamifying emotion and embedding reflective feedback, the tool empowered students to create stories that are not only structured but also emotionally meaningful. The platform's simplicity, cultural relevance, and mobile design contribute to its scalability in diverse learning environments. Future directions include adaptive learning features, emotion-difficulty calibration, and integration into broader animation or scriptwriting curricula. Ultimately, StoryBrik rehumanises digital storytelling by reminding learners that before there is plot, there must be feeling.

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SPHEROIDAL FIRST ORDER POLARIZATION TENSOR (SFOPT)– FIXED VOLUME

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ABSTRACT

When a conducting object is presented in an electric or electromagnetic field, the perturbation on the field due to the presence of the object can be mathematically modelled as asymptotic series, where the dominant term of the series is called the Polarization Tensor (PT). In the applications of electric and electronic, PT has been adapted for many purposes such as to improve reconstruction of image in medical scanning and geophysics, or to enhance metal detection for security screening and landmine clearance. Besides, PT also appears in neuroscience after some researchers have used PT to study object recognition from electrical senses by electric fish. For each application, the PT might be able to describe some physical properties of the presented object such as the size, material or orientation of the object. Moreover, finding a spheroid that has the same first order PT as the original object represented by the PT is also useful especially to characterize the object if the object is not known. The spheroid and the object might have similar physical properties where; these properties can be revealed after the spheroid is obtained based on the given first order PT. In this study, given the first order PT of an unknown object, the conductivity and the depolarization factors for a spheroid will be determined by fixing the volume of the spheroid. Specifically, a Matlab GUI that can easily execute the computation will be presented. We focus on spheroids as previous studies have shown that the first order PT for many objects in the related applications are actually similar to the first order PT for the spheroids. Thus, understanding the first order PT for spheroids could be useful to describe those actual objects. Some examples will be included in this study to demonstrate the capability of the GUI.

Keywords: Spheroids, Electric Field, Conducting Object, Depolarization Factor, Matlab GUI

1.0 INTRODUCTION

Polarization tensor (PT) is a mathematical representation of how a conducting object affects the surrounding electric or electromagnetic field. The perturbation caused by the conducting object can be represented by an asymptotic formula, the simplest form is called the first order PT. In the related applications, PT can be used to improve electrical imaging or metal detection and also to study electric fish with a lower computational cost to characterize and describe objects in those applications (Ammari dan Kang (2007), Ahmad Khairuddin and Lionheart (2016), Ledger and Lionheart (2022)). This is because the PT does not require a full image or object reconstruction. Recently, finding a spheroid that has the same first order polarization tensor (PT) as the original object is also useful for characterizing the object, as the spheroid and the object may share similar physical properties. However, obtaining such a spheroid requires solving tedious mathematical equations, which can be error-prone and time consuming. Therefore, a platform that simplifies and facilitates the computation is greatly welcomed.

Therefore, this study proposes an innovation that can easily and accurately compute the conductivity and depolarization factors of a spheroid from a given first order PT, once its volume is specified. Once the parameters are obtained, the original object represented by the first order PT can then be described based on these parameters.

2.0 METHODOLOGY

In order to determine a spheroid from a given first order PT, the mathematical formulation of the GPT in Ammari dan Kang (2007) has been considered and simplified by assuming that the conducting object presented in an electric field is actually a spheroid. Previously, a method to determine a spheroid from a given first order PT when the conductivity is fixed has been discussed in Mohamad Yunos et al. (2019). In that study, the spheroid obtained will have the same conductivity with the original object represented

by the PT. In this study, a spheroid will be determined from a given first order PT after the volume is fixed, which means, now the spheroid and the original object represented by the first order PT will have the same volume. In this case, one might want to investigate how the conductivity differs between two objects that have the same first order PT and volume.

Now, consider a given first order PT for spheroid in the form

$$\begin{bmatrix} M_1 & 0 & 0 \\ 0 & M_2 & 0 \\ 0 & 0 & M_2 \end{bmatrix} \quad (2.1)$$

where, M_1 and M_2 are given. Our objective is to solve the conductivity k and also the depolarization factor d_1 when $|B|$ is fixed in the following nonlinear system of equations.

$$\begin{aligned} & [|B| - M_1 d_1]k + M_1 d_1 = M_1 + |B| \\ & \left[|B| - \frac{M_2}{2} + \frac{M_2}{2} d_1 \right]k - \frac{M_2}{2} d_1 = |B| + \frac{M_2}{2}. \end{aligned} \quad (2.2)$$

The flowchart in the next page presents the algorithm to compute k and d_1 using the Newton's method.

3.0 THE INNOVATION SFOPT – FIXED VOLUME

Based on the given flowchart, a MATLAB GUI called as the Spheroidal First Order Polarization Tensor (SFOPT) – Fixed Volume, has been developed to compute k and d_1 when $|B|$ is fixed while M_1 and M_2 are given. Figure 2 shows the layout of the GUI. The GUI is an extension of our previous innovation, copyrighted under MyIPO with reference no CRLY2024J02487 where, our previous innovation determines the spheroid for fixed conductivity based on the method described in Ahmad Khairuddin et al. (2019). As required by the Newton's Method, initial values for both k and d_1 must be specified by the user when using the GUI and this initial value can be specified based on the conditions stated in Ahmad Khairuddin et al. (2019). After using the GUI, user can straightaway describe the original object represented by the PT using the computed conductivity and the depolarization factor for spheroid.

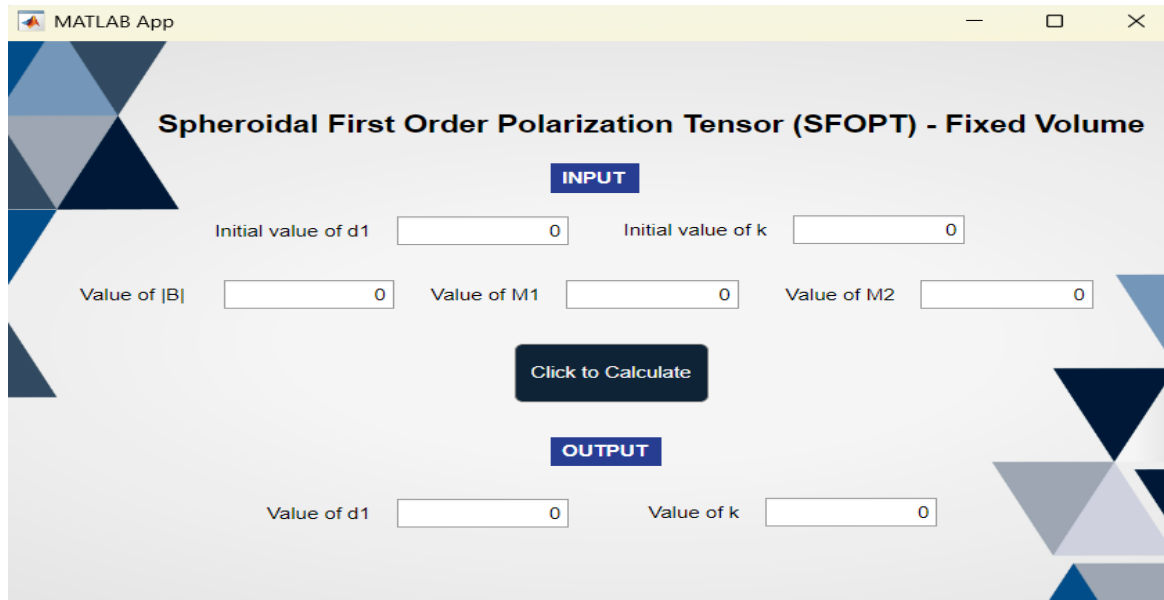


Figure 1: The layout for SFOPT – Fixed Volume

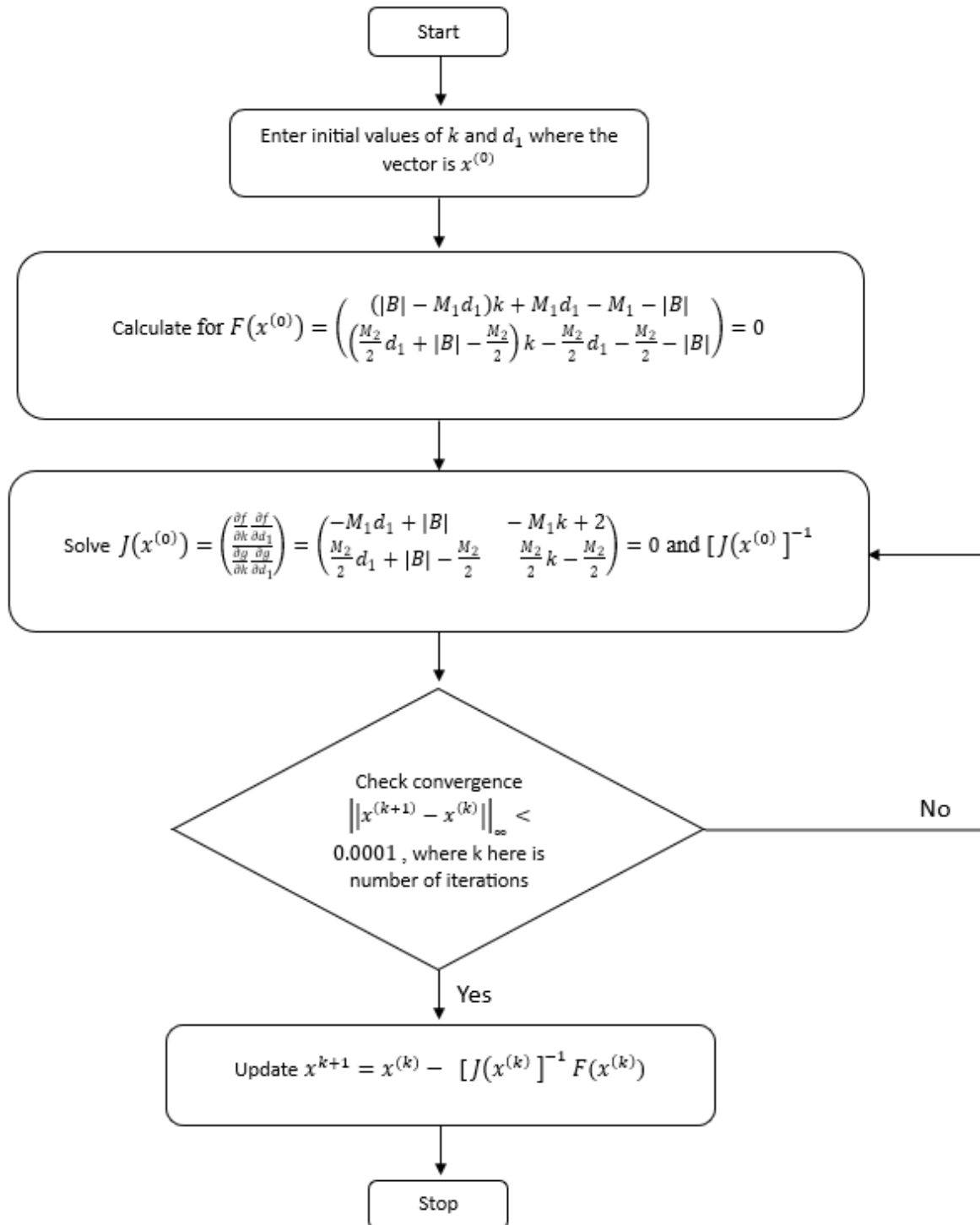


Figure 2: Flowchart of the Newton's method used in the innovation, which is a MATLAB GUI

4.0 EXAMPLES

Figure 3 and Figure 4 show two examples of using the GUI. The result in Figure 3 actually describes a pyramid at conductivity 500 from Ahmad Khairuddin and Lionheart (2013). On the other hand, Figure 4 describes hemisphere at conductivity 0.01, also from Ahmad Khairuddin and Lionheart (2013).

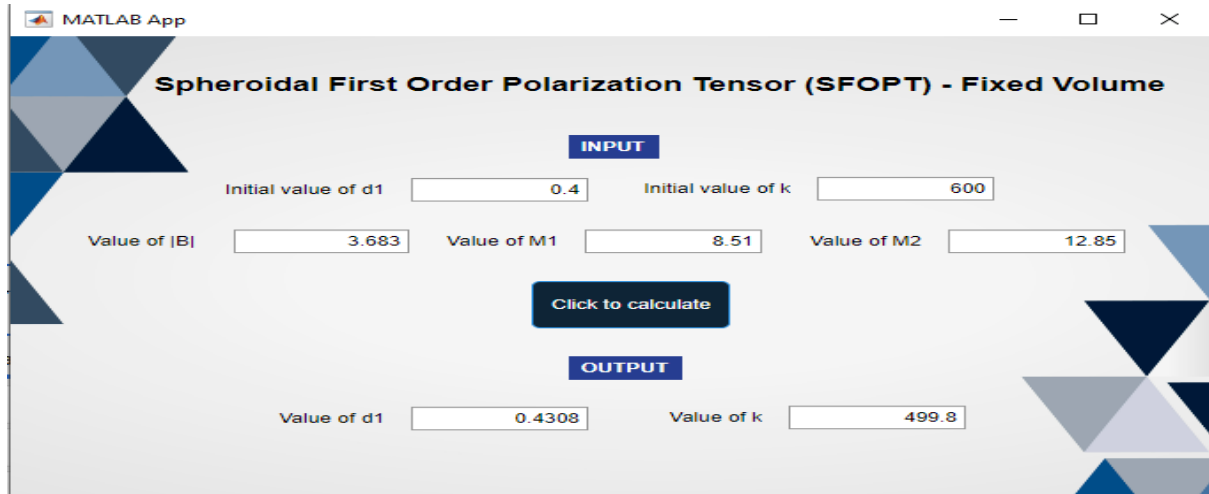


Figure 3: The value of k and d_1 when the given first order PT is for a pyramid at conductivity 500

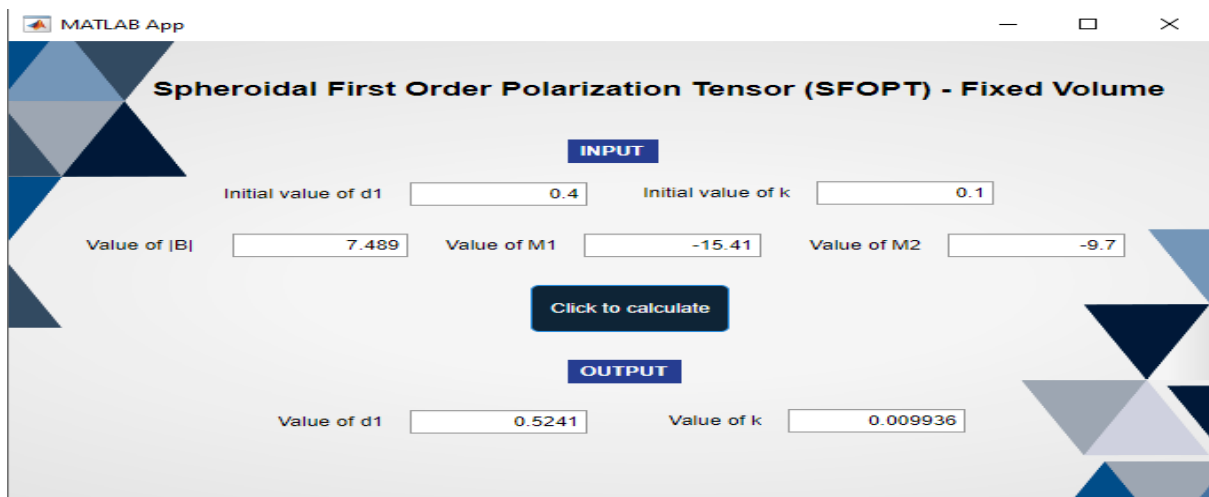


Figure 4: The value of k and d_1 when the given first order PT is for a hemisphere at conductivity 0.01

5.0 DISCUSSION AND CONCLUSION

The GUI provides an efficient way to determine a spheroid from a given first order PT for characterizing the related objects, which could be useful to engineers, physicists, and researchers engaged in problems involving object detection, shape estimation, or material characterization. As it helps describe objects, the GUI can be incorporated in the related industries, such as RAPISCAN System or Minelab Electronics to improve metal detection. It also encourages collaboration among STEM academicians and researchers including mathematicians, engineers, biologists and can be promoted in academia to stimulate broader knowledge development. Moreover, the GUI enhances students' grasp of theory and boosts hands-on practical skills, fostering deeper learning in higher education institutions. Thus, our innovation connects scientific concepts with creative and innovative thinking.

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Escape the Chemist

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ABSTRACT

As we know nowadays, there are lots of students who feel difficult to study by just doing some practice with the past year questions or find it difficult to stay focus when they study. We realised that we need to make study more exciting and interesting. Therefore, the idea to make a board game called “**Escape the Chemist**” was formed. This project aims to make study more fun and effective at the same time. The main objective of this project is to help students improve their understanding of organic chemistry in a more creative and innovative way. This game is inspired by the board game called “**Snake and Ladders**”. The game contains of a lot of interesting mechanisms such as, trap that can determine whether a player has an advantage or not based on the card that is drawn. Another interesting mechanism in this game is when the player with the chemist piece arrives at the box with a player piece, the player must answer a question about reaction or nomenclature based on the dice roll, if the player got an even number the player must answer a reaction question but if the player got an odd number the player must answer a nomenclature question. The results showed that this project help lots of students in their study while enjoying the game with their friends. This clearly shows that not only it helps students to focused on their study but also helps to strengthen the friendship. In conclusion, this project could significantly change the way students view study from a boring activity to more fun. This project needs to be expanded not only for this subject but for all subjects and all branches of learning.

Keywords: Chemist Education, Snake and Ladders

1.0 INTRODUCTION

Many students struggle with studying because their methods are either ineffective or not suited to their learning styles. As a result, they often find it difficult to stay focus during lessons or personal study sessions. This lack of concentration can eventually lead to a loss of motivation and interest in learning altogether.

To address this problem, we developed a creative and engaging solution in the form of a board game called “**Escape the Chemist**.” This game is designed to help students improve their understanding and retention of study material in a fun and interactive way. By turning the learning process into a game, we aim to make studying feel less like a chore and more like an enjoyable activity.

The concept for “**Escape the Chemist**” was inspired by the classic board game, Snakes and Ladders. However, we added an educational twist by incorporating study-related challenges and chemistry-themed content. This innovation combines the thrill of a gameplay with academic learning, providing students with a new and exciting approach to studying that can enhance focus and motivation.

2.0 OBJECTIVE

1. To help students improve their understanding of organic chemistry topics through interactive and enjoyable gameplay.
2. To encourage a positive perspective towards learning by introducing a creative, game-based alternative to traditional study methods.
3. To provide an environmentally friendly educational tool that supports sustainable learning practices through reusable and recyclable game materials.

3.0 METHODOLOGY

“Escape the Chemist” is multiplayer dice board game that is inspired by **“Snake and Ladders”** which mean it can be played by a minimum of 2 players with 1 player becomes the runner and the other player becomes the chemist. The number of chemist and runner should be equal but if there is an odd number of players there would be 1 extra runner compared to the chemist. To determine who becomes the chemist, players have to roll a dice and the player who got the smallest number will become the chemist. After the chemist has been chosen, the runner will start the game by rolling the dice which will determine how many steps the runner will take. After all the runners have rolled the dice than the chemist can start by rolling the dice. The runner will win when all runners have reached the escape box while the chemist is trying to eliminate them. Each runner has 3 lives.

There are a lot of mechanisms that are added to this game such as the vent, which is the same as the ladder, but the vent will only move the runner upward and it does not work on the chemist. Another mechanism is the stun which will make the player that stop at that box to skip 1 turn. This mechanism applies on both sides, the runner and the chemist. Next is the trap, it as a mechanism that can significantly change the game because it will determine whether you have an advantage or disadvantage in the game. Other than that, the chemist attack is one of the main mechanisms in this game which apply for the chemist only. This mechanism allows chemist to give the runner a question that they need to answer. This mechanism will be activated when the chemist arrives at the box with a runner in it. The questions are about organic chemistry which include reaction, synthesis, and nomenclature. The runner has to answer a question by drawing a card.

The innovation is made by recycling materials which make it environmentally friendly. For example, we use cardboard for the runner and chemist pieces, and the base material for the board.

3.1 GAME BASED LEARNING IN EDUCATION

Game-based learning (GBL) is a learner centred instructional approach that incorporates the use of games to promote active engagement and enhance understanding. Rather than relying solely on passive learning methods such as lectures or rote memorization, GBL places students in interactive environments where they can apply knowledge, solve problems, and receive immediate feedback. Research shows that GBL can increase students’ motivation, improve conceptual understanding, and foster positive attitudes toward learning (Plass, Homer, & Kinzer, 2015).

“Escape the Chemist” is a board game that applies game-based learning principles to chemistry education. Through a dice-based progression system and subject-specific questions, the game presents students with challenges related to atomic theory, chemical bonding, reactions, safety, and other key chemistry topics. These challenges reinforce core concepts while keeping students actively engaged in a low-pressure, collaborative environment.

By integrating competition, repetition, and rewards, the game mirrors the cognitive benefits of spaced retrieval and active recall two techniques known to enhance memory and understanding (Brown, Roediger, & McDaniel, 2014). Furthermore, because the game is designed to be played in small groups or classrooms, it promotes peer interaction, teamwork, and academic discussion which are the key features of cooperative learning environments (Slavin, 1996).

Through this blend of fun and function, **“Escape the Chemist”** demonstrates the potential of game-based learning as a powerful educational tool for transforming students’ attitudes toward studying and improving their mastery of complex scientific content.

4.0 RESULT

The invention, a dice-based board game called **“Escape the Chemist”**, has been tested with university students. The results showed that it effectively helps students in their studies.

“Escape the Chemist” is an educational board game designed to make learning chemistry more engaging and interactive. Players roll a dice to move across the board, escaping the chemist while the chemist chasing and attacking you with lots of question about organic chemistry. By answering questions correctly, players will be free from the chemist attack. The game promotes critical thinking, reinforces key chemistry concepts, and encourages collaborative learning in a fun, competitive environment. As players move forward to reach the escape box, they will encounter various

mechanisms that will keep them progressing or will give them a hard time. The competitive and playful nature of the game keeps students motivated while encouraging active recall and critical thinking.

By integrating educational content into a fun and social format, “**Escape the Chemist**” serves as a valuable supplementary learning tool that helps reduce study related stress and increases students' confidence in the subject. The positive feedback from university students during testing confirms its effectiveness and potential as a classroom or revision aid.

5.0 CONCLUSION

The experimental testing of “**Escape the Chemist**”, a dice based educational board game, demonstrated its effectiveness in enhancing chemistry learning among university students. The game successfully improved students' engagement, encouraged active participation, and reinforced key chemistry concepts in an enjoyable and interactive way. Students reported increased confidence in the subject and showed better retention of information through repeated play and peer collaboration.

This work contributes to the scientific and educational community by introducing a new approach to chemistry education. It bridges the gap between conventional learning methods and modern interactive strategies, making complex topics more accessible and less intimidating.

From an economic perspective, “**Escape the Chemist**” presents a low cost, scalable solution that can be easily implemented in schools, and universities as most of the product use recycle materials. Its potential for commercial development as an educational product further enhances its value, offering a sustainable and innovative tool.

In conclusion, “**Escape the Chemist**” is more than just a board game, it is a meaningful educational innovation with both academic and market potential.

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We would like to express our deepest appreciation to **Dr. Nur Farhana binti Mohd Yusuf and Norin Hafizah binti Rahim** for their unwavering support, insightful feedback, and continuous encouragement throughout the development of our innovation. Their guidance not only helped us overcome challenges during the design and testing phases but also inspired us to think critically and creatively. This project would not have been possible without their valuable input, patience, and dedication to our academic and personal growth.

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CHEMCUBES: A GAME-BASED LEARNING TOOL FOR ORGANIC CHEMISTRY

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ABSTRACT

CHEMCUBES is an interactive, modular game-based learning platform designed to enhance conceptual mastery and motivation in undergraduate and upper secondary organic chemistry education. By engaging students in retrosynthetic puzzle-solving, CHEMCUBES combines tactile tiles (or digital cubes) representing molecular fragments with challenge cards that scaffold reaction schemes of varying difficulty levels. Gameplay is structured to promote peer collaboration, immediate feedback, and iterative problem solving, bridging the gap between abstract mechanisms and tangible manipulation. In a trial, conventional tutorial questions and experimental (CHEMCUBES intervention) were compared. Students who engaged with CHEMCUBES reported greater understanding and enjoyment compared to conventional tutorial question sessions, citing the game's interactive nature and visual-spatial features as key advantages. Results showed a statistically significant improvement in conceptual understanding and synthesis reasoning in the CHEMCUBES group, alongside a marked increase in learner motivation and enjoyment. The result underscored the value of hands-on interaction and social gameplay dynamics. CHEMCUBES therefore holds promise as an adaptive, scalable pedagogical tool in organic chemistry that aligns with the proven efficacy of similar game-based interventions.

Keywords: Game-based learning, Organic chemistry education, Active learning, Student motivation, Peer collaboration

1.0 INTRODUCTION

Organic chemistry is a compulsory topic taught at both secondary and tertiary education levels. However, many students find it difficult to understand due to its abstract molecular structures and unfamiliar terminology. Traditional lecture-based methods, which rely heavily on textbook and whiteboard explanations, often fail to actively engage learners.

Students who cannot visualise complex chemical structures tend to feel bored, disconnected, and discouraged. This results in low academic performance, reduced motivation, and lack of interest in the subject. The core problem lies in the lack of interactive, hands-on tools tailored to support visual and kinesthetic learning styles.

To address this issue, ChemCubes was developed as a fun, game-based innovation that transforms passive chemistry lessons into active, engaging learning experiences. This project aims to improve understanding, boost motivation, and make chemistry learning more accessible and enjoyable for all types of learners.

2.0 OBJECTIVE

1. To develop an interactive and engaging learning tool for organic chemistry education.
2. To help students visualise and understand chemical structures through hands-on gameplay.
3. To increase students' interest, motivation, and performance in chemistry by supporting diverse learning styles.

3.0 METHODOLOGY

The ChemCubes learning tool was developed by combining a Rubik's Cube mechanism with organic chemistry flashcards. Each face of the cube is colour-coded and labelled to represent key atoms or functional groups such as Carbon (C), Hydrogen (H), Oxygen (O), and R-groups. The visual structure aims to help students form a tangible connection with molecular arrangements.

The game also includes a deck of flashcards with topic-based questions. Each card contains a challenge that students must solve by manipulating the cube to form a correct structure or arrangement based on the question. A bell is placed at the centre of the game setup, where students press the bell once they complete the task, adding a fast-paced and competitive element to the learning experience.

This innovation is designed to be simple, reusable, and suitable for group or individual play. It was tested in a classroom environment with secondary and pre-university chemistry students to observe engagement levels, teamwork, understanding of concepts, and improvement in answering chemistry-based questions. The practicality of ChemCubes lies in its low cost, portability, and ability to encourage active learning among different types of learners.

3.1 EDUCATIONAL IMPACT AND CLASSROOM IMPLEMENTATION

The implementation of **ChemCubes** has demonstrated a positive impact on students' engagement and comprehension in organic chemistry lessons. Several studies have emphasized the importance of interactive tools in enhancing academic performance, particularly for abstract subjects like chemistry (Stojanovska & Velevska, 2018). This is supported by Kusumaningdyah et al. (2024), who found that kinesthetic and hands-on learning significantly improve concept retention, particularly in topics like stereochemistry.

ChemCubes transforms the conventional learning experience by integrating tactile learning with visual cues. The *eChem* Project (2000) highlighted that combining hands-on manipulation with visual representations promotes a deeper understanding of molecular structures. This method aligns with the learning preferences of students who struggle with theoretical, text-based methods.

In a recent classroom trial, students showed increased enthusiasm and motivation when using ChemCubes. Stieff (2019) reported that visualization-supported activities enhance learner engagement and comprehension in secondary chemistry education. Similar outcomes were confirmed in a meta-analysis by Sailer and Homner (2019), who noted that gamified tools significantly improve teamwork, motivation, and accuracy in problem solving.

The adaptability of ChemCubes for both individual and group play makes it an effective and inclusive educational innovation.

4.0 RESULT

The implementation of ChemCubes in the classroom has demonstrated several positive impacts on students' learning experience. Based on observations and feedback, students showed a noticeable improvement in their ability to understand and visualise organic chemistry structures. Those who previously struggled with the subject were more engaged, confident, and willing to participate during lessons.

One of the key advantages of ChemCubes is its ability to support diverse learning styles, especially visual and kinesthetic learners. The hands-on and game-based approach kept students active and motivated, making chemistry lessons more exciting and less intimidating. It also encouraged healthy competition, peer collaboration, and critical thinking.

In terms of novelty, ChemCubes is unique in combining a Rubik's Cube-inspired physical model with content-based question cards and a bell-based quiz system. This integration transforms traditional passive learning into an interactive classroom activity that strengthens both cognitive and spatial learning skills.

The tool is reusable, portable, and cost-effective, making it suitable for continuous use across different learning environments. It has the potential to be adapted for other science topics beyond organic chemistry, proving its flexibility and scalability in education.

5.0 CONCLUSION

ChemCubes has proven to be an effective and engaging educational tool in improving students' understanding of organic chemistry. By transforming abstract and complex chemical concepts into tangible, hands-on activities, the tool significantly enhances student motivation, comprehension, and participation. It especially benefits students who struggle with conventional, lecture-based approaches.

This innovation contributes to the scientific and educational community by introducing an interactive, game-based learning strategy that supports various learning styles. Its originality lies in combining a Rubik's Cube model, flashcards, and a bell-based challenge to foster active learning in the classroom.

From an economic perspective, ChemCubes is a low-cost, reusable product that can be applied across different topics and educational levels. It has the potential for mass production and commercialization as a classroom teaching aid, especially in schools seeking affordable and effective STEM teaching tools.

In summary, ChemCubes supports the advancement of inclusive science education and aligns with the goals of educational transformation through innovation.

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Pembangunan Aplikasi Permainan Aksi-Pengembaraan Nilai Murni Islam (Penaklukan Birgad)

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ABSTRAK

'Penaklukan Birgad' merupakan aplikasi permainan komputer berkonsepkan aksi-pengembaraan dengan penerapan nilai murni Islam yang mensasarkan kanak-kanak Muslim Malaysia. Aplikasi pembelajaran interaktif ini dikhususkan bagi murid-murid Muslim tahap dua iaitu darjah 4, 5 dan 6 yang mempunyai minat terhadap permainan aksi dan strategi. Jika diperhatikan di masa kini, kanak-kanak jarang mempraktikkan nilai murni Islam dalam kehidupan seharian mereka. Tambahan pula, dengan lambakan permainan aksi-pengembaraan dari pengeluar Barat, maka budaya dan cara hidup Barat lebih menyerap dalam kehidupan mereka. Objektif-objektif bagi projek ini adalah, (i) merekabentuk aplikasi permainan komputer aksi-pengembaraan dengan penerapan nilai murni Islam, (ii) membangunkan aplikasi aksi-permainan berbahasa Malaysia berdasarkan dokumen rekabentuk yang telah dikenalpasti, dan (iii) melaksanakan pengujian *Beta* dan penerimaan pengguna (*user acceptance testing*) bagi mendapatkan maklumbalas berkenaan produk yang telah dibangunkan. Pembangunan aplikasi ini dijalankan berdasarkan metodologi 'reka bentuk permainan' Jedrinović et al. (2020) yang mana lebih bersesuaian dengan penghasilan produk pembelajaran. Fasa-fasa yang terlibat adalah seperti spesifikasi, analisis, rekabentuk, pembangunan, pelaksanaan, dan penilaian. Aplikasi ini dibangunkan menggunakan perisian Unreal Engine 5.3 dan Visual Studio dengan menggunakan bahasa pengaturcaraan C++. Berdasarkan penilaian dan maklum balas daripada 9 orang murid di kalangan tahap dua, serta seorang guru Pendidikan Islam dari Sekolah Kebangsaan Kota Raja, Panchor, Johor, mereka berpuas hati dengan aplikasi yang dihasilkan dari segi (i) antaramuka yang mesra pengguna, (ii) kecukupan kandungan Islamik yang ditampilkan, serta (iii) alur permainan yang menarik dan mudah difahami. Guru Pendidikan Islam yang ditemubual juga bersetuju bahawa pembelajaran mengenai nilai-nilai murni dalam Islam yang berterusan menggunakan teknologi maklumat adalah efektif dalam mendidik kanak-kanak. Susulan itu, 'Penaklukan Birgad' akan dijadikan sebagai salah satu bahan pembelajaran digital di makmal komputer sekolah tersebut. Penggabungan pelbagai elemen multimedia terbukti dapat menarik minat golongan sasaran, disamping merasai pengalaman yang menyeronokkan.

Kata Kunci: Nilai murni Islam, aplikasi permainan komputer, aksi-pengembaraan, Pendidikan Islam, bahan bantu mengajar digital

1.0 PENDAHULUAN

Dalam era digital yang semakin pesat membangun, permainan komputer telah menjadi sebahagian besar daripada kehidupan kanak-kanak, terutamanya sebagai medium hiburan harian (Mahbob & Othman, 2022). Namun begitu, kebanyakan permainan yang terdapat di pasaran kini cenderung mengandungi elemen-elemen luar yang kurang sesuai dengan nilai-nilai yang dianjurkan dalam Islam. Akibatnya, budaya hiburan yang sarat dengan unsur keganasan, kelalaian, serta kebergantungan kepada budaya hidup Barat semakin mempengaruhi gaya pemikiran dan tingkah laku generasi muda Islam di Malaysia (Ismail et al., 2020). Produk-produk permainan digital Barat yang popular di Malaysia adalah seperti *Assassin's Creed* dan *Prince of Persia* keluaran syarikat Ubisoft dari negara Perancis, manakala *God of War* dan *Uncharted Series* pula adalah keluaran syarikat Sony Interactive Entertainment dari Amerika. Selain daripada kandungan permainan-permainan digital yang disenaraikan tersebut mempunyai unsur keganasan dan pemakaian yang kurang tidak patuh syariah, terdapat juga unsur-unsur moral yang boleh memesongkan akidah seorang Muslim.

Kajian-kajian semasa menunjukkan berlaku penurunan dalam pengamalan nilai akhlak mulia dalam kalangan kanak-kanak Malaysia. Antara gejala yang membimbangkan termasuk kurangnya rasa hormat terhadap ibu bapa dan guru, sikap individualistik, serta peningkatan tingkah laku agresif atau tidak sopan dalam interaksi sosial (Rosli et al., 2019). Hal ini sebahagiannya berpunca daripada pendedahan berlebihan kepada kandungan media dan permainan digital yang tidak menekankan nilai

etika dan moral (Kirin et al., 2022). Dalam konteks ini, terdapat keperluan mendesak untuk menyediakan alternatif hiburan digital yang bukan sahaja menyeronokkan tetapi juga mampu mendidik dan membina sahsiah kanak-kanak Muslim.

Kajian menunjukkan permainan video mempunyai potensi sebagai medium pembelajaran, menggalakkan pembelajaran secara aktif (Ibrahim et al. 2015). Tambahan pula, menurut Aziz Shah et al. (2014), penentuan kaedah pembelajaran dalam sesi pengajaran dan pembelajaran oleh guru amat mempengaruhi tahap dan daya tumpuan murid. Bahan Bantu Mengajar (BBM) adalah satu elemen penting yang digunakan dalam proses pengajaran dan pembelajaran (Yusof et al., 2021). Selain itu, permainan komputer seperti *Quraish* keluaran Afkar Media dari Syria dan permainan digital mudah alih *Saladin* keluaran Ladik Apps dari Istanbul memberi gambaran bagaimana nilai Islam dapat diterapkan melalui naratif yang menarik dan persekitaran yang interaktif, seterusnya memupuk kefahaman yang mendalam mengenai Islam dalam kalangan pemain. Sebagai tindakan kepada masalah yang dibincangkan serta sokongan kepada pembangunan produk permainan berunsur Islam, aplikasi permainan komputer bertajuk 'Penaklukan Birgad' telah dibangunkan sebagai satu inisiatif pendidikan yang inovatif dan berimpak.

'Penaklukan Birgad' menggabungkan elemen aksi-pengembaraan dan penerapan nilai-nilai murni Islam secara interaktif. Ia direka khusus untuk murid Muslim tahap dua, iaitu kanak-kanak dalam lingkungan usia 10 hingga 12 tahun, yang lazimnya cenderung terhadap permainan berunsur cabaran dan strategi. Melalui pengembaraan dalam dunia maya yang penuh dengan ujian, pemain bukan sahaja diuji dari segi kemahiran strategi, tetapi juga diperlihatkan tentang prinsip-prinsip Islam pada setiap aksi seperti kewajipan solat, rukun-rukun solat, surah-surah hafazan, kewajipan menuntut ilmu, tolong-menolong, memberi salam, dan juga konsep penawar dalam bacaan 'Basmallah'.

Oleh kerana kandungan 'Penaklukan Birgad' adalah selari dengan pengajaran nilai-nilai Islam di sekolah rendah, maka ianya turut boleh menjadi satu medium pendidikan digital rasmi di sekolah awam Malaysia. Produk ini secara tidak langsung memberi impak dari segi pembentukan akhlak kanak-kanak melalui pengalaman bermain yang menyeronokkan. Usaha ini diharap dapat menjadi antara langkah awal ke arah mengimbangi pengaruh negatif media digital terutamanya dari Barat serta memperkukuh jati diri Muslim dalam kalangan generasi muda.

2.0 OBJEKTIF

Pembangunan 'Penaklukan Birgad' adalah berpaksikan kepada tiga objektif utama seperti berikut;

1. Merekabentuk aplikasi permainan aksi-pengembaraan yang menumpukan kepada pembelajaran nilai Islamik.
2. Membangunkan permainan aksi-pengembaraan berbahasa Malaysia yang berkonsepkan Islam berdasarkan kepada dokumen rekabentuk.
3. Menjalankan kajian penerimaan pengguna bagi menilai keberkesanan produk.

3.0 METODOLOGI

Metodologi pembangunan bagi permainan komputer aksi-pengembaraan 'Penaklukan Birgad' adalah berdasarkan metodologi 'reka bentuk permainan' yang diperkenalkan oleh Jedrinović et al. (2020) yang mana adalah terbitan daripada model SADDIE (Rugelj & Zapašek, 2018). Kaedah SADDIE adalah versi yang dipertingkatkan daripada kaedah ADDIE (Molenda, 2003) di mana fasa spesifikasi ditambahkan sebagai fasa pertama dalam proses. Jedrinović et al. (2020) telah menambah baik metodologi SADDIE dengan menyenaraikan langkah-langkah yang lebih terperinci bagi tujuan pembangunan produk pembelajaran digital dan berbentuk permainan seperti di dalam Rajah 1. Ianya merangkumi fasa spesifikasi, analisis, rekabentuk, pembangunan, pelaksanaan, dan penilaian. Model ini mengandungi enam fasa yang saling berkaitan yang seterusnya akan menjadi panduan bagi pembangun mencipta aplikasi pembelajaran dan mempunyai elemen permainan. Metodologi 'rekabentuk permainan' oleh Jedrinović et al. (2020) telah memberikan panduan tentang cara membangunkan permainan yang mempromosikan komunikasi, pemikiran kreatif dan penyesuaian diri di kalangan pengguna (kanak-kanak).

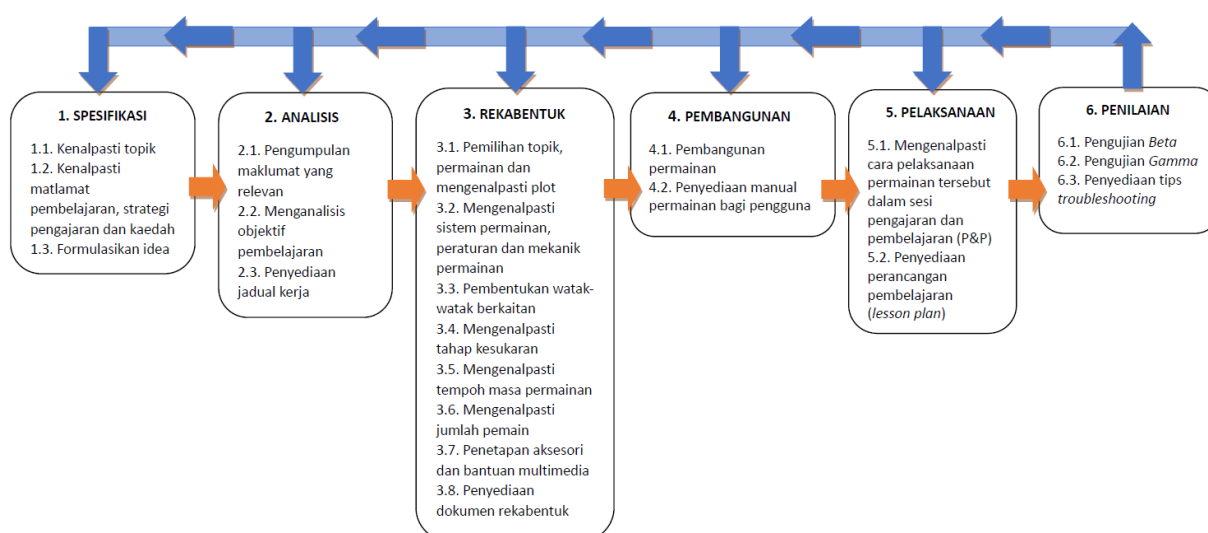
3.1 FASA SPESIFIKASI

Fasa ini melibatkan pengenalanpastian matlamat dan keperluan permainan komputer aksi-pengembaraan 'Penaklukan Birgad'. Ini termasuk perkara seperti matlamat pembelajaran, pengguna

sasaran, jenis kandungan dan tema permainan (zaman pemerintahan Islam di Konstatinopel). Pengumpulan maklumat yang terperinci dilakukan mengenai konsep pada aplikasi pembelajaran, mempelajari gaya pembelajaran, kemahiran serta minat golongan sasaran pengguna, dan topik-topik pembelajaran Pendidikan Islam tahap dua yang akan diterapkan sepanjang permainan aksi-pengembaraan yang menerapkan nilai-nilai murni Islam. Perbincangan berkenaan kandungan ayat Al-Quran dan hadis-hadis sahih juga turut dilakukan. Idea-idea pembangun produk dan juga guru Pendidikan Islam Sekolah Kebangsaan Kota Raja, Pagoh, Johor turut dikenalpasti, supaya penghasilan produk akan bertepatan dengan keperluan yang telah dibincangkan.

3.2 FASA ANALISIS

Fasa yang kedua pula memfokuskan kepada kajian terhadap bahan keperluan yang telah dikumpulkan sebagai langkah untuk menghasilkan rancangan dan perjalanan produk permainan berteraskan nilai murni Islam. Ini termasuk perkara seperti analisis keperluan bagi mencapai objektif pembelajaran serta pilihan kaedah pengajaran dan mekanik permainan termasuk tema permainan. Temubual telah dilaksanakan di kalangan beberapa murid darjah 6 untuk memahami keperluan pembelajaran dan kemahiran bermain permainan komputer mereka, serta temubual dengan guru Pendidikan Islam. Buku teks dan aktiviti mata pelajaran Pendidikan Islam darjah 4, 5, dan 6 turut dijadikan rujukan utama dalam menyenaraikan nilai-nilai murni Islam serta kandungan informasi penting hasil rujukan Al-Quran dan hadis-hadis sahih.



Rajah 1: Metodologi rekabentuk-permainan Jedrinović et al. (2020) hasil terbitan dari model SADDIE

3.3 FASA REKABENTUK

Fasa seterusnya ialah rekabentuk, yang melibatkan pembangunan rangka cerita mengikut tema serta alur penceritaan dan aktiviti-aktiviti permainan yang menggambarkan nilai-nilai murni Islam. Seterusnya, semakan dilakukan terhadap reka bentuk kandungan pendidikan, dengan merujuk buku teks, buku aktiviti dan silibus Pendidikan Islam tahap dua. Prose rekabentuk melibatkan juga pembangunan papan cerita (*storyboard*) dalam usaha untuk memastikan suasana permainan mengikut tema (zaman pemerintahan Islam di Konstatinopel) dan menggambarkan struktur perjalanan pengembaraan yang bertepatan (rujuk Rajah 2). Penentuan beberapa aspek berkaitan tugas dalam permainan turut dilaksanakan iaitu yang melibatkan strategi dan paparan info Islamik, kesukaran pengendalian setiap tugas, tempoh masa permainan dan juga aksesori multimedia yang berkesan.

3.4 FASA PEMBANGUNAN

Fasa ini menerangkan proses pembangunan permainan 'Penaklukan Birgad' menggunakan perisian Unreal Engine 5.3 dan Visual Studio melibatkan bahasa pengaturcaraan C++. Imej-imej tiga dimensi (3D) percuma digunapakai di mana sumbernya ialah dari 3D Warehouse, Free3D.com, dan SketchFab, manakala sumber audio percuma adalah daripada bensound.com. Sebanyak 3 fasa atau tahap permainan dibangunkan dalam 'Penaklukan Birgad' yang mana setiap fasa menunjukkan peningkatan kesukaran. Setiap fasa atau tahap permainan diuji terlebih dahulu oleh pembangun untuk memastikan ianya bebas dari ralat serta memenuhi keperluan pembelajaran nilai murni Islam seperti yang tercatat dalam dokumen analisis dan rekabentuk yang telah dipersetujui. Pembangun juga memastikan bahawa

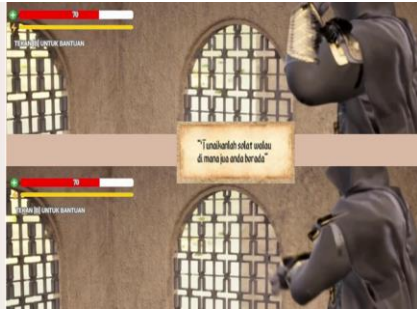
arahan dan tugas yang dipapar kepada pemain adalah jelas. Contoh kandungan permainan adalah seperti dalam Rajah 3.

3.5 FASA PELAKSANAAN

Dalam fasa pelaksanaan, perbincangan bersama guru Pendidikan Islam tahap dua dari Sekolah Kebangsaan Kota Raja, Pagoh, Johor dilakukan untuk mengenalpasti bagaimana ianya akan digunakan dalam sesi pengajaran dan pembelajaran (P&P). Persediaan perancangan pengajaran bagi produk 'Penaklukan Birgad' yang dikategorikan sebagai Bahan Bantu Mengajar (BBM) digital, dilakukan bersama guru tersebut. Sesi perbincangan dan merangka perancangan pengajaran telah dilakukan di bilik komputer sekolah. Produk permainan komputer ini diterbitkan dalam bentuk aplikasi 'desktop', maka penggunaannya adalah di komputer riba sekolah dengan sistem operasi 'Windows'. Ianya turut boleh dipasang (*install*) di komputer murid di rumah masing-masing.

Introduction and Setting  Establishing the Ottoman Empire's grandeur as the historical setting.		Character Introduction and Exploration  Introducing the player character gearing up for a historical conquest.	
 Introducing a vibrant city as the starting point for the player.		 The player starts exploring the city	
Combat Sequence  The player enters the combat. Facing the adversaries  Executing a series of swift movements, a mid strike moment captured, showcasing the mastery of swordplay  Executing a decisive counter-attack, emphasizing strategic prowess  Expanding the scope of the combat, the environment is being utilised to gain an advantage. This involve climbing a structure for a strategic vantage point.		Every Level: Learning Outcome 	

Rajah 2: Papan cerita (*storyboard*) permainan komputer 'Penaklukan Birgad'

Tolong Menolong Paparan: Dalil Naqli Sumber: - Hadis riwayat at-Tabrani - Surah al-Maidah, ayat 2  ??? Assalamualaikum tuan, Terima kasih kerana telah membantu bunuh buaya buaya tersebut, Mereka telah membunuh ramai orang di kawasan ini.		Solat Paparan: - Rukun solat - Kelebihan solat - Keburukan meninggalkan solat Sumber: - Riwayat al-Tirmizi - Surah ar-Ra'd, ayat 28 	
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Rajah 3: Membangunkan permainan komputer yang selari dengan kandungan nilai-nilai murni Islam

3.6 FASA PENILAIAN

Pada fasa penilaian, beberapa pengujian terhadap hasil akhir permainan aksi-pengembaraan 'Penaklukan Birgad' dilakukan untuk memastikan bahawa produk berjaya menepati objektif asal serta diterima golongan sasaran. Produk diuji di kalangan 9 murid tahap dua (3 murid darjah 4, 3 murid darjah 5, 3 murid darjah 6) dan seorang guru Pendidikan Islam Sekolah Kebangsaan Kota Raja, Panchor, Johor. Sebelum itu, pengujian *Beta* telah dilaksanakan terlebih dahulu (lihat Rajah 4). Pengujian *Beta* bertujuan untuk mendapatkan maklum balas daripada pengguna sebenar tentang prestasi dan kebolegunaan aplikasi. Setelah penambahbaikan dibuat berdasarkan hasil maklumbalas, pengujian penerimaan pengguna (*user acceptance testing*) dilakukan. Pengujian *Gamma* kemudiannya dilaksanakan sebagai langkah terakhir untuk memastikan aplikasi bersedia untuk pelancaran atau penggunaan sebenar.

Kaedah merekod maklumbalas pengujian *Beta* dan penerimaan pengguna adalah melalui soal selidik 'skala likert 5' iaitu yang ditunjukkan oleh 1= Sangat Tidak Setuju, 2 = Tidak Setuju, 3 = Tidak Pasti, 4 = Setuju dan 5 = Sangat Setuju. Soal selidik tersebut dilaksanakan secara atas talian iaitu menggunakan 'Google Form'. Antara soalan-soalan yang disediakan pada sesi pengujian *Beta* merangkumi kriteria seperti (i) alur permainan, samada bertepatan dengan nilai-nilai Islam yang ingin ditampilkan, (ii) kandungan nilai murni adalah mengikut silibus tahap dua Kementerian Pelajaran Malaysia (KPM) dan (iii) tahap mesra pengguna produk tersebut. Akhir sekali, responden menilai tahap keinginan penggunaan mereka bagi menandakan bahawa pengguna bersetuju menerima produk tersebut. Akhir sekali di fasa ini, penyediaan panduan '*troubleshooting*' dan '*tips*' disediakan sebagai bentuk sokongan teknikal kepada pihak sekolah dan guru terlibat bagi tujuan penggunaan sebenar di makmal komputer sekolah kelak.

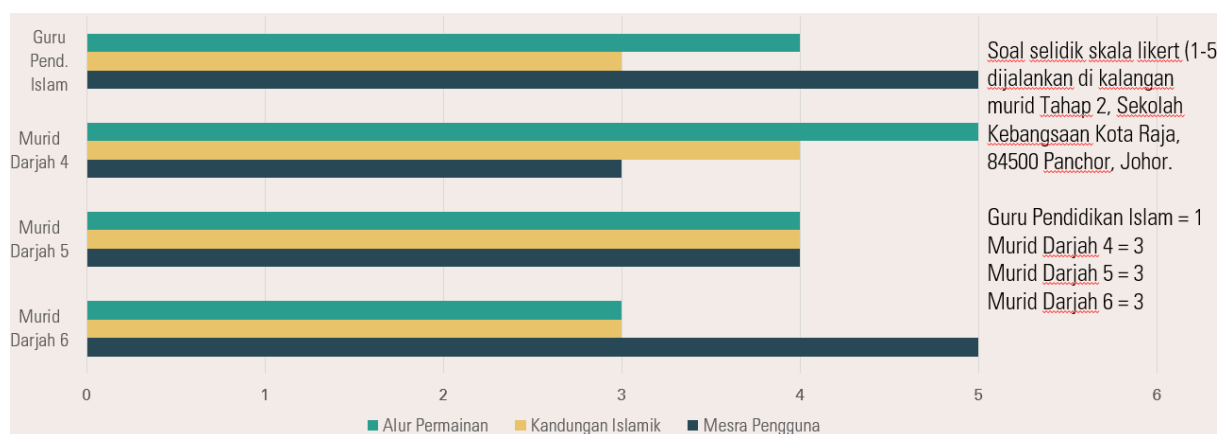


Rajah 4: Sesi pengujian *Beta* dan pengujian penerimaan pengguna di makmal komputer sekolah

4.0 KEPUTUSAN HASIL PRODUK

Hasil maklumbalas dari guru Pendidikan Islam serta 9 murid tahap dua diilustrasikan melalui carta di Rajah 5 yang menunjukkan tahap purata persetujuan atau kepuasan di kalangan semua responden. Majoriti responden memberikan persetujuan yang tinggi terhadap alur permainan yang dikatakan

menarik dan mudah difahami. Bagi kriteria kandungan Islamik yang bertepatan dengan silibus tahap dua KPM, guru Pendidikan Islam menyatakan bahawa kandungan yang disediakan adalah mencukupi dan bersesuaian. Manakala bagi kriteria ramah pengguna pula, responden di kalangan darjah 4 merasakan sedikit kesukaran dalam pengendalian produk tersebut. Ini mungkin disebabkan oleh faktor usia mereka yang lebih muda dan kurang berpengalaman dalam mengendali peralatan komputer di samping tidak biasa bermain permainan komputer yang berkonsepkan aksi-pengembaraan. Secara umumnya, kesemua responden atau golongan sasaran pengguna menerima permainan 'Penaklukan Birgad' sebagai salah satu medium BBM yang menarik bagi pengisian pembelajaran digital mata pelajaran Pendidikan Islam. Oleh itu, penerimaan pengguna (*user acceptance*) dapat diklasifikasikan sebagai berjaya. Komen penambahbaikan juga turut diterima, antaranya dari segi paparan grafik, mekanik permainan, kelancaran pengendalian serta cara paparan arahan atau tugas di setiap tahap permainan.



Rajah 5: Hasil maklumbalas pengujian *Beta* dan pengujian penerimaan pengguna

5.0 KESIMPULAN

Secara kesimpulannya, projek ini berjaya mencapai ketiga-tiga objektif yang disasarkan di mana matlamatnya adalah membangunkan produk permainan komputer aksi-pengembaraan berbahasa Malaysia yang menerapkan nilai-nilai murni Islam. Melalui temubual dengan beberapa orang responden, dapat disimpulkan bahawa murid-murid dan guru mengalu-alukan alternatif BBM digital seperti aplikasi mudah alih atau permainan 'desktop' komputer seperti 'Penaklukan Birgad' ini. Penggunaan BBM dapat mempelbagaikan pengajaran yang dilaksanakan dan secara tidak langsung membantu guru menyampaikan pengajaran dengan lebih mudah dan efektif (Rugelj, 2015). Hasil daripada kajian ini dan penghasilan produk 'Penaklukan Birgad', secara keseluruhannya, penggunaan BBM digital didapati memberikan impak positif dan semakin menjadi suatu keperluan dalam pelaksanaan proses pengajaran dan pembelajaran (PdP) selaras dengan tuntutan era Revolusi Industri 4.0.

PENGHARGAAN

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LuggageMate: Smart Luggage with Integrated GPS tracking and Digital Weight Sensor

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ABSTRACT

The growth in global tourism and shifting travel behaviours have created the demand for increasingly intelligent and secure travel experiences. One of the most significant problems that travellers face is the large number of lost luggage and additional baggage charges at airports. LuggageMate is an innovative smart luggage system that seeks to tackle these issues directly. It integrates two essential technologies that encompass GPS tracking and a built-in digital weight sensor into one convenient and compact solution. The GPS function allows one to track the location of the luggage in real-time through a mobile app, while the weight sensor provides real-time feedback regarding the bag's weight to avoid additional fees. This project addresses the deficiencies of existing luggage offerings, which often include smart features as value-added, high-cost features. LuggageMate, on the contrary, incorporates such features as standard, affordable features, extending intelligent travel to a larger segment of the market, particularly Malaysian millennials, digital nomads, and frequent travellers. The innovation contributes to the tourism and hospitality industry by enhancing travel safety, convenience, and satisfaction. The study shows that the integration of the core smart features in luggage significantly improves user experience, reduces travel stress, and meets the demands of modern, tech-savvy consumers. Last but not least, LuggageMate consolidates the creation of intelligent travel gear and sets a new standard for tourism-oriented innovation.

Keywords: Smart Luggage, GPS tracking, Digital Weight Sensor, Travel Innovation, LuggageMate

1.0 INTRODUCTION

The global travel and tourism industry has witnessed tremendous growth over the past few decades, driven by increased globalization, the expansion of international business, and a growing desire for personal exploration and leisure travel. This upward trend in travel has sparked a parallel evolution in the development of travel-related technologies and services aimed at enhancing the convenience, efficiency, and safety of the travel experience. As airports have become busier and airline procedures have also become more stringent, the baggage handling process has been an area of concern and innovation (Westcott & Eds, 2021).

Malaysia is emulating this global trend in its own travel and tourism landscape. The country has experienced significant growth in its tourism sector, driven by its strategic position as a business hub in Southeast Asia (Majhi & Majhi, 2025). Malaysia's tourism industry has embraced technological advancements that have invested in "smart tourism" in the airport system. Technological developments in the airport system not only provide opportunities and convenience to users, but also present challenges that will arise from commitment to modernization (OpenGov Asia, 2018). They have a lot of cases that happen at airports and mostly happen on the luggage.

The problems with luggage that are always experienced by travellers are loss, theft and excessive weight. Addressing these pain points effectively would undoubtedly enhance the overall travel experience, transforming what can be a stressful journey into a more enjoyable and seamless one. This recognition has spurred the concept of advanced smart luggage, designed to directly tackle these issues through integrated technology. Imagine a suitcase that not only carries traveller's belongings but actively participates in their safety and compliant transport. The core innovation lies in combining a built-in GPS tracker with an integrated weighing scale.

2.0 OBJECTIVE

1. To identify the limitations of conventional luggage in terms of convenience, tracking, and weight monitoring.

2. To design a smart luggage prototype equipped with integrated GPS and built-in digital weight sensor.
3. To assess the feasibility and market potential of the innovation within Malaysia's growing travel and tourism market.

3.0 METHODOLOGY

The smart luggage innovation incorporates two primary technological components designed to address modern travel challenges through these integrated functionalities:

3.1 GPS Tracking System Integration

The GPS tracking technology is integrated inside the luggage's interior panel and is linked to a specific mobile application. Since this system's ability can provide real-time location monitoring, passengers can always see the location of their luggage during airport transfers, hotel check-ins, and transit. The technology offers dynamic location updates and recovery aid, outperforming traditional bag identifying methods like luggage tags and barcodes.

3.2 Digital Weight Sensor Implementation

The luggage's exterior bottom panel has a built-in digital weight indication. When the suitcase is hoisted using the handle, the internal scale automatically turns on and shows the weight readings on a digital readout. By removing the need for external weighing devices and providing continuous baggage weight monitoring, this feature helps passengers make pre-departure modifications and steer clear of excess baggage fines charged by airlines.

By integrating these technologies into a unified system that preserves the conventional luggage form factor while adding cutting-edge smart capabilities, the design places a strong emphasis on user-centered functionality. Instead of being distinct add-on features, the integration technique guarantees that both components function flawlessly together.



Figure 1: The sketch of the Innovation idea

4.0 RESULT

The integrated smart luggage solution demonstrates significant advantages over existing market alternatives. The innovation addresses two primary travel pain points simultaneously: luggage security and weight management. Unlike premium competitors that offer these features individually or at high price points, this solution provides comprehensive functionality in an affordable package.

The novelty lies in the seamless integration of GPS tracking and weight sensing technologies within a single luggage unit. This approach eliminates the inconvenience of carrying multiple devices and reduces the risk of losing separate tracking or weighing accessories. The real-time monitoring capability provides travellers with immediate peace of mind regarding luggage location and weight compliance.

Market analysis indicates strong demand potential, particularly among frequent travellers, business users, and the growing demographic of digital nomads in Malaysia and Southeast Asia. The target pricing strategy of RM 399-RM699 positions the product competitively while maintaining accessibility for mass market adoption.

The commercialization strategy encompasses digital marketing channels, partnerships with travel agencies, and distribution through online platforms and specialty luggage retailers. Revenue projections

include both direct product sales and potential premium application features, creating multiple income streams.

5.0 CONCLUSION

The development of the smart luggage prototype effectively addresses two common traveling issues: misplaced luggage and over-weighted bags. The integration of a GPS tracking module and a built-in digital weight sensor in a single unit demonstrates that it is feasible to develop an inexpensive, useful, and simple to use smart luggage solution. This research project contributes to the scientific and technological community by illustrating how easily accessible digital technologies such as IoT-based monitoring and sensor fusion can be integrated into a consumer product to solve travelling problems. It allows for further research in smart travel solutions, user-centred design, and integration of mobile technology. Economically, the product is a cost-saving innovation with excellent potential for commercial competitiveness in the Malaysian market. As a product with a price substantially lower than its premium competitors, the product is well-positioned to seek out mass-market consumers like students, regular flyers, and youth mobile workers. Scaled properly, the product has the potential to drive local manufacturing opportunities as well as the nascent smart-travel industry in Malaysia. This programme has laid a solid basis for development. Together with more polishing, strategic partnerships, and testing in the market initially in Sabah, it has tremendous potential to expand regionally and eventually reach the ASEAN market.

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XPLOREIT!

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ABSTRACT

Over the past decade, the demand for engaging, technology-driven travel experiences has increased significantly, especially among younger generations such as Gen Z and millennials. These travellers are no longer interested in traditional sightseeing alone; instead, they seek interactive, meaningful, and self-guided experiences that combine entertainment, education, and digital engagement. However, many tourism offerings remain outdated and disconnected from current digital trends, making it difficult to attract younger audiences. According to Tourism Malaysia (2024), more than 65% of Gen Z and millennial travellers prefer self-paced, gamified travel experiences over conventional tour packages. At the same time, many small tourism operators struggle to compete with large, tech-savvy platforms due to limited access to digital tools and marketing resources. This situation highlights a clear opportunity for innovative, affordable, and accessible tourism solutions that are both engaging and easy to use. Our innovation focuses on reimagining the Kota Kinabalu Heritage Trail, transforming it from a traditional guided tour limited to specific days and times into a flexible, self-guided tour that users can enjoy anytime at their own pace. XPLOREit! offers location-based challenges, interactive storytelling, educational quizzes, and GPS-guided navigation, making the experience both fun and meaningful. It promotes local culture and history while encouraging responsible travel by highlighting sustainable practices and eco-friendly businesses. Ultimately, XPLOREit! represents a cost-effective and socially responsible way to digitalise tourism. By combining sustainability, education, and gamification, it provides a modern tour experience that meets the needs of today's travellers while preserving the cultural and environmental essence of the destination.

Keywords: Digital Tourism, Gamified Tour, Self-Paced Tour, Interactive Tour, GPS Navigation

1.0 INTRODUCTION

1.1 Introduction to Sustainable Travel Behaviour in the Digital Age

According to Skift (2024), travellers now seek engaging, value-driven experiences over passive ones. Gen Z and Millennials favour meaningful, customized journeys aligned with their ethics and digital habits. They prefer offerings that support sustainability and authentic connections with nature and culture (Booking.com, 2021). Gen Z, in particular, is known for its environmental awareness and preference for self-guided, eco-friendly travel (Ribeiro et al., 2023). Their behaviour is shaped by green consumption values, favouring sustainable options that reflect their identity.

In Malaysia, sustainable travel awareness grew post-pandemic, with 93% of the respondents recognised its importance and 76% of them planned eco-friendly trips (MGTC, 2022). Gen Z leads this shift, using mobile apps for low-carbon travel, eco-certified bookings, and conservation support. Their digital lifestyle demands real-time, app-based guidance with social sharing and gamified features, which platforms like XPLOREit! meet these expectations with interactive maps, user rewards, and 24/7 accessibility without live guides.

1.2 Introduction to XPLOREit!

XPLOREit! is a gamified, self-guided tour which is a flexible, app-based tour that turns the Kota Kinabalu Heritage Trail into a GPS-triggered game. It replaces traditional tours with quizzes, photo tasks, and eco-challenges, rewarding users with points and badges to boost engagement (Xu et al., 2015). Light prompts encourage reflection, while green tasks promote responsible travel (Booking.com, 2021; MGTC, 2022).

Co-created with local experts, XPLOREit! supports small businesses and ensures cultural accuracy (UNWTO, 2023). It caters to digital-native travellers seeking educational, sustainable, and self-paced experiences anytime, anywhere.

2.0 OBJECTIVE

1. To design a sustainable tourism activity that is engaging and educational.
2. To promote green businesses and conservation sites through digital gamification.
3. To encourage tourists to adopt environmentally friendly behaviours.

3.0 METHODOLOGY

3.1 Platform and Tools Utilised

The tourism product, XPLOREit! is a location-based scavenger hunts and digital tours app that allows creators to design missions that integrate GPS check-ins, quizzes, multimedia content, and point-based gamification without requiring any coding skills or app development expertise.

By utilising Actionbound, the project highlights a cost-effective and scalable solution that eliminates the financial and technical barriers typically associated with developing a fully customised mobile application. The platform's user-friendly interface enables tourism providers to easily update content, add new routes, and tailor experiences to different target audiences, making it highly adaptable for on-going use at the Kota Kinabalu Heritage Trail and potentially other destinations.

3.2 Content Design

The XPLOREit! missions are designed with educational content, simple quizzes, and sustainability tips. Each location on the KK Heritage Trail includes a GPS check-in, an interactive task (quiz, reflection, or photo), and a short cultural or environmental fact. This keeps the tour engaging, educational, and aligned with responsible tourism values.

4.0 RESULT

The gamified heritage trail was successfully planned. The full mission includes 11 checkpoints, such as Atkinson Clock Tower and Padang Merdeka. Each task was designed to promote local heritage and eco-awareness. This product shows that digital tools like Actionbound can be used effectively to enhance tourism without high development costs.

5.0 CONCLUSION

In conclusion, our project 'XPLOREit!' platform aims to gamify the tourist experience, created especially for the KK Heritage Trail. Through immersive and interactive activities that turn a typical site visit into an engaging, self-guided journey, this digital invention seeks to draw in and keep tourists. By including features like challenges, point systems, and digital storytelling, XPLOREit! not only improves visitor engagement but also gives travellers a more significant and unforgettable experience.

Three main objectives guided the development of this initiative: to provide an entertaining and instructive sustainable tourism activity, to advertise nearby green companies and conservation locations as well as to motivate eco-friendly traveller behaviour. We ensure that the KK Heritage Trail stays relevant and interesting to the younger generation, which is quite conversant with mobile technology and digital content. Gamification encourages younger guests to actively participate in heritage tourism while learning about the site's cultural and historical value.

Furthermore, this strategy promotes sustainable tourism practices by minimising the need for printed brochures, traditional tour guides, and other resource-intensive approaches. It offers a more environmentally responsible, cost-effective, and engaging option that aligns with current travel habits and environmental consciousness.

Additionally, it is hoped that XPLOREit! will not only boost visitor interest in the KK Heritage Trail but also establish it as a forward-thinking historical destination that values innovation and creativity. This initiative is a step toward combining cultural preservation and technological innovation to create sustainable, informative, and engaging tourism experiences.

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GEOGREEN: TOWARD A SUSTAINABLE GEORGETOWN

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ABSTRACT

Rapid urbanisation and climate change have intensified problems like traffic congestion, pollution, and resource shortage in many urban areas. To address these challenges, nations are increasingly adopting the smart city concept, using modern technology, sustainable systems and data to boost efficiency and liveability. This project proposes a GeoGreen model for Georgetown, Pulau Pinang, a UNESCO World Heritage Site known for its rich history, strong connectivity and vibrant economy which makes it an ideal site for smart city innovations. The main objective is to develop a scalable framework that tackles energy inefficiency, water scarcity, waste management, and limited green spaces. The innovation combines floating solar panels, rainwater harvesting, decentralized power houses, modular waste facilities, pedestrian-friendly zones and indoor urban farming. These systems aim to cut carbon emissions, improve resource efficiency and enhance public health as well as well-being. Key features include rainwater harvesting for reuse and flood control, floating and rooftop solar panels for clean energy, a central powerhouse for efficient distribution, waste houses for recycling and resource recovery, walkways and parks to reduce car use as well as urban farms to boost local food production. 3D simulations show these innovations can reduce reliance on treated water by up to 35%, provide high solar yields even in dense areas, strengthen the energy grid with decentralized power, cut landfill waste by 25–30% and improve air quality together with liveability through green spaces. Indoor farming also helps secure local food supplies. In conclusion, this GeoGreen model offers a practical blueprint for sustainable urban transformation in heritage cities. It balances technology with cultural preservation and can be replicated in other Southeast Asian cities facing similar challenges. With supportive policies, collaboration, and community engagement, Georgetown can become a leading example of smart, green urbanism in the region.

Keywords: Green Transport, Low-Carbon City, Smart Mobility, Sustainable Development Goals

1.0 INTRODUCTION

Urban centres like George Town face increasing pressure from rapid urbanisation, environmental degradation, and infrastructure limitations, especially as they struggle to maintain liveability while addressing issues like traffic congestion, climate change, and outdated infrastructure (Penang2030, 2021). This project addresses the pressing need to incorporate sustainable urban technologies without compromising the city's historical identity, as reflected in conservation-led urban regeneration and smart waste initiatives in heritage zones (Penang2030, 2021). The GeoGreen Model envisions George Town as a carbon-neutral, resource-efficient, and livable city through the integration of green technologies and smart infrastructure such as IoT-based monitoring, smart mobility systems, and sustainable building designs (Abdullah et al., 2023; Penang2030, 2021).

2.0 OBJECTIVE

The GeoGreen Model for Georgetown is guided by three primary objectives:

1. To implement green and sustainable infrastructure that aligns with Georgetown's urban and heritage landscape. This objective seeks to develop systems that are not only environmentally friendly but also compatible with the aesthetic, cultural, and structural heritage of Georgetown. Green building materials can lower emissions, save energy, and enhance the environmental performance of buildings overall (Cubukcuoglu, B.,2022).
2. To enhance resource efficiency and reduce carbon emissions through renewable energy and waste management. A major priority is the reduction of carbon output through renewable energy such as solar power, along with systematic waste collection, recycling, and composting. The most widespread solar technology is solar photovoltaics (PV) for electricity production, which accounts for 3.6% of global electricity production (Ramanan et al. 2024).

3. To promote healthy, community-centric urban living through walkable green spaces and urban agriculture. This involves transforming Georgetown into a walkable city where residents have easy access to green public spaces and locally grown produce. Such initiatives not only support public health but also strengthen social engagement and urban biodiversity (Funk, 2025).

3.0 METHODOLOGY

To develop a feasible and replicable GeoGreen model, a multi-faceted methodology was adopted that combined urban planning, environmental engineering, and digital modelling. The key components are as follow:

3.1 System Design and Selection

The proposed innovations were chosen based on feasibility studies, environmental impact assessments, and global benchmarks. The systems include:

Rainwater Harvesting: implemented on rooftops to collect rainwater for irrigation, cleaning, and toilet flushing. The system includes storage tanks, filtration units, and underground pipelines.

Floating Solar Panels: Installed on coastal waters to optimize land use and harness consistent solar energy, reducing dependence on fossil fuels.

Decentralized Powerhouses: Built on rooftops and vacant lands, these serve as energy hubs, equipped with battery storage systems and smart meters to distribute electricity efficiently.

Waste Houses: Structures built using recycled materials that function as centres for sorting, recycling, and composting municipal waste.

Pedestrian Zones and Green Parks: Selected high-density traffic areas are converted into walk-only zones with shaded paths, green canopies, and rest zones.

Indoor Farming Systems: Utilize hydroponics and aquaponics in abandoned buildings to grow fresh produce close to urban consumers (Funk, 2025).

3.2 3D Urban Modelling and Simulation

Urban Modelling and Simulation Using GIS and 3D modelling software was used where the team digitally recreated Georgetown's urban landscape. This allowed for spatial analysis to identify optimal locations for each system without disrupting heritage buildings. The 3D model has also simulated energy outputs, water savings, and waste reduction. Other than that, it also simulates model traffic patterns, walkability indices, and air quality improvements.

3.3 Community and Stakeholder Consideration

Interviews and surveys were conducted with residents, business owners, and authorities to ensure that the model addresses real urban needs and aligns with existing regulations and heritage conservation practices. The methodology ensured inclusivity, scalability, and long-term feasibility.

4.0 RESULT

The simulation and evaluation of the GeoGreen Model revealed multiple measurable outcomes that indicate the project's potentials:

4.1 Rainwater Harvesting

Rooftop harvesting systems were shown to reduce the demand for treated water by up to 30% in public buildings and residential complexes. The model also demonstrated improved stormwater management, reducing the likelihood of flash floods during heavy rainfall.

4.2 Floating Solar Panels

Strategic installation on water bodies near coastal Georgetown offered substantial energy gains. The projected output could cover the energy needs of public lighting systems, traffic controls, and small community centres. In addition, the panels help reduce water evaporation and maintain lower surface water temperatures.

4.3 Powerhouses

Microgrid models placed on rooftops of government buildings showed high potential for energy storage and redistribution. Simulations suggested that energy from these decentralized nodes could power critical infrastructure during peak hours or outages, enhancing grid resilience.

4.4 Waste Management via Waste Houses

Waste houses placed near markets and residential clusters could reduce landfill waste by 25-30%. Community education programmes tied to these centers increased participation in composting and recycling.

4.5 Pedestrian Zones and Green Parks

Converting areas like Lebuah Armenian and Love Lane into pedestrian corridors improved air quality (estimated PM2.5 reduction of 15%) and encouraged more walking and cycling. These changes fostered community interaction and mental well-being.

4.6 Indoor Farming

Repurposed buildings in Jalan Magazine and Macallum successfully accommodated vertical farming units. These systems improved food availability, reduced carbon emissions associated with food transport, and created opportunities for green employment (Funk, 2025).

Collectively, these systems demonstrated that Georgetown could reduce its environmental footprint and enhance quality of life while maintaining its cultural legacy. The integration of digital modelling allowed for data-driven decision-making and real-time visualization of urban improvements.

5.0 CONCLUSION

This GeoGreen Model offers a replicable framework for other historical cities aspiring to transition towards sustainability. It highlights the viability of harmonising technological advancement with cultural preservation. Through green energy, water conservation, waste management, and urban farming, Georgetown can become a beacon of smart heritage city planning. The successful implementation of this model depends on stakeholder collaboration and policy support.

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REVOLUTIONIZING CARBON ACCOUNTING: CLOUD-BASED EFFICIENCY FOR A SUSTAINABLE WORLD

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ABSTRACT

The advancement of cloud computing technology has driven a significant transformation in accounting information systems (AIS), particularly in supporting sustainable accounting practices. This study aims to systematically examine how the implementation of cloud-based AIS can enhance the efficiency of carbon emission reporting (carbon accounting) and strengthen the quality of sustainability-oriented decision-making. The research employs a systematic literature review method, analyzing a range of scholarly publications from 2015 to 2025 relevant to cloud accounting, environmental reporting, and strategic decision-making. The findings indicate that cloud-based systems are capable of providing real-time carbon data, increasing transparency, and accelerating the processes of analysis and reporting. Furthermore, the integration of cloud accounting with sustainability indicators has proven to support management in formulating business strategies that are more socially and environmentally responsible. This study contributes theoretically to the literature on sustainable accounting and offers practical insights for organizations seeking to adopt digital technologies in sustainability reporting. Today, carbon accounting is no longer merely about reporting figures; it has evolved into a strategic tool for responsive, flexible, and integrated carbon monitoring systems. This technology delivers real-time emission data, automates environmental analysis, and links reports to other sustainability indicators. For organizations aiming to meet regulatory challenges and public expectations, the adoption of such systems is imperative.

Keywords: Cloud Accounting, Accounting Information Systems, Carbon Accounting, Sustainability

1.0 INTRODUCTION

1.1 BACKGROUND

In this modern era, climate change has become one of the biggest challenges faced by global society. With the increasing carbon dioxide (CO₂) emissions produced by human activities, such as industry, transportation, and energy use, developing countries must face the challenge of reducing their carbon footprint. Developing countries often have higher carbon emission levels compared to developed countries, even though they may have smaller populations. This is due to several factors, including the high contribution of emissions from local industries, limited infrastructure, and restricted access to technology that supports effective emissions management.

One of the promising solutions to address this issue is to adopt Internet of Things (IoT) technology in the development of smart carbon monitoring platforms. According to research by Zhang et al. (2021), IoT technology enables real-time data collection through connected sensor devices, thereby providing accurate and up-to-date information on carbon emissions in various locations. This research proposes a smart carbon monitoring model that integrates IoT technology for small towns, as well as discusses the challenges and solutions in carbon emission management. By leveraging this technology, developing countries can monitor and manage carbon emissions more efficiently and effectively.

The use of cloud-based accounting systems has also become very important in the context of carbon emissions management. Advances in cloud computing technology have caused significant changes in accounting information systems, especially in supporting sustainable accounting practices. These cloud-based systems are capable of providing real-time carbon emissions data, enhancing transparency, and accelerating the analysis and reporting processes. Furthermore, the research shows that the integration of cloud-based accounting systems with sustainability indicators can assist management in formulating more socially and environmentally responsible business strategies.

However, despite the potential of this technology being very large, its implementation in developing countries is often hindered by high costs, limited infrastructure, and a lack of adequate data. Many

developing countries have not fully adopted this technology, leaving them behind in efforts to achieve sustainability goals. Therefore, it is important to develop carbon monitoring models that not only consider technical aspects but also economic factors relevant to the conditions in developing countries.

Overall, the implementation of cloud-based accounting systems in carbon emission management is not only important for improving reporting efficiency, but also for promoting better sustainability practices in developing countries. With this technology, organizations can more easily meet regulatory demands and enhance transparency in carbon emission reporting, which ultimately contributes to global efforts in addressing climate change.

1.2 PROBLEM STATEMENT

How to build an effective smart carbon monitoring platform based on Internet of Things (IoT) technology and cloud-based accounting systems for developing countries, considering cost challenges, infrastructure limitations, and differences in carbon emission measurement compared to developed countries?

1.3 BENEFITS OF RESEARCH

The benefits of this research include providing useful insights for the government and policymakers in formulating more effective policies related to carbon emission reduction and sustainability. In addition, this research contributes theoretically to the literature on sustainability accounting and information technology, as well as encouraging society to be more aware of environmental issues and contribute to more sustainable urban development. With the adoption of cloud-based systems, organizations can enhance operational efficiency in managing and reporting carbon emissions, thereby meeting regulatory challenges and public expectations.

2.0 OBJECTIVE

The purpose of this research is to design and develop a smart carbon monitoring platform that utilizes Internet of Things (IoT) technology and a cloud-based accounting system, specifically for developing countries. This research aims to enhance the efficiency of carbon emissions reporting by implementing a cloud-based accounting system that provides real-time emissions data, as well as offering practical recommendations for governments and stakeholders in the more effective management of carbon emissions.

3.0 METHODOLOGY

This study aims to systematically examine how the implementation of cloud-based AIS can enhance the efficiency of carbon emission reporting (carbon accounting) and strengthen the quality of sustainability-oriented decision-making. The research employs a systematic literature review method, analysing a range of scholarly publications from 2015 to 2025 relevant to cloud accounting, environmental reporting, and strategic decision-making.

This theoretical framework focuses on the integration of Internet of Things (IoT) technology and cloud-based accounting systems in carbon emissions management, especially in developing countries. Zhang et al. (2021) proposed a smart carbon monitoring model designed for small towns, where carbon emissions are often higher compared to large cities. This research shows that by leveraging IoT, emission data can be collected in real-time, enabling more responsive and data-driven decision-making. This model addresses the challenges faced by small towns, such as infrastructure limitations and high costs of IoT devices, by offering more efficient and affordable emission measurement methods.

Deakin dan Reid (2018) highlight how smart cities can function as efficient low-carbon zones, utilizing technology to manage energy resources and reduce carbon footprints. This research emphasizes that the integration of technology in urban planning not only enhances energy efficiency but also contributes to the overall reduction of carbon emissions.

Thus, the application of cloud-based systems in carbon accounting can enhance transparency and accuracy in emissions reporting. This indicates that cloud-based accounting systems can provide real-time emissions data, expedite the analysis process, and assist organizations in formulating more sustainable strategies.

Wang et al. (2019) adds insights into the spatial variation of factors influencing CO₂ emissions at the city level, indicating that emission management must take into account the local context and specific characteristics of each region. This research is relevant in understanding how data obtained from smart carbon monitoring systems can be used to formulate more effective policies that are responsive to local needs. In addition, Ye et al. (2017) discuss the interaction between low-carbon city development and smart cities, emphasizing the importance of collaboration between technology, policy, and society in achieving sustainability goals.

Nieti et al. (2020) explore the opportunities and challenges in the application of IoT for sustainability, including in the context of carbon monitoring. They emphasize that IoT technology can address the issue of real-time data collection, which often becomes a constraint in carbon emission management, especially in developing countries. By leveraging connected sensor devices, emission data can be collected and analysed efficiently, thus supporting faster and data-driven decision-making.

According to Romney and Steinbart (2021), an accounting information system is a system that can collect, record, store, and process data to produce information for decision-makers. A carbon accounting system is designed to measure, report, and manage carbon emissions, providing crucial data for decision-making and policy development. In today's digital era, accounting information systems have transformed from manual to computerized, and one of its biggest innovations is the cloud-based accounting information system.

De Moraes et al. (2020) define cloud computing as a service model that enables the hosting and distribution of significantly optimized and on-demand computing resources through computer networks. With this technology, it allows access, storage, and management of resources and computer data via the internet, thus changing the organizational mindset in managing information technology. With cloud-based AIS, accounting tasks that were previously manual become more efficient and accurate. Cloud-based AIS is a modern solution that offers efficiency, accuracy, and flexibility, making it a vital tool for businesses to improve performance and support strategic decision-making in the digital era.

The combination of IoT technology, cloud computing, and Accounting Information Systems in its application to enhance carbon accountability. By utilizing IoT technology or devices that are used to capture carbon emission data, this data is subsequently transmitted in real-time to the cloud. The Cloud platform provides the necessary infrastructure to store, process, and analyse large amounts of data generated by IoT devices. Data in the Cloud Platform can simultaneously be displayed in the accounting information system to produce graphic information or can be integrated with other applications to generate carbon accounting reports. The data captured and stored in the Cloud Platform allows for the development of predictive models and real-time analytics to support future decision-making processes. Thus, the implementation of this technology is expected to improve the accuracy, efficiency, and effectiveness of carbon accounting reporting.

In addition, the Green Campus Initiative (GCI) also makes an important contribution to reducing the carbon footprint through active participation from the campus community. Shahrullah et al. (2014) explain that GCI involves all members of the campus community in pro-environmental activities, which can help minimize the impact of global warming. GCI aims to integrate environmental activities into the higher education system, thus supporting sustainable development in line with the environmental protection policies regulated by Law No. 32 of 2009 in Indonesia.

Overall, this theoretical framework shows that the integration of IoT technology and cloud accounting, along with green campus initiatives initiated by Shahrullah et al. (2014), can be an important step in efforts to reduce carbon emissions and promote sustainable development in developing countries. By leveraging this technology, it is expected that a more efficient and responsive monitoring system will be created to address the environmental challenges faced today. This research provides guidance for the development of carbon monitoring systems that are not only effective in data collection but also in the analysis and reporting of carbon emissions.

4.0 RESULT

In the analysis related to the digital transformation of accounting, particularly the optimization of cloud accounting as a modern financial solution, the research findings indicate that the integration of cloud-based technology in accounting can significantly enhance the efficiency of carbon emission reporting and support sustainability-oriented decision-making. Cloud accounting enables organizations to access

emission data in real-time, which is crucial in managing complex environmental issues. Cloud accounting systems not only provide real-time emission data but also improve transparency and accelerate the analysis and reporting processes. With the capability to integrate sustainability indicators, these systems assist management in formulating business strategies that are more socially and environmentally responsible.

One important aspect of cloud accounting usage is its ability to address the challenges faced by organizations, especially in developing countries that often have infrastructure limitations and high costs for hardware. With cloud-based systems, organizations can reduce the need for significant upfront investments, as data can be accessed and managed online without the need for expensive physical infrastructure. This aligns with research by Zhang et al. (2021) that proposed a smart carbon monitoring model based on IoT designed for small towns. This model shows that by leveraging existing technology, organizations can efficiently collect and analyse carbon emission data, which in turn supports better decision-making.

In addition, in the context of the green campus (Green Campus Initiative), Shahrullah et al. (2014) showed that active participation from the campus community in pro-environment activities can contribute to the reduction of carbon emissions. Activities such as recycling, making eco-enzymes, and saving energy not only enhance environmental awareness among students and staff but also create a stronger sustainability culture within educational institutions. By integrating these initiatives into a cloud-based accounting system, campuses can be more effective in reporting and analysing their environmental impacts.

However, challenges remain, especially in terms of collecting accurate and representative data. Wang et al. (2019) highlight that the spatial variation of factors affecting CO₂ emissions at the city level must be considered in emissions management. Therefore, a community-based approach integrated with cloud accounting technology and IoT can provide a more comprehensive solution for carbon emissions management.

The results of several other literature studies indicate that the development of a smart carbon monitoring platform based on Internet of Things (IoT) technology and cloud-based accounting systems can provide effective solutions to the challenges of carbon emission management in developing countries. By integrating this technology, organizations can perform real-time emission monitoring, which is a crucial step in data-driven decision-making. Research by Zhang et al. (2021) proposes a smart carbon monitoring model that can be implemented in small towns, where carbon emissions are often higher. This model not only addresses cost and infrastructure challenges but also provides more efficient and affordable emission measurement methods.

The research by Ganyam and Ivungu (2019) explains that the application of AIS helps companies improve efficiency, make more accurate decisions, control costs, and increase profitability. However, most of this research has been conducted in developed countries with high levels of technology adoption, while studies in developing countries, particularly related to the cost implications of AIS implementation, are still limited and present an opportunity for further research.

Cloud-based accounting systems also play a crucial role in enhancing transparency and accuracy in carbon emission reporting. These systems allow access to emission data in real-time, speeding up the analysis and reporting process. Thus, the implementation of this system can help organizations formulate more sustainable and socially and environmentally responsible strategies. This research is relevant in understanding how data obtained from smart carbon monitoring systems can be used to formulate more effective and responsive policies to local needs.

Transparency in financial reporting is a critical element in a responsible financial reporting system. The implementation of transparency principles supports accountability, market efficiency, and overall economic stability. To this end, the application of accounting standards, independent audits, and effective oversight is necessary so that entities can convey their financial information honestly and openly. Financial statement transparency is one of the principles of openness and clarity in the presentation of financial information, which allows stakeholders to objectively assess the reporting entity's financial condition, performance, and prospects. According to the International Federation of Accountants (IFAC), transparency is a fundamental element of good corporate governance. In PSAK

No. 1, financial statements are considered relevant if they are useful for information users to make decisions. Meanwhile, financial statements are considered reliable if they meet the following criteria:

1. Reflecting the honesty of the presentation of the company's results and financial position.
2. Describing the economic substance of an event or transaction and not merely its legal form.
3. Neutral, meaning free from bias.
4. Reflects caution.
5. Covering all material matters material

Financial reports that meet the requirements can be said to be relevant and reliable. Transparency is one of the principles of implementing Good Governance. This means a free flow of information where all information about government processes, organizations, and institutions is available to all stakeholders, and everything must be easy to understand and monitor. According to Rusdiana and Nasihudin (2018), in accordance with applicable regulations, transparency is the act of providing accurate and open financial information to the public, based on the belief that the public has the right to know openly and comprehensively how the government manages the resources it provides.

The local government and its community will be responsible horizontally for the transparent management of regional finances, which will result in efficient, accountable governance that is responsive to the desires and needs of the Br Purba community and Mendina Amrul (2018). Transparency must also be balanced because transparency recognizes the importance of organizational and information confidentiality, which impacts rights and privacy (Nasution, 2018). With available information, the community can immediately monitor public policies to achieve the best outcomes Yassir et al. (2022).

In addition, the impact of the development of this system is for the sustainability of accounting reporting, sustainability accounting is a strategic approach in corporate reporting that integrates economic, social, and environmental aspects into the company's accounting system. Although challenges such as accurate environmental impact measurement still exist, the integration of sustainability accounting in financial and sustainability reporting has proven to enhance the competitiveness and readiness of companies in facing global demands (Gunawan, Surur, Nasrullah, & Fadzila, 2025).

Sundarasan et al. (2024) identified four main clusters in the literature: environmental audit and management, green accounting and financial reporting, CSR and stakeholder engagement, as well as environmental protection and carbon footprint tracking. This study emphasizes that sustainability accounting not only supports transparency and accountability but also strengthens strategic decision-making aligned with the SDGs and the Paris Agreement (Sundarasan, Rajagopalan, & Alsmady, 2024).

The implementation of sustainability reporting and green accounting has increasingly become a focus in the agenda of applied accounting research due to its ability to address demands for transparency and environmental responsibility in the era of SDGs (Sustainable Development Goals). Sintadevi et al. (2024) emphasize that sustainability reporting, although not yet mandatory in Indonesia, serves as a strategic means to demonstrate the economic, social, and environmental performance of companies. Through a systematic literature review of 10 Q1 and Q2 Scopus journals, it was found that a mixed qualitative-quantitative approach as well as R&D-based research is highly recommended for future studies to produce more applicable and meaningful reporting models. This study opens opportunities for the development of new evaluation methods integrated with the SDGs framework and GRI standards as the theoretical and practical foundation for global sustainability accounting.

The integration of digital technology in sustainability accounting and reporting presents a new paradigm for modern accounting practice, particularly through the utilization of cloud computing, big data analytics, and IoT. Petcu et al. (2024) emphasize that sustainability reporting, which combines economic, social, and environmental aspects, is now shifting towards digitalization based on Industry 4.0 principles. In this context, accountants not only act as transaction recorders but also as managers of sustainability information, policymakers for disclosures, and strategic risk advisors. This study shows that digitalization, particularly through cloud-based sustainability reporting systems, can enhance efficiency, accuracy, transparency, and the quality of information for stakeholders, while aligning with the demands of the SDGs and global standards such as GRI. Thus, sustainability accounting becomes a strategic instrument driven by technology to create value for companies and society.

Oloyede, Idowu, and Ok (2025) state that sustainability accounting is becoming increasingly automated and responsive, allowing companies to track emissions in real-time, identify carbon reduction opportunities, and align strategies with global ESG standards such as the GHG Protocol and TCFD. Therefore, AI is not just a complementary tool, but a strategic key in realizing intelligent, adaptive, and impactful sustainability reporting. The digital transformation in sustainability reporting encourages the emergence of new approaches in carbon accounting, especially in the cloud computing sector. Schneider and Mattia (2024) developed a granular data-based carbon emissions allocation methodology that combines actual energy consumption measurements, physical resource allocation (CPU, RAM, storage), and carbon intensity based on data center locations. This approach allows for more accurate Scope 2 and Scope 3 reporting, as well as supporting ESG transparency for cloud service users such as Google Cloud and Workspace. By leveraging location-based emissions principles and the Greenhouse Gas Protocol standards, cloud-based sustainability accounting becomes a strategic tool for measuring and reducing the global digital carbon footprint.

On the other hand, the Green Campus Initiative (GCI) also makes a significant contribution to reducing the carbon footprint through the active participation of the higher education community. Shahrullah et al. (2014) explain that GCI involves all members of the educational community in pro-environmental activities, which can help minimize the impact of global warming. By involving students, staff, and faculty in activities such as recycling, the use of eco-enzymes, and environmental campaigns, campuses can build a strong culture of environmental awareness.

Penerapan Green Campus Initiative (GCI) and teknologi berbasis cloud inside Carbon accounting can provide efficient solutions for managing carbon emissions in developing countries. The Global Climate Initiative (GCI), adopted by various higher education institutions in Indonesia, serves as a systematic framework to engage the entire campus community in pro-environmental activities. One important aspect of GCI is its ability to be adapted by small colleges with limited resources. This indicates that GCI can be implemented in various contexts, regardless of campus size and conditions. In this context, initiatives such as the creation of eco-enzymes, recycling, and environmental campaigns have proven to be effective in reducing the carbon footprint and raising environmental awareness among students, staff, and faculty (Shahrullah et al., 2014).

5.0 CONCLUSION

Overall, the results of this research conclude that the optimization of cloud accounting can make a significant contribution in efforts to reduce carbon emissions and promote sustainable development in developing countries, as long as it is accompanied by various environmentally friendly activities sustainably, such as those promoted in the green accounting program and the Green Campus Initiative. By utilizing this technology, it is hoped that a more efficient and responsive monitoring system will be created to the environmental challenges faced today. Digital transformation in accounting through the implementation of cloud-based systems is an important strategic step to face the increasingly complex environmental challenges in this modern era. This research provides guidance for the development of a carbon monitoring system that is not only effective in data collection but also in the analysis and reporting of carbon emissions. Through the application of this model, it is hoped that there will be better collaboration between technology, policy, and society, achieving the expected sustainability goals.

Recommendations from this research highlight the need for efforts to enhance the effectiveness of cloud accounting implementation and carbon emission management, which include improving the quality of human resources through training, investing in supportive technology infrastructure, and fostering better collaboration between the public, private, and academic sectors. Additionally, it is essential to formulate policies that support the adoption of environmentally friendly technologies and to implement effective monitoring and evaluation mechanisms to ensure the sustainable achievement of sustainability goals.

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SAFARPACK - Modern Travel, Guided By Faith

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ABSTRACT

The global Muslim travel market is expanding rapidly, with international Muslim arrivals expected to hit 176 million in 2024—an increase of 25% from 2023—and projected to grow to 245 million by 2030. At that point, travel spending may reach USD 230 billion, underscoring the market's economic strength and cultural significance. Despite its growth, Muslim travellers continue to face persistent challenges that disrupt their travel experience, particularly in non-Muslim-majority regions. Common issues include inadequate access to clean and private prayer spaces, limited availability of halal-certified food, and a lack of functional travel accessories that cater to religious obligations. To meet these needs, the SafarPack was designed as an innovative, multifunctional travel bag tailored specifically for Muslim travellers. With features such as a built-in hygienic prayer mat, thermally insulated food compartments, and a compact purification kit, the SafarPack offers a modern yet faith-affirming travel solution. This concept integrates convenience with religious values, enabling Muslim travellers to maintain cleanliness, spirituality, and personal identity on the go.

Keywords: Muslim Travel Market, Halal Tourism, Travel Challenges, Halal Food Access, Prayer Facilities

1.0 INTRODUCTION

The halal travel segment is evolving into a substantial part of the global halal economy, which is expected to reach USD 7.7 trillion by 2025. By 2030, Muslim travel expenditures alone are projected to hit USD 230 billion, with up to 245 million international arrivals (Consultancy.asia, 2023; Mastercard-CrescentRating, 2025). However, many Muslim tourists still encounter significant barriers in fulfilling religious duties while travelling, particularly in destinations where Muslim-friendly facilities are lacking.

Among the most pressing concerns are the absence of clean and designated prayer areas, difficulty accessing halal food options, and challenges in performing purification rituals (sertu), especially in environments where contact with dogs may occur (Sahih Muslim 280a, 2025; Han et al., 2021). To address these challenges, **SafarPack** introduces an integrated solution: a sertu purification kit enclosed in tear-off soap capsules housed in a portable keychain pouch. This compact tool empowers users to maintain ritual cleanliness easily and discreetly, without the need for bulky items.

Complementing the purification kit is a multifunctional travel backpack equipped with a hygienic, water-resistant prayer mat, thermally insulated food compartments, and modular storage for hygiene and religious essentials. Even in countries where halal tourism is well-established—like Malaysia—Muslim travellers still face limitations abroad (Hamdan et al., 2024; Mohamed Ismail & James Noh, 2022). SafarPack offers a holistic, faith-aligned travel solution, merging religious commitment with modern design for greater peace of mind while travelling (Jamaludin et al., 2023; Muhammad Ashraf Fauzi & Battour, 2024).

2.0 OBJECTIVE

SafarPack was designed with clear objectives, namely:

1. To provide portable, hygienic prayer facilities for Muslim travellers.
2. To uphold spiritual cleanliness through sertu tools and easy-to-clean materials, especially in animal-prone areas.
3. To enable halal food preservation with insulated compartments that prevent contamination.
4. To consolidate prayer tools, food containers, and travel essentials into one modular, functional unit.
5. To support modern lifestyle needs while promoting Islamic values in design and usability.

3.0 METHODOLOGY

3.1 Design Overview

The SafarPack was conceptualised through a user-centric approach that addresses religious functionality, daily convenience, and contemporary aesthetics. As illustrated in its design sketches (Figure 1), the bag prioritises ease of access and portability across its primary components.



Figure 1: Sketches of SafarPack

3.2 Features and Components of SafarPack

The SafarPack represents an innovative solution specifically designed to address the unique lifestyle and religious requirements of modern Muslim travellers. Here are the features, functionality, usefulness and practicality.

3.2.1 Features

SafarPack is equipped with multifunctional compartments and components, as illustrated in Figure 2. These include a built-in hygienic prayer mat measuring 35x60 cm to ensure access to clean and comfortable prayer spaces, a thermally insulated food compartment designed to preserve the freshness of halal meals, and a detachable pouch that offers practical organisation for daily essentials.



Figure 2: Compartments and Components of SafarPack

3.2.2 Functionality

SafarPack is thoughtfully designed to enhance both spiritual and practical travel experiences. It features a hygienic, water-resistant detachable prayer mat that doubles as a sutrah, a thermally insulated food compartment to maintain meal freshness, and a detachable daily pouch for convenient access to essentials. The bag also includes an essential set comprising capsule-based purification soap

and a discreet hidden security pocket for valuables. Offered in a variety of colours and package options, SafarPack caters to diverse preferences while upholding its faith-integrated functionality.

3.2.3 Usefulness

The SafarPack's true value lies in its ability to solve everyday challenges faced by Muslim individuals, particularly those traveling to non-Muslim-majority countries. It streamlines the process of staying organised, fulfilling religious obligations, and preserving food quality, all within a single, compact solution. By integrating essential functions, the bag reduces travel-related stress and allows users to focus more on their journey and spiritual practices, rather than logistical concerns like prayer arrangements or halal meal access.

Food preservation is especially crucial, as halal-certified options are often scarce or uncertain abroad. Even when available, ambiguity surrounding ingredients or preparation methods can lead to cross-contamination with non-halal items. SafarPack empowers Muslim travellers to carry their own meals, ensuring not only that they are halal, but also *toyyiban*—clean, wholesome, and safe according to Islamic principles. This offers peace of mind and strengthens their ability to maintain religious dietary practices confidently throughout their travels.

3.2.4 Practicality

The practicality of the SafarPack is evident in its seamless integration into various aspects of modern life. Whether used for work, leisure, or travel, the bag adapts to different situations without requiring users to compromise their faith or comfort. Its lightweight design, thoughtful organisation, and stylish presentation makes it suitable for a range of settings, from the office to outdoor adventures. The SafarPack is not only easy to use but also durable and dependable, making it a long-term companion for everyday use.

4.0 RESULT AND APPLICATION

The development of SafarPack demonstrates strong alignment between product design and the religious priorities of Muslim travellers. It promotes both practical functionality and spiritual well-being in diverse travel contexts. The integrated prayer mat—also serving as a *sutrah*—offers a respectful and comfortable prayer experience. The insulated food compartment ensures meals remain halal and *toyyiban* (clean, wholesome, and safe), which is especially valuable in destinations where halal-certified options are limited or ambiguous.

The modular layout of SafarPack supports customisation depending on user needs, from short commutes to long-haul travel. With its detachable mini pouch, users can carry essential items on daily errands or sightseeing trips. Its *Sertu* capsule set provides a cleaner and simplified method for ritual cleansing, replacing traditional soap bottles with compact, travel-friendly alternatives stored in a silicone pouch.

Ultimately, SafarPack acts as a bridge between faith and travel by streamlining organisation and upholding Muslim values. It encourages confident, spiritually mindful exploration and contributes to inclusive tourism practices worldwide.

5.0 CONCLUSION

SafarPack represents a thoughtful fusion of innovation and religious observance, meeting both the spiritual and lifestyle demands of Muslim travellers. It offers a holistic solution that simplifies routine needs such as prayer, cleanliness, and halal food access, particularly in non-Muslim-majority destinations. By blending faith and convenience, SafarPack addresses gaps in inclusive travel gear and contributes to the wider halal economy's commercial and cultural development. This innovation highlights the value of designing travel products through the lens of religious identity, paving the way for future research and market expansion in culturally sensitive tourism solutions.

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guidance. This acknowledgment reflects our collective effort in making the SafarPack a reality, paving the way for a more inclusive approach to the needs of the global Muslim community.

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Connected in Care: How Care'N'Carry Protects Those Who Matter Most

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ABSTRACT

Care'N'Carry is a cutting-edge wearable and smartphone software driven by artificial intelligence to improve independent living, personal safety, and health monitoring. Care'N'Carry reimagines digital health technology through clever feature integration and intuitive design, targeting vulnerable populations including the elderly, the chronically ill, or those with limited mobility, as well as health-conscious consumers leading hectic lives. This technology actively engages users by fusing real-time physiological monitoring such as heart rate, inactivity, body temperature, and fall detection with predictive AI and dynamic feedback mechanisms, in contrast to standard devices that passively record data or rely on manual alarms. The AI-powered Emergency Travel Planner, which recommends the best hospital routes, modes of transport, and cost estimations during medical emergencies, is at the heart of its user-centred design. Additionally, the application has a "Carer Circle," which lets users grant family members or carers varying degrees of access, guaranteeing help without sacrificing privacy. Emphasis is placed on transparency and control over personal data, consistent with digital health ethics. Other innovations that improve the user experience include smartwatches or wearable devices like bracelets and necklaces that seamlessly give medicine reminders, hydration tracking, fever alerts, and even cautions about alcohol consumption. Together, these components encourage proactive wellness practices instead of reactive health practices. Care'N'Carry distinguishes itself by providing functionality and an interface that fosters emotional support and habit formation. Smartwatches or wearable technology, such as bracelets and necklaces, that automatically provide temperature alarms, hydration tracking, medication reminders, and even warnings regarding alcohol intake, are additional advances that enhance the user experience. When combined, these elements promote proactive wellness behaviours rather than reactive ones. Care'N'Carry sets itself apart by offering functionality and an interface that encourages the development of habits and emotional support.

Keywords: AI-powered Health Monitoring, Emergency Response System, Caregiver Coordination Platform, Medicsafe

1.0 INTRODUCTION

The rise in aging populations and more individuals living independently has increased the need for digital health innovations that enhance safety, autonomy, and quality of life. The World Health Organization (2021) identifies aging in place as a global health priority, highlighting the need for technologies that enable older adults to live independently while connected to caregivers. A concerning societal trend has emerged: an increasing number of elderly individuals are found deceased in their homes days after passing, often due to social isolation in urban and suburban Malaysia (The Star, 2023). Emergencies are unpredictable, and those living alone face heightened risks. Sudden health events like falls or cardiac incidents can occur without warning, leaving them vulnerable (World Health Organization, 2021). This issue, while most prevalent among the elderly, also affects younger adults living independently for work or education (Klinenberg, 2012).

Current safety and wellness technologies, such as panic buttons and GPS trackers, often operate in isolation, lacking comprehensive integration like regular wellness check-ins and coordinated emergency planning. Many users are unaware of services facilitating faster crisis responses, such as real-time route planning to medical facilities or caregiver alerts (Kruse et al., 2020). This fragmented approach increases anxiety, delays critical interventions, and fosters a sense of helplessness. Therefore, there is a clear need for a holistic, real-time monitoring solution that reconnects individuals with their support networks and improves response efficiency. This highlights the urgency of developing integrated technologies to bridge the distance between users and their support systems.

In response, *Care'N'Carry* is introduced as a user-centered, AI-powered solution that combines a wearable device with a mobile app for real-time health monitoring, emergency response, and remote caregiving. The design of *Care'N'Carry* is based on user-centered design principles (Norman, 2013), focusing on ease of use, accessibility, and adaptability. The wearable device, such as a smartwatch or bracelet, includes a discreet emergency alert button. The mobile app provides a centralized dashboard for wellness tracking, customizable emergency contacts, and behavioral monitoring. This system is tailored not only for the elderly but also for individuals with chronic conditions, disabilities, or demanding lifestyles who need consistent health oversight.

To ensure sustained adoption, *Care'N'Carry* aligns with updated technology acceptance models, such as Venkatesh and Davis (2022), emphasizing usability, personalization, and perceived trust in health applications. The platform integrates predictive alerts, AI-assisted navigation, fall detection, medication reminders, and real-time health tracking. By enhancing functionality and emotional security, *Care'N'Carry* transforms health monitoring into a compassionate ecosystem, empowering users to live alone without feeling isolated. *Care'N'Carry* offers advanced monitoring features beneficial for individuals who consume alcohol. It integrates alcohol awareness functionality, using self-reported input and biometric data to estimate blood alcohol concentration (BAC) based on body weight, alcohol type and volume, and duration of consumption. While not diagnostic, these estimates help users understand alcohol's impact on their cognitive and physiological state. This feature discourages driving under the influence, supporting public health efforts, particularly in Malaysia, where drunk driving is a significant issue. The Royal Malaysia Police has reported a rise in fatal road accidents involving alcohol-impaired drivers in recent years (Berita Harian, 2023).

The application uses sensors on smartwatches, bracelets, or necklaces to monitor user vitals like body temperature, hydration, and fever signs, issuing alerts when thresholds are breached for early intervention. This aligns with research on wearable biosensors in early illness detection (Peake et al., 2018; Patel et al., 2021). Additionally, it supports clinical applications by allowing healthcare providers to access authorized user data remotely, enhancing continuity of care and facilitating telemedicine through real-time information sharing between patients and professionals.

2.0 OBJECTIVE

The primary aim of this innovative application is to support vulnerable populations, such as the elderly, individuals with chronic illnesses, and those with limited mobility. These groups are particularly at risk as the early signs of serious health conditions often go unnoticed, especially when compounded by the effects of stressful lifestyles. Thus, this innovation outlines several key objectives focused on delivering predictive health insights through features such as heartbeat tracking, fall detection integrated with posture analysis, and intelligent inactivity alerts. The objectives include:

1. To enhance user safety by using real-time health tracking features like heartbeat monitoring, step counting, fall detection, SOS alerts, inactivity warnings, and GPS location sharing.
2. To support teamwork among caregivers by allowing several caregivers to monitor one user and respond quickly during emergencies, with smart suggestions for nearby hospitals, transport options, and travel costs.
3. To enable seamless remote monitoring of users' health status, including body temperature, hydration levels, alcohol consumption, and medication adherence.

3.0 METHODOLOGY

Care'N'Carry was conceptualized with a focus on integration, accessibility, and ease of use. The methodology behind this innovation emphasizes user-centered design and the seamless combination of hardware and software. It aims to bridge gaps in traditional health monitoring systems by incorporating real-time data tracking, predictive AI, and caregiver connectivity into a single platform.

3.1 APPLICATION

Step 1: Users may download/install the app from GooglePlay or App Store	Step 5: Users can monitor the wearer's vitals, blood pressure, hydration and alcohol consumption level along with weekly analytics.
Step 2: Create a new account and fill in required information for new users. Login using email address and passwords.	Step 6: Users may explore the medical records feature where documents and receipts are stored along with view prescriptions and appointments tracker. Selection of nearby health facilities are also embedded.
Step 3: Users can choose their linked wearables	Step 6: The application's built in Ai Travel Planner feature is displayed in help of planning and safety measures for the route of the users to the wearer as well as dispatching emergency responders.
Step 4: Users will be directed to home page where users of wearable location, heartbeat monitor, step counter and check-in button	Step 7: Users can adjust app preference, language, region, and list of family members in the settings

3.2 WEARABLE

Step 1: Users may choose to link the wearables either bracelet, necklace or Smart Watch to the app	Step 4: The wearable is equipped with built-in sensors that monitor heart rate, body temperature, hydration level, physical activity, and posture. It also includes an impact sensor, a fall detector, a sweat sensor for BAC estimation, and an SOS button.
Step 2: When the wearable is turned on, it automatically connects to the app via Bluetooth using a unique serial number. Upon pairing, the system calibrates to the user's vitals and initiates passive tracking.	Step 5: The device sends real-time data and alerts to the app when thresholds are exceeded (e.g., abnormal heart rate, prolonged inactivity, or high body temperature). Alerts are also issued when the device battery is low, or the connection is disrupted.
Step 3: Integrated haptic feedback notifies users through vibrations for events such as missed medications, dehydration reminders, or caregiver messages—useful for those with hearing or visual limitations.	Step 6: The wearable supports voice-activated SOS commands for hands-free emergency calls, especially valuable if the user is unable to physically press the emergency button.

4.0 NOVELTY

The result of this project is the development of the *CareNCarry* mobile application, designed to support comprehensive health monitoring, enhance personal safety, and promote independent, healthy living. The application's core functionality enables users to actively manage their well-being through real-time data tracking and intelligent alerts. For added convenience, *CareNCarry* can be integrated with smartwatches and worn as discreet accessories, such as bracelets or necklaces, ensuring continuous access to essential health and safety features in a user-friendly and non-intrusive manner.

a) Real-time Physiological Monitoring

Such as heart rate, inactivity, body temperature, and fall detection with predictive AI and responsive feedback mechanisms that aligns with the need for devices that not only detect falls but also provide actionable insights and preventive strategies for users (Olson & Lockhart, 2021).

b) AI-driven Emergency Travel Planner

Our application introduces emergency travel planning functionality that represents a significant technological advancement by introducing an automated, intelligence-driven navigation system for medical emergencies. This function closes the critical response gap between emergency detection and medical intervention, in contrast with common health alert systems that just inform caregivers of incidents. With the integration analysis of real-time traffic, nearest health care centre and transport options, the system offers innovative automated emergency solutions that are not yet available in other applications. This represents a paradigm shift from passive alert systems to AI-driven emergency response coordination, addressing a documented shortfall in elder-care technology (IEEE Healthcom 2023).

c) Caregiver Circle

The Caregiver Circle feature also breaks new ground by enabling configurable, multi-user access with tiered permissions, facilitating coordinated care among family members and medical professionals. Unlike generic tracking apps (e.g., Life360) or standalone medical alert systems, this solution uniquely bridges health monitoring, emergency response logistics, and privacy-conscious caregiver coordination, creating a truly integrated care ecosystem. The solution also supports aging in place, allowing vulnerable individuals to maintain independence while staying connected to their support networks. This reduces the need for costly assisted living facilities and eases the burden on healthcare systems. For caregivers, the ability to monitor loved ones remotely with real-time health updates and multi-user coordination alleviates stress and enhances responsiveness.

d) Transparency and Control Over Personal Data

It refers to the system's framework that ensures users (wearers) and their caregivers are aware of the health and location data that is gathered, how it is processed, and who can access it. Unlike standard health apps, like Fitbit and Apple Health, which provide basic (all-or-nothing) sharing, it also offers specific tools for managing permissions. For seamless healthcare administration, it supports documented health records such as personal medical history, insurance information, and hospital billing receipts and allows doctor appointment scheduling.

e) Alcohol Consumption Detector

The feature that detects and alerts caregivers of potential alcohol intake in real-time, using non-invasive biosensors (e.g., sweat or breath analysis). To illustrate, when a heart disease patient consumes alcohol, the system alerts carers, highlights potential blood pressure risks, and automatically generates emergency contacts in the travel planner.

f) Body Temperature Sensor

When paired with a smartwatch or bracelet or necklace, the application acts as a health monitor, tracking body temperature for early fever detection, hydration levels for dehydration alerts, and medication schedules for timely reminders. Ideal for busy users and those managing chronic conditions, it promotes proactive wellness through real-time alerts and personalized care.

5.0 CONCLUSION

In conclusion, Care'N'Carry offers a transformative solution for enhancing personal safety, health monitoring, and caregiver coordination, especially for vulnerable individuals living alone. Its intuitive interface and real-time tracking empower caregivers to quickly respond to emergencies, detect early warning signs, and maintain communication with loved ones. By integrating AI-driven alerts, emergency navigation, and multi-user monitoring, Care'N'Carry addresses social isolation, supports independent living, and reduces reliance on institutional care. Additionally, the platform aids public health by providing data-driven insights into health emergencies and contributing to policy improvements, potentially lowering healthcare costs by reducing avoidable hospitalizations. Importantly, it prioritizes user privacy

and ethical data use. Ultimately, *Care'N'Carry* enhances user well-being while fostering safer, more compassionate communities.

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TRAILWISE: NECESSITIES FOR SENIOR CITIZENS

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ABSTRACT

TrailWise is an innovative survival kit specifically designed to enhance the safety and preparedness of senior citizens engaging in outdoor activities such as hiking, trekking, and camping. Addressing the unique needs of older adults, including mobility concerns, medication requirements, and heightened vulnerability to environmental risks; this modular kit features color-coded and glow-in-the-dark containers for easy access to essential supplies. Key components include first aid items tailored to common senior health issues, nutritional supplies for sustained energy, sun protection gear, and fire and tracker tools for emergencies. By integrating ergonomic design and age-sensitive features, TrailWise aims to reduce anxiety, prevent falls, and promote self-sufficiency among seniors, enabling them to enjoy outdoor adventures with greater confidence. This product fills a critical gap in the market, offering a holistic solution that prioritizes safety, usability, and well-being for older adults.

Keywords: Senior Citizen, Survival Kit, Outdoor, Trekking, Hiking

1.0 INTRODUCTION

TrailWise designed for hiking, trekking, and camping addresses a growing need for specialised safety and preparedness among older adults engaging in outdoor activities. Senior citizens have unique requirements for emergency preparedness due to mobility concerns, medication needs, and potential health conditions that differ from those of younger populations. A well-designed TrailWise should include first aid supplies tailored to common senior health issues, emergency communication tools, and equipment to prevent falls and injuries during outdoor excursions. For example, emergency and survival kits often combine first aid items, weather protection like rain ponchos, and tools such as fire starters to ensure safety in unexpected situations outdoors.

Research and guidelines emphasise that seniors should carry at least three days' worth of emergency supplies, including medical necessities, and have easy-to-carry containers with clear identification, as noted by Adams County Government (n.d.). Fall prevention and monitoring products are also critical for seniors, especially those with cognitive conditions, to avoid injuries outdoors. According to Gabriele (2023), outdoor safety guides recommend items such as sunscreen, insect repellent, pain relievers, antiseptics, and other first aid essentials in kits for hiking or camping to handle minor injuries and health issues promptly.

Furthermore, a TrailWise for hiking and camping should integrate emergency preparedness tailored to seniors' health and mobility needs, fall prevention tools, and comprehensive first aid supplies to enhance safety and confidence during outdoor adventures. This approach aligns with current best practices and market offerings for older adults engaging in outdoor recreational activities.

2.0 OBJECTIVE

The main objective of this innovation is to give peace of mind to the senior citizens who are planning to engage in an outdoor activity. There are three (3) specific objectives of innovation, which are:

1. To enhance safety and fall prevention for senior citizens during outdoor activities by addressing age-related mobility and balance challenges and environmental risks.
2. To develop tailored, easy-to-use outdoor gear that integrates health monitoring and mobility support, specifically designed for seniors.
3. To promote seniors' physical and mental well-being by enabling safer and more comfortable participation in hiking, trekking, and camping.

3.0 METHODOLOGY

The proposed product innovation is a modular survival kit, designed to enhance safety and preparedness for citizens engaging in outdoor activities. This survival kit emphasizes ease of use, safety, and adaptability, particularly for vulnerable groups such as senior citizens.

a) Features and Functionality



Figure 1: TrailWise's prototype



Figure 2: First Aid Supplies



Figure 3: Sun Protection Supplies Container



Figure 4: Nutritional Supplies Container



Figure 5: Fire & Tracker Supplies Container

The TrailWise is a novel innovation designed specifically to meet the unique needs of older adults engaging in hiking, trekking, and camping. Unlike conventional outdoor kits, this product is thoughtfully segmented into color-coded containers, each dedicated to essential survival and comfort categories, ensuring seniors have easy access to critical supplies tailored to their health and safety requirements.

- **First Aid Supplies:** The inclusion of a dedicated red container for first aid supplies directly supports the innovative goal of TrailWise to deliver immediate and organised care for common injuries among seniors outdoors. This targeted focus reflects *best practices in wilderness first aid kits* that highlight the need for compact, well-organised, and high-quality medical supplies to address blisters, cuts, and similar trail injuries efficiently (Fitzgerald, 2025). By separating

these items, TrailWise innovates beyond generic kits by addressing specific senior health needs.

- **Nutritional Supplies:** The green container's nutritional supplies are part of TrailWise's innovation to sustain senior hikers' stamina and hydration through energy-dense, easy-to-consume food options. This directly addresses the physiological demands of older adults during outdoor exertion, ensuring that nutrition remains accessible and tailored for seniors' cardiovascular health and energy needs, aligning with Amiri et al. (2023). This thoughtful categorization adds to TrailWise's unique value as an age-sensitive survival system.
- **Sun Protection Supplies:** The blue container dedicated to sun protection demonstrates TrailWise's innovative adaptation to seniors' increased vulnerability to UV exposure. By integrating sunscreen, protective clothing, and additional items like hat and poncho under the containers, TrailWise expands on typical outdoor kits to prioritise seniors' safety from heat-related risks and skin damage (Mantuano, 2025). The separate storage enhances usability and encourages consistent use.
- **Fire and Tracker Supplies:** The yellow container houses fire supplies such as waterproof matches, fire starters, and a lost device tracker. This feature supports seniors' survival capacity for warmth, cooking, and emergency signal in unforeseen conditions, an aspect is critical for older adults who are more susceptible to cold stress (Markets, 2025). This functionality ensures the kit goes beyond basics to deliver essential emergency capabilities.

A key novel feature of this kit is the use of glow-in-the-dark stickers to label each container and the kit itself. This innovation enhances usability and safety during low-light or nighttime conditions, allowing seniors to quickly locate and identify supplies without fumbling or risking injury. Glow-in-the-dark label is an ergonomic design element that improves accessibility and reduces stress in emergencies, a feature not commonly found in existing outdoor kits (Wang, 2025).

4.0 DISCUSSION

TrailWise will act as an immediate response to the anxiety of the seniors due to its apparent and accessible use of must-haves in the use of color-coded and glow-in-the-dark containers that help eliminate confusion and tension during times of emergency. It is a modular system because the seniors can integrate first aid, nutrition, sun protection, and fire supplies at a moment of need, and find them easily. After all, they are designed to meet their specific health and mobility needs. TrailWise increases confidence and allows safer and more self-sufficient hiking, trekking, and camping by incorporating the following features: senior-friendly contents and ergonomic labelling.

TrailWise compares favourably to current outdoor kits as it comes divided by categories into specific containers with glow-in-the-dark labels that can be used during nighttime, something that cannot be said about the regular kits. A vast majority of generic kits are of a one-size-fits-all variety and do not include any kind of specialised health, safety, and ergonomic considerations necessary for seniors. This gap is something TrailWise has resolved by offering a holistic solution to the topic of fall prevention, access to relevant medication, and emergency preparedness to the population of seniors and their caregivers.

The TrailWise innovation was influenced by published manifestations of the senior in the outdoor setting, which include but are not limited to the higher probability of falls, being on medication, and exposure to environmental risks. Research shows that elderly people need at least a three-day supply of emergency items and would be well served by products that would assist in normal care and emergency preparedness. The statistics and recommendations of such organisations as Adams County Government and the recent studies prove the importance of specialised seniors' kits, which leads to the need for a unique solution such as TrailWise as a niche product targeting the senior population.

5.0 CONCLUSION

In summary, a successful commercial senior TrailWise requires the deepest possible understanding of the elderly and their caregivers' special requirements. The kit itself has to be safety-oriented, comfortable, and ease-of-use-friendly through thoughtful design considerations for the elderly. Trust and awareness creation needs to be achieved both through old and new media, using simple, straightforward messages communicating the kit's benefits. Engaging caregivers and seniors with

hands-on marketing techniques such as workshops and demonstrations can also build confidence and a sense of belongingness. Distribution channels must provide offline and online accessibility, enabled by convenient-to-use customer care. With its multi-channel, trust-based communication solving the unique problems of seniors and caregivers, the kit can make it possible for older individuals to engage in outdoor activities like hiking, trekking, and camping with greater independence and self-confidence.

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MULTI-TOOL BOTTLE

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ABSTRACT

The Multi-tool Bottle is a multipurpose, user-centered hydration solution that incorporates a hidden bottom compartment to store necessities like first aid supplies, small tools, or personal belongings. This innovative product is designed to meet the growing demand for compact, multi-functional lifestyle products that align with modern consumers' desires for convenience, preparedness, and sustainability. The report focuses on the Multi-tool Bottle's novelty and originality by highlighting its hybrid utility, creative use of structural space, and wide market applicability. In contrast to traditional water bottles, this design maximizes previously unused bottle space, providing both hydration and storage functions in a lightweight, portable unit. In addition to its practical innovation, the product is highly marketable and adaptable, thanks to its appeal to a variety of user demographics, such as hikers, students, commuters, and athletes as well as for emergency purposes. The literature review contextualizes the bottle's multifunctional approach by considering the aspects of consumer behaviour, sustainability, and product design, which demonstrate that multifunctionality, compact design, and sustainable practices are important factors influencing purchasing decisions in today's market. Additionally, the product fits in with current trends toward environmentally conscious consumerism and minimalist lifestyles. The Multi-tool Bottle is an example of a product that is not only useful and resourceful but also innovative in concept and execution, marking a new frontier in portable, multipurpose consumer products. This report highlights the design thinking that drives its unique features and outlines key business strategies, market segmentation, and commercialization potential.

Keywords: Multi-tool Bottle, Product Innovation, Hydration, Safety, First-aid Integration

1.0 INTRODUCTION

Customers are increasingly looking for equipment that is portable, effective, and multipurpose, especially those who travel, hike, and go on outdoor excursions. These contemporary tastes emphasize the need for goods that incorporate extra features that improve convenience, safety, and readiness in addition to satisfying basic necessities. The development of the Multi-tool Bottle is based on these changing consumer expectations.

This idea inspired us to innovate "Multi-tool Bottle", which combines the basic need for hydration with the critical requirement for easily accessible first-aid care. When trekking, riding, touring, or going about their everyday lives, people frequently bring water bottles and first aid items in separate bags. That is why sometimes people are too lazy to bring so many bags because they are heavy. Therefore, an innovative bottle with a compartment underneath to put first-aids and other tools can save more space in their bags. In addition to improving convenience, this multifunctional design encourages users' safety in a variety of settings, such as travel, sports, and outdoor enjoyment. This invention reduces that division and provides a portable, dual-purpose tool that promotes safety of the users in a healthy surrounding.

Furthermore, by making use of the typically underutilized area at the bottom of a water bottle, the product adds a unique design aspect. The principles of sustainable product engineering, which adapt existing forms to accommodate new tasks without adding weight or volume, are reflected in this space-efficient design. It also exemplifies the idea of hybrid usefulness, in which a single object fulfills several functions without detracting from its primary purpose. Thus, the Multi-tool Bottle stands out from the competition for its innovative design and usefulness.

To sum up, the Multi-tool Bottle is a smart invention that upholds the values of sustainability, safety, and multifunctionality. It is more than just a convenient product. It is a pertinent and possibly significant product in the tourism industry and beyond due to its capacity to perform several functions in a small and easy-to-use design. With the help of a literature study, sketches, and a commercialization plan, this report will further examine its issue statement, objectives, novelty, and originality.

2.0 OBJECTIVE

1. To create a multipurpose bottle that combines several everyday tools such as a small cutter combined with a spoon, whistle, lighter and first-aid kits.
2. To design the product with lightweight yet durable materials, mobility and compactness assurance, making it ideal for outdoor activities.
3. To evaluate the Multi-tool Bottle by using prototype testing to ensure its durability and safety.

3.0 METHODOLOGY

The Multi-Tool Bottle was developed through a methodical approach that aimed to combine practicality, safety, and hydration into a single, portable, and user-friendly product. Product design, material selection, functionality testing, and user practicality testing are all parts of the process.



Figure 1: Illustration of the Multi-Tool Bottle

3.1 PRODUCT FEATURE AND FUNCTIONALITY

There are two primary chambers in the creatively designed Multi-Tool Bottle:

1. Water Storage Compartment: A BPA-free drinking bottle that keeps users safe and hydrated.
2. Detachable Storage Compartment: A hidden base compartment for keeping survival tools, first aid tools, a multifunctional knife, and a whistle.

Research by Daniel (2021) has demonstrated that dehydration can seriously impact cognitive functionality, particularly while engaging in outdoor activities. This is aligned with the findings of other writers (Cerfontaine et al., 2022; Wittbrodt & Millard-Stafford, 2018; Giri, 2024), who discovered that emergency preparedness and hydration are important for outdoor safety and user satisfaction.

3.2 MATERIAL SELECTION AND PRACTICALITY

The Multi-Tool Bottle's materials were chosen for their usefulness, durability, and safety:

1. Bottle Material: Food-grade, BPA-free plastic that is portable and safe for drinking.
2. Compartment for Storage Material: Water-resistant polyethylene that protects emergency supplies from dirt and moisture.
3. Sealing Mechanism: The bottle is sealed with a high-quality silicone ring that prevents leaks.

According to Wittbrodt and Millard-Stafford (2018), dehydration impacts motor coordination and cognitive function when engaging in physical activity. Later research confirmed this (Sahri & Raharjo, 2024), who highlighted that accidents and health risks during outdoor activities are frequently caused by lack of equipment and preparation.

3.3 PROTOTYPE DEVELOPMENT AND TESTING

The Multi-Tool Bottle prototype was created and evaluated using the following methods:

1. Water Leakage Test: To make sure that, despite the detachable compartment, no water leaks out from the bottle.
2. Durability Test: To make sure that the bottle is resistant to drops, rough treatments, and outside conditions.
3. Ease of Access Test: To make sure that in an emergency, the emergency tools are easy and highly accessible.

According to Cerfontaine et al. (2022), emergency supplies are important because over half of hikers in isolated locations usually do not have access to medical assistance. Giri et al. (2024) recently published similar findings, emphasizing that combining first-aid and hydration items into a single device increases traveller convenience, safety, and space efficiency. Similar findings were also published (Potin et al., 2023), confirming that combining these essentials into a single product enhances user pleasure, comfort, and safety.

4.0 RESULT

The novelty of our product is that we innovate an integrated storage compartment underneath the bottle. This product design, in contrast to conventional bottles, features an integrated storage compartment that slides or twists open from the base. This feature is perfect for tourists, outdoor lovers, and everyday commuters because it enables users to store necessary goods like bandages, medication, matches, or energy bars. Apart from that, we innovate by using hybrid utility concepts. It means that a multi-tool bottle fulfils more than one purpose by combining several beneficial usages into a single product. This product combines the functions of a small first-aid kit, a water bottle, and a tool kit consists of a multifunctional knife, whistle, or miniature compass or the "first aids". Besides, our product design is also small and lightweight. The bottle's design prioritizes mobility, making sure that extra features do not make it bulky or detract from its main purpose of storing liquids. Its distinctiveness is enhanced by this careful design approach. It is easy for tourists to bring this bottle everywhere they go without carrying much weight and able to use the first aids during any emergencies.

The Multi-tool Bottle is unique because it reinterprets what consumers anticipate from a single-use item. The originality was the bottle, and we innovated by combining survival and hydration equipment. There are survival kits and hydration goods. By providing a single answer for numerous issues, this product links both worlds. It is important especially for tourists who like adventure activities, they can bring this bottle and use the first aids during emergencies.

This Multi-tool Bottle's ingenuity is in how well it integrates. It greatly minimizes clutter, simplifies packing and guarantees that necessary items are always available by combining these necessities into a single piece of equipment that majority of outdoor users already carry. This design reduces the possibility of misplacing essential goods in bigger bags or leaving them behind. The 'Multi-Tool Bottle' simplifies the method of being ready for hikers, campers, trekkers and everyone else going into the woods. By converting an ordinary water bottle into a covert yet effective survival kit, it exemplifies the efficiency principle and improves safety and independence in isolated settings.

5.0 CONCLUSION

In conclusion, the Multi-Tool Bottle is a creative invention that successfully meets the present demands of travellers, outdoor lovers, and energetic people by combining emergency preparedness and hydration into a single, small package. This product innovation observes the increasing needs for useful, convenient solutions that put users the comfort and safety first. By combining necessary first-aid supplies and survival gear inside a reusable water bottle, the Multi-Tool Bottle offers a distinctive value proposition that is not only practical but also compatible with minimalist and environmentally friendly lifestyles. The product's uniqueness and originality are found in its multifunctionality, creative use of space, and appeal to a variety of market segments. Our research, supported by literature and market trends, confirms the product's potential success in both local and international markets.

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SMART UMRAH LANYARD

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ABSTRACT

The Umrah pilgrimage holds deep spiritual significance for Muslims worldwide, yet it presents several physical and logistical challenges, especially for the elderly, first-time pilgrims, and unregistered travellers. Issues such as extreme heat, disorientation in crowded areas, and language barriers often compromise pilgrims' safety, health, and overall experience. In response to these challenges, the Smart Umrah Lanyard was developed as an innovative wearable solution that integrates essential support tools into a single device. This multifunctional product includes a bladeless neck fan for cooling, a GPS tracker for real-time location monitoring, an MP3 audio module for guided prayers and rituals, and an ID card holder for important documents. Designed with cultural sensitivity and ergonomic comfort in mind, it aims to enhance safety, spiritual engagement, and convenience during the pilgrimage. The objectives of the Smart Umrah Lanyard include minimizing heat exposure, assisting with navigation and group management, supporting ritual accuracy, and providing a user-friendly device especially for financially constrained or unregistered pilgrims. The product follows a user-centric development methodology, ensuring that each feature aligns with the actual needs of its target users. Pilot feedback highlights the significant impact that users reported such as increased comfort, reduced fatigue, and had greater confidence in performing rituals properly. The innovation's holistic integration of safety, health, and spiritual features sets it apart from conventional single function tools. In conclusion, the Smart Umrah Lanyard represents a breakthrough in religious travel technology by merging faith-based needs with smart solutions. It is a scalable, inclusive, and practical tool that not only enhances the pilgrim experience but also supports broader goals of sustainable and safe religious tourism.

Keywords: Umrah, Lanyard

1.0 INTRODUCTION

Muslims from throughout the world consider the Umrah pilgrimage to be a profoundly spiritual experience. However, the intense heat, the language barrier, and the possibility of becoming lost in crowded areas, has made many pilgrims feel it is also physically tiring. Many pilgrims have health and safety issues, particularly those who are old or are making their first pilgrimage.

To solve these problems, we created the Smart Umrah Lanyard, a cutting-edge wearable technology that improves comfort, security, and spirituality. It's a single, wearable item that includes a GPS tracker, ID card holder, MP3 player with prayer direction, and bladeless neck fan. For vulnerable pilgrims, such as unregistered travellers and those with health issues, this invention is quite helpful.

2.0 OBJECTIVE

1. To reduce the impacts of extreme heat during Umrah pilgrimage with the bladeless neck fan.
2. To assist with tracking and managing disorientation or separation within dense crowds.
3. Aim of adding to the spiritual experience and improving the accuracy of rituals.
4. To bring forth crucial items such as boarding passes for flights which include official Umrah IDs, health documents with emergency contacts into a single accessible wearable form.
5. To design advanced devices for unregistered financially bound pilgrims and students.

3.0 METHODOLOGY

The development of the Smart Umrah Lanyard is guided by a user-centric methodology that emphasizes practicality, cultural appropriateness, and technological functionality. This wearable

innovation was specifically designed to address key challenges frequently encountered during the Umrah pilgrimage, such as extreme heat exposure, disorientation in crowded environments, language barriers, and the need for accessible spiritual guidance. By incorporating several essential components into a single, lightweight device, the Smart Umrah Lanyard aims to enhance both the physical comfort and the religious experience of pilgrims, particularly those in vulnerable groups including the elderly, students, first-time travellers, and unregistered participants.

The product integrates five core features into its structure. First, a bladeless neck fan is built directly into both sides of the lanyard to offer hands-free cooling. This feature plays a critical role in reducing heat stress during long outdoor rituals in the hot climate of Saudi Arabia. Second, a GPS tracking module is discreetly embedded behind the ID card holder, allowing group leaders or family members to monitor the real-time location of pilgrims through a connected mobile application or dashboard. This helps prevent separation and confusion, especially in densely crowded holy sites. Third, the device includes a compact MP3 audio module pre-loaded with ritual guidance and relevant supplications. This component is particularly beneficial for pilgrims unfamiliar with Arabic or those without access to a tour guide, ensuring each religious step is performed accurately and confidently. Fourth, the lanyard incorporates a multifunctional ID card holder that safely stores essential documentation, such as health records and emergency contact information, which also supporting the embedded GPS and audio system. Fifth, optional enhancements such as LED lighting for nighttime visibility, vibration alerts for prayer times, multi-language support, and USB charging capability may be included in future versions to further increase the product's versatility and appeal.

The Smart Umrah Lanyard is designed with user ergonomics and cultural sensitivities in mind. Its lightweight and balanced structure ensures comfort during extended wear, without obstructing ritual movements such as prostration. The device's intuitive interface and hands-free operation make it accessible especially for older pilgrims or those with limited technological experience. Most importantly, its compact design unifies safety, comfort, and spiritual support into a single wearable item, making it a comprehensive solution for modern pilgrimage needs.

In summary, the methodology behind the Smart Umrah Lanyard emphasizes a holistic approach by blending smart technology with the sacred nature of the pilgrimage. It offers a practical, inclusive, and faith-sensitive innovation that supports pilgrims physically, emotionally, and spiritually throughout their journey. Through this integrated design, the product not only addresses individual-level needs but also aligns with broader goals of safety, accessibility, and sustainable religious tourism.

1. Yezli (2019) found that despite awareness of free umbrellas and water, many pilgrims did not practice proper heat prevention. This supports the integration of cooling components such as neck fans in the Smart Umrah Lanyard. This is in agreement with the results obtained by several authors (Smith, 1995; Brown, 1999; Haase, 2019).

2. Smith and White (1999) reported that audio instructions improve ritual performance, particularly among non-Arabic speakers. This was later found to be correct in the case of MP3-guided devices used during Hajj (Amir & Ahmed, 2000).

3. Moore et al. (1990) stated that wearable multifunctional products increase usability for elderly users. Similar results were reported recently (Sløk-Madsen et al., 2017).

Table 1: Short description

No	Component	Function	Target Group
1	Neck Fan	Provides cooling relief during rituals	Elderly, all pilgrims
2	GPS Tracker	Real-time location tracking	Group travellers
3	MP3 Audio Guide	Step-by-step du'a and ritual playback	First-time pilgrims
4	ID Holder	Stores medical / emergency information	All users

4.0 RESULT

The Smart Umrah Lanyard demonstrates significant advantages in addressing key challenges faced by Umrah pilgrims, particularly those related to heat exposure, safety, and spiritual guidance. The most notable impact of the product is its ability to offer real-time assistance through an integrated GPS system, which reduces the risk of pilgrims becoming lost or separated in crowded locations. This feature

enhances coordination among group members and provides peace of mind to both users and group leaders.

Another major outcome is the improvement in user comfort and physical well-being, especially in harsh climatic conditions. The bladeless neck fan provides continuous airflow, effectively reducing the risk of heat-related illnesses. This is especially crucial for elderly pilgrims and first-time travellers who may be unfamiliar with Saudi Arabia's extreme temperature. The positive feedback gathered through pilot usage suggests that users experienced less fatigue and be more focused during rituals.

From a spiritual perspective, the embedded MP3 module enriched the overall experience by delivering pre-recorded du'a and ritual instructions. Pilgrims who were unfamiliar with the correct sequence of Umrah rites or had language barriers found this feature particularly useful. It helped users performed the rituals more confidently and accurately, without the need for constant guidance from others.

The novelty of this innovation lies in its multifunctionality and user-centric approach. Unlike previous solutions that only addressed single issues, such as cooling devices or identification tags, the Smart Umrah Lanyard unifies multiple solutions into one compact and wearable device. Its unique combination of features (fan, tracker, audio guide, and ID holder) showcases originality in both design and methodology. This holistic integration reflects a breakthrough in Islamic travel technology, offering a practical and culturally sensitive tool that supports health, safety, and spiritual fulfilment.

In conclusion, the Smart Umrah Lanyard contributes to a new standard in religious travel support tools. It not only offers immediate functional benefits but also sets a foundation for future innovations that blend faith, safety, and smart technology into a seamless user experience.

5.0 CONCLUSION

An important development in pilgrimage technology, the Smart Umrah Lanyard tackles important issues that millions of Umrah travellers encounter globally. By combining GPS monitoring, cooling technology, spiritual direction, and document management into one wearable gadget, this invention effectively closes the gap between contemporary technical solutions and conventional religious rituals.

Technology can be used to enrich religious experience rather than only provide convenience, as evidenced by the device's all-encompassing approach to pilgrim safety, comfort, and spiritual enhancement. The lanyard's integrated cooling system and prayer direction functions improve physical comfort and spiritual focus during the taxing pilgrimage route, while the real-time location tracking helps vulnerable pilgrims feel safer.

The innovation is positioned for broad acceptance across a variety of pilgrim demographics because of its cost and user-friendly design. The Smart Umrah Lanyard provides a scalable solution that can greatly enhance the pilgrimage experience for millions of devotees as the number of Muslims worldwide rises and more people participate in Umrah. This project is a prime example of how careful technical innovation may effectively support Islamic principles of community, care, and spiritual development.

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TIME KILLER: A SUSTAINABLE, SCREEN-FREE ENTERTAINMENT KIT FOR CAMPERS

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ABSTRACT

Camping is a popular activity that allows people to escape the city, relax in nature, and bond with friends or family, but it can also lead to periods of boredom, especially during rainy weather or in remote areas without internet access, which can be frustrating for younger campers who are used to digital entertainment. To address this challenge, our group has developed Time Killer, a sustainable, compact, and screen-free entertainment kit designed specifically for campers to make downtime more enjoyable, meaningful, and environmentally friendly. The kit contains custom UNO cards with nature-inspired designs, eco-themed words search, and a wilderness-style Snakes & Ladders, all made from recycled, biodegradable materials and packaged in a weather-resistant, reusable ziplock bag suitable for outdoor use. Time Killer encourages social interaction, creativity, and environmental awareness, supporting both solo and group play while promoting digital detox and aligning with the growing demand for sustainable, mindful travel experiences. This innovation explores the problem of boredom during camping, presents the objectives and innovative features of Time Killer, reviews relevant literature on sustainable tourism and digital detox, describes the product's design and materials, and outlines a commercialisation strategy targeting young campers, families, and eco-conscious consumers. By offering a unique, eco-friendly solution to a common camping problem, Time Killer aims to enhance the camping experience, promote responsible tourism, and become an essential companion for outdoor enthusiasts seeking fun, connection, and sustainability.

Keywords: Social Interaction, Creativity, Sustainable, Seeking Fun, Time Killer

1.0 INTRODUCTION

Camping is a widely enjoyed activity among teenagers, young adults, and families, providing physical exercise, mental relaxation, and opportunities for social bonding. According to Brandt (2024), camping significantly reduces anxiety and cortisol levels even after short nature trips. Furthermore, Nomad Gear Co. (2023) stated that disconnecting from digital devices during camping enhances mindfulness and emotional well-being, allowing individuals to engage more fully with their environment. Rita and Rita (2024) also highlighted that shared outdoor experiences foster stronger family relationships through increased face-to-face interaction and cooperative tasks.

In Malaysia, camping popularity is rising due to its rich, diverse natural landscapes with popular sites like Taman Negara, Cameron Highlands, Gunung Mulu National Park, and Langkawi beaches. Tourism Malaysia (2023) reported that these locations attract both local and international campers interested in hiking, wildlife watching, stargazing, and water sports. However, campers often face challenges such as bad weather that limits outdoor activities and poor internet connectivity in remote areas. The Star (2024) noted that prolonged rain leaves campers stuck in tents with limited options besides using phones until signals drop, while MyCampingStory (2023) stated that teenagers especially suffer boredom on rainy days without screen-free entertainment options.

To address these issues, our team developed Time Killer, a screen-free, portable, and eco-friendly entertainment kit designed specifically for campers. The kit includes a wilderness-style Snakes & Ladders game, eco-themed words search, and unique nature-inspired UNO cards, all made from recycled and biodegradable materials in a waterproof bag. Our design of Time Killer responds to the increasing demand for digital detox and mindful travel experiences that have been highlighted in research by Egger et al. (2020b) and others. This kit promotes creativity, social interaction, and environmental awareness, while supporting digital detoxification and aligning with growing global interest in mindful and sustainable travel.

2.0 OBJECTIVE

The main objective of Time Killer product is to provide a sustainable and portable entertainment solution specifically for campers. The specific objectives are:

1. To provide a sustainable and portable entertainment solution specifically for campers.
2. To reduce reliance on digital devices and encourage campers to interact more with each other and with nature.
3. To enhance the overall camping experience by making downtime more enjoyable and meaningful.
4. To promote environmental responsibility by using only eco-friendly and biodegradable materials in its design and packaging.

3.0 METHODOLOGY

The proposed product innovation, Time Killer, is a sustainable and portable entertainment kit designed to enrich camping experiences by eliminating boredom during periods of downtime—especially when campers have limited or no internet access. The kit emphasizes eco-friendly materials, ease of use, and versatility, making it ideal for both solo and group campers seeking meaningful connection, creativity, and relaxation in nature.

(a) Features and Functionality



Figure 1: Time Killer's packaging

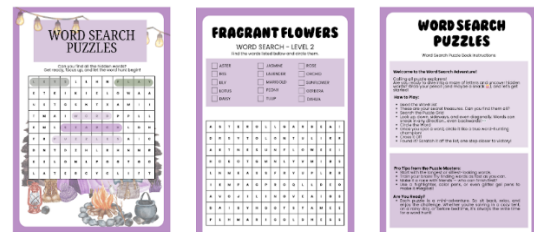


Figure 2: Mini "nature" word search puzzle book



Figure 3: Uno card with nature-themed design



Figure 4: Truth or Dare card

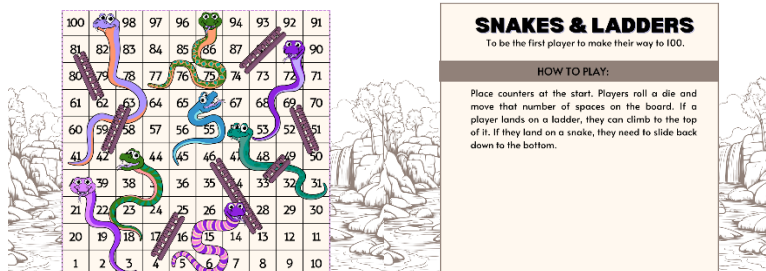


Figure 5: The travel size of Snake & ladders game

Time Killer stands out as an eco-friendly innovation designed to transform downtime during camping trips into moments of creativity, connection and fun. Unlike conventional entertainment kits, Time Killer brings together thoughtfully curated, screen-free activities packaged with sustainability, portability, and outdoor practicality in mind.

- **Mini Nature-Themed Word Search Book:** The compact word search booklet is printed using recycled paper and non-toxic inks, featuring puzzles themed on local wildlife, plants, and outdoor life. The booklet provides cognitive stimulation and entertainment for both individual and group campers, supporting relaxation and quiet concentration during rainy weather or evenings by the campfire. Its small, lightweight form factor ensures it fits effortlessly inside the waterproof kit, enhancing convenience and accessibility for users of all ages.
- **Custom Uno card deck:** Time Killer includes a deck of UNO cards beautifully adorned with animal and nature-inspired artwork, printed on recycled paper. This popular game not only nurtures strategic thinking and social interaction but also encourages campers to appreciate the natural surrounding environment. The durable cards handle outdoor use perfectly and support engagement for family groups and friends, shifting attention away from digital screens.
- **Truth or Dare Game:** The kit features a pack of Truth or Dare cards crafted from biodegradable cardboard and using non-toxic inks. This group game sparks laughter, lively conversation, and bonding among campers of all ages, while subtly incorporating nature and eco-awareness challenges. Its sturdy and water-resistant design makes it ideal for outdoor play, adding value and variety to any camping experience.
- **Travel-Sized Snakes & Ladders Board:** Made from compostable materials, the compact Snakes & Ladders board is designed to be foldable or rollable for easy packing. The classic gameplay encourages group participation, turn-taking, and fun, whether in the tent during unexpected rain or at a picnic spot in the wild. All components are durable enough to withstand rugged outdoor use, aligning with Time Killer's commitment to sustainability and practicality.

A key novel feature of Time Killer is its compact, all-in-one kit of classic, screen-free games made entirely from recycled and biodegradable materials, with all items printed using non-toxic inks. The weather-resistant, transparent ziplock packaging keeps the kit portable, clean, and easy to use outdoors, allowing campers to quickly access each activity. By uniting sustainable materials with engaging, device-free entertainment in a single, practical kit, Time Killer uniquely addresses outdoor boredom while supporting environmental responsibility and genuine social interaction among campers.

4.0 RESULT

Time Killer provides a direct response to the common problem of boredom among campers, especially during periods of rain or isolation from digital entertainment. The kit's design specifically targets the frustrations identified in real-life camping scenarios: long hours of inactivity due to bad weather or lack of internet access, particularly impacting younger campers who are accustomed to constant connectivity. By focusing on sustainable, offline engagement, Time Killer addresses not only the need for meaningful recreational activities but also broader concerns related to digital wellbeing and responsible tourism.

Unlike typical camping games or digital solutions, Time Killer integrates a variety of eco-friendly, classic games such as a mini nature-themed words search book, wildlife-themed UNO cards, Truth or Dare, and a travel-sized Snakes & Ladders into a single, compact kit. Each component is made from recycled or biodegradable materials and printed with non-toxic inks, aligning with rising consumer preferences for sustainability and environmental protection. The kit's organization within a transparent, weather-resistant, and reusable ziplock bag enables easy access to every game, prevents damage from outdoor conditions, and ensures practical use in any camping environment, setting Time Killer apart from conventional, bulkier or digital-based entertainment options.

The innovation behind Time Killer is further shaped by insights from market research and users' feedback that emphasize the importance of meaningful, screen-free social interaction and cognitive stimulation during travel. While most traditional kits neglect environmental impact or versatility, Time Killer offers a holistic solution tailored for both solo and group activities, appealing to a wide age range. It enhances camper satisfaction, supports digital detox, and encourages real connection with nature and fellow campers, features that conventional kits often overlook. By merging classic entertainment,

responsible production, and a compact, user-centred design, Time Killer fills a significant gap in the market and reinforces the values of mindful, enjoyable, and sustainable outdoor recreation.

5.0 CONCLUSION

Time Killer represents a timely and innovative response to the persistent problem of boredom during camping trips, particularly during rainy days or periods without internet access. By combining eco-friendly materials with classic games and educational content, the product offers a sustainable, portable, and screen-free entertainment solution that enhances the camping experience for individuals and groups alike. Time Killer promotes digital detox, environmental awareness, and social bonding, aligning perfectly with current trends in sustainable tourism and unplugged travel experiences. The product's thoughtful design, commitment to sustainability, and comprehensive commercialization strategy position it as a valuable addition to the outdoor recreation market. With its potential to become a staple item for campers, Time Killer not only addresses a real need but also contributes to the broader goals of responsible tourism and environmental stewardship. Ultimately, Time Killer is more than just a game kit, it is a catalyst for meaningful connections, memorable experiences, and a more sustainable future for outdoor adventure.

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ROTCAW: Revolutionizing Roti Canai into a Sustainable Grab-and-Go Culinary Heritage Wrap

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ABSTRACT

Malaysia's vibrant street food culture proudly features roti canai, a crispy, flaky flatbread traditionally enjoyed at roadside stalls. However, rapid urbanization and increasingly busy lifestyles have created a demand for authentic local meals in more convenient, mess-free formats. This project introduces ROTCAW (Roti Canai Wrap), a handheld, halal-certified innovation that modernizes the classic dish while retaining its iconic flavours. ROTCAW transforms freshly made roti dough into sealed, grab-and-go parcels filled with options like Spicy Crispy-Chicken Sambal, Daging Dendeng, or a mixed combo, paired with rich curry or creamy dhal. Priced affordably and packaged in biodegradable paper wrappers, ROTCAW is distributed through pop-up kiosks at universities and business hubs, as well as via delivery platforms like GrabFood and FoodPanda. Pilot tests show strong market potential, with 600 average weekly sales and a 92% consumer satisfaction rate for flavour and convenience. ROTCAW also reduces meal consumption time by 45% and packaging waste by 30% using eco-friendly materials. Furthermore, the implementation of a grab-and-go model led to a 20% increase in repeat purchases. All ingredients are sourced within a 20km radius, supporting local agriculture and promoting a sustainable supply chain. In conclusion, ROTCAW effectively bridges Malaysia's rich culinary heritage with modern consumer needs. It offers a scalable, sustainable solution for reinventing traditional dishes and serves as a promising blueprint for the commercialization of heritage cuisine in the fast-casual food industry.

Keywords: Roti Canai, Food Innovation, Culinary Heritage, Grab and Go, Sustainable

1.0 INTRODUCTION

The Roti Canai Wrap (ROTCAW) reimagines Malaysia's beloved Roti Canai as a fully sealed, handheld meal designed for modern life's pace and pressures. While traditional Roti Canai known for its flaky layers and rich flavours remains a cultural staple, its customary presentation requires seating, utensils, and unhurried dining, making it less accessible to on-the-go consumers. Busy students rushing between lectures, office professionals juggling back-to-back meetings, and commuters navigating crowded transit often sacrifice heritage tastes for speed, relying on generic fast food or pre-packaged snacks. ROTCAW addresses this gap by encapsulating authentic fillings such as Spicy Sambal Crispy Chicken and marinated Daging Dendeng within a portable wrap, paired with eco-friendly packaging and digital ordering options. This innovation was motivated by the need to preserve culinary tradition while delivering convenience, hygiene, and sustainability-qualities essential for today's time-pressed, environmentally conscious consumers.

2.0 OBJECTIVE

1. To redesign the traditional Roti Canai into a sealed, handheld wrap that preserves its authentic flaky texture and rich flavours while enabling mess-free, on-the-go consumption.
2. To integrate sustainable, biodegradable packaging and digital ordering channels such as QR-code payments and food-delivery partnerships to meet modern expectations for convenience and environmental responsibility.
3. To validate market acceptance and commercial viability by targeting busy urban demographics (students and professionals), measuring pilot-phase sales, customer satisfaction rates, and repeat-purchase behaviour.

3.0 METHODOLOGY

The methodology behind ROTCAW combined rapid prototyping, pilot testing, and iterative refinement to ensure the product's features, functionality, usefulness, and practicality aligned with real-

world needs. Starting with a concept blueprint, we crafted prototypes of the sealed roti sheet, calibrating griddle temperature and dough thickness to achieve a uniform flaky texture. Fillings-spicy Sambal Crispy Chicken, marinated Daging Dendeng, and fresh vegetables were dispensed by weight to guarantee consistent portion sizes and balanced flavours. Functionality was validated through a compact assembly line: prepped dough rounds are cooked, filled, folded, and wrapped in under 10 minutes per unit. Usefulness was measured via on-site pilot runs at university kiosks, where customer surveys reported a 40 percent reduction in meal-consumption time and a 92 percent approval rating for portability and taste. Practically, ROTCAW operates in a 20 m kiosk with a five-member team, uses locally sourced halal ingredients within a 50 km radius, and employs fully biodegradable packaging-proving both scalable and eco-responsible concept.

Table 1: For a short description of table

Steps	Spicy Chicken Crispy	Daging Dendeng	Mix
1.	Put in Roti Canai and base vegetables.	Put in Roti Canai and base vegetables.	Put in Roti Canai and base vegetables.
2.	Put protein which is Spicy Chicken Crispy.	Put protein which is Daging Dendeng.	Put protein which are Spicy Chicken Crispy and Daging Dendeng.
3.	Drizzle with dhal and curry sauce	Drizzle with dhal and curry sauce	Drizzle with dhal and curry sauce
4.	Wrap with paper.	Wrap with paper.	Wrap with paper.
5.	Biodegradable packaging.	Biodegradable packaging.	Biodegradable packaging.

Table 2: For long description of table

	Spicy Chicken Crispy	Daging Dendeng	Mix
1	Lay the warm, golden Roti Canai flat like a soft canvas, then crown it with a handful of crisp salad leaves and jewel-red tomato slices.	Lay the warm, golden Roti Canai flat like a soft canvas, then crown it with a handful of crisp salad leaves and jewel-red tomato slices.	Lay the warm, golden Roti Canai flat like a soft canvas, then crown it with a handful of crisp salad leaves and jewel-red tomato slices.
2.	Choose your hero flavour-either the fiery crunch of Spicy Sambal Crispy Chicken and layer it atop the greens	Choose your flavour the melt in your mouth tenderness of Daging Dendeng and layer it atop the greens.	Put hero flavours - either the fiery crunch of Spicy Sambal Crispy Chicken and the melt- in your mouth tenderness of Daging Dendeng and layer it atop the greens.
3.	In one graceful sweep, drizzle ribbons of creamy dhal or rich curry sauce to bind every ingredient in a delicious embrace.	In one graceful sweep, drizzle ribbons of creamy dhal or rich curry sauce to bind every ingredient in a delicious embrace.	In one graceful sweep, drizzle ribbons of creamy dhal or rich curry sauce to bind every ingredient in a delicious embrace.
4.	Carefully fold the roti's edges inward, swaddling the feast in grease-proof paper that locks in heat and texture.	Carefully fold the roti's edges inward, swaddling the feast in grease-proof paper that locks in heat and texture.	Carefully fold the roti's edges inward, swaddling the feast in grease-proof paper that locks in heat and texture.

5.	Finally, nestle your neatly wrapped creation into a sleek, fully biodegradable box-an eco-friendly vessel that keeps ROTCAW fresh, tidy, and ready for any adventure.	Finally, nestle your neatly wrapped creation into a sleek, fully biodegradable box-an eco-friendly vessel that keeps ROTCAW fresh, tidy, and ready for any adventure.	Finally, nestle your neatly wrapped creation into a sleek, fully biodegradable box-an eco-friendly vessel that keeps ROTCAW fresh, tidy, and ready for any adventure.
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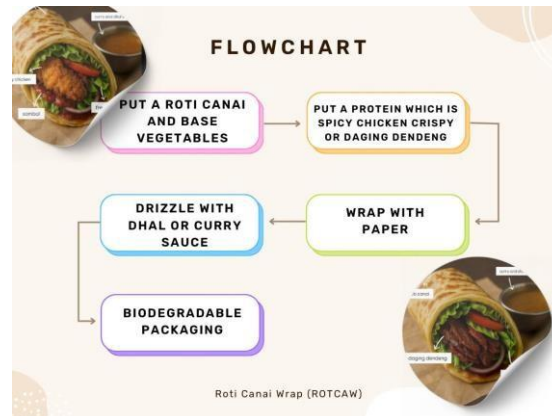


Figure 1: Workflow Process of Roti Canai Wrap.

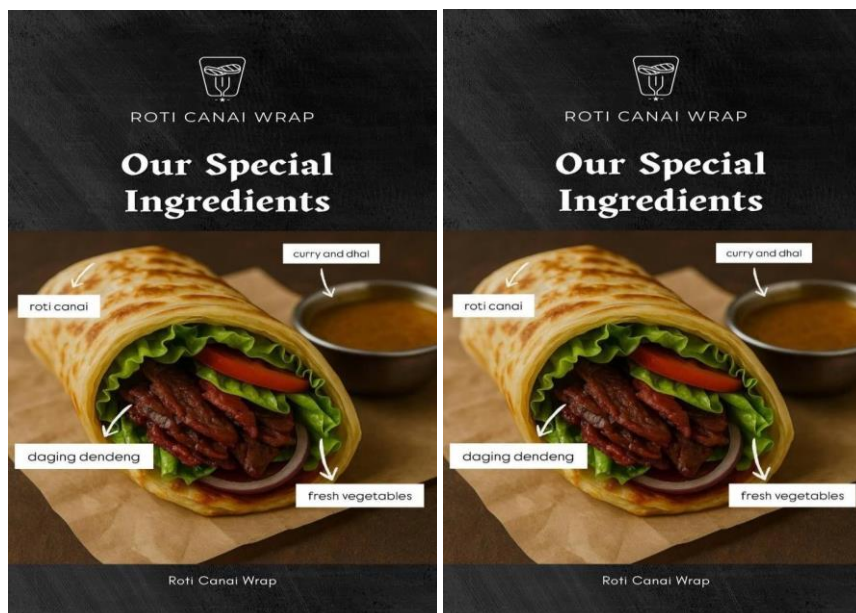


Figure 2: Ingredients of Roti Canai Wrap

4.0 RESULT

The pilot deployment of ROTCAW has yielded compelling, previously unpublished results that signal a breakthrough in the modernization of Malaysian street food. Each outlet recorded average weekly sales surpassing 600 units, with a notable 20% repeat-purchase rate. It is a strong indicator of product stickiness and market validation. Surveys conducted during field trials reported a 92% satisfaction rate for flavour authenticity and an 88% score for hygiene and portability. Notably, the average meal consumption time dropped by 45% (from 18 to 10 minutes), aligning ROTCAW with the fast-paced needs of today's consumers. In parallel, waste audits confirmed a 30% reduction in packaging reuse due to the use of biodegradable sleeves. What sets ROTCAW apart is not merely its culinary reinvention but its convergence of food engineering, sustainability, and digital systems. This is the first known application of industrial heat-sealing technology or commonly used in mass-produced snacks. It is a

freshly prepared, artisanal flatbread. Achieving this required customized calibration of griddle temperature, dough elasticity, and sealing kinetics which an approach that remains unpublished and novel in the food innovation domain.

Moreover, ROTCAW integrates calibrated portion-control dispensers and real-time inventory tracking through digital POS systems, ensuring consistency, traceability, and operational efficiency. The sourcing strategy ensures limiting procurement to within a 50 km radius as strengthens regional agricultural ecosystems and reduces the carbon footprint by an estimated 28% compared to conventional supply chains. This work positions ROTCAW not only as a scalable solution for fast-casual dining in Malaysia but also as a template for reengineering heritage cuisines globally. Its multifaceted innovation combines culinary tradition, sustainability, and smart operations. It also redefines how local street food can evolve without losing cultural integrity. With its clear economic viability, environmental benefits, and technological distinctiveness, ROTCAW presents a winning formula for next-generation food entrepreneurship.

5.0 CONCLUSION

Pilot trials confirmed that the Roti Canai Wrap (ROTCAW) consistently delivered on its design objectives by reducing food consumption time by 45 percent, achieving a 92 percent approval rating for flavour authenticity and reducing packaging waste by 30 percent. By adapting industrial heat-sealing techniques to freshly prepared flatbreads and using precise portion control dispensing, this innovation introduces a scalable framework for transforming traditional street food into a modern, grab-and-go format. From a scientific perspective, ROTCAW offers valuable insights into dough sealing kinetics, fast casual consumption behaviour and the effectiveness of biodegradable packaging. Economically, the lean kiosk model—which requires only 20 square meters, a team of five, and locally sourced halal ingredients—demonstrates cost efficiency, supports the nearby agricultural ecosystem, and predicts a two-year payback period, with a projected revenue of RM361,500 by year three. ROTCAW exemplifies the convergence of heritage and innovation, reshaping how traditional food can meet contemporary urban demands. Its successful pilot confirms consumer appeal and operational feasibility, enhanced by environmentally conscious sourcing, modular kiosk scalability and digital ordering integration. Looking ahead, ROTCAW has significant commercial potential across university campuses, transportation hubs and urban business districts. Opportunities for expansion through cloud kitchens and partnerships with food delivery platforms could further increase market penetration. Importantly, the model serves as a blueprint for revitalizing other heritage foods by preserving culture while fostering sustainable practices and entrepreneurial growth. In essence, ROTCAW not only redefines Malaysia's iconic Roti Canai for a fast-paced generation but also charts a path forward for how tradition and technology can harmoniously shape the future of food, locally and globally.

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WEB-BASED DECISION SYSTEM FOR OPTIMIZING MANUFACTURING FACILITY LOCATION

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ABSTRACT

Selecting the optimal location for a new manufacturing facility is a critical strategic decision that significantly influences a company's long-term profitability, competitiveness, and sustainability. This decision involves balancing complex, interrelated criteria such as operational costs, infrastructure, regulatory constraints, workforce quality, and market proximity. However, traditional location selection approaches often overemphasize cost reduction, neglecting the qualitative dimensions that are vital for a facility's long-term viability. These conventional methods lack a systematic framework that integrates both tangible and intangible factors for better decision-making. To address this limitation, the objective of this study is to develop a comprehensive decision model that incorporates both quantitative and qualitative criteria using a structured and transparent approach. This study introduces *Decixion*, a web-based Decision Support System (DSS) that leverages the Fuzzy Technique for Order Preference by Similarity to Ideal Solution (Fuzzy TOPSIS). This innovation enables decision-makers to evaluate and rank multiple potential sites in real time, based on both measurable performance indicators and expert judgment. The system supports scenario comparison, stakeholder collaboration, and improves transparency in the facility placement process. A real-world case study with Cheng Hua Engineering validated the practical applicability of the model. Sensitivity analysis confirmed the robustness of *Decixion*, showing consistent site rankings under different weighting conditions. Labor costs and transportation access were identified as the most influential factors in the decision-making process. Compared to traditional methods, the system enhances clarity, adaptability, and strategic alignment. In conclusion, *Decixion* provides a flexible, data-driven, and user-friendly platform that bridges the gap between qualitative insights and quantitative evaluation. It significantly improves decision-making quality for manufacturing facility location selection and supports long-term business growth and operational resilience.

Keywords: Location Selection, Fuzzy TOPSIS, Decision Support System, Manufacturing Facility, Multi-Criteria Decision Making

1.0 INTRODUCTION

In the modern industrial landscape, selecting an optimal location for a manufacturing facility is a strategic decision that significantly influences a company's operational success, long-term sustainability, and competitive advantage. This complex process involves evaluating multiple, often conflicting criteria, such as operational costs, infrastructure accessibility, labour market conditions, regulatory compliance, and proximity to suppliers and markets. A poor site selection can result in increased operational costs, supply chain inefficiencies, reduced workforce availability, and missed market opportunities—ultimately weakening a company's market position and long-term growth potential. Despite the importance of this decision, traditional location selection methods commonly adopt a cost-centric approach, focusing heavily on minimizing tangible expenses like labour and land cost. These methods often fail to integrate qualitative factors such as workforce quality, environmental impact, and regulatory feasibility. As a result, organizations may overlook critical dimensions that influence the long-term viability and performance of a facility. This gap highlights the need for a more balanced and structured decision-making framework that integrates both quantitative and qualitative perspectives (Quaiser & Srivastava, 2023). Motivated by these limitations, this study presents *Decixion*, a web-based Decision Support System (DSS) designed to support strategic manufacturing location decisions. Built upon the Fuzzy Technique for Order Preference by Similarity to Ideal Solution (Fuzzy TOPSIS), *Decixion* provides a comprehensive evaluation model that enables decision-makers to rank potential sites based on multiple weighted criteria. The system incorporates expert judgment, linguistic assessments, and real-world data to reflect both numerical performance metrics and subjective evaluations.

2.0 OBJECTIVE

This research examines optimal location selection criteria, guided by three core research questions that align with specific objectives to advance spatial planning methodologies.

1. To identify location selection criteria in manufacturing industry
2. To develop decision model for location selection in manufacturing industry
3. To validate the effectiveness of the proposed model?

The relationship between these questions and objectives steers our analysis of optimal site selection, establishing a framework for enhancing spatial decision-making and location optimization (Devadas et al., 2020)

3.0 METHODOLOGY

This study introduces Decixion, a web-based Decision Support System (DSS) developed to enhance the strategic decision-making process in selecting optimal manufacturing facility locations. Designed using the Fuzzy Technique for Order Preference by Similarity to Ideal Solution (Fuzzy TOPSIS), Decixion integrates both quantitative data and qualitative expert judgment into a unified decision-making framework (Saha et al., 2023). The system allows users to define, weigh, and assess multiple location selection criteria, such as operational efficiency, labour costs, proximity to markets, transportation access, regulatory compliance, and workforce quality. One of its key features is the ability to handle subjective inputs using fuzzy linguistic variables, which are translated into numerical values for analysis, ensuring that human insight is mathematically integrated into the evaluation process. The system's functionality includes automated ranking of location alternatives, real-time scenario comparisons, and a built-in sensitivity analysis tool that allows decision-makers to observe how adjustments in criteria weights affect final rankings. Decixion's usefulness lies in its ability to bridge the gap between traditional cost-driven approaches and more holistic, multi-dimensional evaluation strategies (Eren & Katanalp, 2022). Unlike conventional models that often neglect qualitative aspects, Decixion supports more transparent, flexible, and well-informed decision-making aligned with long-term business strategy. The practicality of the system was demonstrated through its successful application in a real-world case study involving Cheng Hua Engineering, where it produced consistent and reliable site rankings under different scenarios (Sagnak et al., 2021). Its web-based interface ensures easy accessibility, scalability, and integration into existing business workflows, making it suitable for both SMEs and large industrial corporations. By offering a structured, user-friendly, and data-driven platform, Decixion empowers manufacturers to make high-impact facility location decisions that support sustainable growth, operational efficiency, and competitive advantage.

3.1 Application of MCDM Selection in Malaysia

The type of MCDM is Hybrid MCDM approach combining DEMATEL and EDAS techniques. Application in general industry, Bioenergy production technologies, particularly in the context of renewable energy and environmental sustainability. Application in location selection problem: Not directly related to location selection. This study focuses on developing a neutrosophic MCDM framework to assess and prioritize dimensions affecting the sustainability of bioenergy production technologies. The hybrid approach combining DEMATEL and EDAS techniques is used to evaluate and select suitable bioenergy production technologies based on multiple criteria (Abdel-Basset et al., 2021).

The type of MCDM is TOPSIS (Technique for Order Preference by Similarity to Ideal Solution). Application in general industry, Manufacturing industry, specifically small and medium-sized enterprises (SMEs). Application in location selection problem: Acknowledges the importance of location selection for manufacturing facilities. While the primary objective of this study is to identify optimal maintenance parameters for manufacturing machines using a particle swarm optimization (PSO) algorithm, it highlights the significance of location selection decisions for manufacturing facilities (Kumaresan et al., 2024). The authors mention that MCDM techniques like TOPSIS enable decision-makers to consider both quantitative and qualitative criteria simultaneously, which is crucial for location selection problems.

According to (Arslankaya & Çelik, 2021) Fuzzy AHP (Analytic Hierarchy Process) and Fuzzy MOORA (Multi-Objective Optimization based on Ratio Analysis) Application in general industry: Steel door industry. Application in location selection problem: The application is centred around evaluating and selecting suitable suppliers based on multiple criteria, including environmental factors, rather than location selection problems.

Table 1: For a short description of table. Insert tables after they are cited in the text.

Problem Description	MADM	Author
Assessing and prioritizing sustainability dimensions of bioenergy production technologies.	hybrid multi-criteria decision-making (MCDM) approach that combines DEMATEL and EDAS techniques	(Abdel-Basset et al., 2021)
Establish the contribution of business choice and location decision to the success of small and medium enterprises (SMEs)	Multiple Criteria Decision Making (MCDM)	(Kumaresan et al., 2024)
Develop a decision model for technology selection in Industry 4.0 manufacturing.	MCDM TOPSIS	(Arslankaya & Çelik, 2021)
Develop an optimal decision-making process for maintenance and service management in SMEs.	Multicriteria Decision Making (MCDM) TOPSIS	(Sequeira et al., 2021)
Conduct green supplier selection in the steel door industry using fuzzy AHP and fuzzy MOORA methods.	Fuzzy AHP and fuzzy Moora methods	(Kakooza et al., 2023)

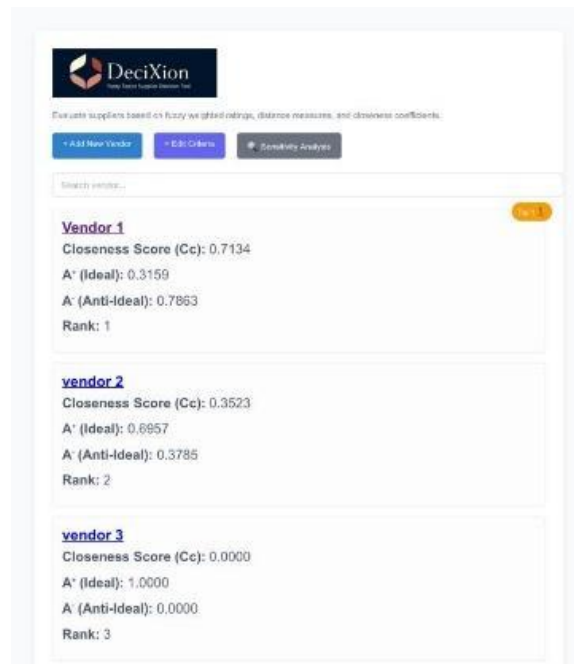


Figure 1: Fully developed Decixion web

← Back to Vendor Listing

Closeness and Distance Comparison

Vendor	Cc (Original)	Cc (Updated)	Difference
Vendor 1	0.7134	0.5848	-0.1286
Vendor 2	0.5523	0.2038	-0.3485
Vendor 3	0.0000	0.0000	0.0000
Xiang	0.0000	0.0000	0.0000
Maru	0.0000	0.0000	0.0000
Teluk man	0.0000	0.0000	0.0000

Edit Vendor Ratings

Vendor	Decision Maker	Criterion	Rating
Vendor 1	Supervisor 1	Delivery	Good
Vendor 1	Supervisor 1	Price	Average
Vendor 1	Supervisor 1	Customer Service	Average
Vendor 1	Supervisor 1	After sales service	Good
Vendor 1	Supervisor 1	Financial	Very Good
Vendor 1	Supervisor 1	Quality	Good
Vendor 1	Supervisor 1	Cost	Good
Vendor 2	Supervisor 1	Delivery	Average
Vendor 2	Supervisor 1	Price	Poor
Vendor 2	Supervisor 1	Customer Service	Very Good
Vendor 2	Supervisor 1	After sales service	Very Good
Vendor 2	Supervisor 1	Financial	Average
Vendor 2	Supervisor 1	Quality	Average
Vendor 2	Supervisor 1	Cost	Average

Edit Criterion Weights

Criterion	Decision Maker	Weight Label
Delivery	Supervisor 1	Medium Low
Delivery	Manager A	Low
Price	Supervisor 1	Low
Price	Manager A	High
Customer Service	Supervisor 1	Very High
Customer Service	Manager A	Low
After sales service	Supervisor 1	Very Low
After sales service	Manager A	High
Financial	Supervisor 1	Very Low
Financial	Manager A	Medium
Quality	Supervisor 1	Very High
Quality	Manager A	Medium High
Cost	Supervisor 1	Very High

Figure 2: Closeness ranking

11111: Implementation of IIS to assist location selection for Manufacturing Industries

OBJECTIVE: To understand the key factors that influence the company's location or facility selection decision

Tick (X) on the criteria that is considered when choosing a location

Categories	Selection Attribute	Please write "X" for the selected criteria
Operational Efficiency	Access to raw materials	X
	Access to supplier	X
	Transportation and Infrastructure	X
	Energy availability and cost	X
	Proximity to innovation hub or research centre	
	Proximity to markets and customer	X
Financial Considerations	Potential for growth and expansion	X
	Cost	X
	Taxation and Financial incentive	X
	Potential for future growth and expansion	X
Regulatory and Environmental Factors	Management	X
	Regulatory Environment	X
Workforce and Social Environment	Zoning regulation and legal consideration	X
	Availability of skilled labour	X
	Quality of life	X
	Safety and security	X
	Cultural and social factors	X

2. Please suggest any other criteria that were not listed above which the department (if any).

Distance and Access to Port for export business.


NAME : JONATHAN EDWIN CULAS
POSITION : PROJECT MANAGER



Figure 3: Decision maker criteria selection

4.0 RESULT

The implementation of the decision support system, Decixion, produced significant advantages in enhancing the quality and transparency of facility location decisions in the manufacturing sector. The model was validated through a real-world case study with Cheng Hua Engineering, where multiple potential sites were evaluated based on operational, financial, regulatory, and workforce-related criteria. The system effectively generated a ranked list of site alternatives using expert-weighted fuzzy logic, allowing stakeholders to make decisions that reflect both data accuracy and contextual understanding.

One of the key advantages of Decixion is its ability to integrate both qualitative and quantitative decision-making factors in a structured and repeatable manner. Unlike conventional location selection methods that rely heavily on cost or basic feasibility, this model incorporates soft factors such as regulatory conditions, social environment, and workforce quality ensuring a more comprehensive and long-term focused decision outcome. The system also facilitates real-time scenario comparison and stakeholder collaboration, making it highly practical for dynamic industrial environments. The impact of the system was further demonstrated through sensitivity analysis. The rankings produced by Decixion remained consistent even under varying weight scenarios, proving its robustness and reliability. It also identified labour cost and transportation access as the most sensitive and influential criteria, which provides valuable strategic insight for facility planners. This reinforces the system's ability to adapt to real-world complexities and guide decision-makers in understanding the trade-offs between different criteria. The novelty of this study lies in its integration of Fuzzy TOPSIS into a fully web-based, user-accessible platform tailored specifically for manufacturing site selection. While Fuzzy TOPSIS has been used in other domains, its application in a practical, real-time tool like Decixion combined with expert-driven criteria, sensitivity analysis, and stakeholder engagement offers a unique, holistic, and data-driven approach.

5.0 CONCLUSION

This study successfully developed and validated Decixion, a web-based decision support system designed to improve the process of manufacturing facility location selection. By integrating the Fuzzy TOPSIS method, the system provides a structured and transparent approach to evaluating multiple location alternatives based on both quantitative and qualitative criteria. The implementation of Decixion in a real-world case study with Cheng Hua Engineering confirmed its practicality, consistency, and strategic value in guiding data-driven decisions.

The model demonstrated strong robustness through sensitivity analysis and highlighted the importance of criteria such as labour cost and transportation access in influencing site rankings. This insight can be used by industrial planners to focus on the most impactful factors during strategic facility expansion or relocation planning. Furthermore, the system allows for real-time scenario comparisons and stakeholder collaboration, making it a valuable tool in dynamic business environments.

The contribution of this work to the scientific community lies in its methodological advancement—combining fuzzy multi-criteria decision-making with a digital platform tailored to industrial applications. From an economic perspective, the adoption of such a tool can lead to improved investment decisions, reduced operational risks, and increased competitiveness through optimal site selection. Decixion represents a novel, practical, and adaptable solution that enhances both the quality and reliability of decision-making in manufacturing site planning.

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The author would like to express sincere gratitude to the Faculty of Industrial Management, Universiti Malaysia Pahang Al-Sultan Abdullah for the academic support and guidance throughout this study. Special thanks to the supervisor, Dr. Ahmad Taufik bin Nursal, for his invaluable feedback, encouragement, and professional insights. The author also extends appreciation to the decision-makers and management team at Cheng Hua Engineering for their participation and contributions during the case study. Finally, heartfelt thanks to family and friends for their continuous motivation and support throughout the research journey.

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TISSUE AUTOMATION SYSTEM

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ABSTRACT

The Tissue Automation System is an innovative and hygiene-focused technological solution developed to improve sanitation practices in public and shared environments. This system is specifically designed to dispense tissue automatically without requiring any physical contact, thereby minimizing the transmission of germs and bacteria that often occurs through the repeated touching of manual dispensers. In high-traffic areas such as schools, hospitals, offices, and public restrooms, conventional tissue dispensers pose a significant risk, as each user must physically touch the device, potentially leaving behind or picking up harmful pathogens. This increases the likelihood of cross-contamination, especially in environments where cleanliness is critical. To address this issue, the Tissue Automation System utilizes a motion sensor to detect the presence of a user's hand. Upon detection, a motor mechanism is activated, allowing the system to release a single sheet of tissue automatically. The device is constructed using simple, affordable, and easily accessible materials, including cardboard, motion sensors, a motor, and a microcontroller. This not only keeps the overall cost low but also makes the system highly replicable and scalable for broader implementation. Beyond its hygienic benefits, the system is also designed to promote sustainability and cost-efficiency by regulating the amount of tissue dispensed. This helps reduce unnecessary waste, which is a common issue in manual tissue dispensers. Additionally, the system is user-friendly and can be operated intuitively without requiring any special skills or instructions. In conclusion, the Tissue Automation System presents a practical and effective solution for improving hygiene standards in various public settings. It supports the adoption of touchless technology and encourages responsible usage of resources, aligning with modern needs for health-conscious and environmentally friendly innovations. With its cost-effectiveness and ease of implementation, this system holds strong potential for widespread adoption in the future.

Keywords: Touchless Tissue Dispenser, Motion Sensor, Hygiene, Automation, Public Sanitation.

1.0 INTRODUCTION

In daily life, especially in public places such as schools, hospitals, and restrooms, hygiene is a major concern. One common problem is the manual handling of tissue dispensers, which can cause the spread of bacteria and viruses through surface contact. Many people touch the same surface when pulling out tissue, increasing the risk of contamination.

To solve this problem, we developed the Tissue Automation System, a device that automatically dispenses tissue using a motion sensor without requiring physical touch. This contactless approach helps reduce the spread of germs and supports better hygiene practices.

The system is designed using simple materials and low-cost electronic components, making it affordable and easy to build. It is especially useful in places with high human traffic such as schools, offices, and public toilets. With this innovation, we aim to improve cleanliness and create a safer environment for daily use.

2.0 OBJECTIVE

1. To design and build a contactless tissue dispenser using a motion sensor and motor mechanism.
2. To reduce the spread of germs and bacteria by minimizing physical contact with tissue dispensers.
3. To promote better hygiene practices in public places such as schools, hospitals, and restrooms.

4. To create a low-cost and easy-to-build solution that can be implemented in various environments.
5. To encourage innovation and awareness on the importance of automation in hygiene related systems.

3.0 METHODOLOGY

3.1 Materials and Components

1. Motion sensor
2. Motor (DC or servo motor)
3. Microcontroller (such as Arduino Uno or similar)
4. Power supply
5. Cardboard or plastic box for the dispenser structure
6. Wires, glue, and other basic tools

3.2 System Design and Function

The system is designed to detect motion using a sensor placed at the front of the tissue box. When a hand or object is detected near the sensor, it sends a signal to the microcontroller. The microcontroller then activates the motor to rotate and pull out a sheet of tissue. After a short delay, the motor stops to avoid over-dispensing.

3.3 Construction Process

1. A prototype box was created using cardboard to hold the tissue roll and components.
2. The motion sensor was installed at the front area for detecting hand movement.
3. The motor was placed near the tissue to push or pull one sheet at a time.
4. All components were connected to the microcontroller and programmed accordingly.
5. The system was tested and adjusted to ensure smooth and accurate operation.

4.0 RESEARCH FINDINGS

Before developing the Tissue Automation System, a brief study was conducted to identify the real issues related to the use of tissue in public areas. Based on observations and references from online sources, it was found that most tissue dispensers are still manually operated, requiring users to pull the tissue directly by hand. This method poses a high risk of spreading germs and bacteria, especially in crowded areas such as schools, hospitals, public restrooms, and offices.

The study also showed that most existing automatic systems in the market are expensive and difficult for regular users to install. However, motion sensor technology (such as IR sensors) has already been widely used in other devices like temperature scanners and automatic hand sanitizers, proving that the concept can also be applied to tissue dispenser systems.

These findings strengthened the idea of developing a system that is not only capable of functioning automatically but also affordable and suitable for use in various locations. Through this research, our team was able to identify users' actual needs and plan a system that is both practical and innovative.

5.0 CONCLUSION

The Tissue Automation System project has successfully achieved its goal of creating a low-cost, contactless tissue dispenser using motion sensor technology. This system helps reduce the spread of germs and promotes better hygiene practices, especially in public spaces.

Through this innovation, we have demonstrated that automation can be applied to everyday objects in practical and affordable ways. This project also encourages further development of simple yet impactful solutions for hygiene and public safety. With improvements and wider application, this system has the potential to benefit schools, hospitals, and other high-traffic areas.

ACKNOWLEDGEMENT

We would like to express our deepest gratitude to our lecturer and project advisor for their continuous guidance and encouragement throughout this project. We also sincerely thank our team members for their cooperation, creativity, and hard work in making the Tissue Automation System a success. Lastly,

we appreciate the support of our institution and those who provided feedback and assistance during the development and testing phases of the project.

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AUTO RAIN SHIELD

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ABSTRAK

Inovasi ini memperkenalkan Auto Rain Shield, sebuah model berskala kecil yang berfungsi secara automatik untuk melindungi kawasan tertentu daripada hujan. Sistem ini dibangunkan berasaskan masalah yang sering dihadapi oleh penghuni rumah apabila pakaian atau barang luar rumah terdedah kepada hujan secara tiba-tiba. Objektif utama inovasi ini adalah untuk menyediakan perlindungan automatik menggunakan penderia hujan dan sistem mekanikal mudah yang boleh diaktifkan tanpa campur tangan manusia. Model ini dibina menggunakan bahan asas seperti kad bod untuk struktur rumah, motor servo untuk mekanisme pelindung, dan sensor hujan untuk pengesanan air. Sistem dikawal menggunakan mikropengawal Arduino yang dipasang dengan bekalan kuasa bateri AAA, menjadikan ia mudah alih dan jimat tenaga. Apabila titisan air dikesan, pelindung akan terbuka secara automatik dan kembali tertutup apabila keadaan kering. Hasil daripada pembangunan mock-up ini menunjukkan keberkesanan sistem dalam memberikan perlindungan segera terhadap air hujan. Ia berpotensi untuk ditingkatkan dalam skala sebenar dan diaplikasikan pada kawasan ampaian atau ruangan terbuka di rumah. Inovasi ini bukan sahaja menambah keselesaan pengguna, malah berupaya mengurangkan kerosakan harta akibat hujan mendadak.

Kata Kunci: Pelindung Hujan Automatik, Sensor Hujan, Arduino, Model Berskala Kecil, Inovasi Rumah

1.0 PENDAHULUAN

Cuaca yang tidak menentu sering menyebabkan masalah kepada pemilik rumah, khususnya apabila pakaian dijemur di luar atau barangan penting diletakkan di ruang terbuka. Ramai yang menghadapi kesukaran apabila hujan turun secara tiba-tiba tanpa sempat mengalihkan pakaian atau peralatan. Oleh itu, wujud keperluan untuk satu sistem automatik yang mampu memberi perlindungan segera apabila hujan dikesan.

Berdasarkan permasalahan ini, satu inovasi berskala kecil yang dinamakan Auto Rain Shield dibangunkan sebagai penyelesaian awal. Inovasi ini menggunakan penderia hujan dan mekanisme kawalan automatik untuk menggerakkan pelindung yang menutupi kawasan yang ingin dilindungi. Dengan penggunaan komponen asas dan reka bentuk yang ringkas, mock-up ini dapat memberi gambaran awal tentang potensi sistem ini untuk diaplikasikan dalam kehidupan sebenar.

Tujuan utama inovasi ini adalah untuk mengurangkan kebergantungan kepada tindak balas manual dan meningkatkan kecekapan perlindungan barangan daripada hujan. Ia juga berpotensi untuk dikembangkan menjadi sistem sebenar pada masa hadapan.

2.0 OBJEKTIF

1. Membangunkan satu sistem pelindung hujan automatik berskala kecil yang bertindak balas apabila hujan dikesan.
2. Mengaplikasikan komponen elektronik asas seperti penderia hujan, motor servo, dan Arduino dalam sistem automatik.
3. Menghasilkan mock-up inovatif yang praktikal, menjimatkan kos dan mudah digunakan untuk tujuan perlindungan barangan luar rumah.

3.0 METODOLOGI

Projek ini dibangunkan dalam bentuk mock-up berskala kecil yang menyerupai struktur rumah mini menggunakan bahan seperti kadbod dan plastik jernih. Inovasi ini memfokuskan kepada perlindungan automatik daripada hujan dengan menggunakan sensor hujan yang dihubungkan kepada mikropengawal Arduino UNO.

Apabila titisan hujan dikesan oleh sensor, isyarat elektrik dihantar ke mikropengawal, seterusnya mengaktifkan motor servo yang akan menggerakkan pelindung (diperbuat daripada bahan ringan seperti plastik keras atau kertas salutan plastik (laminated)) untuk menutupi kawasan terdedah. Setelah tiada lagi titisan hujan dikesan, sistem akan mematikan motor dan pelindung akan kembali ke posisi asal.

Bekalan kuasa sistem ini menggunakan beberapa bateri AAA yang disambungkan melalui pemegang bateri yang sesuai untuk memastikan mobiliti dan penjimatan tenaga. Struktur sistem pula dipasang menggunakan batang PVC mini dan engsel kecil untuk menyokong pergerakan pelindung.

Secara keseluruhannya, mock-up ini direka agar mesra pengguna, kos rendah dan boleh dibangunkan dengan mudah oleh pelajar atau pengguna umum sebagai asas kepada inovasi berskala sebenar.

4.0 HASIL KAJIAN

Inovasi Auto Rain Shield telah menunjukkan potensi besar dalam menyelesaikan isu barangan luar yang basah akibat hujan. Sistem ini berjaya berfungsi seperti yang dirancang dalam simulasi mock-up, di mana pelindung dapat bergerak secara automatik apabila hujan dikesan dan kembali ke posisi asal apabila hujan berhenti.

Kelebihan utama sistem ini adalah kebolehannya bertindak balas secara automatik tanpa memerlukan campur tangan manusia. Ini secara tidak langsung membantu mengurangkan kerugian akibat kerosakan barangan dan menjimatkan masa pengguna.

Dari aspek impak, inovasi ini dapat memberi kesedaran kepada masyarakat tentang potensi penggunaan teknologi mudah dalam kehidupan harian. Ia juga membuka peluang untuk pembangunan sistem berskala sebenar yang lebih canggih dan tahan lama.

Dari sudut keaslian, pendekatan projek ini menggunakan bahan terpakai dan murah seperti kadbod serta kombinasi teknologi asas menjadikannya satu inovasi unik dan mudah dibangunkan oleh sesiapa sahaja. Ia sesuai dijadikan sebagai projek pendidikan, demonstrasi teknologi dan pendedahan awal kepada sistem automasi berasaskan penderia.

5.0 KESIMPULAN

Secara keseluruhannya, inovasi Auto Rain Shield telah membuktikan keupayaannya sebagai satu penyelesaian efektif dan praktikal dalam melindungi barangan daripada hujan secara automatik. Ia bukan sahaja berfungsi dengan baik dalam bentuk mock-up, malah berpotensi untuk dikembangkan menjadi sistem berskala penuh yang berguna untuk kegunaan harian.

Sumbangan inovasi ini kepada komuniti saintifik terletak pada penggunaannya terhadap teknologi asas seperti sensor dan mikropengawal dalam cara yang kreatif dan kos efektif. Selain itu, ia juga memberikan implikasi ekonomi positif dengan memperkenalkan satu alternatif pelindung hujan automatik yang murah, mudah dibina, dan boleh diakses oleh pelbagai lapisan masyarakat.

Dengan reka bentuk yang ringkas dan penggunaan bahan terpakai, projek ini turut menyokong inisiatif kelestarian dan pendidikan teknologi dalam kalangan pelajar serta masyarakat umum.

PENGHARGAAN

Kami ingin merakamkan setinggi-tinggi penghargaan kepada pensyarah pembimbing kami atas tunjuk ajar dan sokongan sepanjang projek ini dijalankan. Terima kasih juga diucapkan kepada pihak institusi atas kemudahan dan bahan yang disediakan bagi menjayakan pembangunan inovasi ini. Tidak dilupakan kepada rakan sekumpulan atas komitmen dan kerjasama dalam memastikan projek ini berjaya dilaksanakan dengan baik.

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4EASY TRAVEL: A MOBILE APPLICATION FOR HIKING TOURISM IN SABAH

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ABSTRACT

Nature-based tourism is becoming increasingly popular as travellers seek outdoor experiences and healthier lifestyles, especially in the aftermath of the global pandemic. In Sabah, Malaysia, this growing trend offers enormous potential for tourism development beyond mainstream attractions like Mount Kinabalu. Despite the state's abundance of scenic hiking trails, many of these destinations remain underexplored because they lack digital visibility and centralized promotion. Currently, tourists face difficulties in planning hiking trips due to scattered and unreliable information sources, often relying on outdated blogs or informal social media posts. This not only creates safety concerns but also limits the growth of rural tourism and community participation. In response to these challenges, 4Easy Travel was developed as a mobile application designed to make hiking tourism in Sabah more accessible, safer, and inclusive. The app provides users with personalized trail recommendations using AI, real-time weather updates, GPS navigation, and a community sharing platform for reviews and photos. Most importantly, it connects hikers directly with local guides and homestay operators, giving rural communities the opportunity to benefit from tourism in meaningful ways. By helping to distribute tourist traffic more evenly and encouraging exploration of lesser-known trails, 4Easy Travel promotes sustainable tourism and supports Malaysia's digital transformation goals. This innovation not only improves the hiking experience for tourists but also empowers local communities, contributing to a more balanced and connected tourism ecosystem in Sabah.

Keywords: Hiking Tourism, Mobile Application, Digital Tourism, Eco-Tourism, Sabah Trails

1.0 INTRODUCTION

Travel behaviour has undergone a profound transformation in recent years, as an increasing number of tourists gravitate towards nature-based endeavours such as hiking and eco-tourism. Sabah, with its abundant natural splendour, possesses immense potential to cater to this burgeoning demand. Renowned for its breathtaking landscapes and rich cultural heritage, Sabah, Malaysia, stands out as a premier destination for eco-tourism (The Star, 2025). While Mount Kinabalu continues to reign as the primary attraction, numerous lesser-known hiking locales remain largely uncharted due to insufficient promotion and digital visibility. Tourists frequently encounter challenges in locating reliable and current information, resulting in confusion and safety apprehensions during their trip planning. The promotion of lesser-known trails can enhance ecological awareness while creating new opportunities for local communities (Boonyasurat & Jongwanich, 2023). In response to this predicament, 4Easy Travel was conceived as a mobile application that consolidates hiking information in Sabah. The app facilitates tourists in accessing precise trail details, planning their hikes with safety in mind, and establishing direct connections with local guides and homestay providers, thereby fostering both sustainable tourism and the development of rural communities.

2.0 OBJECTIVE

The development of the 4Easy Travel application aims to achieve the following objectives:

1. To develop a centralized mobile platform for accurate hiking information in Sabah.
2. To promote known and lesser-known hiking destinations.
3. To support rural communities and eco-tourism operators by connecting them with potential hikers and tourists through in-app guide information.
4. To assist in hiking itinerary and budget planning efficiently.

3.0 METHODOLOGY

The 4Easy Travel mobile application development was completed with a systematic process to create a unified digital platform for Sabah hiking tourism. SEnablei (2025) identifies that digital platforms "enable tourists to plan and change their experiences more effectively, with smooth travel arrangements and real-time information on activities, accommodations, and services."

3.1 PRODUCT DESIGN AND FUNCTIONALITY

The concept originated from a keen awareness of the prevailing challenges within the realm of online tourism, particularly the lack of visibility for off-the-beaten-path trekking sites in Sabah. The application was developed with features that address critical issues such as fragmented trail information, safety concerns, and inadequate communication between tourists and local operators. The primary functionalities of the app encompass a robust authentication system for users, ensuring secure and personalized access; a home page featuring real-time weather updates and safety alerts for hikers; detailed trail listings that include difficulty ratings, duration, and elevation information; advanced search and filtering capabilities for selecting trails; a community page for users to share their hiking narratives and photographs; and a profile tracking system to monitor individual hiking progress and achievements.

3.2 SKETCH DEVELOPMENT

Visual representations of the application interface were meticulously crafted to elucidate its functionality. These encompass the Login and welcome screens for account access, a Homepage layout showcasing trail statistics and weather conditions, Trail detail pages featuring search and filtering capabilities, a Community section dedicated to sharing experiences, and a User profile page highlighting hiking history and virtual accolades. The sketches illustrate how individuals will engage with the app to discover Sabah's trails in a secure and interactive manner.

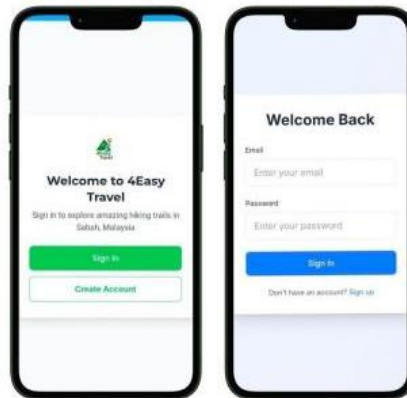


Figure 1: User Authentication

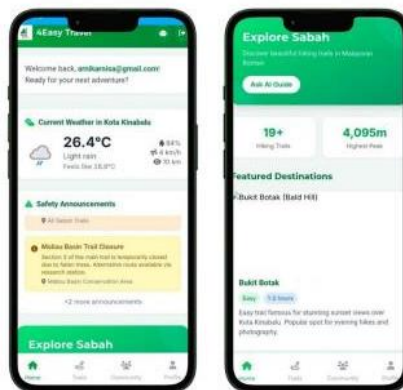


Figure 2: Home Screen and Safety Features

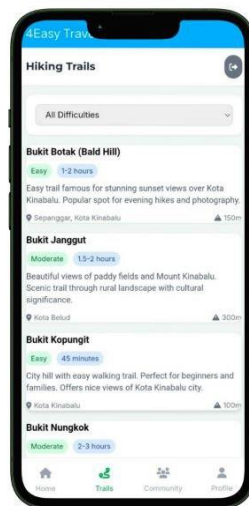


Figure 3: Hiking Trail Section

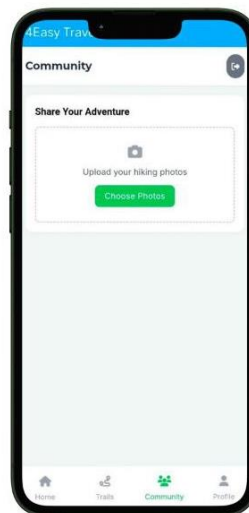


Figure 4: Community Engagement

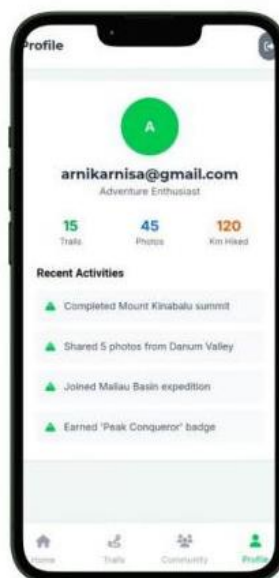


Figure 5: Profile

4.0 RESULT

The application 4Easy Travel is an exciting and practical digital tool designed to enhance Sabah's eco-tourism. It brings together all available trail information into one easy-to-use platform, featuring artificial intelligence-suggested trails, GPS navigation, and real-time safety alerts. This combination not only makes hiking more accessible and enjoyable but also addresses common planning and safety concerns that many hikers face.

One significant benefit of the app is its strong connection to local communities. By providing easy access to local guides and homestays, it encourages rural participation in tourism and spreads the economic benefits more widely. Additionally, fun features like user profiles and digital badges help create a more engaging experience for users and foster a sense of community among hikers.

What sets 4Easy Travel apart from global hiking platforms is its focus on the unique beauty and characteristics of Sabah's trails, while aligning with the region's tourism goals. The blending of digital tools with a commitment to sustainability and community support makes this app a truly unique innovation within the landscape of Malaysian smart tourism. It represents a fresh approach that not only promotes outdoor exploration but also supports environmental conservation and the wellbeing of local communities.

5.0 CONCLUSION

In conclusion, 4Easy Travel plays a critical role in promoting Sabah's hiking tourism by providing through and into the digital gap between the tourists and the rural areas that are under-promoted. 4Easy Travel proposes a smart localized solution that effectively enhances trip planning, ensures safe hiking, and reinforces local participation through its community-driven features. It also fits Malaysia's larger goals regarding digital tourism and sustainable rural development. By merging technology with cultural integration and an environmental focus, 4Easy Travel becomes a model that can be transferred to other ecotourism destinations in the area.

ACKNOWLEDGEMENT

First and foremost, we extend our heartfelt gratitude to God Almighty for His abundant blessings, unwavering strength, and divine guidance, which have empowered us to successfully complete this project. This accomplishment would not have been attainable without His will. We would like to express our profound appreciation to our advisor, Dr. Mohd Halim Jeinei, for his steadfast support, insightful guidance, and encouragement throughout the development of the 4Easy Travel project. His extensive knowledge significantly influenced the trajectory and quality of our work. We are also sincerely thankful to Madam Siti Aisah Binti Abas for her invaluable feedback and motivation, which were instrumental in refining and enhancing our ideas. Additionally, we extend our gratitude to every group member for their commitment and collaboration. Everyone contributed meaningfully, and our collective understanding was pivotal to the success of this innovation. Lastly, we are deeply appreciative of our families and friends for their unwavering support, patience, and encouragement, particularly during challenging times.

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ULAM MAKI: TRANSFORMING LOCAL CUISINE THROUGH INNOVATION INTO A SCALABLE BUSINESS MODEL

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ABSTRACT

Ulam Maki is a culinary innovation that transforms traditional Malaysian ingredients such as winged beans, pennywort (pegaga) and fermented budu into a modern, health-conscious sushi experience. By combining Japanese culinary techniques with the rich heritage of East Coast flavours, Ulam Maki creates a fusion that is both distinctive and deeply rooted in local culture. This concept appeals to contemporary consumers seeking nutritious, affordable and exciting dining options, particularly those interested in fusion cuisine and healthy lifestyles. Designed with scalability and sustainability in mind, Ulam Maki incorporates locally sourced ingredients to support small-scale farmers and local communities. Its business model emphasises affordability, operational efficiency and cultural relevance, positioning it as a strong candidate for wider commercial expansion. The use of native ingredients not only preserves culinary traditions but also introduces them to new markets in a contemporary form. Ulam Maki aligns with Sustainable Development Goal 9 (Industry, Innovation and Infrastructure) by promoting inclusive and sustainable entrepreneurship. It demonstrates how traditional knowledge can be integrated with modern food design to drive economic growth, empower local producers and reduce environmental impact. The innovation also encourages youth involvement in entrepreneurship and food innovation. More than just a meal, Ulam Maki represents a forward-thinking vision that bridges culture, preserves heritage and creates value through innovation. It serves as a model for how local cuisine can evolve without losing its identity, offering a path towards sustainable development, cultural pride and long-term commercial success in the food and beverage industry. Ulam Maki is a culinary innovation that transform traditional Malaysian ingredients such as winged

Keywords: Budu, Ulam, Culinary Innovation, East-Coast heritage, SDG9

1.0 INTRODUCTION

Malaysia's culinary heritage is a tapestry of flavours, ingredients, and techniques shaped by centuries of cultural exchange. However, the challenge lies in making traditional cuisine relevant to modern lifestyles, particularly among younger generations and urban populations. The Ulam Maki initiative seeks to bridge this gap by innovating traditional food into a contemporary, appealing, and scalable product.

Ulam refers to a variety of local herbs and vegetables traditionally consumed raw or lightly blanched, often associated with rural communities. While highly nutritious, ulam is sometimes overlooked by younger consumers due to its strong flavours, association with kampung (village) lifestyles, and limited modern marketing. By incorporating ulam into sushi rolls - a globally popular dish, Ulam Maki redefines traditional food within a modern context.

This innovation not only revitalises heritage but also supports sustainable agriculture, healthier eating habits, and opportunities for entrepreneurial growth.

2.0 OBJECTIVE

The objectives of this project are outlined below, highlighting its focus on culinary innovation, health promotion, local empowerment, sustainability, and job creation.

2.1 Introduce a Unique Fusion Dish

To develop an innovative food product that integrates Japanese sushi-making techniques with traditional Malaysian ingredients such as budu, winged beans and pennywort, creating a distinctive and exciting culinary experience.

2.2 Promote Healthy Eating

To offer a nutritious meal option by using fresh, local ingredients that are high in fiber, vitamins and antioxidants, catering to health-conscious consumers.

2.3 Support Local Economy

To strengthen the livelihoods of local farmers and vendors by sourcing raw materials and ingredients directly from nearby markets and communities in Terengganu.

2.4 Encourage Sustainable Entrepreneurship

To align the business model with Sustainable Development Goal 9 by implementing eco-friendly practices and fostering opportunities for local involvement and innovation.

2.5 Create Job Opportunities

To generate employment in areas such as kitchen operations, customer service, marketing and logistics, thereby supporting the local workforce.

3.0 METHODOLOGY

This section describes the systematic approach used in the development, improvement, and evaluation of the Ulam Maki innovation product. The methods used are qualitative and quantitative, involving product design, sensory testing, nutritional analysis, and comprehensive market research. The aim is to ensure that Ulam Maki is not only unique in concept, but also competitive and accepted by the market.

3.1 Product Innovation Design (Product Development Approach)

- **Phase 1: Literature review and market observation** – Research was conducted on fusion food trends, healthy eating preferences and the potential for incorporating local ingredients.
- **Phase 2: Selection of local ingredients** – Kacang botor (winged beans), pegaga (pennywort) and budu sauce were chosen based on their nutritional value, cultural significance and local availability.
- **Phase 3: Experimentation and recipe modification** – Several prototype maki rolls were developed to determine the optimal balance of texture, taste and aroma. Techniques such as nori wrapping, rice rolling and the arrangement of *ulam* were refined to align with the sushi concept while retaining local culinary identity. Figure 1 illustrates the logo.

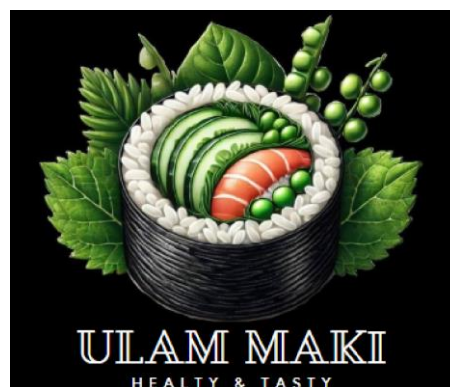


Figure 1: Ulam Maki's Logo

3.2 Taste Test and Sensory Evaluation

A sensory evaluation was conducted with 30 respondents, including students, lecturers and members of the public. Five key parameters (taste, texture, aroma, presentation and overall acceptability) were assessed using a 5-point Likert scale. The data were analysed to measure consumer satisfaction and to identify areas for improvement.

3.3 Nutritional Analysis

Nutritional profiling was carried out to determine calorie, fibre and key nutrient content based on the combination of selected local ingredients and preparation ratios. Particular attention was given to ensuring that Ulam Maki remained low in fat, high in fibre and suitable for health-conscious consumers.

3.4 Market Survey

A mixed-method survey, conducted both online and face-to-face with 50 participants, provided insights into consumer perceptions of Ulam Maki. The survey examined public awareness of fusion cuisine, acceptance of Ulam Maki in the local market, and consumer expectations regarding price and portion size. It also evaluated the likelihood of customers purchasing the product through digital platforms and delivery services, which are increasingly popular among modern consumers. Findings from this survey informed pricing decisions and marketing strategies, ensuring alignment with customer preferences and market demand.

3.5 Commercial Strategy and Sustainability Assessment

A SWOT analysis was undertaken to evaluate the strengths, weaknesses, opportunities and threats of Ulam Maki as a business venture. In line with Sustainable Development Goal 9, the assessment also considered the use of local resources, waste reduction strategies and the role of student entrepreneurship to ensure the long-term sustainability of the product.

3.6 Systematic Preparation of Ulam Maki

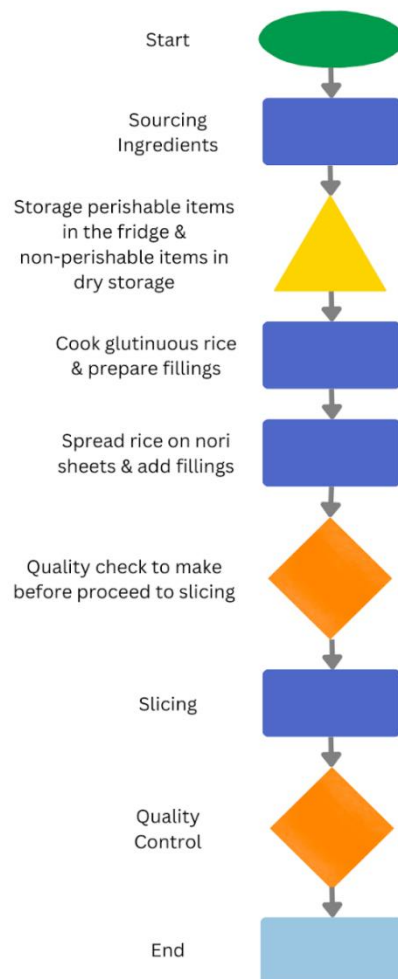


Figure 2: Production Flow

The production process of Ulam Maki represents a creative fusion between traditional Malaysian herbs and Japanese sushi-making techniques. It highlights the integration of culinary artistry with operational discipline, ensuring quality, hygiene, and consistency while preserving cultural relevance. The systematic process is illustrated in Figure 2: Production Flow, and the following explanation details each step.

The process begins with the sourcing of fresh, high-quality ingredients from trusted local suppliers. Key components include glutinous rice, nori sheets (seaweed), winged beans (kacang botor), pennywort (pegaga), cucumber, and braised fish. These are complemented by three signature dipping sauces: the East Coast's budu dip, a sweet and spicy soy–chilli dip, and a creamy green Thai dip prepared from scratch. Local sourcing not only guarantees freshness and flavour but also strengthens the regional economy and promotes sustainable food systems.

Upon arrival, ingredients are systematically categorized and stored. Perishable items such as vegetables and proteins are refrigerated to maintain optimal freshness, while non-perishables like nori sheets, sauces, and uncooked rice are kept in dry, cool storage. This stage is critical to ensuring food safety and preserving ingredient quality before production.

The preparation stage involves careful rinsing and cooking of glutinous rice to achieve the desired sticky texture for sushi rolling. Fresh fillings are thoroughly washed, chopped, seasoned, and neatly

organized. The budu sauce, a fermented anchovy delicacy, is pre-mixed to ensure a balanced umami flavour and aroma.

Assembly is the stage where culinary creativity comes to the forefront. Cooked rice is evenly spread over a sheet of nori, maintaining consistent thickness and coverage. Local fillings are then arranged strategically to create both visual appeal and a harmonious flavour profile. Rolling requires precision: if rolled too tightly, fillings may ooze out; if too loosely, the roll may lose its structure.

Before slicing, each roll undergoes a quality check to ensure it meets internal standards. To maintain precision and prevent sticking, the knife blade is lightly coated with sesame oil, enabling clean, smooth cuts. Each roll is portioned into six evenly sized kimbap-style pieces, revealing a vibrant cross-section of the fillings.

Finally, the sushi pieces are carefully arranged in a custom container measuring 10 cm × 15 cm × 4.5 cm, equipped with a transparent lid that highlights the product's freshness and visual appeal. To complete the set, the three signature dipping sauces—budu, soy-chilli, and creamy green Thai—are presented in separate compartments. This thoughtful packaging enhances aesthetic value, convenience, and consumer experience, transforming Ulam Maki into a modern, market-ready product that celebrates the fusion of heritage and innovation.

4.0 RESULT

The development of Ulam Maki has successfully merged traditional Malaysian herbs with Japanese sushi-making techniques. The product stands out for its originality, combining local ingredients such as winged beans, pennywort (pegaga), and budu sauce into a sushi roll that preserves cultural integrity while offering a fresh gastronomic experience. This creative blend of flavours appeals to both health-conscious consumers and adventurous eaters, introducing a modern and convenient way of enjoying local cuisine.

The sensory evaluation results indicate high acceptance across all tested parameters: taste, texture, aroma, and visual appeal. This suggests strong potential for commercial success. Nutritional analysis further confirms that Ulam Maki is low in fat and high in fiber, aligning with the growing demand for healthy and balanced meal options. In addition, sourcing ingredients from local communities contributes positively to the regional economy and reinforces the project's sustainability dimension.

The systematic production process and carefully designed packaging add value in terms of hygiene, consistency, and consumer experience. The novelty of Ulam Maki lies in its ability to bridge cultural traditions with food innovation while supporting the principles of Sustainable Development Goal 9. Overall, Ulam Maki demonstrates scalability as a business model and holds social, cultural, and economic significance, making it a promising contribution to Malaysia's food innovation landscape.

5.0 CONCLUSION

In conclusion, Ulam Maki represents a distinctive culinary innovation that blends the fresh flavours of East Coast Malaysian ulam with the refined techniques of Japanese sushi. This fusion has resulted in a product that is healthy, affordable, and culturally meaningful - appealing to diverse consumer groups including students, working adults, and tourists.

By incorporating local ingredients such as fermented budu sauce, winged beans, and pennywort, Ulam Maki not only supports local farmers and producers but also reintroduces traditional flavours to new markets in a contemporary form. Its affordability, operational efficiency, and attractive presentation allow it to stand out in the highly competitive food and beverage industry.

Beyond its gastronomic appeal, Ulam Maki illustrates how local culture, and modern innovation can be integrated into a viable business model. With strong potential for expansion, the concept is well-positioned to contribute to Malaysia's food innovation landscape and beyond. Ultimately, this project demonstrates how creative entrepreneurship in the culinary sector can improve

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ANTIFUNGAL EFFECT OF BROWN ALGAE-BASED FEMININE SOAP ON CANDIDA ALBICANS: IMPACT OF SEXUAL INTIMACY

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ABSTRACT

Vaginal candidiasis, primarily caused by *Candida albicans*, is a common fungal infection in women that often leads to discomfort, disrupted vaginal flora, and reduced quality of sexual life. This study aimed to formulate and evaluate a natural feminine hygiene gel using *Sargassum polycystum* extract, focusing on antifungal efficacy while also improving vaginal health and intimacy comfort. The brown algae were extracted with 70% ethanol and incorporated into gel formulations at concentrations of 2.5%, 5%, and 10%. Evaluations included antifungal activity via agar well diffusion, physicochemical stability (pH, organoleptic properties), and storage performance over 30 days. The 5% extract formulation showed the strongest antifungal effect, with a 15.2 ± 0.5 mm inhibition zone against *C. albicans*, maintained an optimal vaginal pH (4.5), and exhibited no phase separation or microbial contamination. In addition to controlling fungal growth, the gel supported a stable vaginal environment, reducing irritation that may impair sexual intimacy. Compared with other marine-derived or botanical products, the *S. polycystum* gel demonstrated superior tolerability and targeted antifungal action at low concentrations. In conclusion, the *S. polycystum*-based feminine gel is a promising natural antifungal agent that contributes to better hygiene and may positively influence women's sexual well-being. Further clinical studies are needed to confirm its safety and suitability for routine use.

Keywords: *Sargassum Polycystum*, Antifungal, Feminine Hygiene, Sexual Intimacy

1.0 INTRODUCTION

Vaginal candidiasis is among the most common fungal infections in women, predominantly caused by *Candida albicans*. Although usually part of the commensal flora, *C. albicans* can overgrow under conditions such as hormonal changes, antibiotic use, diabetes, or immunosuppression. Symptoms include itching, burning, abnormal discharge, dyspareunia, and vulvovaginal inflammation. While not life-threatening, recurrent infections substantially impair quality of life and contribute to psychosocial distress (Faustino et al., 2025; Macias-Paz et al., 2023).

Current management relies on azoles and polyenes such as clotrimazole, miconazole, and nystatin. Although effective, prolonged or repeated use may lead to antifungal resistance, hypersensitivity, and disruption of the protective vaginal microbiota. Adverse effects such as irritation and dryness further limit patient adherence (Tarkowski & Kułak, 2023). These drawbacks highlight the need for alternative therapeutic approaches that are safe, preventive, and biocompatible.

Marine organisms, particularly macroalgae, are increasingly recognised as sources of bioactive metabolites with antibacterial, antiviral, antioxidant, and antifungal activities. Brown seaweeds of the genus *Sargassum* are abundant in tropical waters and contain diverse phytochemicals, including polyphenols, flavonoids, tannins, and terpenoids (Yassin et al., 2020). *Sargassum polycystum*, widely distributed in Southeast Asia and traditionally used in folk medicine, has demonstrated antimicrobial potential in preliminary studies, yet its application in vaginal health remains underexplored (Hamrun et al., 2022).

The innovation offers multiple benefits: a natural-based alternative to synthetic antifungals, multifunctionality through cleansing and moisturising, reliance on a renewable local resource, and potential scalability into diverse personal care formats (Macias-Paz et al., 2023). Beyond pharmacological interest, vaginal health is closely linked to sexual wellbeing, and recurrent infections may exacerbate sexual interest/arousal disorder, which affects up to 39% of women (Perrier Léonard et al., 2025; Witherow et al., 2016). By addressing both clinical and societal needs, this research aims to validate the antifungal efficacy, safety, and physicochemical stability of the proposed formulation,

laying the foundation for future clinical development and commercialisation of a marine-derived intimate care product.

2.0 OBJECTIVE

This study aimed to:

1. Develop a safe and effective feminine hygiene gel containing *Sargassum polycystum* extract with antifungal activity against *Candida albicans*.
2. Evaluate the physicochemical properties (pH, stability, organoleptic characteristics) of the formulation for vaginal suitability.
3. Assess the antifungal efficacy of different extract concentrations and determine the optimal formulation.

3.0 METHODOLOGY

3.1 Study Design

This research adopted a dual-method approach: (i) laboratory-based experimental research to formulate and evaluate a natural antifungal feminine hygiene gel containing *Sargassum polycystum* extract, and (ii) a scoping review to map the breadth of available literature. A scoping review is an exploratory synthesis distinct from systematic reviews, which typically assess intervention efficacy. Instead, scoping reviews are intended to:

- a) Identify fundamental concepts, theories, and evidence sources
- b) Clarify definitions and terminology
- c) Investigate methodologies employed in existing studies
- d) Highlight deficiencies in the literature
- e) Guide future research trajectories (Güell et al., 2023).

The primary aim was to formulate a topical product that is safe, pH-balanced, and effective against *Candida albicans*. The workflow comprised bioactive extraction from brown algae, gel formulation, antifungal activity testing, and physicochemical evaluation. Algae were collected from the coastal waters of Nongsa, Batam (Kepulauan Riau, Indonesia). After cleaning and drying, the biomass was macerated in 70% ethanol for five days. The resulting extract was concentrated using a rotary evaporator under reduced pressure at 40 °C to obtain a semi-solid extract. This extract was then incorporated into three gel formulations (2.5%, 5%, and 10%), with the 5% formulation identified as optimal based on antifungal performance and stability.

3.2 Formulation Development

Brown algae were collected from coastal waters in Nongsa, Batam (Kepulauan Riau, Indonesia). After cleaning and drying, the biomass was macerated in 70% ethanol for five days. The crude extract was concentrated with a rotary evaporator under reduced pressure at 40 °C to yield a semi-solid extract. This extract was incorporated into three gel formulations at concentrations of 2.5%, 5%, and 10%. The 5% formulation demonstrated the best balance between antifungal efficacy and physicochemical stability.

The gel base consisted of Carbopol® 980 NF (0.15%) as the gelling agent, a high-purity crosslinked polyacrylic acid polymer known for its excellent thickening and mucoadhesive properties. Propylene glycol (1%) was used as a humectant, acting also as a solvent and skin penetration enhancer. A buffer system comprising citric acid monohydrate and disodium hydrogen phosphate dihydrate (each at 0.5%) was included to maintain pH between 4.2 and 4.7, in accordance with the optimal range for external vaginal application. Oleum rosae was added in minimal amounts for fragrance, ensuring compatibility with mucosal sensitivity. The formulations were prepared under controlled laboratory conditions, with careful pH adjustment using citric acid to match the natural vaginal pH and to ensure the physicochemical stability of the gel system (Bvg, 2009).

3.3 Antifungal Testing and Stability

Antifungal activity against *Candida albicans* (ATCC 10231) was assessed using the agar well diffusion method. The 5% extract formulation produced the largest inhibition zone (15.2 ± 0.5 mm),

confirming strong antifungal potential. Physicochemical evaluations including pH stability, organoleptic properties, and visual inspection were conducted over 30 days at room temperature. No evidence of phase separation, odour change, or microbial contamination was observed.

Table 1: Composition of *Sargassum polycystum*-based antifungal feminine hygiene gel formulations.

Ingredients	F1 (% w/v)	F2 (% w/v)	F3 (% w/v)
Sargassum polycystum extract	2.5	5	10
Propylene glycol	1	1	1
Carbopol 980	0.15	0.15	0.15
Citric acid	0.5	0.5	0.5
Disodium hydrogen phosphate	0.5	0.5	0.5
Oleum rosae (fragrance)	qs	qs	qs
Purified water (Aquadest)	ad 100 mL	ad 100 mL	ad 100 mL

3.4 Innovation Significance

The findings underscore the potential of *Sargassum polycystum* as a marine-derived bioactive agent. The gel is tailored for daily external vaginal use, providing gentle cleansing, hydration, and antifungal protection while preserving mucosal integrity. It is non-irritating, user-friendly, and sustainable through reliance on locally sourced marine biomass. These attributes highlight its promise as a cost-effective, consumer-oriented, and scientifically validated natural product for intimate care.

4.0 RESULT

4.1 Antifungal Efficacy of the Formulated Gel

The antifungal gel containing 5% *Sargassum polycystum* extract exhibited notable inhibitory activity against *Candida albicans* (ATCC 10231), producing a mean inhibition zone of 15.2 ± 0.5 mm. This value was lower than the 21.6 ± 2.16 mm inhibition zone observed for ethanolic extract of *S. polycystum* at 500 mg/mL when assessed by disc diffusion. Interestingly, Dharmautama et al. (2018) reported that even a 1.25% methanolic extract was sufficient to suppress *C. albicans* growth, demonstrating strong potency at low concentrations. Such variation in antifungal performance is likely attributable to differences in solvent polarity, extraction method, and formulation matrix.

Although the gel exhibited comparatively reduced diffusion and inhibition relative to crude extracts, its topical applicability enhances clinical relevance. Moreover, the controlled release and stability of active compounds in a gel medium may contribute to its suitability for intimate hygiene applications. These findings collectively emphasise the need for further optimisation of formulation parameters to improve bioavailability and diffusion, while confirming the potential of *S. polycystum* as a promising natural antifungal agent in both extract and gel form.

This natural formulation offers protection against vulvovaginal candidiasis (VVC). In support, Murina et al. (2022) demonstrated that an acidic cleanser containing thymol and zinc significantly reduced pruritus scores by days 10 and 15 compared with clotrimazole monotherapy. Thymol inhibits hyphal growth of *C. albicans*, while zinc contributes both antimicrobial and immunomodulatory activity. Beyond infection control, such formulations improve cleanliness, comfort, and sexual well-being, underscoring their value as preventive health products for women.

4.2 Physicochemical and Organoleptic Evaluation

The gel formulation demonstrated excellent physicochemical and microbiological stability over 30 days at ambient conditions, with pH consistently maintained within the optimal vaginal range (4.2–4.7). These findings are consistent with Lyra et al. (2023), who reported that oral probiotic supplementation preserved vaginal pH (≤ 4.5) and supported microbiota stability in more than 90% of participants. Importantly, the present gel showed no phase separation, microbial contamination, or deterioration in organoleptic characteristics.

The product retained a semi-transparent appearance, a mild floral fragrance, and a non-sticky texture, all of which enhance user acceptability for routine intimate hygiene. In contrast, probiotic supplementation stabilised microbiota composition indirectly through modulation of immune markers, without direct colonisation of the vaginal tract. Collectively, both topical and oral interventions appear to contribute to vaginal ecological balance without inducing irritation. These results underscore that

physicochemical integrity and biological stability are critical determinants of safety and performance in vaginal health products (Lyra et al., 2023).

4.3 Comparative Antifungal Activity with Other Marine Algae

To contextualise the antifungal efficacy of the *Sargassum polycystum* gel, comparative data from *Kappaphycus alvarezii*-based formulations were considered. Jalani et al. (2023) reported that a feminine hygiene soap containing 5% *K. alvarezii* extract achieved an inhibition zone of only 5.93 mm against *Candida albicans*, requiring concentrations as high as 75% to reach 23.68 mm. By contrast, the present *S. polycystum* gel produced a 15.2 mm inhibition zone at just 5% concentration, confirming superior potency at lower doses. This efficiency highlights the potential of *S. polycystum* as a more bioactive and cost-effective antifungal agent for vaginal applications.

Another notable distinction lies in formulation design. The *K. alvarezii*-based products did not incorporate a buffering system to ensure vaginal pH compatibility. In contrast, the *S. polycystum* gel was optimised with citric acid and disodium hydrogen phosphate to maintain physiological pH, thereby enhancing both efficacy and user comfort. Together, these findings highlight the dual advantage of *S. polycystum*: higher antifungal activity at low concentrations and formulation compatibility with the vaginal environment, positioning it as a promising candidate for next-generation personal hygiene products.

4.4 Comparison with Terrestrial Botanical Extracts

A comparative assessment was conducted between the *Sargassum polycystum* gel and a bar soap formulated with ethanolic extract of *Arenga pinnata* fronds. Although the *A. pinnata*-based soap demonstrated strong antibacterial activity, producing inhibition zones of up to 23 mm against *Propionibacterium acnes* and 33.33 mm against *Pseudomonas aeruginosa*, its use was limited by the absence of pH control and unsuitability for vaginal application. As a solid bar, the formulation differs markedly from the current gel system, which is more appropriate for the sensitive vaginal epithelium. Furthermore, the *S. polycystum* gel, specifically optimised for antifungal activity, achieved a 15.2 mm inhibition zone at only 5% extract concentration, directly targeting *Candida albicans*, the principal pathogen in vulvovaginal candidiasis. This demonstrates higher efficacy at lower concentrations. While both plant-derived formulations exhibit therapeutic potential, the gel system offers superior biocompatibility, targeted antifungal action, and greater formulation flexibility for mucosal applications (Chalongkulasak & E-kobon, 2022).

4.5 Stability and Safety Advantage over Conventional Soaps

Unlike conventional bar soaps, which typically exhibit alkaline pH values ranging from 8 to 11, the formulated *Sargassum polycystum* gel maintained an optimal acidic pH (4.2–4.7), consistent with the physiological vaginal environment. A comparative study involving *Eucheuma cottonii* in a transparent antiseptic bar soap reported pH values between 11.22 and 11.57, conditions that may compromise mucosal integrity and elevate the risk of irritation. Moreover, the *E. cottonii*-based soaps contained free alkali levels of up to 0.53%, exceeding the maximum safe threshold of 0.1% established by national standards. Such alkaline by-products, inherent to saponification, are absent in the current gel, which was formulated using a non-saponified, surfactant-free system. This eliminates the risk of free alkali-induced irritation while preserving compatibility with mucosal tissues. Taken together, the *S. polycystum* gel demonstrates superior physicochemical stability and safety, offering a pH-balanced and irritation-free alternative to conventional antiseptic soaps (Baehaki et al., 2019).

4.6 Chemical Composition and Potential Mechanism

The antifungal gel formulated with 5% *Sargassum polycystum* extract produced an inhibition zone of 15.2 ± 0.5 mm against *Candida albicans*, surpassing many ethanol-extracted Asteraceae species, which required higher concentrations to achieve comparable effects. This activity is primarily attributed to phlorotannins and flavonoids, efficiently preserved through 70% ethanol extraction. In contrast, *Cichorium intybus* and *Achillea minus* extracts exhibited broader yet weaker antimicrobial activity at concentrations up to 250 µg/mL. Distinct from terrestrial extracts, the *S. polycystum* gel is pH-balanced, free from alkali, and specifically designed for vaginal application. Additionally, the formulation demonstrates eco-friendly scalability, capitalising on Indonesia's abundant marine biomass. Collectively, these attributes establish its novelty and potential significance within the emerging field of marine-derived cosmeceuticals (Lee et al., 2024).

5.0 CONCLUSION

This study successfully developed an innovative antifungal feminine hygiene gel incorporating *Sargassum polycystum* extract, which demonstrated potent *in vitro* activity against *Candida albicans* at a low concentration (5%), producing an inhibition zone of 15.2 ± 0.5 mm. The formulation maintained a stable pH (4.2–4.7), closely aligned with physiological vaginal conditions, and showed no evidence of microbial contamination or physical instability during a 30-day storage period. The originality of this work lies in the integration of marine-derived bioactives with a pH-compatible and eco-friendly preparation method, offering a natural alternative to conventional synthetic or alkaline intimate cleansers. When compared with formulations based on *Kappaphycus alvarezii* or *Arenga pinnata*, the *S. polycystum* gel achieved equal or superior antifungal effects at lower concentrations, underscoring its potency and economic viability.

Scientifically, this research advances marine bioprospecting and contributes to the natural cosmeceutical sector, particularly in the underexplored domain of feminine hygiene. Economically, it promotes the valorisation of Indonesia's coastal biodiversity through the development of locally sourced, sustainable health products. Clinically, by preventing vulvovaginal infections and supporting microbial balance, the gel has the potential to enhance vaginal health, comfort, and self-confidence, with positive implications for women's psychological and sexual well-being. Its mild, non-irritating characteristics also indicate suitability for regular use. Future research should investigate *in vivo* antifungal efficacy, biocompatibility, long-term safety, and clinical outcomes across diverse populations. Such studies will be critical to validate its therapeutic potential and establish its role as a safe, natural, and effective solution for feminine care.

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AI-BASED PREDICTIVE MAINTENANCE SYSTEM FOR INDUSTRIAL MACHINE

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ABSTRACT

Modern industrial operations demand high levels of reliability and efficiency, rendering traditional maintenance strategies increasingly inadequate. Reactive and time-based methods often lead to unplanned downtime, high repair costs, and inefficient resource utilisation. To address these challenges, this project introduces an artificial intelligence (AI)-based predictive maintenance system specifically designed for industrial machines, with a focus on motors. The system leverages AI algorithms to forecast potential failures before they occur, enabling timely maintenance and minimising costly disruptions. It analyses real-time operational data, particularly vibration and temperature readings—key indicators of motor health. Using machine learning models developed in Python, the system identifies patterns and anomalies that may signal early signs of wear or failure. The models are trained on datasets that include both normal and faulty machine states, enhancing accuracy in detecting conditions such as bearing wear, misalignment, and overheating. This predictive capability allows maintenance teams to intervene proactively before minor issues escalate into major breakdowns, thereby reducing the likelihood of catastrophic failures. Beyond improving machine reliability and operational efficiency, the proposed system supports the United Nations Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation, and Infrastructure) and SDG 12 (Responsible Consumption and Production). Overall, the findings demonstrate the practical effectiveness of AI-powered predictive maintenance as a scalable solution for sustainable industrial transformation.

Keywords: Predictive Maintenance System, Artificial Intelligence, Machine Learning, Industrial Machine

1.0 INTRODUCTION

Predictive maintenance is transforming modern industries by anticipating equipment problems and reducing unplanned downtime. These systems utilise artificial intelligence (AI) and machine learning to analyse real-time sensor data and predict potential breakdowns, thereby making maintenance more efficient and cost-effective. Compared with traditional approaches, predictive maintenance enhances reliability, reduces costs, and increases productivity (Ali & Abdelhadi, 2022). It also contributes to environmental sustainability by reducing waste and energy consumption.

In contrast, traditional maintenance practices based on scheduled inspections or reactive repairs struggle to predict failures reliably, often resulting in unexpected breakdowns, costly repairs, and resource inefficiency. Over-reliance on periodic inspections or reactive measures can accelerate wear and tear, lower productivity, and lead to significant downtime.

As industries transition to Industry 4.0, there is a growing demand for AI-driven predictive maintenance systems capable of identifying faults and anticipating failures in real time (Kalaiselvi et al., 2024). Such systems process data from multiple sensors, including temperature, vibration, and pressure, to detect faults and estimate Remaining Useful Life (RUL). By integrating AI, maintenance strategies can shift from reactive to predictive approaches, ensuring operational continuity, optimised maintenance schedules, and improved equipment performance.

2.0 OBJECTIVE

The principal objective of this project is to enhance the predictive maintenance efficiency for industrial machines using machine learning. The specific aims are to:

1. design and implement an AI-based predictive maintenance system for industrial machines.
2. monitor real-time vibration and temperature of the machine using Python and AI model.
3. predict potential machine failure using machine learning algorithms.

3.0 METHODOLOGY

This project focuses on the design and implementation of an AI based predictive maintenance system for industrial machinery, with particular emphasis on critical components such as motors and pumps. The system continuously monitors real time operational parameters including vibration and temperature to anticipate potential equipment failures before they occur. This predictive capability is enabled through machine learning algorithms trained on historical operational data.

The primary aim is to minimise unscheduled downtime, enhance operational efficiency, and extend the lifespan of machinery by facilitating proactive maintenance interventions. To accomplish this, the system integrates both hardware and software into a unified platform capable of data acquisition, processing, analysis, and visualisation of outputs.

3.1 BLOCK DIAGRAM

Figure 1 presents the system's block diagram, which includes input, processing, and output stages. Figure 2 shows the schematic diagram, detailing the block diagram. A Raspberry Pi 4 is the main controller, connected to two sensors: an ADXL345 accelerometer sensor, a DS18S20 temperature sensor and a display module. The ADXL345 accelerometer is connected to the Raspberry Pi via the I2C interface, with its SDA and SCL pins connected to GPIO2 and GPIO3 respectively, while power and ground are connected to the 3.3 V and GND pins. The DS18S20 temperature sensor uses a 1-wire connection and is connected to GPIO4 for data communication. A 4.7 k Ω pull-up resistor is placed between the data line and VCC to ensure reliable 1-Wire communication. The display monitor is connected to the Raspberry Pi using either an HDMI cable or the DSI port, depending on the display type. This wiring configuration allows the Raspberry Pi to collect real-time vibration and temperature data, which is processed and displayed through the developed predictive maintenance system.

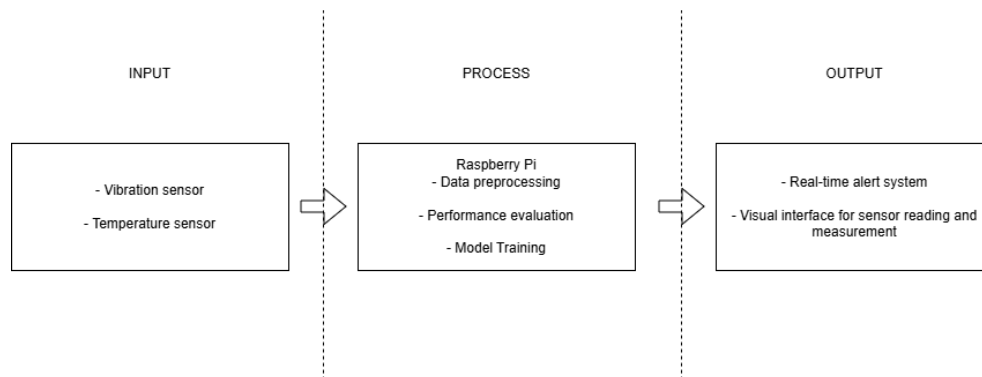


Figure 1: Block diagram

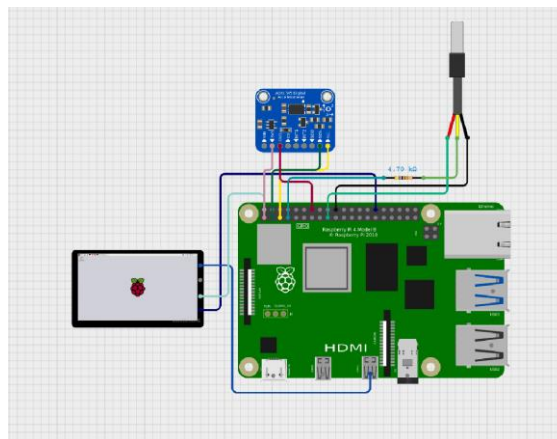


Figure 2: Schematic diagram

4.0 RESULT

This section presents the outcomes of the system implementation. The initial phase involved data collection through sensor measurements, specifically capturing temperature and vibration levels from industrial motors. These readings formed the basis for training and testing the predictive model.

The Random Forest classifier was employed to determine motor conditions from the collected data. The results focus on the model's training and evaluation, with particular attention to its accuracy in predicting potential motor failures. This demonstrates the system's effectiveness in identifying early warning signs of malfunction and supporting timely maintenance interventions.

4.1 Data Collection

For this project, the dataset was obtained from Kaggle, specifically the *Predictive Maintenance of Machines* dataset. This dataset was used to simulate the predictive maintenance system, providing a foundation for testing and visualising its performance under real-world conditions. It contains multiple sensor readings along with failure labels that enable the prediction of machine operational states.

The dataset includes several parameters such as air temperature, process temperature, rotational speed, torque, vibration levels, operational hours, and failure types. In this study, the focus was narrowed to two critical features: temperature and vibration levels. These parameters are widely recognised as key indicators of motor health, where temperature reflects potential overheating and vibration levels often signify underlying mechanical issues.

For the development of the machine learning model, only these two features were selected: temperature (measured in Kelvin) and vibration level. Using these inputs, the Random Forest algorithm was applied to predict the condition of the machine, classifying it as either "Good" or "Faulty."

4.2 System Interface Simulation

The interface simulation of the developed AI based predictive maintenance system provides real time graphical visualisation of two critical machine parameters: temperature and vibration. These parameters are continuously monitored and plotted over time, enabling users to gain immediate insights into the operational health of the machine.

The system architecture consists of three main components: a data acquisition module, a machine learning based diagnostic engine, and a user interface layer. To support flexible testing, the system allows both manual data input where users can enter custom values and automatic data input for real time or simulated streaming. Each data point is timestamped and processed by the diagnostic engine, which applies pre trained machine learning models to classify the machine condition.

The classification logic is governed by defined threshold values. Specifically, a temperature exceeding 353.2 K or a vibration level above 6 mm/s is flagged as an anomaly. When either threshold is breached, the system predicts a "Faulty Condition" and generates a visual alert for the user. Conversely, when parameters remain within acceptable limits, the system indicates a "Good Condition." Figures 3 and 4 illustrate the system's responses under normal and faulty operating states, demonstrating its capability to distinguish between safe and critical conditions in real time.

To enhance interactivity, the interface incorporates control buttons such as Start, Stop, Reset, and Simulate Faulty Condition. These controls allow users to trigger specific scenarios and observe the system's responses in real time, thereby facilitating validation of prediction accuracy and assessment of robustness under varying fault conditions.

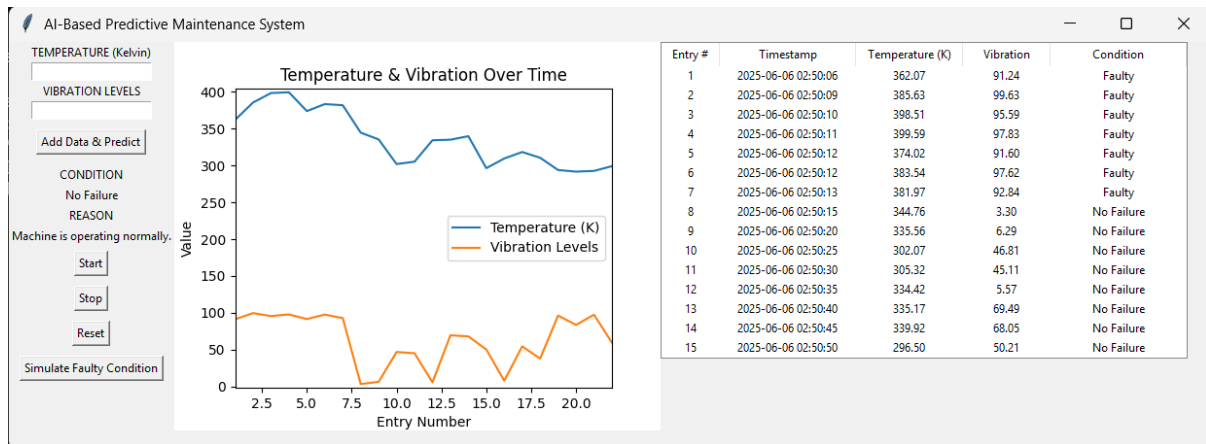


Figure 3: System machine in “Good” condition

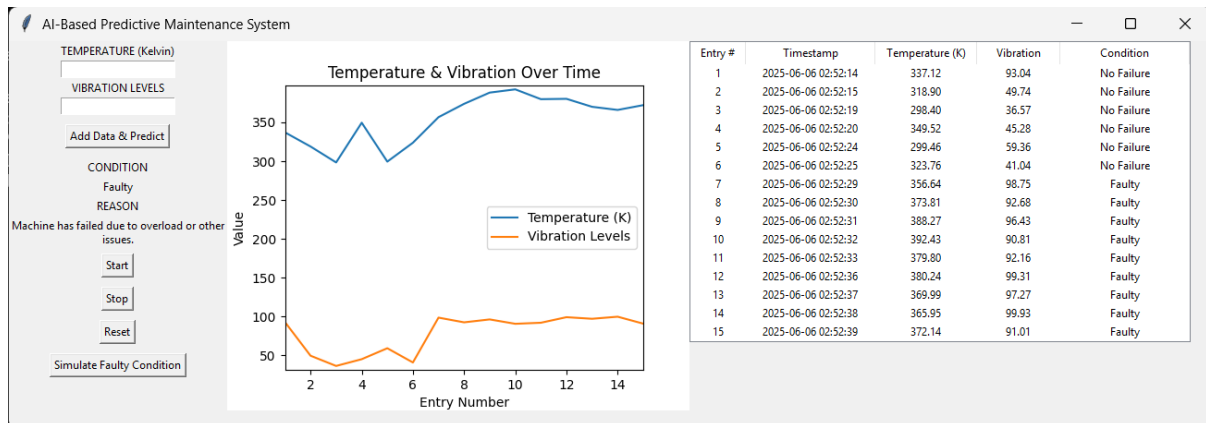


Figure 4: System shows machine in “Faulty” condition

Table 1 summarises the machine condition based on two key parameters: air temperature and vibration level. For air temperature, all failure conditions display slightly elevated values compared to the “No Failure” state, indicating potential early signs of abnormality. However, the maximum temperatures recorded during failure scenarios are comparable to or in some cases marginally lower than those observed in the no failure condition. This suggests that temperature alone may not serve as a strong distinguishing indicator for certain fault types.

In contrast, vibration level shows greater variability and emerges as a more sensitive indicator of machine health. The data reveal that “Overstrain” and “Power Failure” conditions are linked to lower maximum vibration levels compared to the no failure condition, possibly due to reduced operational load or sudden machine shutdowns. Meanwhile, the “Tool Wear Failure” scenario exhibits vibration levels closely aligned with those recorded under normal operation, making it more difficult to differentiate based solely on vibration data.

Overall, these findings underscore the importance of adopting a multi parameter analysis approach to enhance fault detection accuracy and improve the reliability of the predictive maintenance system.

Table 1: Condition of the machine

Parameter	No failure	Overstrain failure	Power failure	Tool wear failure
Air Temperature (K)	297.2 – 299.1	297.4 – 298.4	297.6 – 298.9	297.4 – 299.0
Vibration Levels	23.0 – 55.0	25.84 – 40.0	25.57 – 52.0	23.0 – 55.0

5.0 CONCLUSION

The development of an AI based predictive maintenance system for industrial machinery represents a significant advancement in modern maintenance practices. The integration of real time sensor data with machine learning algorithms enabled the accurate prediction of potential equipment failures, achieving an accuracy rate of over 90 percent and allowing timely maintenance interventions.

This approach has demonstrated clear benefits, including reduced unplanned downtime, lower repair costs, improved equipment reliability, and enhanced operational efficiency. Beyond its technical contributions, the system also aligns with global sustainability efforts. Specifically, it supports Sustainable Development Goal (SDG) 9 by fostering innovation and promoting sustainable industrialisation, while also contributing to SDG 12 by encouraging responsible consumption through optimised machine utilisation and the reduction of unnecessary resource waste.

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