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Sustainable Urban Innovations for the Development of Well-being

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Open International Innovations Challenge (OpIIC 2024):
Sustainable Urban Innovations for the Development of Well-being

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FOREWORD FROM RECTOR

Assalamualaikum WBT and Salam Malaysia Madani.
Ladies and Gentlemen, Distinguished Guests, Participants, and Esteemed Colleagues,

اَلسَلامُ عَلَيْكُم وَرَحْمَةُ اَللهِ وَبَرَكاتُهُ and good morning and a warm welcome to the Open International Innovation Challenge 2024 (OpIIC2024). It is a great honour and privilege to stand on this exciting journey of innovation and creativity. This year's theme, "Sustainable Urban Innovations for the Development of Well-being," sets the stage for us to explore groundbreaking ideas that will shape the future of our societies and enhance the quality of life for all.

First and foremost, I would like to extend my heartfelt congratulations to the dedicated committee from the Department of Computer & Mathematical Science, Universiti Teknologi MARA, Pulau Pinang branch, and Universitas Negeri Semarang (UNNES), Indonesia, who have jointly collaborated to organize this prestigious event. Your exceptional efforts, hard work, and commitment to excellence have made OpIIC2024 a reality, and for that, we are truly grateful.

To our participants, who have travelled from near and far, we warmly welcome you. Your presence here reflects a shared passion for innovation and a collective commitment to tackling some of the most pressing challenges facing urban environments today. The diversity of perspectives and expertise gathered here is truly inspiring, and I am confident that the solutions we generate during this challenge will be both transformative and impactful.

The theme of this year's challenge is especially significant, as it highlights the urgent need for sustainable solutions that not only address the immediate needs of urban populations but also ensure the well-being of future generations. As urbanization continues to accelerate worldwide, it is essential that we rethink how we design, build, and manage our societies. Our aim is to foster innovations that promote environmental sustainability, social inclusivity, and economic vitality, thereby creating urban spaces that are resilient, livable, and thriving.

Throughout OpIIC2024, you will have the opportunity to engage in collaborative problem-solving, leverage cutting-edge technologies, and present your innovative ideas to a panel of esteemed judges. This event is more than just a competition; it is a platform to showcase your ingenuity, challenge conventional thinking, and contribute to a brighter, more sustainable future.

I encourage everyone to seize this opportunity to network with your peers, learn from one another, and push the boundaries of what is possible. Remember that innovation often arises from collaboration, and the diverse insights you bring are invaluable in our quest to develop sustainable solutions.

To all participants, I wish you the best of luck. May your creativity and determination shine throughout this challenge, and may your contributions pave the way for a more sustainable and prosperous urban future. We hope that this effort will help UiTM achieve its goal of becoming a globally renowned university by 2025.

I would like to reiterate my gratitude to the organizing committee, our collaborators, sponsors, and all those who have worked tirelessly behind the scenes to make this event a success.

Thank you.
Professor Dato' Ir. Dr. Hj. Ahmad Rashidy Razali
Rector Universiti Teknologi MARA Cawangan Pulau Pinang

FOREWORD FROM ADVISOR

Assalamualaikum WBT… and a very good morning

Welcome to the Open International Innovation Challenge 2024, or as we proudly call it, OpIIC2024. My name is Dr. Nor Hanim Abd Rahman. As the Coordinator of the Department of Computer and Mathematical Science, Universiti Teknologi MARA (UiTM), Cawangan Pulau Pinang, it gives me great pleasure to greet all of you at the commencement of this event.

First and foremost, I would like to extend my deepest appreciation to the incredible committee members of OpIIC2024 and our collaborator Universitas, Negeri Semarang (UNNES), Indonesia. Without your dedication, hard work and commitment, all of these might not have been possible. Thank you for your extraordinary efforts.

This year, we are delighted to host around 81 participants from diverse backgrounds, all brought together by a common passion for innovation and sustainability. To all the participants, I extend a warm welcome, may your presence here today underscore a collective commitment to addressing some of the most challenges of our time through sustainable urban innovation.

OpIIC2024, provides a unique platform for us to showcase our innovative ideas and to engage in meaningful collaboration. Our theme, "*Sustainable Urban Innovations for the Development of Well-being*", encourages us to think creatively and strategically about improving and enhancing the quality of life for all. So, let us take full advantage of the opportunities presented by this event that was innovated to challenge our conventional thinking, and strive to develop solutions that are not only visionary, but also practical and impactful.

Through this platform, we have the chance to make a significant contribution to the field of sustainable urban development. OpIIC2024 is an excellent opportunity to build and strengthen our professional networks. Engage with our peers, share our insights, and learn from one another. The connections we are developing here could lead to meaningful collaborations and lasting partnerships, that will extend well beyond this event.

Last but not least, once again, thank you to the organising committee, our collaborator and sponsor, and all those who have contributed to making OpIIC2024, a reality. Your support and dedication are truly commendable.

To all our participants, I wish you the best of luck. May your time here be filled with inspiration, innovation, and meaningful connections. Together, let us pave the way for a sustainable and prosperous urban future.

Thank you, and welcome to OpIIC2024!
Dr. Nor Hanim Abd Rahman
Advisor of Open International Innovations Challenge 2024 (OpIIC2024)
Universiti Teknologi MARA Cawangan Pulau Pinang

FOREWORD FROM CHAIRMAN

In a rapidly evolving world, innovation has become the cornerstone of progress, driving advancements that redefine industries and improve lives. The Open International Innovations Challenge 2024 (OpIIC2024) stands as a testament to the boundless creativity and determination of individuals and teams committed to pushing the boundaries of what is possible.

This year's challenge brought together visionaries, problem-solvers, and pioneers from diverse fields, each contributing unique perspectives and expertise. The submissions we received reflect not only the ingenuity of the participants but also a deep understanding of the complex challenges we face in today's global landscape. From revolutionary technologies to groundbreaking social initiatives, the solutions presented demonstrate a profound commitment to creating a better future.

The proceedings of OpIIC2024 capture the essence of this remarkable journey. Each project included in this collection represents a significant contribution to the ongoing dialogue around innovation. They offer insights into the creative process, lessons learned from experimentation, and the potential impact of these innovations on society.

As you explore the content of this proceedings, we invite you to appreciate the diverse approaches and innovative thinking that have emerged from this challenge. We hope that these proceedings will inspire further exploration, collaboration, and action in the pursuit of excellence and meaningful change.

On behalf of the OpIIC2024 organizing committee, we extend our heartfelt gratitude to all participants, judges, and supporters who have made this challenge a resounding success. It is through collective effort and shared vision that we continue to advance the frontiers of innovation.

Dr. Siti Nurleena Abu Mansor
Director of Open International Innovations Challenge 2024 (OpIIC2024)
Universiti Teknologi MARA Cawangan Pulau Pinang

PREFACE FROM CHIEF EDITOR

It is with great pleasure that I welcome you to the e-proceedings of the Open International Innovation Challenge 2024 (OpIIC2024) on Sustainable Urban Innovations for the Development of Well-being. This event, organized by Universitas Negeri Semarang in collaboration with UiTM Cawangan Pulau Pinang, brings together a diverse group of scholars, practitioners, and innovators dedicated to advancing sustainable urban development.

As the Chief Editor, I am honored to present this collection of extended abstracts, which reflect the interdisciplinary efforts and innovative solutions aimed at enhancing urban well-being. The contributions within these proceedings highlight the importance of collaboration across various fields to address the complex challenges of urban sustainability.

I extend my heartfelt gratitude to all the authors, reviewers, and attendees for their invaluable contributions and participation. Your dedication and insights are crucial in driving forward the discourse on sustainable urban innovations.

We hope that the ideas and discussions generated through this conference will inspire further research and practical applications, ultimately contributing to the development of more sustainable and livable urban environments.

Thank you for your commitment to this important cause, and I wish you all a productive and enlightening reading experience in this e-proceedings of OpIIC2024.

Sincerely,
Dr. Azhar Ahmad
Chief Editor of Open International Innovations Challenge 2024 (OpIIC2024)
Universiti Teknologi MARA Cawangan Pulau Pinang

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SECTION 1

Civil Engineering

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ECO-FRIENDLY GEOPOLYMER COMPOSITE FOR SOIL STABILIZATION

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Abstract

Geopolymer has emerged as an innovative and eco-friendly alternative to traditional soil improvement products such as ordinary Portland cement (OPC) and lime. Geopolymer precursors that are high in silica (Si) and alumina (Al) minerals. The use of boiler ash in this study has a high potential for geopolymerization in soil stabilisation applications. This study investigates a green technology geopolymer as an additive for enhancing the properties of landfill soil liner. Soil liners are used to contain waste in modern landfills. Geopolymer can be considered the key factor that could enhance laterite's properties in terms of hydraulic conductivity. Boiler ash is another industrial waste product from the combustion of coal. Residual soil was mixed with different percentages of boiler ash-based geopolymer to improve the properties of the soil liner application. This research aims to determine the optimum percentage of geopolymer mixed with residual soil as an additive and reduce the value of hydraulic conductivity. Based on the results, the increases in geopolymer content are associated with a decrease in hydraulic conductivity, leading to a significant reduction in hydraulic conductivity. An empirical model was successfully developed from this study. The empirical model for predicting hydraulic conductivity, k, was developed as alternative guidelines for engineers to design landfill soil liners without conducting laboratory testing, which takes a long time and can reduce cost and time.

Keywords: Geopolymer, Soil Stabilization, Boiler Ash, Landfill Soil liner

1. INTRODUCTION

Population growth and rapid urbanization have increased the amount of municipal waste and become challenging in developing countries like Malaysia. The main component of a landfill is the landfill liner or known as the soil liner. The soil liner is a barrier layer between waste and groundwater. The generation of daily waste has created a harmful liquid waste known as leachate. It is a crucial aspect in designing soil liner in landfill to prevent the infiltration of leachate in the groundwater and drained into the collection tank for treatment process. It therefore becomes essential to develop a product that is environmentally friendly and capable of soil stabilization. According to Abdullah et al., (2020) and Zainuddin et al., (2021), geopolymers have a low shrinkage potential and excellent adhesion to aggregates, making them effective soil stabilizers. Given the above benefits, this study innovates the use of geopolymer as a potential material in developing new green technology in landfill area.

2. MATERIALS AND METHODS

The soil was collected at Tanjung Langsat, Johor. The geopolymer was produced by mixing palm oil boiler ash, with an alkaline solution of sodium hydroxide (NaOH), and sodium silicate (Na2SiO3).All laboratory tests were based on existing engineering practice guideline standards of British Standard (BS) and American

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Society Testing Materials (ASTM). Basic properties test conducted includes Particle Size Distribution (PSD), Potential Hydrogen (pH), Plastic Index (PL), Liquid Limit (LL), Plasticity Index (PI), and Linear Shrinkage (LS) according to BS 1377: Part 2:1990. XRF and SEM analyzed micro-mechanism observations to determine sample particles' chemical composition and structure Williams et al (2021). The empirical formula developed using Minitab 16 software to evaluate the statistical analysis by the correlation and regression analysis.

3. RESULTS AND DISCUSSION

The addition of Geopolymer as additives in laterite has significantly improve soil strength in the geopolymerization process. The addition of Geopolymer turns laterite to alkaline soil and gives the effect of less soluble and does not absorb or allow leachate infiltration. The Atterberg test of Laterite- Geopolymer mix gives LL range of 39 to 48%, PL range of 29 to 34% and PI range of 10 to 19% as shown in Figure 1. According to minimum requirement based on BS 1377; 1990 test specification, the value of plasticity index ranges between 10% and 65% ($10 \leq PI \leq 65\%$), and LL at $\leq 90\%$. Hence, the addition of Geopolymer to laterite satisfies the requirement for plasticity index and liquid limit in soil liner.

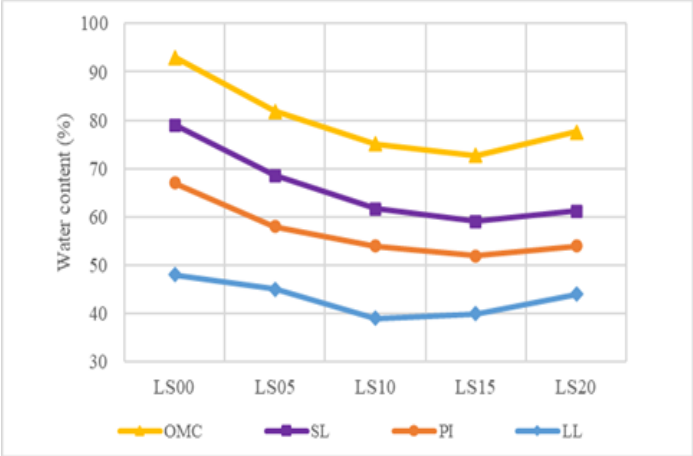

Figure 1. Atterberg and Shrinkage test value

In compaction test, the results show that Laterite-Geopolymer mixtures have an increased MDD than plain laterite, with a corresponding reduction in the OMC as the Geopolymer content increases, up to 15% of Geopolymer. A drastic increase in MDD at 15% of Geopolymer content at 2.19 Mg/m^3 and, a reduction of OMC at 13.58% give positive results for geopolymerization reactions. The compaction characteristic of laterite with Geopolymer for all mixtures increased the MDD and decreased the OMC. Increasing dry density at low moisture content reduces soil voids, which become more accessible for the particles to move past one another during compacting forces.

Table 1. Compaction result of Laterite-Geopolymer Mix

Sample	Moisture Content, OMC (%)	Maximum Dry Density, MDD (Mg/m^3)
LS00	14.07	1.80
LS05	13.88	1.88
LS10	13.70	1.90
LS15	13.58	2.19
LS20	16.38	1.71

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Based on the result in this study, hydraulic conductivity is affected by the percentage of Geopolymer, and it can be observed that the hydraulic conductivity values were decreased with increment of Geopolymer content. t was observed that the range result for k-value is between 2.50 x 10^{-8} to 5.50 x 10^{-9} m/s. LS20 give the lowest value of hydraulic conductivity, k at 5.50 x 10^{-9} m/s. Laterite containing Geopolymer can be used as alternative material in landfill liner soil. The addition of 15% Geopolymer resulted in a significant reduction in hydraulic conductivity value and meets the optimum percentage of Geopolymer suit the landfill soil liner requirement of less than 1 x 10^{-9} m/s.

In predicting k, Log k has a strong relationship correlation with the P-value of lower than α (< 0.05) including LL, C, S, and %GEO. Hence, the null hypothesis is rejected at 0.05 significant. These mentioned parameters can be a good consideration as independent variable (x) in finding Log k as predictor variable (y). The correlation of k-value with variable with strong relationship from several parameters such as clay, sand, liquid limit, and the percentage of Geopolymer were accurately and in accordance with the statistical validity condition. According to regression data, all equations show regression coefficient R^2 (adj) more than 70% and nearest to 100%, with a P-value less than 0.05. The obtained data proved that the chosen variables are suitable for predicting k model. The null hypothesis was rejected by having the P-value less than 0.05, and alternative hypotheses were accepted. This study has successfully developed nomograph in predicting hydraulic conductivity, k-value. The data of succeed nomograph on predicted k-value content will simplify the landfill construction process can be used as a guideline in designing a soil liner system at landfill area.

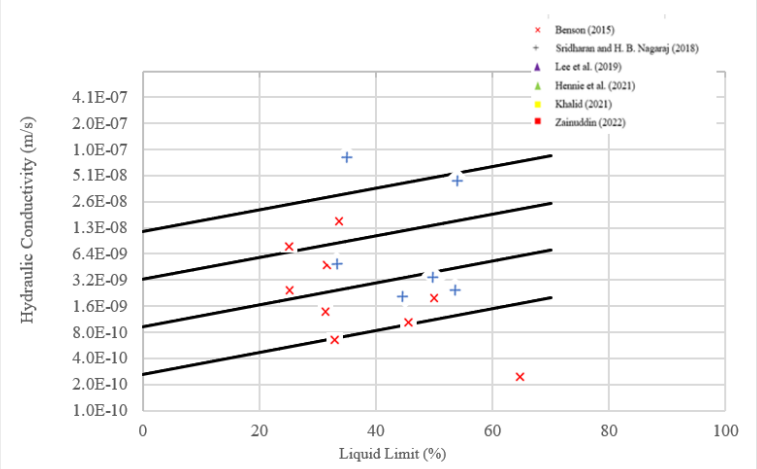

Figure 2. Nomograph in predicting k-value

4. CONCLUSION

Geopolymer at different percentages has different effects on the laboratory sample, resulting in good knowledge and understanding about the properties of the product. Preliminary and main laboratory tests of the soil-geopolymer based provided a good prediction of hydraulic conductivity, k for soil liner application from statistical validation of physical and engineering properties. Empirical formulas and nomograph in predicting hydraulic conductivity, k, based on available variables (LL, Clay and geopolymer content) were developed as alternative guidelines for engineers to design landfill soil liners without conducting laboratory testing that takes a long time and thus can reduce the cost and time

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The authors would like to acknowledge the support of Universiti Teknologi MARA (UiTM), Johor Branch Pasir Gudang Campus, Malaysia for providing the facilities such as the geotechnical laboratory, advanced geotechnical laboratory, and support to accomplish this study.

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LEVELLING STAFF UPRIGHT POSITION DETECTOR USING ARDUINO UNO AND SENSOR GY-61 ADXL335

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Abstract

The position of a point on the earth's surface is translated through horizontal coordinates and height information. Height information is obtained by performing a levelling survey. When performing height measurement, the position of the levelling staff should always be in an upright position. The position of the levelling staff that is not upright will cause inaccurate results. The results of observation based on the Teaching and Learning (TnL) process in the past semesters found that, many students had to perform levelling surveying practice repeatedly due to inaccurate results. Through the same observation, the main cause was found to be the position of the levelling staff that was not upright when the reading was taken. This study aims to produce a device that detects the upright position of a levelling staff to help launch the TnL process for the topic of levelling survey. This detection device is innovated using an Arduino Uno and a GY-61 ADXL335 sensor. Technological teaching aids with IOT (Internet of Thinks) features. The students can use this tool by placing it behind the set and placing the plate on the surface of the earth while carrying out level measurement practice. A prototype design has been drawn and made using electronic components namely Arduino Uno, Sensor GY-61 ADXL335, buzzer, breadboard, wire, 9V battery, potentiometer and LCD screen. This tool has been tested for accuracy through comparison of levelling survey data through the method of using a sensor tool and without a sensor tool. The result of measuring the level using the sensor obtained -0.009m of the value of the error while the measurement without the sensor -0.013m. This tool has also been used by Semester 1 Geomatics Diploma Program students. As a result, the students successfully performed the practice of level measurement accurately with only one attempt. The ability of this tool can also be proven by making a comparison using an existing vertical position determination tool, which is an air bubble mount. The results of this study are expected to help lecturers and students in the TnL process for the topic of levelling survey.

Keywords: Levelling survey; Arduino Uno; sensors; geomatics.

1. INTRODUCTION

In Civil Engineering, elevation data is an important element in planning development. Height data on the earth's surface has been needed since human existence. Knowledge of height is important information in human civilization, constructions and old buildings that are still standing. Elevation is the vertical distance a point is either above or below a reference datum. The commonly used reference datum is mean sea level. One of the methods to obtain the height data of a point is to use a level gauge. Based on the Circular of the Director General of Surveying and Mapping Malaysia number 7, in 2021, accurate height data is obtained when the collimation line is parallel to the horizon plane when making a reading on the setaf. This definition means that the level tool must be parallel to the horizontal plane and be perpendicular to the axis of the pugak. To determine the condition, the air bubbles on the level and setaf should be in the middle.

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A study to produce a level measuring device to determine the height difference between two or more points on the earth's surface. The instrument detection tool is designed using arduino uno and sensors to help and facilitate students to carry out level measurement practice more effectively and efficiently. In this study, the main focus is to obtain the correct level of measurement. The sensor used is the GY-61 ADXL335 Accelerometer Sensor. An accelerometer is a device that measures the acceleration due to gravity along the X, Y and Z axes. It is used in all applications that require the detection of tilt and tilt of an object. In this study, the GY-61 ADXL335 Accelerometer was used to determine the accuracy of the level measurement set above the earth's surface. Arduino is an open source platform used to create electronic projects. Arduino consists of two physical programmable circuit boards (referred to as microcontrollers) and software, known as an Integrated Development Environment (IDE) that runs on the computer, used to write and upload code (coding) from the computer to the circuit board. Then, Arduino does not need separate hardware equipment because it just uploads the new code to the circuit board and only uses a usb cable. This Integrated Development Environment (IDE) uses a simplified version of C++, making it easier to learn programming. Arduino provides a variety of common form factors that are divided into several microcontroller functions into a more accessible package.

The prototype of the level surveying tool's detection tool was tested on students in the 1st semester who had just learned level surveying. Currently, surveyors and Geomatics Diploma students use air bubbles as an aid in level surveying. This study will introduce a teaching aid with the characteristics of the Internet of Things (IOT) which is a detection device (sensor) to determine whether the setaf is standing upright or not called HS:1 (Horizontal Sensor:1). With the production of HS:1, it can make it easier for students to identify the usefulness of the level measurement set. HS:1 will be placed behind the seta during leveling work. By utilizing the microcontroller and Sensor GY-61 ADXL335 will detect objects that block in front of it and access in the form of a sound signal. The signal buzzer (buzzer) will give a sound signal after getting data from the sensor.

2. MATERIALS AND METHODS

HS:1 component consists of Arduino Uno, GY-61 ADXL335 sensor, buzzer, breadboard, wire, 9V battery, potentiometer and LCD screen. The Arduino Uno R3 is a commonly used microcontroller board because it uses the ATmega328P microcontroller. It is a board that can accept programs from open source. This open-source program is available for free and can be modified. It is a compact board with 14 digital input and output pins, 6 analog input pins, 16 MHz quartz crystal, USB connection for programming and power, and power jack for external power source. Breadboard is a component used to make a body or shield for electronic components. Buzzer is used as an audio signal device as an alarm (alarm devices). A potentiometer is a three-terminal resistor with a sliding or rotary contact that forms an adjustable voltage divider. The LCD screen used is a type of display that uses liquid crystals. The GY-61 ADXL335 sensor works to detect the position of an object that is vertical at 90 degrees. Then, this sensor can be used in applications that require tilt detection.

2.1 Product Design of HS:1

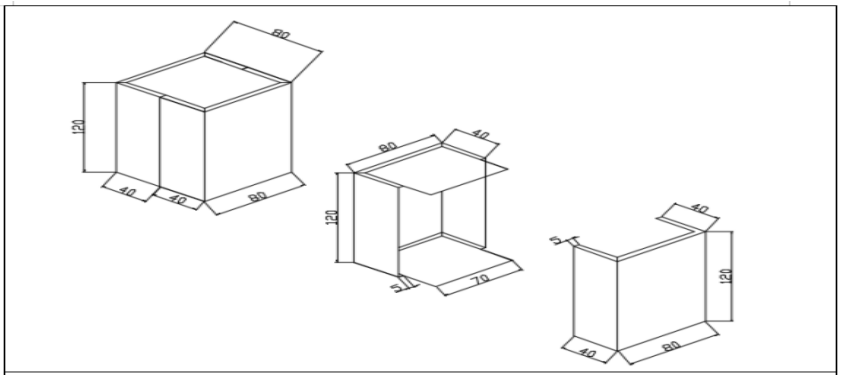

Figure 1. Product Design of HS:1

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2.2 HS:1 Component Wiring

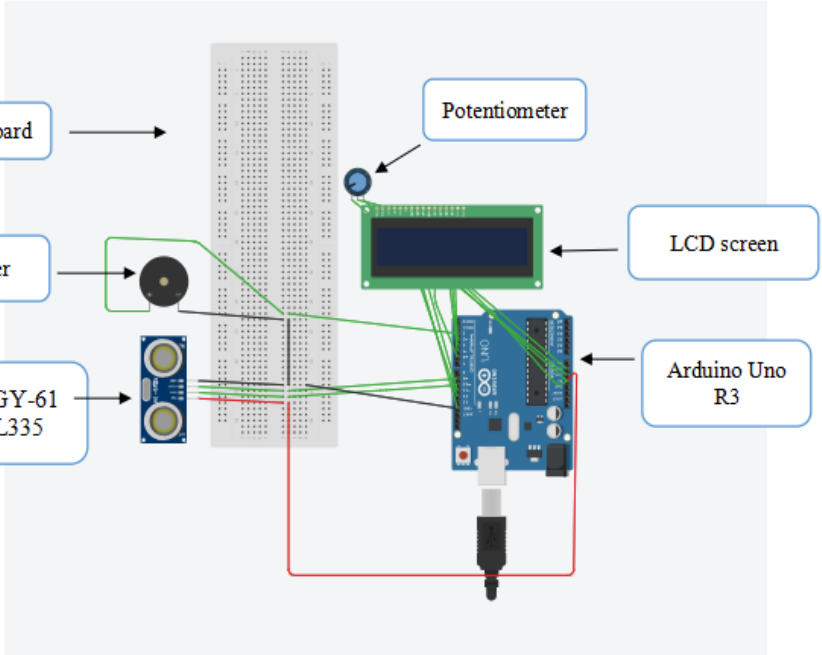

Figure 2. Component Wiring of HS:1

2.3 Product

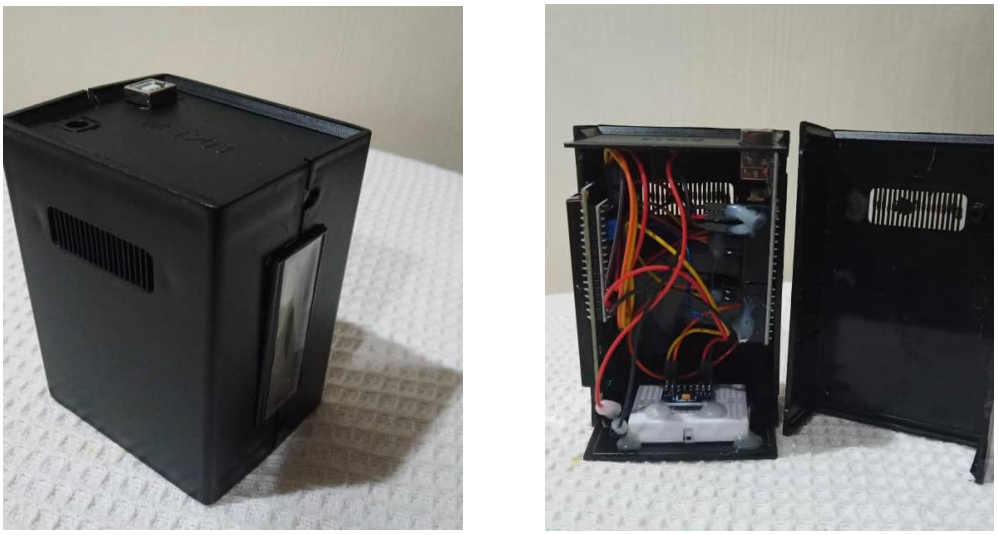

Figure 3. HS:1

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3. RESULTS AND DISCUSSION

3.1 Test Area

HS:1 has been tested for accuracy through a comparison of levelling data through the method of using a sensor device and by using a bubble without a sensor device. Levelling activities are carried out on the tar road starting from the Bench Mark (BM K2201) to the Temporary Bench Mark (TBM). The levelling activity is repeated from the Temporary Bench Mark (TBM) to the Bench Mark (BM K2201).

Figure 4. Test Area.

3.2 Result of Levelling Using a Bubble Without a Sensor Device.

Table 1. Data of Levelling Using a Bubble.

Pandangan			Naik	Turun	TGK	Aras laras Mula	Pemb.	Aras Laras Akhir	Jarak (m)	Catatan
PB	PA	PH								
1.366						37.648		37.648		BM
2.085		1.020	0.346			37.994	-0.002	37.992		CP1
1.735		1.128	0.957			38.951	-0.004	38.947		CP2
0.774		0.780	0.955			39.906	-0.006	39.900		TBM
1.130		1.733		0.959		38.947	-0.008	38.939		CP2
1.028		2.080		0.950		37.997	-0.010	37.987		CP1
		1.364		0.336		37.661	-0.012	37.649		BM

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1) Tikaian
   - R
   - 37.648 - 37.661
   - - 0.013

2) Pembetulan
   - $\frac{0.013}{7}$
   - 0.002

3) Had Tikaian
   - $\pm \sqrt[5]{7}$
   - 0.013 m

The error obtained is -0.013m and the correction result is 0.002m for each changing point. The error limit is 0.013m.

3.3 Result of Levelling Using HS:1

Table 2. Data of Levelling Using HS:1

Pandangan			Naik	Turun	TGK	Aras laras Mula	Pemb.	Aras Laras Akhir	Jarak (m)	Catatan
PB	PA	PH								
1.360						37.648		37.648		BM
2.090		1.015	0.345			37.993	- 0.001	37.992		CP1
1.720		1.128	0.962			38.955	- 0.002	38.953		CP2
0.785		0.795	0.925			39.88	- 0.003	39.877		TBM
1.132		1.715		0.930		38.95	- 0.004	38.946		CP2
1.025		2.085		0.953		37.997	- 0.005	37.992		CP1
		1.365		0.340		37.657	- 0.006	37.651		BM

1) Tikaian
   - R
   - 37.648 - 37.657
   - - 0.009

2) Pembetulan
   - $\frac{0.009}{7}$
   - 0.001

3) Had Tikaian
   - $\pm \sqrt[5]{7}$
   - 0.013 m

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The error obtained is -0.009m and the correction result is 0.001m for each changing point. The error limit is 0.013m.

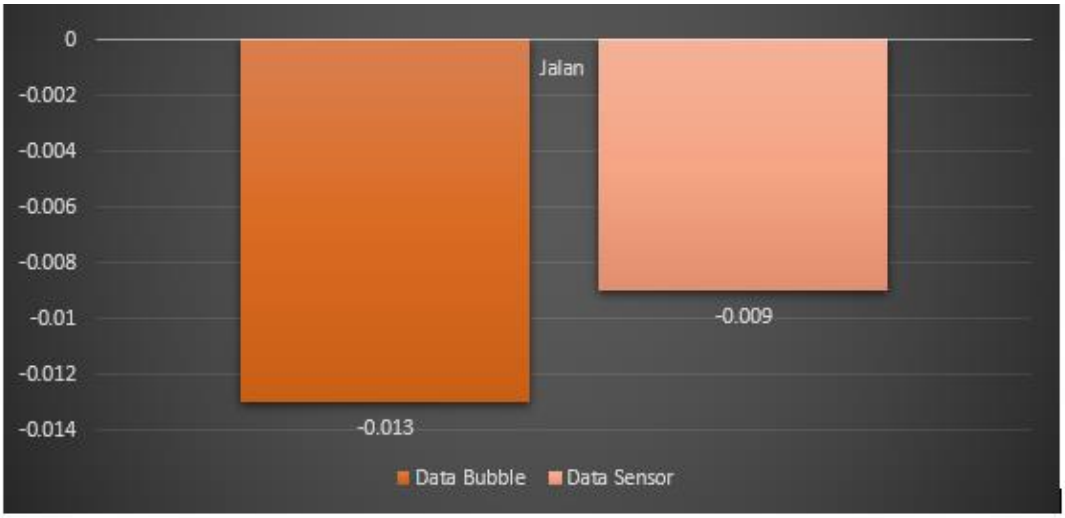

Figure 5. Graph Comparison of Scores Resulting From Both Methods.

The results of the tests found that the levelling activity using HS:1 produced a smaller value of error compared to the result of levelling with bubble. This proves that HS:1 is successful in helping to reduce the value of error or increase the value of accuracy in levelling activity. The value of levelling with HS:1 obtained -0.009m compared to -0.013m levelling with bubble. The difference between bubble data and HS:1 is -0.004m.

4. CONCLUSION

Through tests that have been carried out on HS:1, data from HS:1 is more accurate than bubble data. The use of HS:1 by Geomatics program students will be able to help them do levelling survey activities better, improve the accuracy of levelling survey data and not have to repeat levelling survey practice many times. The creation of a tool to detect the levelling staff upright position can help students to better understand the basic concept of levelling survey and to perform it more perfectly. It can also help lecturers in implementing levelling survey practical classes. However, this study is still at an early stage and can be improved for future studies.

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AGROCRETE LINTEL

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Abstract

The depletion of natural aggregates and steel, combined with escalating costs, drives the need for sustainable alternatives in construction. This research explores the potential of oil palm shell (OPS), an agro-industrial waste, as a coarse aggregate in AgroCrete—a novel agro-waste concrete. The study aims to reduce environmental impact and resource consumption by enhancing the physical properties of OPS through pretreatment with styrene acrylic emulsion (SAE). This approach addresses challenges such as high porosity and biodegradability. Various SAE concentrations were applied to OPS, and the resulting concrete's physical and mechanical properties were assessed. The findings demonstrate that SAE pretreatment significantly improves adhesion between OPS and the cement matrix, leading to enhanced compressive, flexural, and tensile strengths. Optimal SAE concentrations (15%) provided the best mechanical performance, while excessive amounts were found to be detrimental. The study also introduced the AgroCrete Lintel as a practical application of the treated OPS-based concrete, showcasing its viability in construction. The lintel prototypes exhibited competitive load-bearing capacity, underscoring OPS's potential as a sustainable material for lightweight structural components. Future research should focus on the long-term durability and performance of AgroCrete under various environmental conditions and explore its scalability for larger construction projects.

Keywords: Oil Palm Shell; AgroCrete; Styrene Acrylic Emulsion; Lintel; Aggregates; Eco-Friendly Materials.

1. INTRODUCTION

Aggregate is a fundamental component in concrete, essential for providing structural integrity. However, the ongoing depletion of natural aggregates and steel, coupled with rising costs driven by high demand, underscores the urgent need for sustainable alternatives in construction materials. Oil palm shell (OPS), a byproduct of the agro-industrial sector, emerges as a promising substitute. Utilizing OPS as an aggregate has the potential to significantly reduce energy consumption and CO2 emissions associated with the extraction and processing of natural aggregates (Kareem, Raheem, Oriola, & Abdulwahab, 2022). Despite its environmental benefits, OPS presents challenges such as high porosity, increased void content, and biodegradability, which can adversely affect the engineering properties of concrete (Hamada et al., 2020; Nadh, Vignan, Hemalatha, & Rajani, 2021). To address these issues and maximize the utility of OPS in construction, this study investigates the pretreatment of OPS with styrene acrylic emulsion (SAE) to enhance its physical properties. Moreover, this research introduces the AgroCrete Lintel—a structural component developed from treated OPS-based concrete—as a practical application of this innovative material. The AgroCrete Lintel serves as a proof of concept, demonstrating the potential of AgroCrete to meet the demands of sustainable construction while delivering reliable structural performance.

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2. MATERIALS AND METHODS

This research investigates the pretreatment of oil palm shell (OPS) with styrene acrylic emulsion (SAE) to enhance the physical properties of OPS for use as a coarse aggregate in the production of AgroCrete. The objective is to improve OPS's performance by applying SAE surface coatings, addressing issues like high porosity and poor adhesion with the cement matrix. Figure 1 illustrates the surface treatment process for OPS aggregates. Various SAE concentrations were tested to assess their impact on OPS's physical properties and the resulting concrete's engineering characteristics. Table 1 presents a comparative analysis of the physical properties between untreated and treated OPS. Pretreatment methods were specifically aimed at enhancing water resistance and bonding between OPS and the cement matrix.

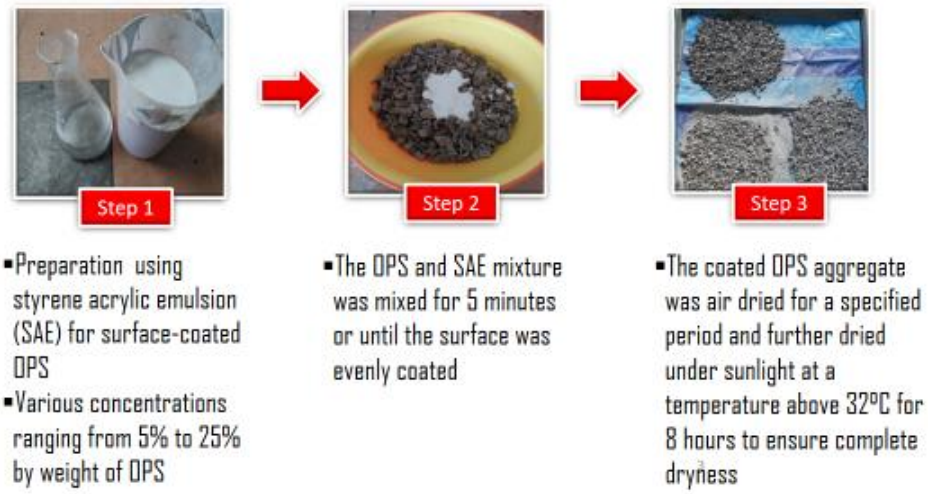

Figure 1. OPS Surface Treatment Process

Table 1. Physical Properties of Untreated vs. Treated Oil Palm Shell (OPS)

Properties of aggregate	Untreated OPS (NT)	Treated with 5% SAE (S5)	Treated with 10% SAE (S10)	Treated with 15% SAE (S15)	Treated with 20% SAE (S20)	Treated with 25% SAE (S25)
Particle Density – Oven Dry (Mg/m^3)	1.02	1.07	1.09	1.11	1.17	1.15
Particle Density – SSD (Mg/m^3)	1.27	1.26	1.27	1.29	1.31	1.28
Apparent Particle Density (Mg/m^3)	1.35	1.32	1.33	1.36	1.35	1.32
Water absorption (%)	24.32	17.92	16.28	16.86	11.14	10.93

In this study, AgroCrete was produced by completely replacing conventional coarse aggregates with OPS in the concrete mix. The design mix had a weight ratio of approximately 1:1.68:1.10 (cement: sand: OPS) and maintained a consistent water/cement ratio of 0.4 across all mixtures, targeting a compressive strength of 20 MPa at 28 days. A superplasticizer was also added at 1.5%-1.7% by weight of cement to improve workability. Table 2 presents the different specimens, each using varying concentrations of treated OPS as coarse aggregate. These treated OPS concrete specimens were compared to untreated OPS (NT) concrete, which served as the control. For the AgroCrete Lintel, the prototypes were designed and tested using the optimal AgroCrete mix identified from preliminary evaluations.

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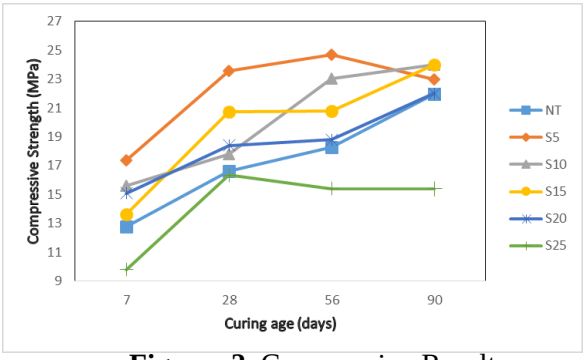
Table 2. Mixes Design

Mix	OPS (kg/m^3)	Cement (kg/m^3)	Water (kg/m^3)	Sand (kg/m^3)	SP (%)
NT (control)	498	450	180	760	1.5±2
S5	498	450	180	760	1.5+2
S10	498	450	180	760	1.5+2
S15	498	450	180	760	1.5+2
S20	498	450	180	760	1.5+2
S25	498	450	180	760	1.5+2

Note : S5
- → Percentage of SAE
- → Types of OPS

3. RESULTS AND DISCUSSION

The study revealed that pretreating OPS with styrene acrylic emulsion (SAE) significantly enhances the mechanical strength of AgroCrete. The optimal SAE concentration improved the bond between OPS and the cement matrix, leading to superior mechanical performance, including increased compressive, flexural, and tensile strengths. However, excessive SAE concentrations (>20%) adversely affected strength, indicating the importance of precise dosage. This pretreatment method also effectively enhanced the physical properties of OPS, establishing it as a viable aggregate for lightweight concrete. The compressive, flexural, and tensile strength results that determine the mechanical strength properties of treated OPS concrete are shown in Figures 2, 3, and 4, respectively.



Figures 2. Compressive Results

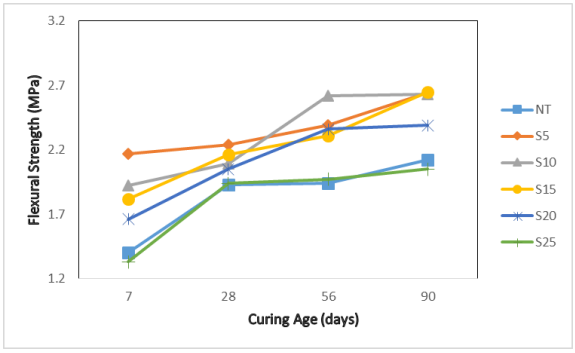


Figure 3. Flexural Strength Results

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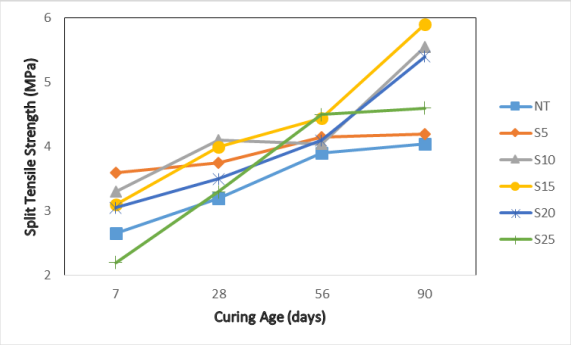

Figure 4. Split Tensile Strength Results

For the AgroCrete Lintel, test results confirmed that the OPS-based concrete provided adequate structural integrity and durability for lightweight construction applications. The lintels exhibited competitive load-bearing capacity and flexural strength, making them suitable for construction scenarios that prioritize reduced weight and sustainability. Table 3 provides a comparative analysis of the performance metrics between AgroCrete, utilizing OPS as an aggregate, and traditional concrete using conventional aggregates.

Table 3. Performance Comparison Between AgroCrete and Conventional Concrete

Concrete Design & Performance	**AgroCrete**	**Normal Concrete**
Mix Design	1:1.68:1.10 (cement: sand: OPS)	Gr. 25 - 1 : 1.5 : 3 (cement: sand: coarse aggregate)
Compressive Strength	21.5 N/mm²	25.1 N/mm²
Flexural Strength	2.2 N/mm2	2.6 N/mm²
Density	< 2000 kg/m³	2400 kg/m³
Air Content	Range of 4.8% - 5.5%	Range of 4% - 1.5%
Weight	30% lighter 7.26kg	Heavy 10.69kg

These findings underscore the effectiveness of SAE pretreatment in improving the physical and mechanical properties of OPS aggregates, paving the way for eco-friendly concrete solutions. The enhanced mechanical performance of OPS-based concrete through this method highlights its potential as a sustainable construction material. This innovative approach not only reduces environmental impact but also promotes the use of agro-industrial waste in the construction industry.

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4. CONCLUSION

This study demonstrates the potential of OPS as a sustainable alternative to conventional aggregates in concrete production, particularly through the development of AgroCrete. By treating OPS with SAE, the research successfully mitigated challenges such as high porosity, increased void content, and biodegradability, which are typically associated with OPS. The SAE pretreatment significantly improved the mechanical properties of AgroCrete, including compressive, flexural, and tensile strengths, making it a viable material for lightweight structural applications. The introduction of the AgroCrete Lintel as a practical application further highlights the material's potential in the construction industry. The lintels demonstrated sufficient load-bearing capacity, proving that AgroCrete can effectively replace traditional concrete in certain contexts, especially where sustainability and reduced weight are critical considerations.

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INNOVATION WASTE CONCRETE AND CLAM SHELLS AS ENVIRONMENTALLY FRIENDLY CONCRETE AGGREGATE SUBSTITUTES

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Abstract

With the rise of infrastructure development that uses concrete as the main element in the structure of the building, it will have an impact on further environmental degradation. If there is no effort to reduce the use of concrete, the author believes that in the future, this will have an adverse impact on environmental degradation. Concrete itself consists of a mixture of Portland cement or other hydraulic cement, coarse aggregate, fine aggregate and water, with or without additives that form a solid mass (SNI-03-2847, 2002). However, concrete is considered to be environmentally unfriendly, due to CO2 emissions generated by the cement production process and overexploitation of aggregates, which has an impact on environmental damage and balance. The solution to the problem is to use the concept of concrete innovation with environmentally friendly aggregate composition. This study aims to analyze the impact of using 55% concrete waste as a substitute for coarse aggregate, 45% clam shell waste as a substitute for fine aggregate, and design the innovative composition to obtain the desired optimum compressive strength. The value of slump and compressive strength will represent the quality of the concrete itself. Through this research, it is expected to know the extent to which clam shell waste can affect concrete properties. So as to provide insight into the potential use of clam shell waste as an alternative material in concrete production.

Keywords: Waste Concrete Material, Clam Shell Waste, Eco-Friendly Concrete, Construction.

1. INTRODUCTION

The rapid development of technology and industry today provides significant changes to life, especially in the field of construction. Based on records in 2016, national concrete work exceeded 137 million tons and is expected to continue to increase every year. this proves that concrete construction has a role in infrastructure development. This causes concrete to become a popular building material in construction because the material is easy and easy to shape and easily molded as needed.

According to Tri Mulyono (2004:135-136) concrete is a mixture of Portland cement or any other hydraulic cement, coarse fine aggregate, and water with or without the use of additives. The aggregate can be divided into coarse aggregate (crushed stone/split) and fine aggregate (sand). Aggregate in concrete serves as a filler, but aggregate has a very important role in determining the quality and properties of the resulting concrete. As the demand for concrete materials increases, it is directly proportional to the increase in cement production and the exploration of other raw materials for concrete.

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The mixture of elements forming concrete must be set in such a way as to produce fresh concrete (Fresh Concrete) that is easy to work with (workability) and meets the compressive strength of the plan after the concrete hardens (hardened concrete), and is quite economical. (Susanti, Rika Dewi. 2011, Construction material technology). The basic ingredients of concrete are factors that greatly support the quality of concrete. The concrete mix design, type, quality and amount of concrete composition materials must be calculated in certain proportions or comparisons in order to produce the desired concrete quality. Concrete mix design is intended to get the best concrete, namely, high compressive strength, easy to work with, wear-resistant and long, cheap or economical.

Environmentally friendly concrete consists of cement, sand, gravel and water, and other admixtures to achieve the desired concrete performance. The use of cement, although in small quantities (about 7-15%), to produce cement uses considerable energy and produces a lot of waste, which will have an impact on the surrounding environment. Based on data from the Indonesian Cement Association (ASI 2022), total cement sales in 2021 reached 77 million tons, up 6.94% from 2020 of 72 million tons. The cement industry contributes huge carbon dioxide (CO2) emissions to the atmosphere.

This factor causes the author to be motivated to innovate concrete using the concept of high compressive strength, economical and environmentally friendly by utilizing the potential waste around us, namely concrete waste and clam shell powder as a substitute for sand and concrete waste as coarse aggregate. Concrete waste is one of the waste problems in the construction world because there are so many new projects or infrastructure developments that massively use new concrete. While concrete itself is something that cannot be decomposed, in the sense that it is not environmentally friendly.

Clam shell waste can be utilized as an additive in concrete mixes. This provides an alternative to utilizing wastes that are not utilized, clam shells are parts of shells that cannot be consumed. The utilization of clam shell waste so far is only limited to handicrafts, so it is only left to accumulate into waste. While the shells contain chemical compounds that are pozzolanic, namely lime (CaO), alumina and silica compounds (Siregar, S.M, 2015).

In the implementation of construction, there are also many concrete wastes resulting from testing and demolition of buildings and the results of learning tests on concrete, causing the contribution of concrete waste to construction waste piles to be quite large. So the author seeks to minimize this by replacing coarse aggregate in concrete with concrete waste. This is a profitable alternative to concrete materials, as the aggregates that have been used are those that have been discarded on open land and some are used as urungan. The availability of these materials is so great that the potential for recycling is very much possible.

2. MATERIALS AND METHODS

To making this eco-friendly concrete innovation we use unused materials and we have the principle of utilizing innovation opportunities that we can develop, all materials we use consist of Waste Concrete Material because Concrete waste has characteristics that are strong and slow to decompose, so it takes a long time to decompose. time for decomposition. This used material is available in very large quantities for recycling. Innovative construction technologies are needed that not not only reduce the exploitation of natural resources but also utilize concrete waste efficiently. concrete waste efficiently. One of the measures to reduce this negative impact negative impact is to reuse concrete waste to produce new concrete (Soelarso & Baehaki, 2016). The following is the Concrete Waste laboratory testing data:

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Aggregate Testing	Testing Results
Sludge Content	0.3%
Specific gravity	2,61
SSD Specific gravity	2.68
Maximum Size	12.7 mm
Modulus of Smoothness	13,89%

Concrete waste is a hard material like aggregate, the use of concrete waste is a hard material like aggregate, the use of concrete fractions as a substitute for coarse aggregate in concrete mixes can produce significant differences in compressive strength. With the use of 100% concrete waste can produce a compressive strength with 28-day conversion reaches 74.82 Mpa.

The next material we use clams are a group of shelled sea stars that have high nutritional value and are favored by the community. In a survey conducted by the author, in a fishing village around the coast of Demak, which is the final disposal site for shellfish waste. around the coast of Demak, which is the final disposal site for processed sea waste, every day can accommodate an average of ± 13 kg and in a month can reach ± 390 kg one month can reach ± 390 kg from one landfill. So that the waste collected in the final disposal disposal is not maximally processed and some of it just just piled up. The following is the chemical compound content of Clam Shells:

Composition Chemistry	Content (%)
$CaC0_3$	98,7
SiO_2	7,88
Fe_2O_3	0,03
MgO	22,28
AL_2O_3	1,25

In this research, clam shells were chosen because they have a chemical compound of CaO chemical compound of 66.7% (Siregar 2009) and after heating ± 500 ° C produces 98.7% $CaCO_3$ (Hafisko, Handa, et al. 2007). 500 ° C produces 98.7% $CaCO_3$ (Hafisko, Handa. Dkk. 2007) which is the main compound of seman, besides that if it reacts with water, it will produce $CaCO_3$. the main compound of seman, besides that if it reacts with water, it will produce acetylene gas which produces heat. produce acetylene gas which generates heat so that it helps accelerate the hardening and binding process in concrete.

The concrete mix planning process is carried out based on SNI 03-2834 2000 for innovation concrete planning with a target compressive strength of 75 MPa at the age of 28 days. Below are the details of the mixdesign calculations in this test.

For the first we need to determine the Water/Binder Ratio, to obtain a compressive strength of 75 MPa, a water/binder of 0.54 with a total plan moisture content of 216 kg/m3 and a maximum coarse aggregate of 12.7 mm. maximum coarse aggregate used is 12.7 mm.

For the second we need to determine the Binder Composition, based on the water/binder ratio that has been determined, the amount of binder per m3 of concrete can be calculated with the amount of binder = 216 / 0.54 = 400 kg/m3 and the cement used is 400 kg/m3.

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For the third we have to determination of Density of Concrete, the weight of concrete (Um) is calculated using the equation Um. Ga is the aggregate SSD average fineness modulus, A is the air content (%), Cm is the cement demand (kg), and Gc is the specific gravity (kg). air content (%), Cm is cement requirement (kg), and Gc is specific gravity of of cement. Ga and Gc are calculated based on the sum of the percentage multiplication of of each component with its specific gravity.

For the fourth one we have to determine Coarse and Fine Aggregate Composition, based on the total composition that has been determined, the amount of coarse aggregate and fine aggregate is determined as follows:

AG Coarse + AG Fine = mass of concrete - binder - water - voids
AG Coarse + AG Fine = 2385 - 400 - 216 - 0
AG Coarse + AG Fine = 1,769 kg/m3

The ratio of coarse aggregate and fine aggregate was chosen as 45:55 from this ratio, the aggregates used were 972 kg/m3 of sand and 796.05 kg/m3 of concrete waste.

For the fifth we have to Determine the Composition of Superplasticizer Sika Viscocrete 10, the amount used is 1.4% of the cement, which is 5.6 Kg/m3:

Perhitungan Mix Design setiap 1 m^3		
W/C		0,54
Slump Area		0,6
Material		Berat (Kg/m^3)
Semen	=	400
Serbuk cangkang kerang	=	486,475
Pasir	=	486,475
Limbah Beton	=	796,05
Air	=	216
Admixture	=	5,6
Berat Total		2390,6

3. CONCLUSION

Based on the trial and mixing of various variations that have been conducted, our innovative concrete uses a substitution of fine aggregate with a ratio of 70% waste powder shells and 30% sand and coarse aggregate substitution with 100% waste concrete fragments with a ratio of 100% waste concrete fragments, judging from the data on the availability of the waste innovations we use (kernag shell waste powder and waste concrete) is very much in the Semarang area and the surrounding even in Indonesia, these wastes are easy to find and not yet worth utilizing so that its use in concrete mix innovation is a very appropriate choice.

The innovative concrete in this study can minimize pollution and is more environmentally friendly because the use of waste that is difficult to decompose can be utilized so as not to damage the surrounding environment, and the use of these wastes as fine aggregate substitutes and coarse aggregate substitution can reduce the cost of production cost by 38.00% or more precisely Rp.1,063,611.25 from normal SCC. We need further research on the selection of concrete mixes and the percentage of each innovation material and there must be further research to find out more about the effectiveness of these innovative additives in mass production of concrete and precast concrete. in mass production of concrete and precast concrete.

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UTILIZATION OF PT FREEPORT INDONESIA'S TAILINGS WASTE FOR SUSTAINABLE PAVING BLOCK AND BRICK PRODUCTION

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Abstract

Amid Indonesia's rapidly expanding construction industry, using tailings waste as a raw material for producing paving blocks and bricks presents significant potential for sustainable solutions. Tailings, previously considered as useless remnants from mining processes, can now be harnessed as a resource for creating construction materials. Mining activities, such as those by PT. Freeport Indonesia, produce around 223,100 tons of tailings daily, presenting a significant opportunity to lessen environmental impact by converting these tailings into high-quality, eco-friendly construction materials. Compression strength and water absorption tests show that tailings waste bricks achieved a maximum compression strength of 59.87 kg/cm² with a low water absorption rate of 3.67%. Tailings waste paving blocks had compression strength results ranging from 18.9 MPa to 28.1 MPa, complying with the Indonesian National Standard (SNI) for class B compressive strength. TCLP toxicity tests showed heavy metal concentrations in tailings waste were well below the limits for hazardous waste categories 1 and 2. Considering the potential and urgency for utilization of addressing tailings waste, establishing a processing plant to convert tailings waste into construction products, such as bricks and paving blocks, will greatly support sustainable construction industries in Indonesia and help manage the increasing volume of tailings waste.

Keywords: Tailings Waste Utilization; Sustainable Construction Materials; Paving blocks; Bricks

1. INTRODUCTION

In Papua, there are loamy soils and the availability of local materials such as tailings. Since PT Freeport Indonesia began mining activities, the number of tailings generated has increased significantly. From 7,275 tons/day in 1973, the amount of tailings waste has increased to 31,040 tons/day in 1988, and currently reaches 223,100 tons/day (Murdohardono, 2019). Tailings are an inevitable result in the mining industry because a small part of the excavation or mining process produces ore products, while most of the rest becomes tailings waste (Irianto et al., 2021). Tailings waste, the residual result of the mineral processing process, is currently still neglected in terms of its utilization for the environment. In fact, this tailings waste ranges slurry to solid which can be utilized not only for landfill. Green Building is an eco-friendly approach in construction aimed at reducing energy consumption, conserving natural resources, and minimizing pollution by emphasizing efficient water and energy use and incorporating renewable energy sources (Massie & Dundu, 2018).In this context, the utilization of tailings becomes relevant. Often overlooked, tailings have the potential to be used as construction materials in Green Building, helping to reduce construction waste and support the efficient use of local resources in an effort to protect the environment. With the amount of tailings waste reaching 223,100 tons/day and potentially damaging the environment because it is hazardous waste. If the waste is not managed properly, it can cause environmental damage, health problems for humans, and harm the company's reputation ultimately affects sales or profits (Rachman et al., 2022). This research will discuss utilization tailings waste as a building material bricks and paving block.

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2. MATERIALS AND METHODS

2.1. The Source of Tailing Waste Comes From

Tailing waste comes from PT. Freeport Indonesia which is located in Mimika Baru District, Mimika Regency, Papua.

2.2. Tailings Waste Brick Testing

Tailings samples (sand and water mixture) were mixed with cement in a 1:6 ratio of cement to sand. The mixture was then put into a 20 cm x 10 cm x 10 cm brick mold, then dried until the brick hardened. Tests to measure the compressive strength and water absorption of the bricks were conducted after 28 days.

Cement : $\frac{1}{7}$ x 2000 cm^3= 28,71 cm^3

Sand : : $\frac{6}{7}$ x 2000 cm^3= 1714,29 cm^3

Table 1. Physical Requirements of Pejal Bricks

Solid Concrete Steel Quality	Minimum Compressive Strength (kg/cm^2)		Maximum Water Absorption (% Weight)
	Average	Each	
I	100	90	25
II	70	65	35
III	40	35	-
IV	25	21	-

Reference: Sandy et al., 2019.

From the testing of six samples of bricks made from tin tailings, the average compressive strength was obtained in Table 2.

Table 2. Average compressive strength values of tailings brick samples

Sample No.	Average Compressive Strength (kg/cm^2)
1	24.20
2	16.56
3	40.76
4	59.87
5	39.49
6	24.20

Reference: Sandy et al., 2019.

Then, the test was continued by measuring the specific gravity and water absorption of tin tailings waste bricks on the six samples tested. The results of the tests are listed in Table 3.

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Table 3. Average Absorption Value of Tailings Brick Samples

Sample No.	Average Absorption Value (%)
1	5.94
2	4.07
3	5.74
4	3.67
5	5.75
6	6.59

Reference: Sandy et al., 2019.

The test results showed that all six samples had water absorption rates below the maximum limit, indicating suitable absorbency quality. Therefore, these materials can be used as building construction materials. The lowest water absorption was recorded in sample 4 at 3.67%, while the highest was in sample 6 at 6.59%.

From the results of the research involving six sampling sites, it can be concluded that samples 3, 4, and 5 met the quality standards for categories 4 and 3 according to Table 1. Sample 4, in particular stood out with the highest average compressive strength, reaching 59.87 kg/cm2, and a low level of low water absorption of only 3.67%. This confirms that tin tailings waste has the potential to be managed and utilized as a basic material in brick production (Sandy et al., 2019).

2.3 Tailings Waste Mortar

Table 4. Characteristics and Tests of Tailings Waste for Mortar Production

Characteristic/Test	Findings/Implications	Source
Chemical Composition Testing	- Contains metals like As, Zn, Hg, Pb, Cd, Cu, SiO2, Al2O3, Fe2O3. - SiO2, Fe2O3, and Al2O3 exceed 60%, making it suitable for cement-based materials like mortar.	Paradise & Nurkhamim (2020)
Metals Consideration	- Metals like As, Zn, Hg, Pb, Cd are hazardous and toxic. - These metals can harm the environment and reduce mortar mechanical strength.	Pandeleke (2014)
Gradation Check	- Proper gradation improves mortar adhesion. - Incorrect gradation (too fine/coarse) can reduce mortar performance.	Mulia & Sari (2018)
Physical Characteristics Testing	- PT Freeport Indonesia's tailings meet SNI 6882:2014 standards for plastering and thinbed lightweight brick products. - Suitable for load-bearing and filler walls.	Mulia & Sari (2018)

Tailings waste has a range of characteristics and tests to make mortar. First, there is chemical composition testing, conduct to identify the elements and compounds that make up tailings waste. The chemical composition of tailings waste includes metals such as arsenic (As), zinc (Zn), mercury (Hg), lead (Pb), cadmium (Cd), copper (Cu), silica oxide (SiO2), aluminum oxide (Al2O3) and iron (III) oxide (Fe2O3) (Paradise & Nurkhamim, 2020). Tailings waste from mining activities carried out by PT Freeport Indonesia has the potential to become a ready-to-use mortar base material because it contains chemical compounds that support mortar performance. The levels

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of SiO2, Fe2O3, and Al2O3 in the waste exceed 60%, making it possible to be used in the construction of cement-based building materials, such as concrete and mortar (Mulia & Sari, 2018).

In addition, the content of tested metals from PT Freeport Indonesia is considered hazardous and toxic, which can have consequences for damage to the environment and a decrease in the mechanical strength of mortar mixtures (Pandeleke, 2014). Secondly, the gradation check, which involves the distribution of the appropriate particle size to fill the space between the cement and sand grains, helps to improve the adhesion of the mortar. However, if the gradation is too fine or too coarse, it can reduce the performance of the mortar. Then the third is testing the physical characteristics of tailings which include moisture content, mud content, absorption, and specific gravity. The results of testing the gradation and physical characteristics of tailings at PT Freeport Indonesia show that the plastering and thinbed lightweight brick products comply with the technical standards set out in SNI 6882:2014 for the formation of mortar. These products can be used for load-bearing walls as well as fillers, both for exterior and interior parts (Mulia & Sari, 2018).

2.4 Tailings Toxicity Test

The TCLP (Toxicity Characteristic Leaching Procedure) test measures heavy metal toxicity in tailings waste. Using two methods, TCLP A and TCLP B, the test simulates the leaching of contaminants by adding an acid solution to the tailings sample, extracting it, and then filtering it for analysis (Tras et al., 2016). Results from PT Freeport Indonesia show that heavy metal concentrations are well below hazardous waste limits for categories 1 and 2 (Ekaputri et al., 2020). This low toxicity suggests that tailings can be directly used as mortar raw material without additional treatment (Mulia & Sari, 2018).

2.5 Tailings Waste Paving Block Testing

Table 4. Test value of compressive strength of paving block dimension 20cmx10cm

Code ID	Sample dimension (cm)	Total testing area (cm^2)	Days of resting (days)	Load (kN)	Tension (Kg/cm^2)
PN-7	20 x 10	200	7	666	339.66
PN-14	21 x 10	200	14	589	300.39
PN-28	22 x 10	200	28	666	485.23
PN-7	23 x 10	200	7	372	189.72
PN-14	24 x 10	200	14	485	247.35
PN-28	25 x 10	200	28	485	281.08

Note: PN = Paving Normal; PT = Paving Tailing (Algifari & Adiansyah, 2021).

Regular paving blocks have a compressive strength of 33.9 to 48.5 MPa, while tailings waste paving blocks range from 18.9 to 28.1 MPa. This difference is due to varying cement percentages, with regular paving blocks showing a 26% higher strength increase from day 14 to day 28. Despite the lower strength, tailings waste paving blocks still meet SNI standards for quality B, suitable for parking pavement construction. The study suggests that increasing the percentage of tailings waste can reduce costs while producing paving blocks that meet SNI class B standards (Algifari & Adiansyah, 2021).

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2.6 Press Machine

The manufacturing process for paving blocks and bricks uses a press machine. A press machine is a tool that can apply pressure to an object. The source of the large pressure comes from the working mechanism of the hydraulic machine (Attorik et al., 2022). The frame of this press machine uses steel material. Steel was chosen because it has high enough strength to withstand large pressure.

3. RESULTS AND DISCUSSION

3.1 Design of paving block and concrete brick

The result of our innovation is the use of tailing waste from the process of breaking down mining rocks containing minerals to produce paving blocks and bricks with the following specifications.

Table 5. Dimensions of Paving Blocks and Bricks

Product Image	Dimension of Paving Block and Brick
Figure 2. Paving Block Type 1 (Personal Documentation)	1. Dimension of Paving Block Type 1 • Length = 210 mm • Wide = 105 mm
Figure 3. Paving Block Type 2 (Personal Documentation)	2. Dimension of Paving Block Type 2 • Side = 105 mm
Figure 4. Brick (Personal Documentation)	3. Dimension of Brick • Length = 210 mm • Wide = 105 mm • Length (s) = 70 mm • Wide (s) = 50 mm

4. CONCLUSION

Tailings waste from mineral processing, often overlooked, can be used to make bricks and paving blocks. Tests show tailings waste can produce bricks with a compressive strength of 59.87 kg/cm² and low water absorption (3.67%). Its high SiO2, Fe2O3, and Al2O3 content makes it suitable for cement-based materials like concrete and mortar. Toxicity tests confirm that heavy metal levels are well below hazardous limits, allowing direct use in mortar. Tailings waste paving blocks meet SNI class B standards, and production uses a press machine.

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SECTION 2

Design and Creativity

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OXYGEN GENERATOR BENCH: UNVEILING THE POTENTIAL OF MICROALGAE IN ENVIRONMENTAL DESIGN

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Abstract

Carbon dioxide concentration has been relatively local problem, but today, scientists are analysing the air quality in a global scale. Cities are responsible for close to 70% of global carbon dioxide emissions. In fact, the rate of urbanization in Malaysia is observed relatively fast, where the urbanisation rate has tripled over five decades from 28.4% in 1970 to 75.1% in 2020. In recent decades, microalgae-based carbon dioxide capture has emerged due to its sustainability as well as converting it into oxygen. Cities in Malaysia deals with the challenges of air pollution and lacked of greenery spaces, integration of microalgae in landscape architecture and design can be part of alternative solution, thus author came out with Oxygen Generator Bench idea. Study done by author has identified 420 liter of *Chlorella vulgaris.* in a bioreactor system (1750mm x 800mm x 300mm of glass panel) able to absorb 172.2 kp/m3/kg/year of CO2. Higher numbers of landscape infrastructure and facilities using microalgae in the cities, will reduce carbon concentration in the city. Although capture carbon dioxide via microalgae photosynthesis will not significantly slowdown the increase in global atmospheric but it could be useful to decrease emission from point of source and make our city less polluted.

Keywords: microalgae, environmental design, oxygen generator bench

1. INTRODUCTION ON MICROALGAE

Carbon dioxide concentration has been relatively local problem, but today, scientists are analysing the air quality in a global scale. Cities are responsible for close to 70% of global carbon dioxide emissions. In fact, the rate of urbanization in Malaysia is observed relatively fast, where the urbanisation rate has tripled over five decades from 28.4% in 1970 to 75.1% in 2020. In recent decades, microalgae-based carbon dioxide capture has emerged due to its sustainability as well as converting it into oxygen. Cities in Malaysia deals with the challenges of air pollution and lacked of greenery spaces, integration of microalgae in landscape architecture and design can be part of alternative solution (Luqman et. al., 2023).

Microalgae has ability to withstand in polluted environment and function as microorganism that successfully purified urban air quality and increase oxygen production (Latif et al., 2020). Phycology is the science that studies all forms of algae, from very tiny microorganisms that float through the ocean to huge forests

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of seaweed. Algae refers to a diverse group of photosynthetic non-vascular organism that contain chlorophyll and simple reproductive structure. Algae do not have true roots, stem, leafy shoots and complete their life cycle by releasing gametes or spores into the environment (Malcata et al., 2019). Microalgae are species that smaller than algae, it is microscopic and invisible to the naked eye. These unicellular aquatic microorganisms have 50,000 classified species and some notable examples include, a) *Spirulina maxima, b) Botryococcus, c) Scenedesmus quadricauda, d) Chlorella vulgaris, e) Dunaliella salina and f) Chaetoceros muelleri.* Microalgae use carbon dioxide and light energy for photosynthesis to produce their own food. They are the key source of food and energy for other aquatic organism. Compared to terrestrial plants, efficiency of microalgae for photosynthetic process is higher (6-8%) than terrestrial plant (1.5-2.2%) He. Y (2024). Based on research done by Udaypal et al., (2024), microalgae are also a good candidate for use as a carbon sink because they have high photosynthetic efficiency (potentially removing up to 273.75 g/L of CO2) as compared to terrestrial plants. The following equation explains the photosynthesis process:

$$CO2 + H2O \text{ --- } (CH2O) + O2$$

Figure 1. *Chlorella vulgaris*
Source: https://en.wikipedia.org/wiki/Chlorella_vulgaris

2. CONCEPTUAL IDEA

The Oxygen Generator Bench can be referred as a photo-bioreactor unit that has been placed in an outdoor environment. This project using UV light and 'upcycle product' as well as one of the environmental smart solution technology and design. In an aquarium of 420 litters of water, the algae that bind carbon dioxide and produce pure oxygen through photosynthesis. The project is designed to be multifunctional that provides seating area, chargers for mobile phones, and solar panel to generate the electricity. The designed product approximately estimated to replace two number of 10 years old trees or 200m2 of lawn. After the treatment process, used microalgae it can be reproduced as organic fertilizer, wastewater treatment, garden compost and production of biofuels by the local authority.

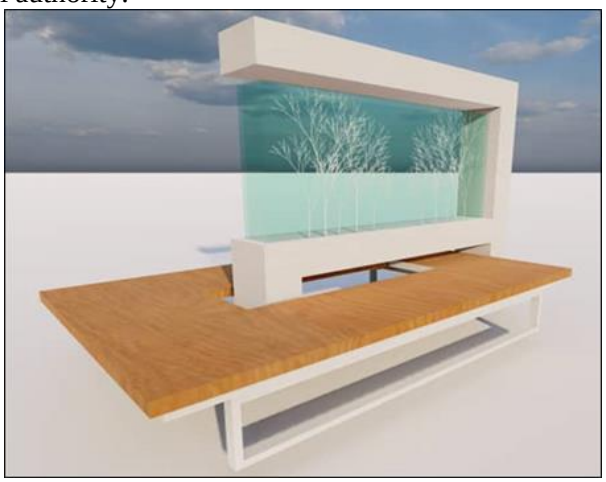

Figure 2. *Design Concept*

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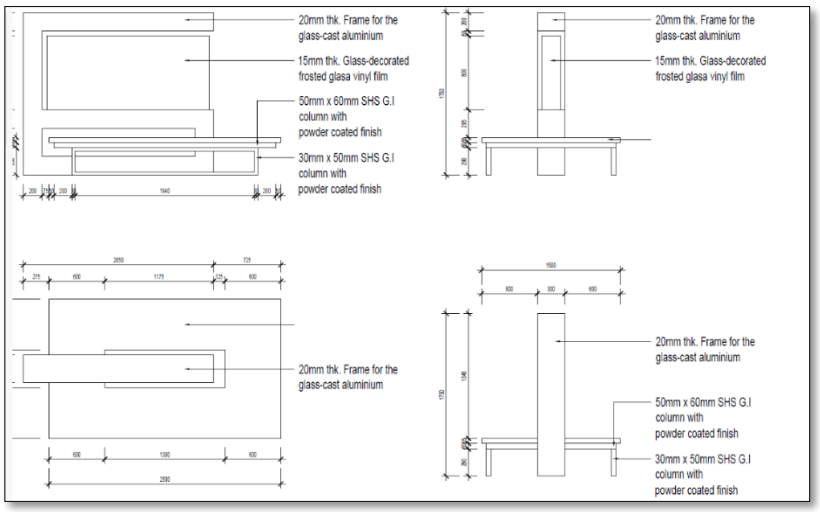

Figure 3. *Construction Detail*

3. RESULTS AND DISCUSSION

We can assume that some of innovation ideas that illustrated by designers using microalgae are still under test condition. However, the idea of using this microorganism is not new, but now being taken seriously in several countries. Live projects in Siberia and Germany serve as examples for developers, local authorities, and individuals interested in using microalgae to lower carbon levels in cities. This approach offers an alternative to challenges linked with city tree planting, such as limited space, tree hazards, and maintenance issues. Microalgae can be integrated in landscape architecture design in many ways, such as garden and street furniture, public sculpture, vertical greenery system, bioreactor garden (open space and roof top), open runway pond in recreational park, bioremediation, and as future construction materials. Other than that, microalgae can be part of sustainable landscape practice in urban farming by contributing to soil health and fertility and the extract from algae can be used by urban farm community as organic fertilizer and enhance plant growth. Study done by author has identified 420 liter of *Chlorella vulgaris*. in a bioreactor system (1750mm x 800mm x 300mm of glass panel) able to absorb 172.2 kp/m3/kg/year of CO2. Higher numbers of landscape infrastructure and facilities using microalgae in the cities, will reduce carbon concentration level at local scale. Although capture carbon dioxide via microalgae photosynthesis will not significantly slowdown the increase in global atmospheric but it could be useful to decrease emission from point of source and make our city less polluted.

4. CONCLUSION

In conclusion, the contemporary urban has very large and complex organism that function in linear way. Human needs and their everyday routine have extracted a lot natural resources and generate a lot of waste which also need to be removed. The landscape metabolism in the urban is no longer able to balance the ecological system of the city. Therefore, it is an urgent to redevelop landscape of the city that can function living organism circularly and microalgae to be part of urban ecosystem, again.

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AN-FLO-T

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Abstract

AN-FLO-T stands for anti-flood table. It is an innovation of a table and a boat. The ideal material for this product is fiberglass. This product can be use when floods happen. It can be a table and a boat at the same time. It also have storage space where we can put our things in there. AN-FLO-T can accommodate several people based on the size. It uses the concept of buoyancy force and applies Archimedes principle so the product can float. The idea of this product was generated due to the flood problem that often plagues our country and other countries as well. The main purpose of AN-FLO-T are to save lives, make it easier to deal with floods and lessen the burden of the rescue teams. But on the same time AN-FLO-T also can save up space and money and has multiple functions. It's also environmentally friendly because AN-FLO-T doesn't require any technology that can cause pollution. Hence, this innovation will bring so many benefits to everyone and absolutely worth to be created.

Keywords: Flood, table, boat.

1. INTRODUCTION

Floods are the most frequent type of natural disaster and occur when an overflow of water submerged land that is usually dry. This natural disaster are often caused by heavy rainfall, snowmelt or a storm surge from a tropical cyclone or tsunami in coastal areas. It also caused by ocean waves come on shore or when dams or leeves break. Floods are a type of natural disaster that can cause heavy destruction to life and property. They can also lead to the loss of numerous lives. At times, it can be highly dangerous and can wipe off an entire village or city. Sabah is one of the state where floods often occurs especially in Penampang, Inanam, Tamparuli, Manggatal, Telipok, Sipitang and etc.

To lessen the loss of lives, goverment has created some special organisation or agency like the Malaysia Civil Defence Force also known as Angkatan Pertahanan Awam Malaysia; popularly known as APM or MCDF, formerly JPAM or JPA3 is the civil defence services agency in Malaysia. Until 31 August 2016 it was known as the Civil Defence Department. Other than that, there's one more agency that's the same as Malaysia Civil Defence Force. It was the Fire and Rescue Department of Malaysia; Jabatan Bomba dan Penyelamat Malaysia (JPBM), commonly known as Bomba, is a federal agency of Malaysia responsible for firefighting and technical rescue. It is undeniable that the establishment of organizations and agencies like this can help in reducing the loss of life during floods. But it is still not enough to solve the problem which is how to save ourself when floods happened.

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To solve the problem, we create an innovation of a table and boat that we named AN-FLO-T. The reason why we named it AN-FLO-T is because AN-FLO-T stands for anti-flood table. We combined the table and boat which mean it can be a table and boat at the same time. Other than that, it also have storage space where we can put our things in there. It's basically a three-in-one furniture. When the AN-FLO-T is still in the table state and has not yet become a boat, it can be use as a casual table outside of the house. It will be more practical and easier for the user to make it an emergency boat when a flood occurs if the AN-FLO-T is placed outside the house.

AN-FLO-T has soo many advantages and will benefit us. Other than save lives and lessen the burden of the rescue teams, AN-FLO-T also has multiple functions because it can be a table, boat and a storage space at the same time. AN-FLO-T will also save users space and money. It is also easy to use because it doesn't require any complicated system. Besides that, it's also help improve our country's economy. (Mugantan, Durie & Sandra, 2024; Bernama, 2024)

2. MATERIALS AND METHODS

2.1. Materials

1. Fiberglass

A common type of fiber-reinforced plastic using glass fiber. The fibers may be randomly arranged, flattened into a sheet called a chopped strand mat, or woven into glass cloth. The plastic matrix may be a thermost polymer matrix most often based on thermosetting polymers such as epoxy, polyester resin, or vinyl ester resin or a thermoplastic. Cheaper and more flexible than carbon fiber, it is stronger than many metals by weight, non-magnetic, non-conductive, transparent to electromagnetic radiation, can be molded into complex shapes, and is chemically inert under many circumstances. Applications include aircraft, boats, automobiles, bath tubs and enclosures, swiming pools, hot tubs, septic tanks, water tanks, roofing, pipes, cladding, orthopedic casts, surfboards and external door skins.(Amirrudin, Zainul, M.K Puteri, Jaswar & Peter, 2015; Mitchell, Steve 1999; Rudow, Lenny, 2022; Shahrin, 2022)

2.2. Methods

1. Sketch the shape of the AN-FLO-T on paper along with the measurements as a reference. Use scale for the measurement so it'll be easier to draw.

2. Sketch again on fiber with the accurate measurements. Don't use the scale measurement, use the real measurement.

3. Cut all the fiber according to the sketch that has been drawn on the fiber neatly.

4. Attach the fiber pieces to make the AN-FLO-T shape using superglue, epoxy resin and 2-part polyurethane adhesive.

5. Leave the fiberglass until it dry.

6. Trim the glued side of the fiberglass to get rid of the messy superglue so the AN-FLO-T will be neater.

7. Paint AN-FLO-T with the desired color.

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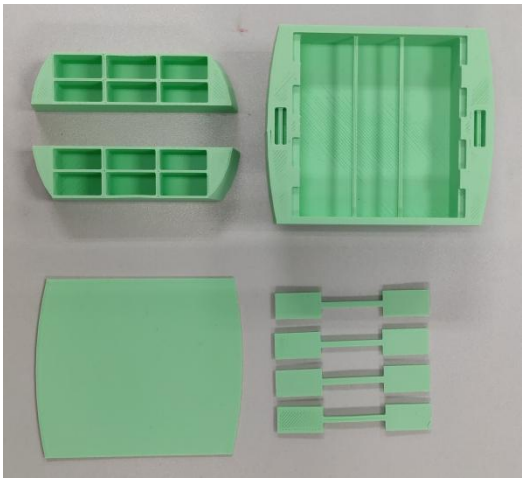
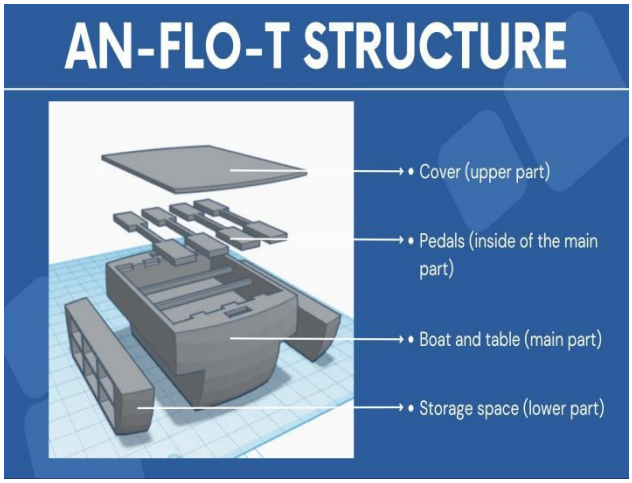
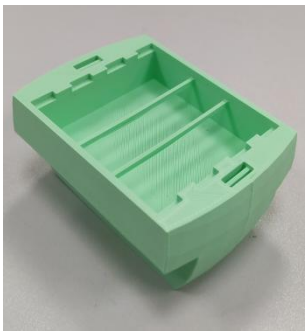
3. RESULTS AND DISCUSSION

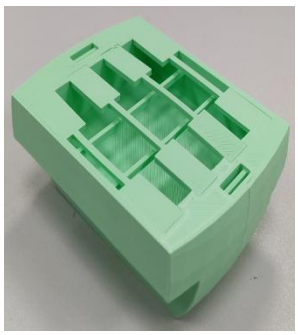
3.1. Results

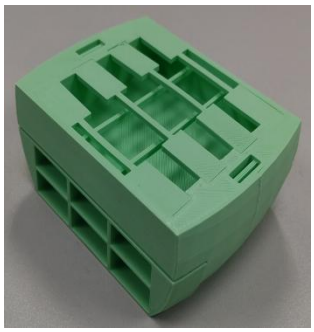




The cover of AN-FLO-T function as a complement fo the AN-FLO-T when it's a table. The pedals is to make it easier for us to control the AN-FLO-T when it become a boat while the main part works as the boat and table body. Storage space is where we put our things like shoes, slippers and etc.







3.2. Suitable Place to Put The AN-FLO-T

AN-FLO-T can be use at rural and city areas.

AN-FLO-T should be place outside of the house.

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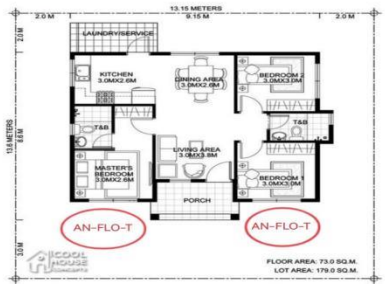

3.2. Size and The Number of People It Can Accommodate

SIZE	TOTAL OF PERSON IT CAN ACCOMODATE
1.6 m X 1 m	2 people
1.8 m X 1.2 m	4 people
2.4 m X 1.4 m	6 people
3 m X 1.6 m	8 people

4. CONCLUSION

AN-FLO-T is a multi-functions product. It's not only will bring many benifits to us but also to other and our country in many aspects. AN-FLO-T is worth to be create.

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2024 OPEN INTERNATIONAL INNOVATION COMPETITION
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MATHVENTURE

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Abstract

MathVenture is an educational game designed to help educators create an enjoyable and engaging learning experience for their students. This game aims to dispel fear and promote excitement about mathematics. By offering engaging exercises, it makes mathematics more approachable and enhances interest in the subject. The game focuses on enhancing mental calculation skills, encouraging students to rely less on calculators for simple calculations. It provides a fun and creative way for students to improve their math skills and deepen their understanding of the subject. Educators serve as facilitators, assisting students while allowing them to complete the game independently. The main target users for this board game are first-semester university students. The game requires at least two players and one moderator. Each player rolls the dice and moves forward according to the number of spaces shown. Players must answer the questions correctly within 3 to 5 minutes. Besides classroom use, the board game is suitable for workshops and educational events to spark interest in mathematics. MathVenture aligns with the current educational trend of promoting active learning, where students actively engage in the learning process. Overall, MathVenture is a valuable tool for teachers to create an engaging and interactive learning experience in calculus. It reinforces mathematical concepts and develops critical thinking, collaboration, and communication skills, all while making the learning process enjoyable for students.

Keywords: board game, limit, calculus, mathematics

1. INTRODUCTION

Mathematics is a compulsory subject in Malaysia's primary and secondary schools as well as universities. Despite its significance, many students find mathematics challenging to study. Like their peers worldwide, Malaysian students encounter various difficulties with mathematics, often leading to poor performance in the subject. Additionally, the Malaysian Certificate of Education (SPM) 2023 have just been announced on Mei 2024. A total of 11,713 candidates got all A's and at the same time, there were more than 85,000 students who failed in Mathematics. This is a huge problem since some are only able to achieve the minimum pass level in Mathematics with grades D and E, making the total number of students who are weak in Mathematics reach almost 190,000 people (Ahmad, A.,2024).

The teaching methods employed in classrooms varies depending on the teachers, students and environment of the schools. When mathematics is taught in a passive and one-sided manner, it can deter active participation, exploration, and problem-solving, leading to boredom and disinterest among students. Moreover, some students may perceive mathematics as difficult from the outset, which can create anxiety or fear, resulting in a negative attitude towards the subject. Students with high mathematics anxiety get low results in mathematics (Zakaria, et al., 2012).

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Although getting students to enjoy mathematics can be challenging, various strategies can enhance their engagement and enjoyment in the subject. One effective approach is by using interactive teaching methods. Incorporating interactive techniques, such as group activities and games, can make learning mathematics more enjoyable and allow students to view the subject from different perspectives (Wiersum, 2012).

A lack of engagement is one of the reasons why some people find mathematics boring. Compared to formal activities, games allow for more interaction and provide opportunities to test intuitive ideas and problem-solving techniques. In addition, playing games can create a positive learning environment by reducing mathematics anxiety and increasing students' motivation.

Therefore, MathVenture was designed for educators to help them create an engaging and interactive learning experience in calculus. It not only reinforces mathematical concepts but also fosters critical thinking, collaboration, and communication skills for making the learning process enjoyable for students.

2. PROBLEM STATEMENT

Calculus is often perceived as a challenging subject by many students, which can lead them to feel frustrated and lost interest. Several factors contribute to students' dislike of calculus includes its perceived difficulty, misconceptions, anxiety, and negative experiences. Therefore, employing innovative and imaginative teaching strategies is crucial to motivate students and enhance their engagement with calculus.

One effective method to address these challenges is the integration of educational games focused on calculus. This approach offers students with valuable opportunities to explore their strengths and weaknesses in a supportive and engaging environment. Incorporating games into calculus subject provides a dynamic platform for students to actively explore, assess, and develop their skills about calculus.

This product aims to achieve several objectives. Firstly, it aims to make learning calculus more engaging and enjoyable for students. By incorporating game elements such as challenges and interactive puzzles, students are more likely to stay motivated and focused on learning. Secondly, it aims to provide a dynamic way to reinforce calculus concepts. Through this product, students can repeatedly practice applying calculus principles which helps strengthen their understanding. Finally, the objective is to promote critical thinking and problem-solving skills. Students have to apply mathematical concepts creatively to solve challenges within the game environment.

3. PRODUCT DESCRIPTION

MathVenture is an exciting and educational board game that focuses on the topic of limits in calculus. This topic is fundamental and is used multiple times in other applications of calculus. The subtopics covered in this game are limit as x approaches a, limit as x approaches infinity, and also the squeezing theorem. Through this board game, students will be able to improve their critical thinking skills, develop collaborative skills, and solidify their understanding in limits.

This game consists of an interactive game board, four sets of question cards that cover different subtopics named earlier, a dice, and game pieces that will be used as the pawns. Figure 1 below shows the board game MathVenture, including the question-and-answer cards.

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Figure 1: MathVenture board game

The rules for MathVenture are simple and can be adjusted to fit the preferences of the students playing the game. Basically, a moderator is needed to facilitate the game and check the students' answers. Students can play individually, in pairs or in groups. They will challenge each other and themselves while completing the game. If the student successfully answers the question, he or she can move up spaces according to the values the student get on the dice. But if the student fails to answer the question correctly, he or she will stay at the same spot and not able to move the pawn.

4. NOVELTY

MathVenture stands out in the educational game landscape due to its emphasis on developing mental calculation skills while learning calculus concepts. The game enhances computational articulacy by encouraging students to perform calculations mentally, reducing reliance on calculators and enabling quicker and more accurate problem-solving without electronic aids. The combination of calculus and engaging game elements creates a dynamic learning environment, making the subject more enjoyable and enhance comprehension in calculus.

One of the unique aspects of MathVenture is its versatility. MathVenture's design not only caters to classroom use, but also to workshops and educational events, offering students a unique approach to solidify their understanding in calculus across diverse settings. This flexibility allows educators to tailor the game to different learning environments and teaching strategies.

MathVenture also shifts the educator's role from traditional instruction to facilitation, promoting a student-centered learning experience. Educators provide guidance and support as needed, allowing students to explore and solve problems independently. The game requires at least two players and one moderator, fostering collaborative learning, peer interaction, and teamwork.

By combining mental calculation with active learning principles, MathVenture aligns with contemporary educational trends that emphasize hands-on problem solving and critical thinking. The target users for this game is the university freshmen where the game will act as a bridge to close the gap between high school and higher education, reinforcing fundamental mathematical skills and preparing students for advanced coursework.

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5. PRODUCT COMMERCIALIZATION

MathVenture is a game designed to make learning calculus fun and engaging for first-semester university students. It is aimed at academic institutions, instructors, and workshop facilitators that wish to help students become more proficient in limit topic and less afraid of the topic. The primary draw of the game is its ability to transform difficult mathematics ideas into entertaining tasks that motivate students to work together and think critically.

Before introducing MathVenture publicly, we first created a prototype and tested it in selected classes to receive feedback and make improvements. After the game was polished, we made improvements to the game to meet users' needs. In the future, we intend to collaborate with academic institutions to endorse the game as a valuable pedagogical aid. In addition, sales will be made through online platforms and educational product distributors. In order to ensure a positive user experience, a quick response (QR) code explaining the rules and regulations of this game will be attached.

MathVenture has the potential to become a well-liked tool in education, assisting students in learning and enjoying calculus more. Due to its distinct method of making calculus interesting and approachable, it provides both educators and students with substantial advantages. MathVenture has the potential to significantly expand its market share and leave a long-lasting influence in mathematics education by implementing a comprehensive marketing plan.

6. CONCLUSION

In conclusion, MathVenture uniquely combines mental calculation, gamification, collaborative learning, and active teaching methods to create an engaging and effective educational tool. It not only enhances mathematical comprehension but also cultivates essential skills such as critical thinking, collaboration, and communication, making the learning process enjoyable and accessible. It also promotes students to perform calculations mentally, reducing reliance on calculators and enabling quicker and more accurate problem-solving without electronic aids. By blending gameplay with educational content, the game creates a positive learning environment that motivates students to actively learn calculus and deepen their comprehension in limits.

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2024 OPEN INTERNATIONAL INNOVATION COMPETITION
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INFINITY CARD AS A MODERNIZATION COMMUNICATION IN PRINTING ADVERTISING

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Abstract

The transformation of traditional promotional materials, such as flyers and business cards, has led to the creation of the infinity card, an innovative product that reimagines interaction in visual communication. The paper analyzes the innovation of traditional print media into an infinite card, highlighting its numerous benefits and potential to transform ways of advertising. The infinity card, also known as the never-ending card, has a unique folding that allows for continual opening, cyclically displaying several panels that capture the recipient's attention, and improve the delivery of complex messages and information. Businesses can achieve greater interactivity and longer engagement with their audience by developing standard flyers and business cards into infinity card designs. To ensure seamless transitions between panels, infinity cards require precise cutting and folding techniques. High-quality materials and meticulous assembly are critical to the card's durability and functionality. This study presents a detailed methodology for making infinity cards from standard print materials, emphasizing the significance of design accuracy and structural integrity. In addition, the card includes Braille. Braille is a tactile writing system used by people with visual impairments, consisting of raised dots that indicate letters, numerals, and punctuation marks. Hence, this infinity card is designed not only for normal people to read, but also for visually impaired persons, allowing for diversity and involvement in visual communication.

Keywords: Infinity Card, Never-ending Card, Flyers.

1. INTRODUCTION

The infinity card is ingeniously designed to allow continuous unfolding, revealing a new panel with each turn.This unique mechanism not only captivates the recipient but also provides a dynamic platform for conveying messages, showcasing products, or narrating a story. The seamless transitions between panels offer an immersive experience, making the card a novelty and a powerful communication product. Einat Kessler (2018) wrote, creating infinite cards with a moving mechanism requires a lot of trial and error, but the end result is always worth it.

1.1 Objectives

The objectives of "never-ending cards" and "infinity cards" in the context of design, art, or crafting often revolve around creating visually engaging and interactive experiences. Here's a breakdown of these objectives:

1. Interactivity: These cards frequently unfold or flip in a way that creates a loop, encouraging the recipient to continue interacting with the card.
2. Surprise and Delight: The card's unfolding nature may reveal hidden messages or images, surprising the recipient.
3. Creativity: Creating a card that unfolds indefinitely allows for a unique display of creativity and artistry.

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4. Memorability: Because of their distinctive and playful design, these cards are likely to be remembered and treasured.
5. Gift Enhancement: They add a layer of thought and effort to a gift, making the experience more memorable.

2. MATERIALS AND METHODS

An infinity card is typically made using sturdy materials like cardstock or thick paper. Here are some materials used for making never-ending cards:

1. Cardstock: This is the most common material due to its thickness and durability.
2. Double-sided Tape: Essential for securing the panels of the card together. Make sure to use strong adhesive to ensure the card functions smoothly.
3. Ruler and Cutting Tools: For precise cutting and scoring of the artcard or paper.
4. Scissors or Paper Cutter: For cutting out the panels of the card to the desired size.

These materials for creating a never-ending card. The key is to use materials that are sturdy enough to withstand repeated folding and unfolding without tearing or wearing out quickly.

2.1 Materials needed:

1. 4 pieces of artcard 230gsm (24 x 20 centimeter each)
2. Scissors or a craft knife
3. Ruler
4. Pencil
5. White glue or double-sided tape

2.2 Instruction of making Infinity Card

1. Design and Layout:
Before inserting the necessary information, the first step is to organize and categorize it so that it may be placed in four distinct panels. Measure and create it with Adobe InDesign and Canva.

2. Print the Artcard:
Print the artworks by dividing to 4 pages on A4 size. Then, cut 4 pieces of art card to 24 x 20 cm for each design.

3. Score and Fold:
Take part of the section 1 and glue the back to the place on part of the section B .Then, fold the sheet on each red dotted line. When look at the section 1, both must fold towards. Then cut the sheet in half, vertically, along the gray line. Repeat the same way for the other two section. Take part of the section 2 and glue the back, upside down this time under the section A. Then, fold the sheet on each red dotted line.

4. Cut the Pieces:
Then cutting the sheet into two halves in the horizontal direction, along the gray line . Now it have 4 pieces of paper.

5. Assemble the Card:
-Place double-sided tape/glue on each rectangular area purple.
-A blue rectangle glue on the purple rectangle A.
-Glue the B blue rectangle on the purple rectangle B.
-Glue the C blue rectangle on the purple rectangle C.
-Glue the D blue rectangle on the purple rectangle D.

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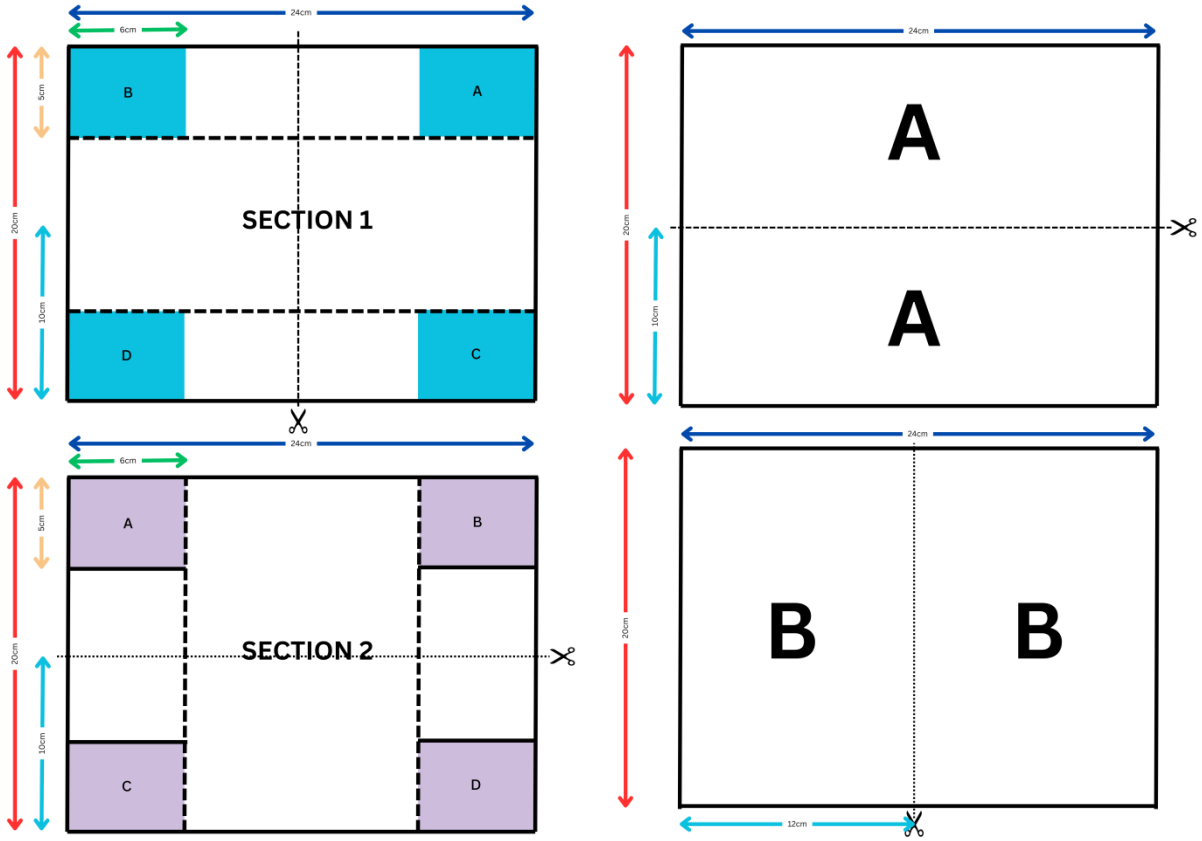
6. Test the Folding Mechanism:
- Fold the card by flipping the top sections outward, then folding down and up repeatedly to ensure all sections move smoothly. The card should continuously open to reveal different sections.

Visual Guide:



3. RESULTS AND DISCUSSION

3.1. Advantages of Infinity Card

Constructing an infinity card involves precise cutting and folding techniques to ensure seamless transitions between panels. The choice of high-quality materials and meticulous assembly are critical to maintaining the card's durability and functionality. This study provides a detailed methodology for creating infinity cards from standard print materials, emphasizing the importance of design accuracy and structural integrity.

The conversion of flyers and business cards into infinity cards presents several advantages:

1. Increased Engagement: Because the infinity card is interactive, recipients are more likely to spend time exploring its content, resulting in improved information retention.
2. Increased Memorability: The card's unique, perpetual unfolding design makes a lasting impression, setting it apart from traditional promotional materials.
3. Versatile Applications: Infinity cards can be used for a variety of purposes, such as marketing campaigns, event invitations, educational tools, and personalized greetings, providing a dynamic platform for a wide range of content.

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4. Effective Communication: The multiple panels provide plenty of space to convey detailed information in a structured and engaging manner, making it ideal for storytelling and displaying products or services.
5. Customization Potential: Businesses are able to customize the design and content of infinity cards to match their branding and messaging strategies, resulting in creative and impact advertising.

Incorporating infinity cards into marketing strategies can significantly improve the effectiveness of promotional campaigns. Businesses can improve their communication outcomes by transforming static flyers and business cards into interactive and memorable experiences.

3.2 Benefits Apply Braille in Infinity Card

Adding braille to information or business cards offers several significant benefits:

1. Accessibility: It makes the card accessible to visually impaired people, allowing them to read and use the information independently.
2. Inclusion: It demonstrates a commitment to inclusivity, implying that the company or individual values all customers and clients.
3. Positive Image: It improves the company's image by emphasizing its understanding and support for diverse needs, potentially attracting a larger customer base.
4. Differentiation: It distinguishes the card from others, leaving a lasting and distinct impression, particularly in professional networking situations.

Overall, using braille on business cards demonstrates a proactive approach to accessibility and can benefit both the business and its customers.

4. CONCLUSION

In conclusion, the infinity card represents a significant innovation in print media, offering numerous benefits over traditional flyers and business cards. Its interactive design and versatile applications make it a powerful tool for modern marketing and communication. Future developments in this area could further expand its potential, establishing the infinity card as a cornerstone of innovative promotional materials.

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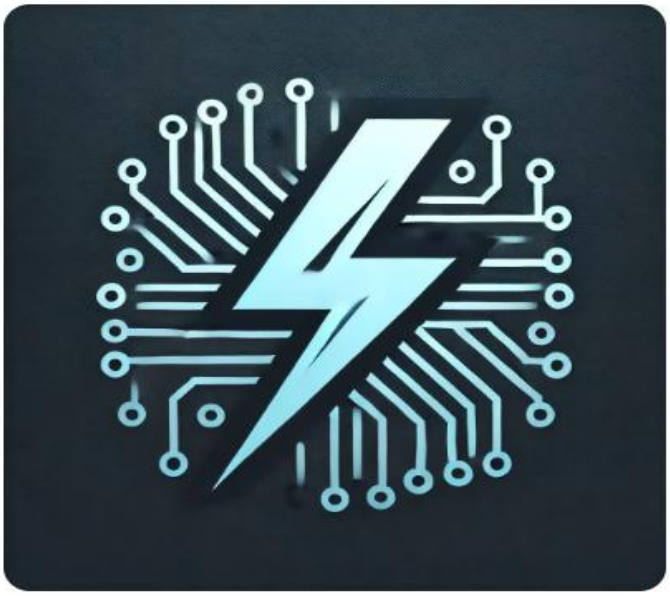
SECTION 3

Electrical Engineering



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STRING INVERTER FOR A GRID CONNECTED PHOTOVOLTAIC (GCPV) SYSTEM WITH ARTIFICIAL INTELLIGENCE MPPT TECHNIQUE

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Abstract

This study presents the design of a single-phase, single-stage string inverter for grid-connected photovoltaic (GCPV) systems. The proposed system employs an artificial intelligence Maximum Power Point Tracking (MPPT) technique named Integrated Perturb and Observe (P&O) - Fuzzy Logic Control (FLC). Previous research on single-phase, single-stage inverters has utilized various circuit configurations and switching techniques in conjunction with MPPT, each with its own set of advantages, disadvantages and limitations. To address issues related to switching losses and complex circuit configurations, the proposed single-stage converter aims to reduce the number of power switching components while enhancing power conversion efficiency. This is achieved through a new control scheme for MPPT and Pulse Width Modulation (PWM) within a single power circuit (single stage) without a boosted DC link. The prototype inverter was tested with a 340Wp PV capacity system using two series of STP170s-24/Ac PV modules. The novel MPPT algorithm combines P&O and FLC, achieving MPPT by adjusting the modulation index and phase angle of the inverter's output voltage. The inverter operates at a switching frequency of 25kHz, utilizing IGBTs as power switching devices in a full-bridge configuration. Simulation models were developed and analyzed using Matlab/Simulink and Mathcad software, and experimental results under steady-state and dynamic conditions were evaluated. The performance of the developed string inverter was assessed based on international standards. The inverter complies with IEC 61727, achieving low Total Harmonic Distortion (THD) of less than 5% at rated output, fast Maximum Power Point (MPP) tracking within 1 second and a quick turn-off response within 2 seconds during a loss of utility. The findings demonstrate that the new control technique effectively operates the PV system without the need for a DC-DC converter or a complex inverter topology.

Keywords: Fuzzy Logic Control (FLC); inverter; Maximum Power Point Tracking (MPPT); Perturb and Observe (P&O); Grid connected Photovoltaic (GCPV)

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1. INTRODUCTION

In recent times, research on PV system components such as inverters has rapidly expanded. PV conversion circuit topologies can be classified into two configurations: two-stage conversion and single-stage conversion. The two-stage conversion involves a boost or MPPT circuit and an inverter circuit, whereas the single-stage configuration combines both MPPT and inverter operations into one power circuit. Although two-stage configurations are widely used, they have drawbacks such as larger size, lower reliability and a higher part count. Current research is concentrated on designing various types of single-stage inverter configuration circuits including H-Bridge, buck-boost, flyback-type chopper and Z-Source inverters (G.Petrone, G. Spagnuolo, and M. Vitelli, 2011). The most straightforward and simplest circuit topology for single-stage configuration is the conventional H-Bridge inverter. The H-Bridge inverter for grid-connected PV systems can be classified into two categories: i) Conventional H-Bridge Inverter connected to a step-up transformer (P. Q. Dzung, 2012) (C. Yang, 2004) and ii) Transformer-less H-Bridge Inverter fed by a large rated voltage (string voltage) of the PV array (E. S. Sreeraj, 2013) (S. L. Prakash, 2015). Each configuration has its advantages and disadvantages in terms of size, electronic part count, control strategies, output filter, power and efficiency. A critical consideration is that grid-connected PV systems must comply with standards regarding the level of DC current injection into the grid and harmonic content such as those specified in IEC 61727-Table 1 and IEEE 929-2000. Based on international standards, Malaysia's largest electricity utility company, Tenaga Nasional Berhad (TNB) has introduced a technical guidebook on the grid interconnection of photovoltaic power generation systems to Low Voltage (LV) and Medium Voltage (MV) networks. Generally, an inverter's ability and performance are critically assessed before connecting the PV system to the grid.

This work introduces the design of a single-phase, single-stage string inverter for grid-connected photovoltaic (PV) systems. The proposed approach utilizes a novel intelligent MPPT algorithm that combines the advantages of Perturb and Observe (P&O) and Fuzzy Logic Control (FLC). This innovative MPPT and Pulse Width Modulation (PWM) control scheme is implemented on a single power circuit without a boosted DC-link. MPPT is achieved by adjusting the modulation index and the phase angle of the inverter’s output voltage. Consequently, the single-stage converter is designed to reduce the number of power switching components while enhancing power conversion efficiency. The proposed algorithm minimizes voltage and current overshoot and undershoot compared to the P&O algorithm and it improves the inverter's response time for detecting maximum power.

2. INTEGRATED P&O – FLC MPPT TECHNIQUE

Figure 1 illustrates a single-phase, single-stage string inverter with a control technique. The proposed MPPT technique employs the same algorithm as the conventional Perturb and Observe (P&O) method using the differential of power (ΔPpv) and voltage (ΔVpv) as inputs, but implements it using a simple Fuzzy Logic Control (FLC) approach. The outputs are the phase angle and the sum of the modulation index with an initial modulation index (Ma) of 0.7. This enables the FLC to work efficiently with a low step size to achieve the Maximum Power Point (MPP). Figure 2 presents a comparison flowchart between the proposed inverter control method and the conventional P&O method. Figure 3 displays the inputs and outputs of the MPPT technique algorithm. The inputs ΔPpv and ΔVpv are assigned linguistic variables using five fuzzy subsets: Negative (N), Zero (Z), Positive Small (PS), Positive (P), and Positive Big (PB).

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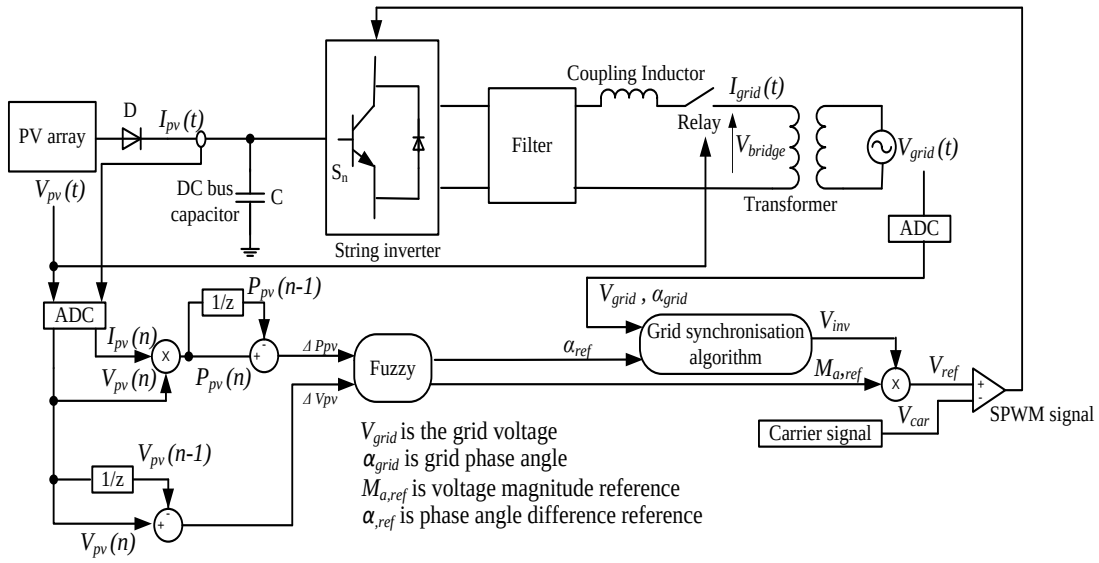

Figure 1. The proposed control strategy of the string inverter

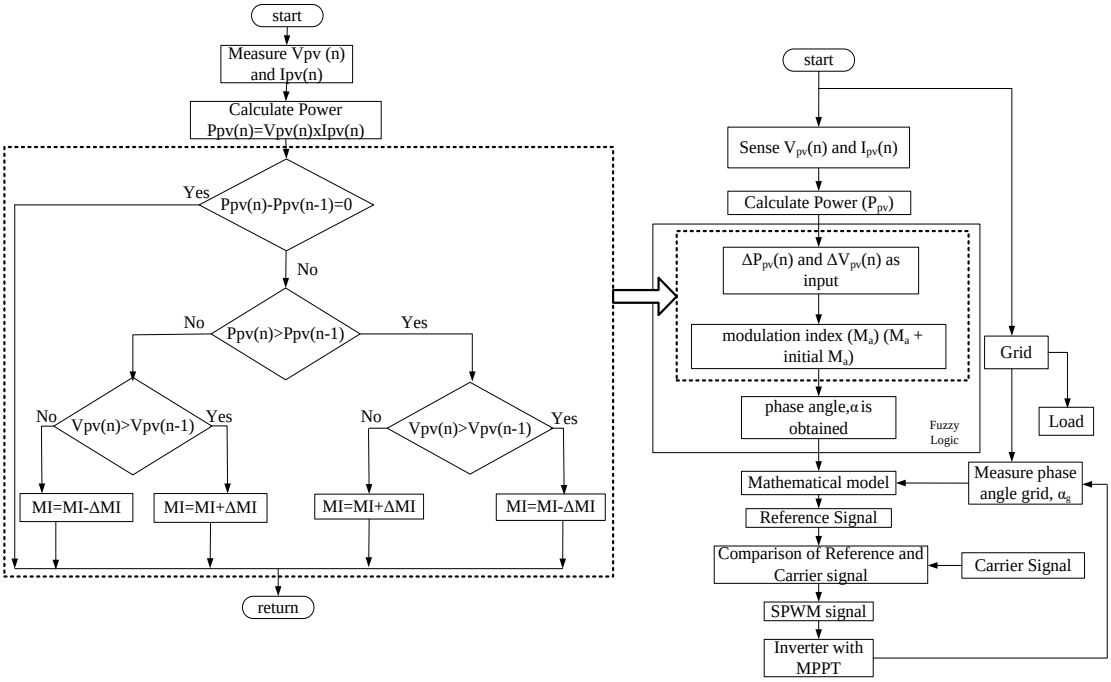

Figure 2. Comparison Flowchart of Conventional P&O and Integrated P&O Algorithm Implemented using Fuzzy Logic Control (FLC) as Maximum Power Point Tracking (MPPT) for Inverter Control

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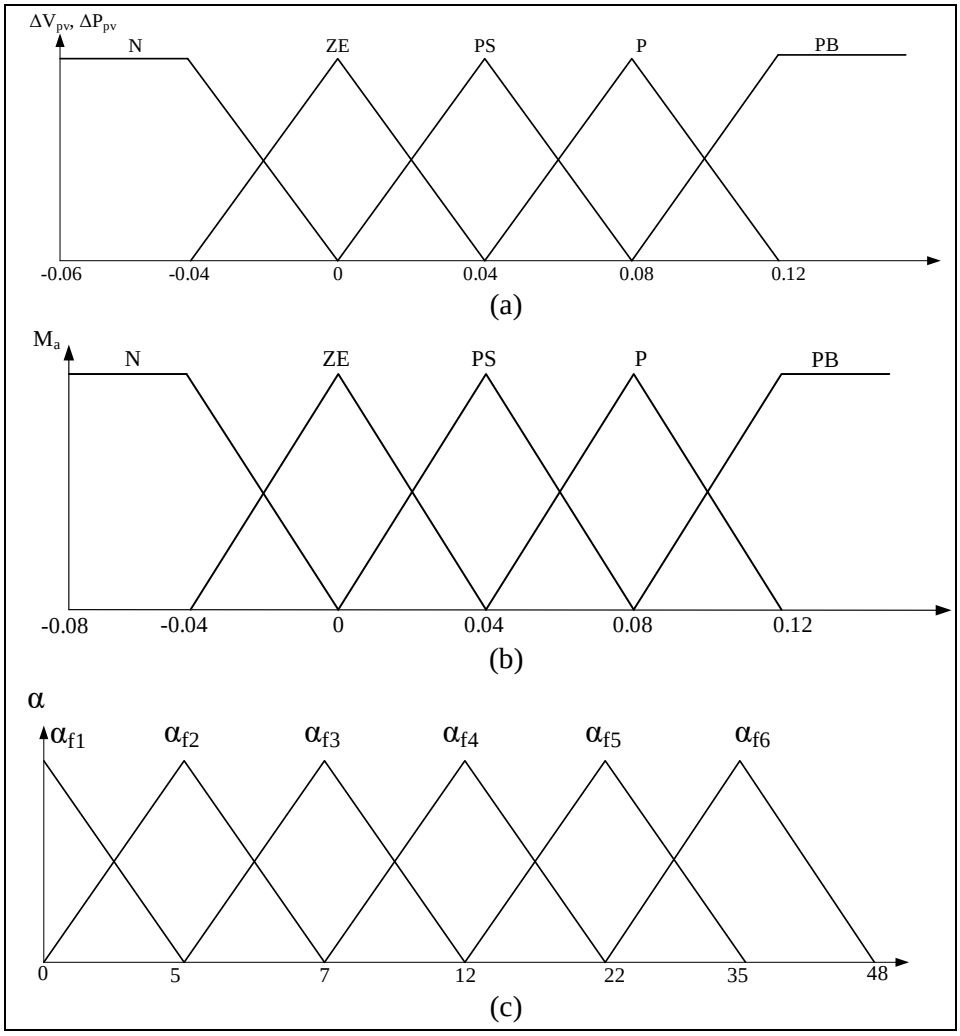

Figure 3. Membership Functions (a) Inputs of ΔV_{pv} and ΔPpv (b) Output of M_a and (c) Output Phase Angle, α

3. RESULTS AND DISCUSSION

Figure 4 provides the measured output voltage, current and power produced by the string inverter. The red dot indicates the current MPP operating voltage and current on the DC side of the string inverter. Figure 5 presents the MPPT in terms of PV array voltage and current. At a solar irradiance of 937 W/m² and module temperature of 54.9°C, the inverter reaches the MPP level in 0.11 s with a phase angle of 26° and a modulation index of 0.83. Figure 6 shows the trajectories of the I-V and P-V curves at solar irradiance levels from 650 W/m² (module temperature 43°C) to 850 W/m² (module temperature 53°C) and vice versa. The red dot represents the current MPP operating voltage and current on the DC side of the string inverter. Figure 7 shows that the inverter current is in phase with the grid voltage at a solar irradiance of 1200 W/m².

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Figure 4. Trajectories of I-V and P-V Curve at Solar Irradiance Irradiance 937W/m^2, Module Temperature T = 54.9ºC from PV Simulator

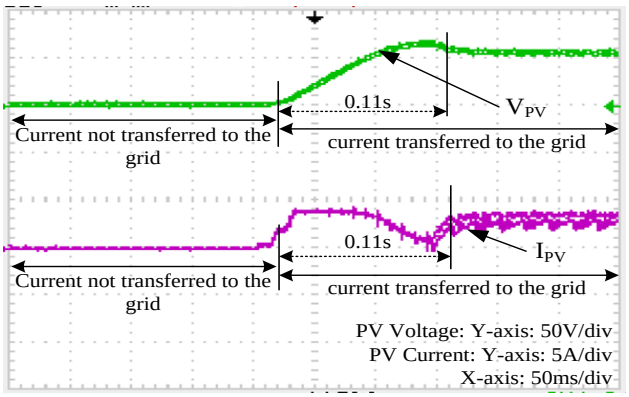

Figure 5. Dynamic Response of MPPT when the inverter current starts transferred to the grid

(a) (b)

Figure 6. Trajectories of I-V and P-V Curve as seen on PV Simulator Display (a) 650 W/m^2 with Module Temperature T = 43ºC to (b) 850W/m^2 with Module Temperature T = 53ºC

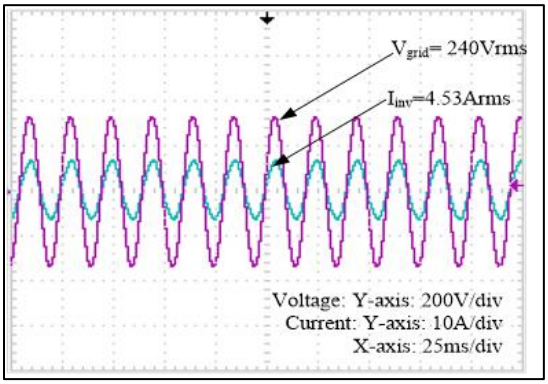

Figure 7. Experimental Results of Grid Voltage, V_{grid} and Inverter's Output Current, I_{inv} at Solar Irradiance of 1200W/m^2

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4. CONCLUSION

The principles of the single-stage string inverter have been demonstrated and the switching function has been implemented using an integrated P&O FLC. The procedure for designing the FLC in a string inverter for grid-connected PV systems has been outlined. It has been shown that the integrated P&O FLC is simpler compared to the conventional P&O method. Future work could involve designing a driver circuit for IGBT with a higher frequency of more than 25kHz to study the performance of the inverter.

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SECTION 4

Food Technology

2024 OPEN INTERNATIONAL INNOVATION COMPETITION
Sustainable Urban Innovations for the Development of Well-being

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NATURENERGY

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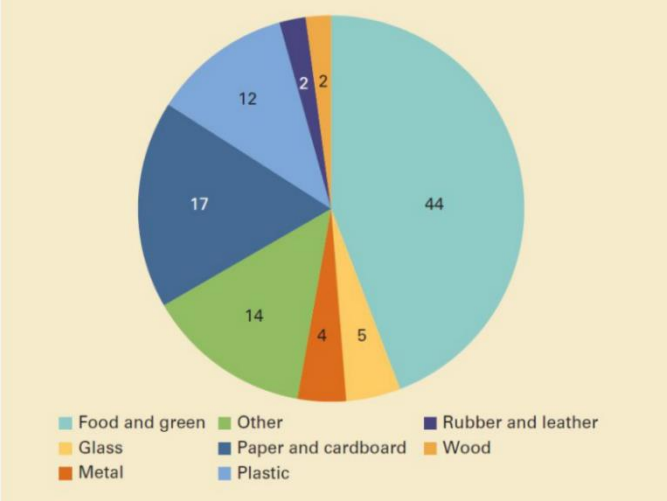
Abstract

NATURENERGY is a food waste bin that is able to separate solid food waste and liquid food waste in residential areas to be more efficient. Previously, the use of commercial food waste bins did not seem to help much in separating food waste. Therefore, we created a new innovation which will speed up the process of separating solid food waste and liquid food waste. This trash bin that we created has special features, such as filter components, IOT systems and even dryers. Our product are suitable for households, commercial kitchens, and industrial settings where efficient waste separation is essential. Not only that, we create our products in a form that is suitable for the place. For example, our dormitory dining halls we create our trash bin with large capacity. If we focus on housing, our product will be created with the appropriate size again.

Keywords; Dust bin,filter component,iot system and dryer

1. INTRODUCTION



"**Pie chart above shows the percentage of content in a waste substance"**:

The chart illustrates that food and green waste are the predominant components of the waste stream.

In the landscape of waste management and environmental sustainability, managing food waste presents a pressing challenge. With its high moisture content and substantial presence in global waste streams, effective disposal of food waste is crucial. This abstract delves into the concept of a specialized water filtration system designed for food waste, aimed at efficiently separating water from organic materials. Such innovations promise

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to mitigate environmental impacts by reducing landfill contributions and unlocking valuable resources embedded in food waste, thereby advancing sustainable practices in waste management.

Problems that arise among the Malaysian community, especially those who live in residential areas and apartments have difficulty managing their food waste. Where they do not have a special waste bin for food waste in liquid form. Not only that, this problem can also lead to other problems such as odor pollution in their home area. From that,we created an innovation that comprises of a commercial waste bin ,where we implement a filter component ,IOT systems,and dryers onto the model. Therefore, this invention will be able to separate solid and liquid waste at the same the users can use it as a liquid foliar fertilizer.

The process of using our innovation starts with the disposal of food waste that is mixed into the upper component of the bin, after that, it will be filtered after reaching the base of the upper component. This separation process occurs because of the filter section. The remaining filtered liquid will be in the bottom component. what about the separated waste? the filtered liquid residue can be separated by opening the pipe provided. Not only that, our product can be used with just the tip of the finger, which we have completed our innovation with the IOT system. The dryer components in our innovation are also able to reduce the effect of odors apart from our airtight components. This dryer gets electricity from the solar panels we connect.

Lastly,our inovation are not just helping the users on managing their food waste , but this invention are also helping on preventing the odor polution in the same time save the environtment.Our inovation have a big role on saving the earth by reducing the uses of electricity among the people. (Astghik Karapetyan, 2024; Rietra, R. P. J. J., Heinen, M., Dimkpa, C. O., & Bindraban, P. S., 2017)

2. MATERIALS AND METHODS

2.1 Procedure 1

a) Two compartments are prepared as for the upper and lower components.

b) In the upper component, a filter system is placed at the base of the bin.

c) The lower component is used for containing the filtered waste.

d) An IOT system is placed at the back of the trash bin.

e) A hinge is placed in between the upper and lower component.

f) The lid at the top has a fan that can be controlled by the IOT system.

g) A detection sensor is placed on the lid and on top of the upper component.

h) A pipe is connected at the lower component to help the flow of the filtered waste.

2.1.1 Procedure 2

a) Compost production, Unfiltered food waste can be turned into compost by directly planting it into the soil. As for liquid waste, it should be placed in a container and left for 3-4 weeks.

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3.RESULTS AND DISCUSSION

3.1. Result Of Survey Forms

This Figure 1 shows about the shortcomings of a trash can. Based on the survey forms that have been conducted on restaurant premises.There are three shortcomings of a trash can which is musical trash can,eletronic trash can & Filtered trash can. Meanwhile, Figure 2 shows the survey on necesity of filtered trash can. Survey was conducted on 4 diffrence residence.

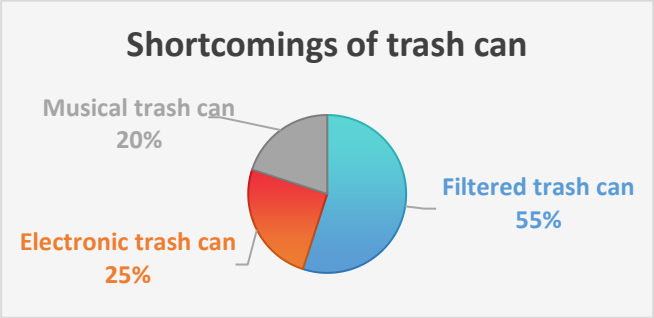

Figure 1: The shortcoming of trash

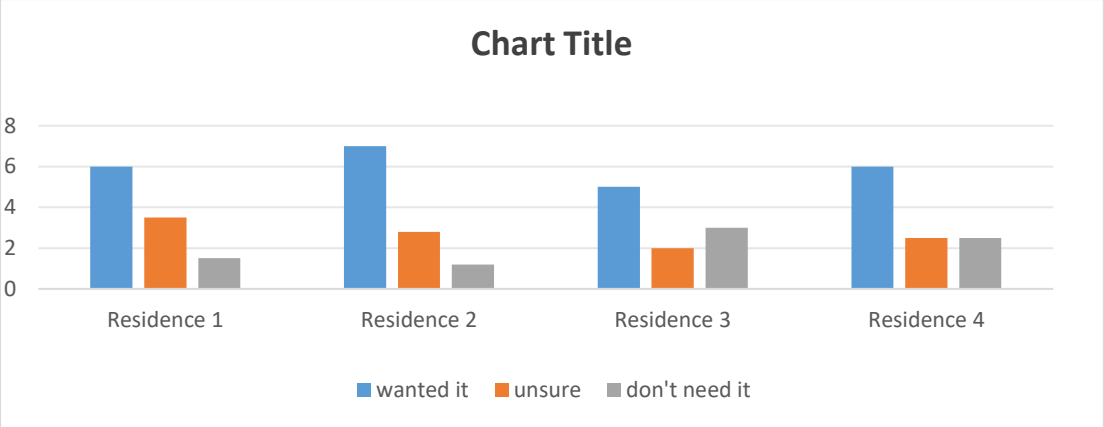

Figure 2: The survey of whether filtered trash can need or not

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3.2. Description on our respondent

Table 1. Descriptive on Background of Respondent

Respondent	Gender	Choice
1	Male	Musical trash can
2	Female	Electronic trash can
3	Female	Musical trash can
4	Male	Filtered trash can
5	Female	Musical trash can
6	Male	Electronic trash can
7	Male	Electronic trash can
8	Female	Filtered trash can
9	Male	Musical trash can
10	Female	Electronic trash can
11	Male	Filtered trash can
12	Male	Filtered trash can
13	Female	Filtered trash can
14	Male	Filtered trash can
15	Female	Filtered trash can
16	Male	Electronic trash can
17	Male	Filtered trash can
18	Male	Filtered trash can
19	Female	Filtered trash can
20	Female	Filtered trash can

3.3 Discussion

The results of the first survey indicate that most of the restaurant require a waste bin with filters rather than electronic or musical trash cans. These filtered trash cans function to separate solid waste from liquid waste. The waste will be placed into the trash can, then the liquid waste will descend through the filter while the solid waste remains on top of the filter. Solid waste can be disposed by bend the uper component towards plastic bag to let the waste get inside it, while liquid waste could be separate by opening the tap at the bottom of the waste bin. The main purpose is to facilitate restaurants in disposing food waste separately without experiencing problems such as liquid spillage from plastic trash bags. The accumulated liquid waste can also be used as foliar fertilizer for daily use. Typically, the liquid waste is left for several days to become foliar fertilizer before being use.

Second survey conducted to determined wether this filtration bin was needed or not for the most resident. The data obtained shows that most of resident on various place needed filtered trash can. The reason behind it was most of resident or restaurant throw food waste with high concentration of moisture.

4. CONCLUSION

Data obtained indicates a preference for filtered trash cans over electronic or musical alternatives. The surveyed premises show a significant demand for waste separation solutions, with an emphasis on practicality and efficiency. Although filtered trash cans emerge as the primary choice, there are circumstances where electronic or musical variants are preferred based on specific needs or aesthetic considerations. Some premises face challenges in implementing waste separation due to spatial constraints or logistical issues.

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The findings underscore the importance of adapting waste management solutions to meet the unique needs and constraints of different environments. Practical implications include promoting sustainable waste disposal practices and the potential for cost savings through efficient waste separation.

In conclusion, this study highlights the importance of filtered trash cans in effectively addressing waste management needs. Recommendations include the widespread adoption of filtered trash cans in various commercial settings, accompanied by awareness campaigns to encourage responsible waste disposal habits.

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SECTION 5

Gamification

2024 OPEN INTERNATIONAL INNOVATION COMPETITION
Sustainable Urban Innovations for the Development of Well-being

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EMPOWERING LEARNING ADVENTURES: A FUSION OF GAMIFICATION AND HEUTAGOGY IN INTERACTIVE CROSSWORD GAMES

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Abstract

Hospitality and Tourism to You (Ht2U) games kicked off as a book, followed by board games, later on online through website, Jamboard, a Google feature attached to Google Meet, and recently, the interactive Ht2U website. The games emerge in the form of crossword puzzle and word search, however, at the moment, the interactive website focuses on only crossword puzzle. The uniqueness of the games is the focus to cater undergraduate tourism courses, Tourism Geography and Culture (HTT280) and Tour Planning and Guiding (HTT353) offered at the Faculty of Hotel and Tourism Management, Universiti Teknologi MARA (UiTM), Pulau Pinang Branch. The main objectives of the games are not only to enrich vocabulary among the students, but also to assist students in understanding the course better and empower learning. This paper aims to study the students' feedback on the interactive Ht2U website in meeting the needs arising from blended learning sessions. The results highlight the students' feedback towards the interactive Ht2U website in encouraging the students' engagement during learning process. Most of the students are satisfied with the website, nevertheless, the website requires improvement in terms of design. It is intended that future research would result in the development of synchronous online capabilities that are primarily targeted for vocabulary games.

Keywords: interactive; crossword puzzle; website; blended learning.

1. INTRODUCTION

According to Bukit et al. (2023), students in the recent era expect to learn in an enjoyable way. After all, many researchers believe that games increase students' engagement with lessons, which in turn make them more motivated and open to learning (Yin & Chen, 2024; Gozcu & Caganaga, 2016; Yolageldili & Arikan, 2011). In tandem with this effort, Hospitality and Tourism to You (Ht2U) games have been developed to enrich the various ways of fun learning using technology, specifically in promoting better understanding of the vocabulary and terms used in the respective course. Introducing vocabulary to students is not always an easy task (Subon & Unin, 2023; Patesan et al., 2019). Vocabulary acquisition is the foundation in improving course comprehension. Figure 1 below shows the current website consisting of a homepage, a Notes section, and Crossword section.

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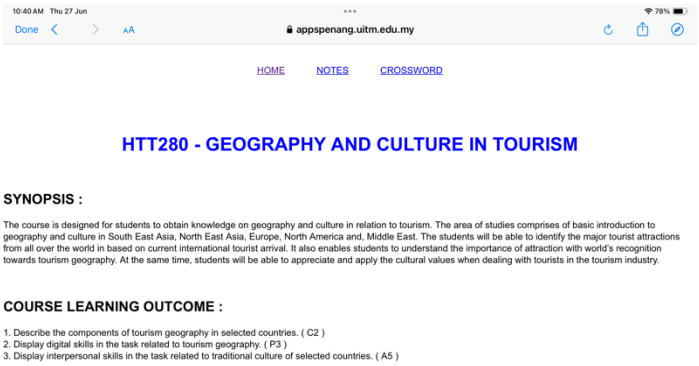

Figure 1 Website's Homepage

On the homepage, students can view the course synopsis and course learning outcomes. Under the Notes section, the notes are arranged according to the chapters and can be viewed in the form of slides. On the other hand, under the Crossword section, there are crossword puzzles (one crossword puzzle for each chapter) and link to the questionnaire. There are seven chapters altogether in the Tourism Geography and Culture (HTT280) course. Figure 2 below portrays one of the examples of the crossword puzzle from one of the chapters.

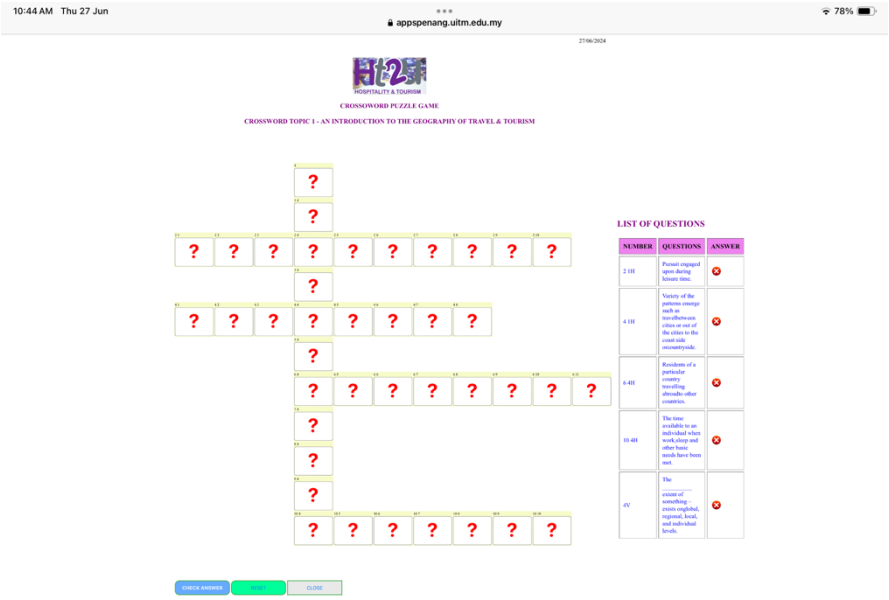

Figure 2 The Example of Crossword Puzzle

The website is interactive since students are able to check their answers immediately after their attempt. Hence, they would be able to learn better without the need to wait for the lecturer to check their answers. The element of prompt response offered by interactive website is highly appreciated by users (Fernandez-Rubio & Fernandez-Oliveras, 2017). This successfully promotes excitement among students in moving to the next level or chapter. Furthermore, students will indirectly revise the lessons when they utilise this interactive games.

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The Crossword Web Application has been developed using PHP and HTML. The code is designed flexibly to accommodate any number of rows and columns as specified by the user. Whether the crossword requires a 10x10, 15x15, or 20x20 grid, the same code applies. The parameters for the crossword are saved into text files, eliminating the need for users to modify the original code. This ensures that users do not need coding knowledge, making the application easier to maintain.

The crossword parameters are stored in six separate text files, as follows:

1. **File001**: Specifies the number of rows and columns for the crossword. The available designs are 10x10, 15x15, and 20x20.
2. **File002**: Identifies the presence of characters in the crossword boxes. If a character exists in a box, it is marked with a 1; if not, it is marked with a 0. These indicators are generated automatically via an Excel template, which users can utilize to create the crossword. The generated indicators are then copied and pasted into the text file.
3. **File003**: Contains the list of answers for each crossword question, with one answer per line.
4. **File004**: Determines the orientation and position of each answer in the crossword. Vertical answers are marked with a 1 and horizontal with a 0. Each line of the file includes three parameters: orientation (1 for vertical, 0 for horizontal), row number, and column number.
5. **File005**: Similar to File004, it determines the position of each answer, requiring three parameters: row number minus one, column number, and orientation (H for horizontal, V for vertical).
6. **File006**: Stores the list of questions for each crossword answer.

Once the data is entered into these six text files, the crossword is generated accordingly without any need to amend the original code. Any changes to the crossword can be made directly in the text files.

2. MATERIALS AND METHODS

This innovation study employed a quantitative approach to understand students' feedback towards the usage of the website. Technology Acceptance Model (TAM) were used to assess students' perspectives towards self-efficiency, perceived usefulness (PU), and perceived ease of use (PEOU). There were 170 respondents involved in this study, consisting of previous and current students taking the course. From the population, 82.4% of the respondents were female and 17.6% males. 59.4% used mobile device (mobile or tablet) to access the online crossword games, meanwhile the other 48.6% used personal computer (desktop or laptop). The respondents from the Faculty of Hotel and Tourism Management (current and previous students) taking the respective subject were randomly approached.

3. RESULTS AND DISCUSSION

This section will discuss the outcomes of the Technology Acceptance Model (TAM) used to evaluate students' attitudes toward self-efficacy, perceived usefulness (PU), and perceived ease of use (PEOU) among 170 respondents. The questionnaire employed a Likert scale, offering respondents a five-point range from Strongly Agree to Strongly Disagree, with a neutral midpoint option of neither agree nor disagree.

3.1. Self-Efficacy (SE)

Self-efficacy refers to an individual's belief in their capability to successfully complete tasks or achieve goals. It encompasses their confidence in managing their actions, exerting influence over their surroundings, and maintaining motivation to pursue objectives. Based on Figure 1, it is observed that 30.6% of respondents were in agreement, and 8.2% of respondents expressed strong agreement regarding their ability to independently use and complete the task without the need for manuals or external assistance. This
positive response can be attributed to the crossword's easy-to-understand structure and usability, which evidently facilitated participants' ability to navigate and accomplish the task without additional guidance or support.

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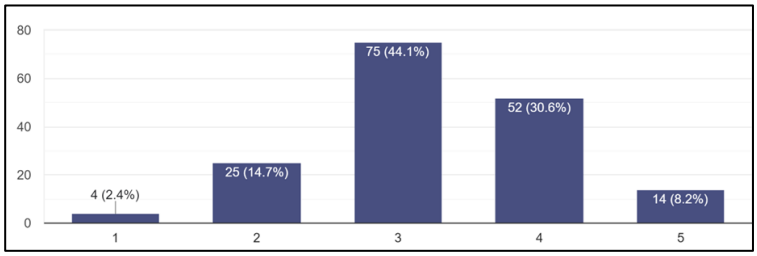

Figure 1. SE

3.2. Perceived Usefulness (PU)

Perceived usefulness refers to the extent to which an individual believes that utilizing a specific technology would provide benefits. As an individual's perception of the usefulness of technology grows, so too does their inclination to use it. According to Figure 2, 55.9% of respondents agree and 11.8% strongly agree that the game will enhance their ability to grasp the subjects being taught, indicating a strong willingness among participants to utilize and integrate this game into their study routine. This data highlights a significant readiness among respondents to embrace the game as a tool for enhancing their learning effectiveness and application of the taught materials.

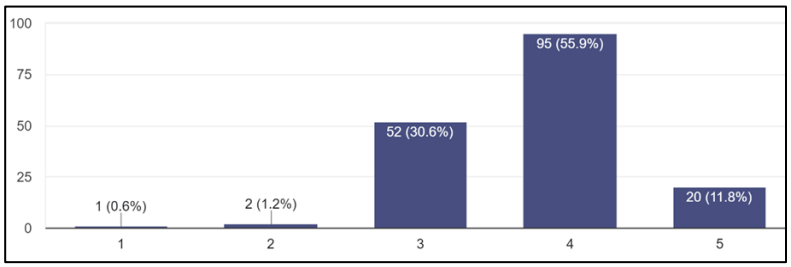

Figure 2. PU

3.3. Perceived Ease of Use (PEOU)

Perceived ease of use indicates the degree to which individuals believe that utilizing a particular technology will be effortless or straightforward. The data from Figure 3 reveals that a notable proportion of respondents, 40.6% who agreed and 15.9% who strongly agreed, view this game as highly user-friendly. This widespread positive perception suggests that many participants find the game intuitive and easy to navigate, contributing significantly to their positive interactions and comfortable use of the gaming interface.

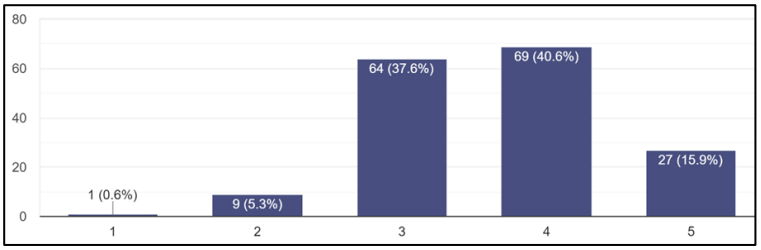

Figure 3. PEOU

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4. CONCLUSION

HT2u has been successfully developed and introduced to students, with initial pilot feedback indicating positive responses towards the Technology Acceptance Model (TAM), encompassing aspects such as self-efficacy (SE), perceived ease of use (PEOU), and perceived usefulness (PU). However, there are identified areas for enhancement in terms of user interface design. As this marks the initial phase of online game development, there remains ample opportunity for refinement and advancement. Looking ahead, the goal is for HT2u to not only serve as an effective educational tool but also to cultivate greater student engagement and interest in campus subjects. The ongoing development aims to harness student feedback to improve usability and functionality, ultimately fostering a learning environment where students are more motivated and invested in their academic pursuits.

ACKNOWLEDGEMENT

We would like to express our appreciation towards our organisation, Universiti Teknologi MARA Cawangan Pulau Pinang for the endless motivation and encouragement in completing this study. Ultimately, we are grateful for the respondents' willingness to participate in this study.

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GEOGRAM: INTEGRATING TANGRAM ELEMENTS TO IMPROVE GEOMETRY UNDERSTANDING

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Abstract

GeoGram is an innovative educational tool inspired by the traditional tangram puzzle, specifically designed to enhance students' learning of geometry. By integrating elements of edutainment, GeoGram promotes learning through play, combining geometric shapes with fundamental geometry formulas. The tool features a spinning wheel mechanism that randomly selects shapes and corresponding formulas, which players must use to construct diagrams within a given time frame. This dynamic approach aims to improve students' understanding and retention of basic geometry concepts while fostering creativity and critical thinking skills. GeoGram's development and application have been explored to create a more engaging and effective learning experience. The primary objective is to provide a hands-on, interactive method for learning geometry, making the subject more accessible and enjoyable for students. By encouraging active participation and problem-solving, GeoGram helps students build a solid foundation in geometry, enhancing their spatial abilities and overall mathematical performance. Through its unique combination of play and education, GeoGram offers a promising solution for overcoming the challenges associated with traditional geometry teaching methods, making learning both fun and effective.

Keywords: Geometry shapes; edutainment; interactive learning; spatial skills; critical thinking.

1. INTRODUCTION

Geometry, a fundamental branch of mathematics, plays a critical role in the development of spatial reasoning, problem-solving, and analytical skills. However, many students often find geometry challenging due to its abstract concepts and the necessity for strong visual and cognitive abilities. Traditional teaching methods, which are frequently teacher-centered, may not effectively engage students or cater to their diverse learning needs. Consequently, there is a growing need for innovative educational tools that make learning geometry more interactive and enjoyable.

Numerous studies have highlighted the difficulties students face when learning geometry. According to Ayşen (2012), students often possess misconceptions, lack prior knowledge, and make basic operational errors in geometry. Gagatsis & Geitona (2021) note that the abstract nature of geometry requires strong cognitive and spatial skills, making it one of the most challenging subjects for students. Moreover, William (2010) points out that elementary students frequently struggle with understanding and applying geometric concepts, underscoring the need for effective instructional strategies.

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Traditional geometry teaching methods are often teacher-centered, focusing on direct instruction and rote learning. These approaches may not sufficiently engage students or address their individual learning needs. Research by Alam (2023) found that while teacher-centered methods dominate, they may not be the most effective in fostering deep understanding and interest in leaning. The need for more interactive and student-centered learning approaches is evident.

Educational tools that integrate play and learning, known as edutainment, have shown promise in enhancing student engagement and learning outcomes. The use of games in education can provide an interactive and enjoyable learning experience, making complex subjects like geometry more accessible. Botelho et al. (2019) and Beck et al. (2013) demonstrated the effectiveness of using spinning wheels as teaching aids, which can attract students' interest and improve their conceptual understanding. By incorporating playful elements, these tools can make learning more dynamic and engaging, thus addressing the limitations of traditional methods.

Tangram, a traditional Chinese puzzle consisting of seven geometric shapes, has been widely recognized for its educational benefits. Becker (2016) reported that tangram puzzles could improve students' understanding of mathematical concepts and enhance spatial skills. The manipulation of shapes and the requirement to form specific patterns help develop critical thinking and problem-solving abilities. Tangrams encourage hands-on learning and can make abstract geometric concepts more tangible.

GeoGram draws inspiration from tangram puzzles and incorporates a spinning wheel mechanism to create a dynamic and interactive learning tool. By combining geometric shapes with fundamental geometry formulas, GeoGram aims to address the challenges of traditional teaching methods and improve students' geometry skills. This tool encourages active participation, creativity, and critical thinking, aligning with research findings that highlight the benefits of play-based learning in education.

By integrating elements of play and education, GeoGram promotes learning through play, combining geometric shapes with essential geometry formulas, creating an engaging and hands-on learning experience. This dynamic approach aims to improve students' understanding and retention of basic geometry concepts while fostering creativity and critical thinking skills. Through its unique combination of play and education, GeoGram offers a promising solution for overcoming the challenges associated with traditional geometry teaching methods, making learning both fun and effective.

2. MATERIALS AND METHODS

The development of GeoGram involved several methodical steps to ensure it effectively enhances students' understanding of geometry through an engaging and interactive approach. Below are the key stages in the development process:

2.1. Conceptualization

The idea for GeoGram was inspired by the traditional tangram puzzle, known for its educational benefits in improving spatial reasoning and mathematical understanding. The core concept involved combining tangram-like geometric shapes with the application of geometry formulas.

2.2. Design and Planning

A comprehensive design plan was created, outlining the game mechanics, educational objectives, and user interface. This included the decision to use a spinning wheel mechanism to randomly select shapes and formulas, adding an element of chance to the game.

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2.3. Prototyping

Initial prototypes of the game were developed, focusing on the physical components such as the spinning wheel and the geometric shapes. Each shape was designed with formulas for area and perimeter pasted on the back.The game mechanics were tested to ensure that they were intuitive and engaging. Adjustments were made based on feedback from initial trials. Figure 1 shows the prorotypes of GeoGram.

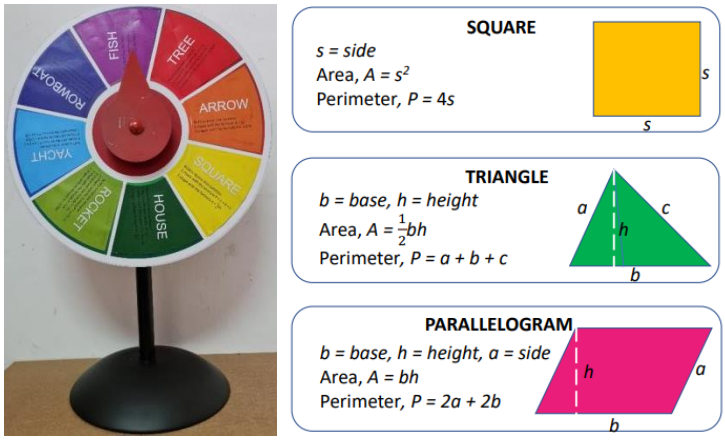

Figure 1. Prorotypes of GeoGram

2.4. Content Development

Detailed educational content was created, including a variety of geometric shapes and corresponding formulas. This content aimed to cover basic geometry concepts that are essential for students. Instructional materials and guidelines as shown in Figure 2 for gameplay were developed to ensure that players and educators could easily understand and implement the game.

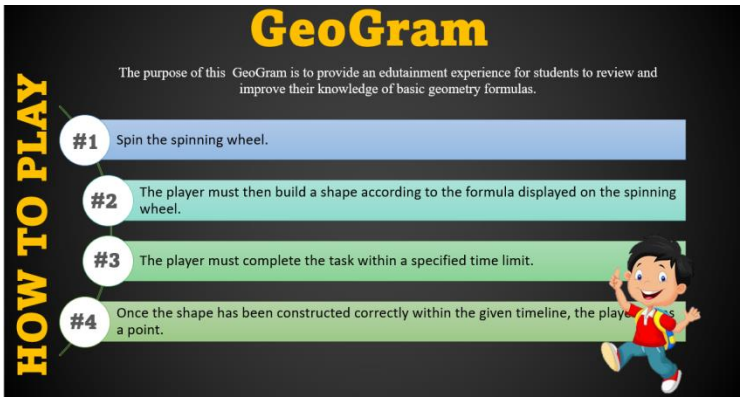

Figure 2. The Guidelines for Playing GeoGram

2.5. Pilot Testing

GeoGram was piloted in a few students as shown in Figure 3. The pilot testing focused on the game's effectiveness in improving geometry skills, as well as its overall engagement and usability. Feedback from these sessions was used to refine the game. This included modifications to the spinning wheel mechanism, the clarity of the formulas, and the overall user experience.

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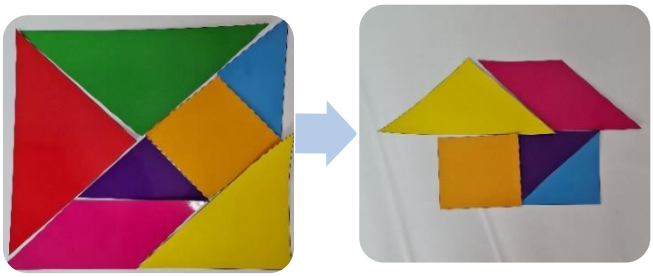

Figure 3. The Pilot Test for Playing GeoGram

2.6. Evaluation and Iteration

The effectiveness of GeoGram was evaluated through both quantitative and qualitative measures. Surveys and assessments were used to measure students' improvement in geometry understanding and their enjoyment of the game. Based on the evaluation results, further iterations and improvements were made. This iterative process ensured that the final version of GeoGram was both educationally effective and enjoyable for students.

3. RESULT

The implementation and testing of GeoGram yielded several noteworthy results that highlight its effectiveness as an educational tool for learning geometry. 25 students who used GeoGram showed a significant improvement in their understanding and retention of basic geometry concepts. According to the results of the pre-test and post-test as shown in Figure 4, students are better able to solve basic geometry applications after being introduced to the GeoGram. Students demonstrated enhanced ability to recall and apply formulas for area and perimeter, indicating that the game effectively reinforced these fundamental concepts.

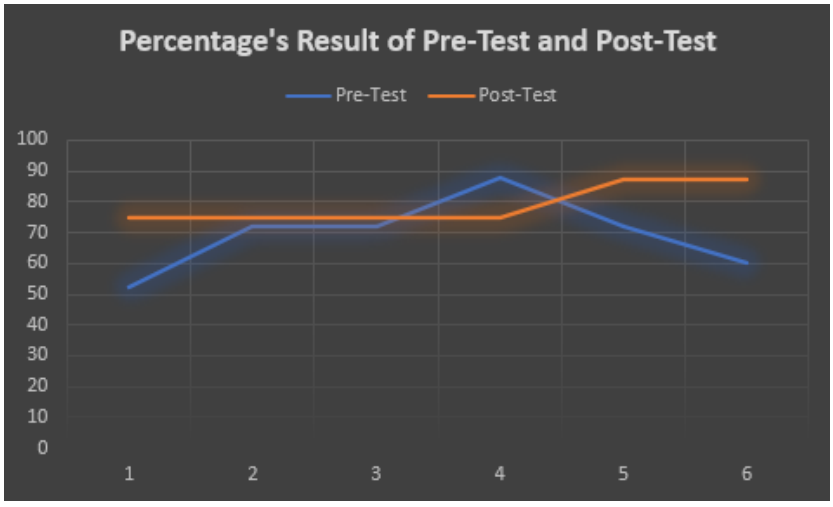

Figure 6: Percentage's Result of Pre-Test and Post-Test

Moreover, GeoGram was highly engaging for students. Observations and feedback indicated that students were more motivated and enthusiastic about learning geometry through the game compared to traditional methods. The element of play, combined with the challenge of constructing shapes within a time limit, kept students actively involved and eager to participate. The game also contributed to the development of students' spatial reasoning skills.

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By manipulating geometric shapes and understanding their properties, students enhanced their ability to visualize and analyze spatial relationships. They were able to progress from basic visualization to more advanced analytical thinking, as suggested by improvements in tasks that required higher-order thinking skills.The results of the GeoGram implementation highlight several important aspects of its effectiveness and potential for broader application in geometry education. The significant improvement in students' understanding of geometry concepts underscores the educational value of GeoGram. By incorporating elements of play, the game transforms abstract mathematical concepts into tangible and interactive experiences. This hands-on approach aligns with constructivist theories of learning, which emphasize the importance of active engagement and experiential learning in knowledge acquisition. GeoGram's ability to engage and motivate students is a critical factor in its success. Traditional geometry instruction can often be perceived as dry and challenging, leading to disengagement. GeoGram addresses this issue by making learning fun and interactive, thereby increasing students' intrinsic motivation to participate and learn. This heightened engagement is likely to contribute to better long-term retention of geometric concepts. The development of spatial skills through GeoGram is particularly noteworthy. Spatial reasoning is a key component of success in STEM fields, and activities that enhance these skills are valuable in educational settings. By requiring students to manipulate shapes and solve spatial problems, GeoGram helps build the cognitive abilities necessary for advanced mathematical and scientific thinking.

4. CONCLUSION

The success of GeoGram suggests several avenues for future development and research. Expanding the game to include more advanced geometric concepts and integrating digital versions could broaden its applicability and impact. Additionally, longitudinal studies could provide deeper insights into the long-term benefits of using GeoGram in geometry education. In conclusion, GeoGram has demonstrated significant potential as an innovative and effective tool for teaching geometry. By enhancing understanding, engagement, and spatial skills, it offers a promising solution to the challenges associated with traditional geometry instruction. Further development and research will continue to refine and expand its educational impact.

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SnaP EDU (V1): SNAP & LEARN

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Abstract

SnaP Edu is a card game designed as a novel approach to learning through engaging gameplay. In the current era of globalisation and the internet, educators and students need to experiment with various methods of study and revision in order to stay current with trends. Gamification in the learning and revision process will improve student comprehension. This card game was developed to assist students in making the process of learning and revision engaging and fun. Any educational level can use SnAP Edu game cards, whether they are used in schools or at a higher university. This card game can be played by two people up to a maximum of six. These cards have a vibrant design with floral image. These upgrade version SnaP Edu (V1) are design especially for student from secondary school. SnAP Edu (V1) card is played individually with overlook by instructor. Exercise questions from topic Science & Science Technology will be asked during the game. A sample of respondents for this research consists of approximately thirty students ranging in grade level from 3 to 5. The outcome demonstrates that when playing this SnAP Edu card game, players found it enjoyable, fascinating, and simple to review. In addition, students become more committed and focused on spending a substantial amount of time honing their gaming skills.

Keywords: card game, STEM education, education game.

1. INTRODUCTION

According to Wikipedia, a card game is any game, conventional or unique in form, that is primarily played with playing cards. A minimum of two players and a maximum of eight players can participate in the card game. There are other card game varieties on the market, including Snap Family Fantasy, Happy Family, and Poker Card. The SnAP Edu card game, which combines the playing and learning processes, is introduced in this study.

Game-based learning involves more than just making games for students to play; it also involves developing instructional activities that can lead users towards a final objective and progressively introduce concepts (Pho & Dinscore, 2015). Ritzko and Robinson (2006) wrote that when business students use an active learning strategy, games have a substantial association with engagement and excitement. These studies indicate that the generation that grew up with interactive video games, TV game shows, and the Internet as sources of information and amusement are the most current sorts of responders from undergraduate college students.

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According to Paramjit et al. (2021), intrinsic motivation—which fuels a desire for more—is the most overt sign of the "joy of learning." Students are more motivated to study when they are actively participating in their play. This kind of joyful nurturing produces a really nice environment and is incredibly rewarding because kids naturally participate more when they appreciate what they are doing. Ritzko and Robinson (2006) found that when business students use an active learning strategy, games have a substantial association with engagement and excitement. These studies indicate that the generation that grew up with interactive video games, TV game shows, and the Internet as sources of information and amusement are the most current sorts of responders from undergraduate college students. A type of flash card that can fulfil the basic elements of an active teaching and learning approach by incorporating elements of speaking, listening, and reading activities all at once (Fakrulhazri at al, 2018).

SnaP EDU (V1) card game that apply learning while playing it. This card can help the school student in process learning and doing revisions. Any level of age student can play this SnaP EDU (V1) card. SnAP EDU (V1) card is played individually with overlook by instructor. Exercise questions from topic Mathematic & Science Technology will be asked during the game. Actually, this approach revision during playing will encourage student and enhance the student interest in the topic discuss.

2.Project Scope

The SnaP EDU (V1) application aims to address the syllabus content related to mathematics and science technology designed for secondary school students. The scope of the user for this application involves the secondary school students, teacher and parents. The question are prepared in English and Bahasa Melayu.

2.1 Secondary School Student

A group of students can play this card game. They can play in pairs of 2 person per group. There can be up to 4 groups. There will be a question asked once the student win the snap session and if the students able to answer they will keep the cards. The winner will be decided based on the number of cards collected.

2.2 Teachers and Parents

Teachers and Parents may also monitor and be the person in charge to read the question during plating the SnaP EDU (V1) card.

3. MATERIALS AND METHODS

Snap EDU (V1) card has been developed based on the method applied the Program Development Life Cycle (PDLC) steps as shown in Figure 1. There are five main steps in PDLC that start with analysis, design, implementation, testing and documentation.

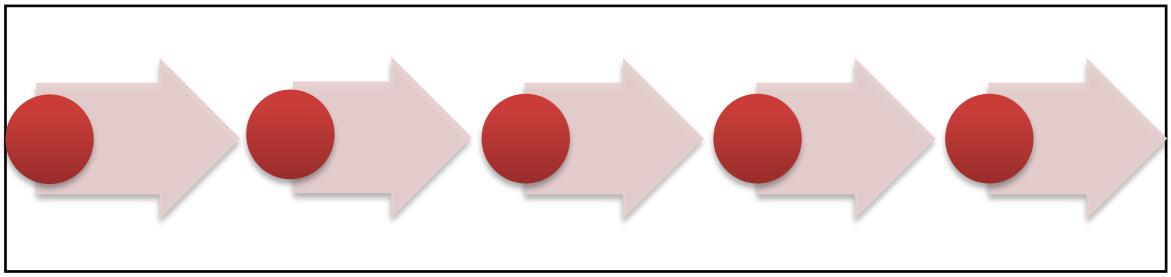

Figure 1: PDLC design

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The problem statement was initially identified earlier in the development of the SnaP EDU (V1) card project. Students becoming bored while doing revision in the traditional manner is the main issue. Thus, the following stage is to proceed after you have a clear understanding of what is needed to fix the problem. Subsequently, at the design stage, the card's interface design was created in a manner distinct from the widely used design. The card was sent to print after the design was complete because numerous sizes and quality flash cards were available. Along with being prepared, a set of questions is printed on separate cards and packaged with the SnaP EDU (V1) card. The card is used in education training to gauge student satisfaction and efficacy once it is ready.

3.1. Materials

The card game SnaP EDU (V1) was inspired by Snap Family Fantasy. This card was created with flower themes. The card was being created in a rather unique and distinct manner. The SnaP EDU (V1) card in size of 12 cm by 15 cm. The front and rear views of the SnaP EDU (V1) interface design are displayed in figures 2 below. The interface for the game's questions is depicted in figure 3.

Figure 2: SnaP EDU design

Figure 3: SnaP EDU question card

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3.2. Method

SnaP EDU (V1) is card game, whereby can be played in individually or by group of 2 person per group from different ages. This game can be played with a maximum number of 8 players and 1 instructor. Simple questions on English or Bahasa Melayu will be asked to increase students' knowledge according to different level of difficulties.

As usual, the game start with a player to the dealer's left turns over the top card of his pile and places it face up, beginning a pile of cards next to their face down cards. The player to the left follows suit, and so on around the table. When a card is turned up that matches a card already face up on another player's pile, the first person to notice the two matched cards calls out "Snap!" and wins both piles. To keep the piles the player wins, the player has to answer the question asked by the instructor. If the player answers correctly then the player can keep the piles if not the player can't keep it. The cards are added to the bottom of this player's face-down pile. The winner of the game can be define based on the card the player collects at the end of the game. If we have same number of cards they have to answers a questions to find a winner. Figure 4 below show the flow how the game is played.

4. RESULTS AND DISCUSSION

A survey has been conducted among 30 students from SMK Tasek Gelugor. The main objective of the questionnaire is to identify the student's opinion and satisfaction using SnAP Edu. The questions are divided in two parts which are:

a) Demographic
- Gender
- Age

b) SnAP Edu satisfaction

The demographic information about the respondent, there are 30 students involved in this study, 14 of them are female student while 16 of the are male student. There are 7 male and female students from age between 13 to 14 years old meanwhile there are 7 female and 9 male students in age of 15 years old.

Figure 4 illustrates the respondent's satisfaction in using SnaP EDU (V1). The result shows, 95% of the respondents are satisfied with SnaP EDU (V1) card game as it can help and make them enjoy during their revision time.

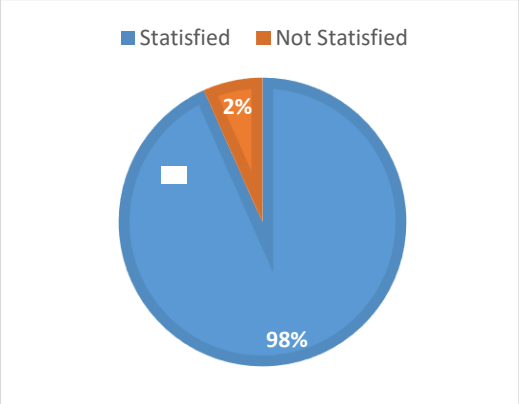

Figure 4: Student's level of satisfaction using SnAP Edu

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5. CONCLUSION

As a result, students become more determined and prepared to invest a substantial amount of time in enhancing their gaming abilities. Several studies have demonstrated that including students in directed play yields superior pedagogical practices than the conventional teaching approach. Additionally, SnaP EDU (V1) has demonstrated that players are happy to play the card even after changes.

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GAME-BASED LEARNING FOR SECONDARY MATHEMATICS EDUCATION: QUADZZLE©

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Abstract

The integration of STEM fields into Malaysia's secondary education curriculum, as outlined in the Malaysian Education Blueprint, has greatly improved STEM education. Furthermore, game-based learning (GBL) has become a prominent educational approach in mathematics, utilising games to enhance learning results and have a favourable impact on students' emotional and attitudinal reactions. This paper introduces Quadzzle©, an innovative puzzle game that was developed with the specific purpose of fostering a more comprehensive understanding of quadratic functions and equations. Quadzzle© offers a 15 to 20-minute gameplay experience that is both engaging and mathematically based, combining traditional puzzle elements. The game was tested for Form Five students from Mukah and attendees at the STEM booth in Sibu. Assessment questions were distributed to the students at Mukah one week before they participated in the game. The Wilcoxon Signed Rank test revealed significant improvements in students' academic performance post-engagement. The game was highly successful in assessing the student's comprehension of quadratic functions and equations, as it ignited their curiosity and provided an exhilarating playing experience. The findings indicate that Quadzzle© enhances the understanding of quadratic problems. Future research should explore the broader impacts of puzzle-based learning on students' achievement, motivation, and self-confidence, as well as its effectiveness in teaching algebraic and trigonometric concepts. The practice of creating educational puzzles provides valuable perspectives, which justify the need for additional exploration into education focused on puzzles.

Keywords: Quadzzle©; Game-based Learning (GBL); Mathematics Education

1. INTRODUCTION

STEM education in Malaysia has been under notable spotlight in recent years, mostly due to the integration of Science, Technology, Engineering and Mathematics (STEM) subjects into the secondary standard curriculum (KSSM) nationwide, according to the Malaysian Education Blueprint in between the year of 2013 until 2025 (Idris et al., 2023). The initiatives to develop STEM education in Malaysia come with an intention to address challenges such as students' lack of proficiency in mathematics and science (Jaafar & Maat, 2020). Even so, there are concerns about the decreasing interest of students in STEM, not only in schools but also in most institutes of higher learning, as mentioned by Mohtar et al., (2019). This calls for educators to update approaches to delivering knowledge in the classroom. One way is through game-based learning in mathematics education.

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Game-based learning has gained significant attention in the field of mathematics education. It is not a game but a learning approach. Specifically, game-based learning refers to the process and practice whereby students acquire knowledge through games (Bonner & Dorneich, 2021). Hussein (2023) highlighted that game-based learning creates a better learning environment for mathematics education, by improving the engagement, collaboration, and understanding of mathematical concepts.

Educational board games, including puzzles, have been recognised as among the best tools to enhance the learning experience in different disciplines. It provides a dynamic and engaging learning environment that encourages active participation and enjoyment (Osman et al., 2024). According to Thomas et al., (2013), puzzles in lessons can contribute to the improvement of student learning as they enhance problem-solving and independent learning skills and improve their motivation to learn mathematics. Quadzzle© aims at a more engaging and innovative way to learn quadratic functions and equations. This innovation is invented to spark students' interest in learning the subject.

2. MATERIALS AND METHODS

Quadzzle© is an innovative puzzle game that blends classic elements from traditional puzzle games with the principles of quadratic functions and equations, creating a unique and intellectually stimulating gameplay experience. This game takes 15 to 20 minutes for the player to complete the puzzle. The game was tested in two distinct locations to determine its usefulness. Initially, the game was given to twenty Form Five students from various secondary schools in Mukah. Subsequently, it was evaluated during one of the Mathematics STEM activities at the *Jom Masuk Universiti* event in Sibu.

For the first testing location, a group of students was given five minutes to complete a set of four-mark questions related to the game's topic. This was done one week before they played the game. After playing, they were given the same questions to answer again. The results obtained were analysed using the Wilcoxon Signed Rank test to evaluate the effectiveness of the game at a 5% level of significance. Meanwhile, the attendees at the second testing location were given a short Likert scale questionnaire after playing Quadzzle© at the STEM booth. The responses from this questionnaire were analysed using descriptive statistical analysis. However, only thirteen attendees were willing to respond to the survey.

3. RESULTS AND DISCUSSION

3.1 Secondary Schools in Mukah

According to Table 1, there is a statistically significant difference between the scores obtained before and after playing the game ($Z = -2.17$, $p < 0.05$). The results of the study indicate that after experiencing the game, the students achieved higher scores than they did before. The median score has improved from 3 to a full score.

Table 1. Results of Pre-Test and Post-Test

Measure	**Mean**	**SD**	**Median**	***Z***	***p***
Pre-test	2.65	1.35	3	-2.17	0.03
Post-test	3.45	0.83	4		

Note: N = 20

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3.2 STEM Booth in Sibu

Meanwhile, Figure 1 depicts that most attendees at the STEM booth who played the game strongly agreed that the game was exciting. Similarly, they strongly agreed that the game could stimulate their interest in mathematics. Besides, most attendees also agreed that the game could be used to evaluate their understanding of mathematics.

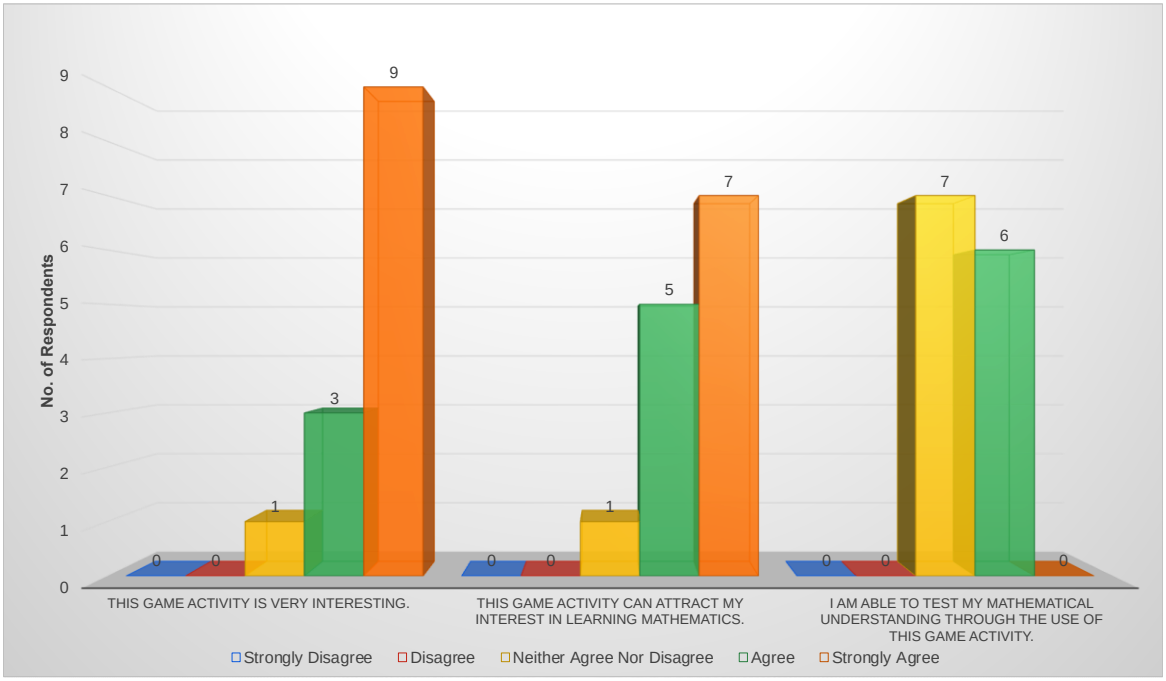

Figure 1. Attendees' Feedback on the Game at the STEM Booth

4. CONCLUSION

In conclusion, Quadzzle©, an innovative puzzle game has provided a unique and intellectually stimulating experience for the attendees to practice the principles of quadratic functions and equations. The Quadzzle© has helped to improve the attendees' understanding in quadratic functions and equations as evidenced by the increment of mean scores in the pre-test and post-test. Further, the increment in the median score from 3 to a full score also indicates the effective use of Quadzzle© to improve the mastery skills of the attendees in solving quadratic functions and equations. The findings are in line with Gorev et al., (2018) who reported that the inclusion of puzzles in the teaching and learning of mathematics increased the users' interest in mathematics and developed their mathematical abilities. Proof has been seen through the increase in the level of users' abilities, especially in the indicators proposing predictions for problem-solving and making logical conclusions (Hidayat et al., 2022). Apart from that, Al-Absi (2017) also supported that puzzles and games had a positive effect on improving users' mathematical thinking.

Besides, the attendees expressed their positive and supportive feedback on the use of Quadzzle© for the learning of quadratic functions and equations, as supported by strong agreement on the excitement and interest stimulating of the game. This is in line with Meyer et al., (2014) who reported that the concept of puzzle-based learning aims to improve students' general analysis and problem-solving skills by using puzzles that are educational, interesting and not boring.

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In the future, it is recommended to use puzzles and games in the teaching process to examine the effect on users' achievement, motivation and self-confidence. The process of drawing a puzzle to identify mathematical concepts and using them was insightful. On the other hand, future research should look into the effect of applying puzzle-based learning on the mathematical thinking abilities of the users especially pertaining to algebraic and trigonometric concepts. Researchers should have conducted good time management to ensure all puzzle-based learning processes ran optimally.

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SECTION 6

Health Sciences

2024 OPEN INTERNATIONAL INNOVATION COMPETITION
Sustainable Urban Innovations for the Development of Well-being

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TUBERCULOSIS TREATMENT DEFAULT MAPPER

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Abstract

Tuberculosis (TB) has been the leading cause of death from an infectious disease in Malaysia for over a decade now. Geographic information system (GIS) is widely used in both developed and developing countries for tuberculosis spatial analysis. However, there is a paucity of literature in Malaysia on the use of GIS in tuberculosis. The objective was to study the spatial distribution of TB treatment default in Selangor and develop hotspot maps for the same. Selangor was selected for the study because it has the highest number of TB cases and TB treatment defaulters on the Malaysian peninsula. The uniqueness of this innovation was the creation of hotspot map of TB treatment default. Knowledge of this map will help to reduce TB treatment default which is the forbearer of multi-drug resistant tuberculosis (MDR-TB). The knowledge gained from this can be used by health policymakers to make more informed decisions about resource allocation, type of control/interventions, and specific targeted areas. As a result, the existing TB burden will be reduced. Other states can then incorporate successful TB control programmes in Selangor by deploying GIS alongside their existing TB control programmes.

Keywords: Tuberculosis; Default; GIS; Malaysia

1. INTRODUCTION

Tuberculosis (TB) is a chronic air-borne infectious disease caused by bacillus Mycobacterium tuberculosis and usually affects the lungs. According to World Health Organization (WHO) in 2023, TB is still one of the main cause of mortality and ill-health globally, despite it being a curable and preventable disease. There is one new TB case every 4 seconds and more than 2 TB deaths every minute in the world (Hemserk et al., 2015). The progress in provision of essential TB services and reducing TB disease burden was severly hampered by the recent Covid-19 pandemic. The number of people newly diagnosed and reported increased to 7.4 million in 2022 from 5.8 million in 2020. Reduced access to TB diagnosis and treatment during the Covid-19 pandemic has led to an increase in the TB deaths across the globe (WHO, 2023). Malaysia is currently not in the list of the 30 high TB burden countries but geographically is a neighbour to few of them (Indonesia, Thailand, Philipines, Cambodia and Vietnam). According to the Ministry of Health, Malaysia (MOH), the TB incidence rate was 77.76 per 100000 population and TB mortality rate was 7.88 in 2022 (MOH, 2023a).

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The TB mortality rate in Malaysia has increased by 42% from 5.56 per 100000 population in 2015 to 7.88 per 100000 population in 2020 (MOH, 2016a; MOH, 2023a). The 2020 milestones of the End TB strategy were not met by Malaysia as seen in the Table 1. Instead of the reduction in the number of TB deaths by 35% in the year 2020 compared to 2015 baseline, Malaysia had an increase in the number of TB deaths by 41.7% at national level and 21% at the state level of Selangor and is above the 2020 milestone of less than 3 per 100000 population of the End TB Strategy (WHO, 2023b). Malaysia also could not meet the target of more than 90% of TB treatment success rate for both Malaysian and Non-Malaysian citizens. Lastly, the TB mortality rate in Malaysia was higher than the target of 3/100000 population both at national and state level in the year 2020. Current literature regarding the work subject should be examined and the differences of the said work from the past, similar works should be presented clearly in the introduction section.

Table 1: Current Malaysian TB situation

Indicators	2020 Milestones		Malaysia (MOH, 2023a)	Selangor (MOH, 2023b)
	WHO target (WHO, 2023)	MOH target (MOH,2016b)		
Reduction in the number of TB deaths compared with 2015	35%	25%	36.8%	21%
Reduction in the TB incidence rate compared with 2015	<85/100000		72.57/100000	74.44/100000
TB treatment success rate	>90%	90%[1]	78.3%[1]	80.4%[1]
		75%[2]	77%[2]	55.7%[2]
TB mortality rate	3/100000	≤5/ 100000	7.88/ 100000	7.45/ 100000

TB= tuberculosis, WHO= world health organization, MOH= Ministry of Health, Malaysia, [1]= Malaysian citizen, [2]= non-Malaysian citizen

Tuberculosis (TB) has been a top communicable disease and a leading cause of death in Malaysia for over 20 years (MOH, 2023b). Selangor, Malaysia's most populous and urban state (DOSM, 2022), has the highest TB cases, with districts like Hulu Langat, Gombak, and Sabak Bernam exceeding the national incidence rate (JKNS, 2021; JKNS, 2022). Urbanization promotes TB spread (Kaur et al., 2020). Despite GIS being an effective epidemiological tool in developed countries (Shen et al., 2024; Ghalandari et al., 2024), its use in analyzing TB treatment defaulters in Malaysia is limited. This study, part of the National Strategic Plan (2016-2020), developed a GIS tool to identify TB and defaulter hotspots in Selangor to aid targeted interventions.

2. MATERIALS AND METHODS

This was a cross-sectional study conducted in Selangor state of Malaysia. Selangor, is one of the 14 states in Malaysia which is spread across 7,931 km2 of area and has a total population of 6.29 million (3.27 million males; 3.02 million females). It is located in the middle of the west coast of Peninsular Malaysia and is divided into nine districts comprising of. The population consists of a majority of Malays (52.24%), followed by the Chinese (25.52%) and Indians (12.12%) (DOSM, 2022).

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2.1. Materials

The ethical approval was obtained from the National Medical Research & Ethics Committee, Ministry of Health Malaysia (NMREC) with the reference number NMRR-14-1956-22325. The study population was the tuberculosis patients registered into Malaysian National Tuberculosis Information System (MyTB) in Selangor from 1st January 2014 till 31st December 2017.

2.2. Methods

The study analyzed TB cases registered with the Selangor State Health Department from 2014 to 2017. Inclusion criteria were new TB cases in patients over 18 registered during this period, considering only the first instance of multiple registrations due to default, relapse, or treatment failure. Exclusion criteria were missing treatment outcomes or incomplete addresses in the TB registry. Data were extracted, cleaned, and converted to a CSV file for use in ArcMap 10.7.1. Addresses were geocoded and matched to the map of Selangor, with five out-of-state addresses excluded. The TB incidence rate was defined according to WHO (2014) and MOH (2012) guidelines, including new and relapse cases. The geocoded data were validated to ensure accuracy within Selangor's boundaries. Spatial attributes were created, and geostatistical analysis was conducted to develop standardized TB and TB treatment defaulter hotspot maps. The study aimed to identify and analyze these hotspots, aiding in the formulation of targeted strategies for TB control and reducing treatment defaulters in Selangor. The use of Arc-GIS software facilitated the creation of detailed maps, providing a visual representation of TB incidence and treatment defaulter patterns across the state. This approach supports better understanding and management of TB, contributing to more effective public health interventions.

3. RESULTS AND DISCUSSION

3.1. Results

The first maps developed using this tool were TB distribution maps followed by hotspots maps of TB and TB mortality. However upon discussion with the State Health Department of Selangor, it was noticed that these maps were not useful as they were based on the number of TB cases which reflects the areas with higher population as the hotspots of the disease. Therefore, standardization was carried out and hotspot analysis was carried out on TB incident cases which reflected true picture of TB transmission in the area. Subsequently hotspot maps of TB and TB treatment default were developed. The conceptual design of TB treatment defaulter hotspot identification tool is depicted in Figure 1 whereby the map of Selangor can be seen at the sub-district level in the Arc-map. The marked areas of Kuala Lumpur and Putrajaya were not included in the study as they are not part of the Selangor state.

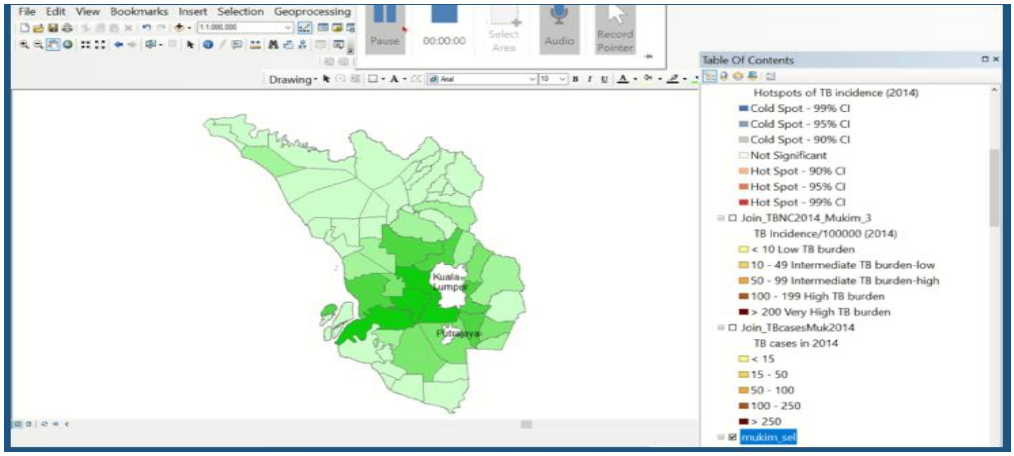

Figure 1. Conceptual Design of the TB treatment defaulter Hotspot Identification Tool

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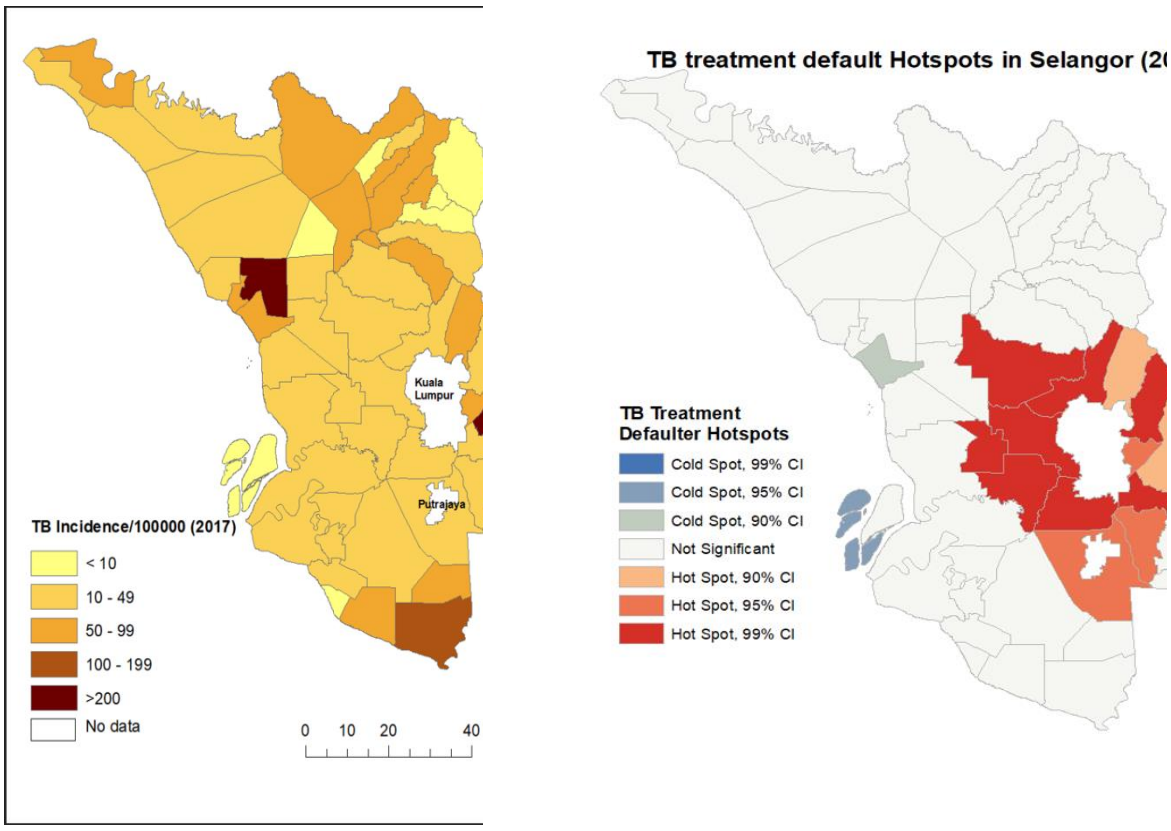
The standardized TB maps of TB incidence and subsequent TB hotspot maps based on TB incidence are shown in **Figure 2**. The Figure 2a shows the high TB incidence of >200 per 100000 in the year 2017 in Selangor state at the mukim level of Hulu Langat and Pasangan. While the Figure 2b shows hotspots of 99% Confidence Interval of TB treatment defaulters in the eight mukims surrounding Kuala Lumpur and Putrajaya in Selangor state.



(a) TB incidence map

(b) TB treatment defaulter Hotspot map based on TB incidence

Figure 2: TB treatment defaulter Hotspot maps based on TB incidence where a) TB incidence map and b) TB treatment defaulter Hotspot map based on TB incidence

3.2. Discussions

The TB incidence rate of Selangor fluctuated over these four years and ranged between 70.20 and 75.85 per 100 000 populations. Incidence rate of a disease represents the actual risk of disease transmission of the disease in the population and its universal unit of per 100 000 population makes it easier for comparison with studies conducted elsewhere. The heterogeneity in the TB incidence rate at district level of Selangor implied that certain districts were faring better in terms of TB disease burden compared to others. So even though, the districts of Petaling and Hulu Langat were noted to have highest number of TB cases, the TB incidence rate was highest in the district of Gombak for each of the four-year ranging from 83.85 - 96.13 per 100 000 population.

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This TB incidence rate is even higher than the national TB incidence rate of Malaysia which was 82.10 per 100 000 population in 2014 and 80.78 per 100 000 population in 2017 (MOH, 2016; MOH, 2023b). The spatial distribution of TB cases in Selangor state at sub-district (mukim) level also showed higher number of TB cases in the central region of the state. Six mukims which were identified to have very high (>250 TB cases) TB cases in each of the 4 years were Kelang, Damansara, Petaling, Sungai Buloh, Batu and Ampang. The mukim of Kajang was noted to have very high (>250 TB cases) TB cases only in the year 2014. The mukims with very low (<15 TB cases) TB cases in all the 4 years were distributed along the northern and western regions of the Selangor state. The proximity of the mukims to the Federal Territories makes them a more likely hub of internal immigration for people from other states, districts and mukims for trade, business, education, work related to government offices, tourism and entertainment.

The areas identified with high TB incidence are all noted to have high population density compared to the other areas of Selangor. Overpopulated areas increase the risk of TB transmission (Masabarakiza & Adel Hassaan, 2019). Seven hotspots (Sungai Buloh, Damansara, Petaling, Kajang, Cheras, Ampang and Hulu Kelang) of TB incidence were identified mainly in the central and eastern regions of Selangor district encompassing both the Federal Territories of Kuala Lumpur and Putrajaya in each of the four-years. However, Hulu Langat and Hulu Semenyih were TB incidence hotspots only in the year 2015 and 2017. It was noted that these eight mukims comprised of half (52.93%) of the total population of Selangor in 2017. The hotspots of TB mortality among TB incidence cases were located in the central eastern region from 2014 till 2016 but changed to central western regions in the year 2017. This could be explained by the improved TB care in the sub-districts of Hulu Kelang, Hulu Semenyih, Semenyih and Sabak Bernam. This also implies that hotspots delineated at smaller unit scales are better. This spatial heterogeneity of the hotspots can be explained by the fact that the hotspots had higher population compared to the coldspots.

The mukims identified as hotspots are among those with good infrastructure and healthcare services in place. The previous studies conducted in Malaysia have identified the two Federal Territories of Kuala Lumpur and Putrajaya as the areas with very high risk of TB. TB being an airborne disease can be easily transmitted to those within close proximity and this can explain the hotspots in the mukims neighbouring the Federal Territories. To reverse the TB epidemic, many municipal authorities since 2014 have become part of Zero TB Cities Project, whereby they support their local communities to move to zero deaths as opposed to the central/ national government (Mahara et al., 2018). Hotspots created using Global Moran's I and Getis Ordi Statistics is novel as the previous maps have been created using other geostatistical methods in Malaysia. No published maps for TB mortality hotspot maps for Selangor at sub-district level in the literature are available. It offers a cheap, easy and fast depiction of large data that can be visualized and understood better. It provides insight into the areas where the TB prevention and control strategies should be targeted. This tool provides standardized maps as it was based on TB incidence cases making the findings more robust. This tool provides a convenient and reliable method to identify the hotspots of TB mortality. This tool has commercial potential to the following industry in Malaysia: National TB Department, Institut Perubatan Respiratori (IPR), State TB Department, District TB Department, Public Health Department.

4. CONCLUSION

The sub-district of Hulu Langat had highest TB incidence in each of the four-year study period making it a region with high TB transmission. Spatial analysis revealed that the hotspots of TB treatment defaulters were identical to hotspots of TB incidence and were located in the central region of Selangor encompassing the federal territories of Kuala Lumpur and Putrajaya. GIS provides an additional tool to the existing surveillance mechanism. It has huge potential in guiding the national TB programs to execute effective TB control interventions. This tool can be further used to develop TBGIS portal for more accurate and live detection of TB hotspots in the future.

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SECTION 7

Information and Communication

2024 OPEN INTERNATIONAL INNOVATION COMPETITION
Sustainable Urban Innovations for the Development of Well-being

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MALAYSIAN SECONDARY BOARDING SCHOOL MENU PLANNING SYSTEM WITH POST-OPTIMALITY PROCESS

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Abstract

A boarding school student needs to eat well-balanced, nutritious food, which includes proper calories, vitality, and supplements for legitimate growth, with the aim of repairing and supporting the body tissues while preventing undesired ailments and diseases. Serving a healthier menu is a significant step towards achieving that goal. Planning a nutritious and balanced menu manually is complicated, inefficient, and time-consuming. This study intends to develop a scientific mathematical model and a decision support system for menu planning that improves and meets the vital nutrient requirements for boarding school students aged 13-18, while also saving on financial costs. It provides flexibility and allows the cook to change any preferred menu even after the optimal arrangement has been generated. A recalculation procedure was performed based on the optimal arrangement. The data were collected from the Ministry of Education and boarding schools' authorities. Menu planning is a well-known optimization problem and one of the longstanding issues in optimization. A well-balanced menu schedule is generated that meets all the constraints. The model was solved using Binary Programming and the "Sufahani-Ismail Algorithm," and a system was developed to address the problem. The user can change the menu even after obtaining the optimal solution. A recalculation process, known as the "Post-Optimality Process," will take place. The Malaysian Secondary Boarding School Menu Planning System is the first system in Malaysia and in the world. It can also be used for other problems such as the military, hospitals, and others.

Keywords: Menu Planning System; Mathematical Modelling; Nutrient Intake; Optimization; Post-Optimality Process; Operational Research; Decision Support System.

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1. INTRODUCTION

Planning adequate menus faces many economic and psychological constraints. It involves simultaneous con-sideration of several types of constraints: the desired nutritional content, the likes and dislikes of the person that it is being planned for, the amount (volume or weight) of food to be consumed, and the expected form and content of different kinds of meals (Balintfy, 1975; Bassi, 1976; Benson & Morin, 1987; Endres et al., 1983). The menu or diet problem model was first formulated by Stigler in 1945. This model, as in most operation research models, has been set up on the traditional fundamental assumption that the decision maker seeks to optimize a single objective function. The problem has continued to be investigated by scientists and nutritionists (Foytik, 1981; Gallenti, 1997; Garille & Gass, 2001; Dantzig, 2002) . In Malaysia, nutritionists/dietitians are responsible for planning menus based on the cost of food and recommended daily allowances (RDAs) exclusively for boarding schools using a traditional approach known as the "Match-Box Method." Typically, caterers provide six meals per day without offering a proper menu for creating good memories. We have a wide range of Malaysian recipes, making it challenging to select the healthiest and most appetizing menu. It is difficult to plan palatable menus that consider nutrient intake, the cost of raw foods, menu variety, student preferences, and food for improving memory. Combinations of foods may either exceed or fall short of RDA recommendations.

2. PROBLEM STATEMENT

In the current scenario, there is no proper and ideal situation for menu planning being implemented in secondary boarding schools. The ideal solution for the menu planning problem for children aged 13-18 in secondary boarding schools is to minimize costs, provide a quick solution, ensure accurate nutrient intake and boundaries, offer a daily variety of local food, allow flexibility in changing the food while staying within nutrient boundaries and budget, and establish a systematic approach that generates menus for more than one day. However, several problems persist, as illustrated in Figure 1.

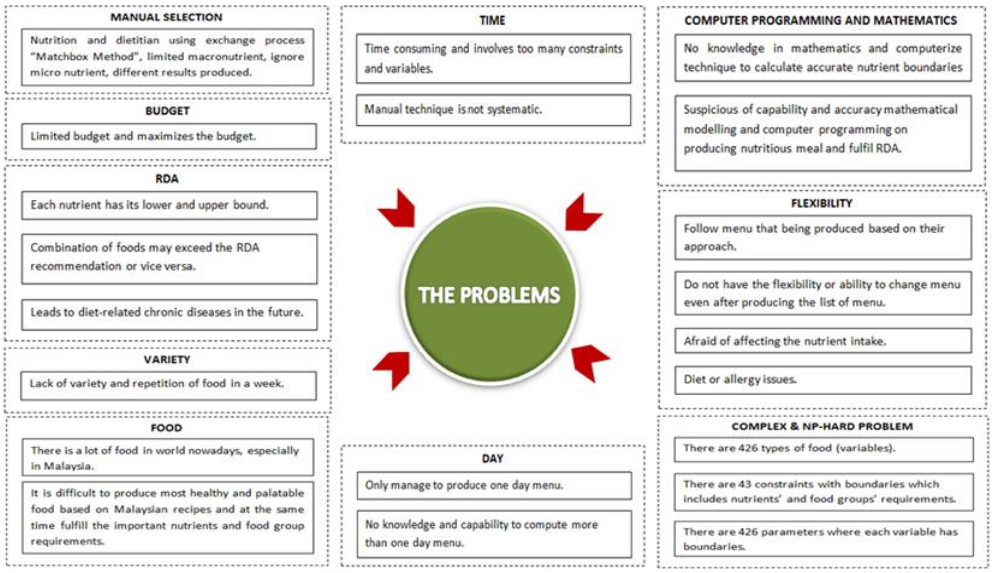

Figure 1: Research Problem

These are the challenges for our studies and how to convince nutritionists and dietitians that a mathematical method and computerization approach are the best techniques for producing a palatable menu that can handle complex menu problems and create an accurate system that generates healthy menus.

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3. CHARACTERISTIC OF THE PRODUCT INNOVATION

Several approaches have been deployed in the system, and these are the characteristics of the research and the system. Therefore, this research has successfully improved current studies on the diet problem and addressed previously unexplored issues. The system is the first of its kind in the world, and it offers the following advantages (refer to Figure 2):

4. METHOD OF PRODUCT HANDLING

This system focuses on Malaysian secondary boarding school children who have different nutrient requirements compared to primary school children and adults. As mentioned in Section 2.0, the objective is to minimize the budget allocated by the government (Ringgit Malaysia RM15.00 @ USD3.50 per student). Simultaneously, all constraints related to 11 nutrient requirements and 10 food group requirements (Table 1), user preference, ability and flexibility, meal orders, and structure (Table 2) must be satisfied to obtain an optimal and feasible solution, improve memory function, and develop a dedicated decision support system to address the problem.

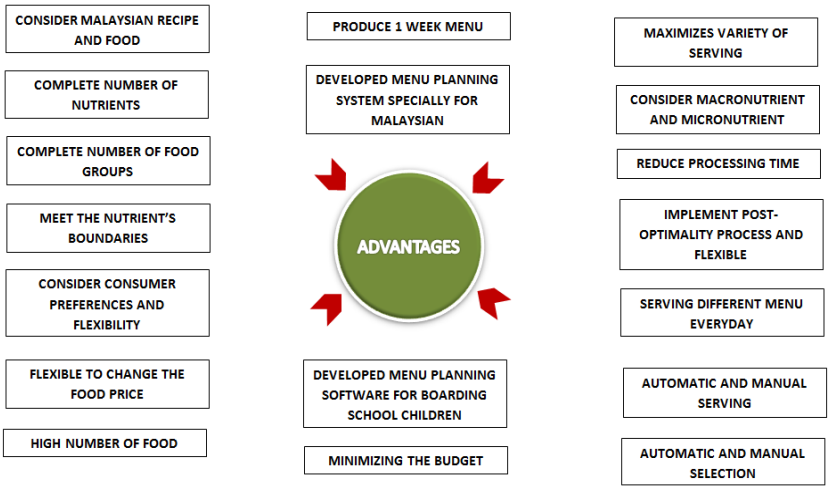

Figure 2: Research and System Advantages

Table 1: 11 Type of Nutrient and 10 Type of Food Group Daily for School Children Aged 13-18

Nutrients	Lower Bound (LB)	Upper Bound (UB)
Energy (kcal)	2050	2840
Fat (g)	46	86
Carbohydrate (g)	180	330
Protein (g)	54	No Upper Limit
Calcium (g)	1000	2500
Vitamin A (mg)	600	2800
Vitamin B1 (mg)	1.1	No Upper Limit
Vitamin B2 (mg)	1.0	No Upper Limit
Vitamin C (mg)	65	1800
Niacin (mg)	16	30
Iron (mg)	15	45

Type of food	No. of requirement per day (n)
Beverage (x_1 - x_{37})	6 * including 2 Plain Water (x_9)
Cereal Flour Based (x_{38} - x_{85})	1
Rice Flour Based (x_{86} - x_{113})	1
Cereal Meal Based (x_{114} - x_{126})	2 * including 1 Plain Rice (x_{104})
Meat Dishes (x_{127} - x_{158})	1
Vegetable (x_{159} - x_{212})	2
Fruits (x_{213} - x_{261})	2
Wheat Flour Based (x_{262} - x_{286})	1
Seafood (x_{287} - x_{324})	1
Miscellaneous (x_{325} - x_{426})	1
Total Dishes Per Day	**18**

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Table 2: Daily Meal Order and Structure

Meals Structure	Categories of Food Groups
Breakfast	Beverage, Cereal Flour Based
Morning Tea	Beverage, Rice Flour Based
Lunch	Beverage, Cereal Meal Based, Meat Dishes, Vegetable, and Fruit
Evening Tea	Beverage, Wheat Flour Based
Dinner	Beverage, Cereal Meal Based, Fish and Seafood Dishes, Vegetable, and Fruit
Supper	Beverage, Miscellaneous

The menu planning system in this study utilizes the Sufahani-Ismail Algorithm approach to achieve the best results by addressing all research questions and fulfilling the research objectives. The fundamental concept underlying the menu planning model is to generate accurate and appetizing menus for secondary boarding schools in Malaysia. To obtain optimal results, the values of each nutrient and costs must be precisely determined in the data file before proceeding with the menu problem calculations. This system was developed to facilitate quick and informed decision-making by the caterer or user, resulting in a healthy and palatable menu. When utilizing this system, menu items or preferred choices must be selected through the user interface, which comprises 10 food categories for secondary school students. Subsequently, the program transfers the selected data to the main program of the proposed system to generate optimal solutions. Once the conditions are met, the best solutions are displayed on the screen, listing all the final meals and menu items according to the 10 food groups and organizing them within a menu structure. This enables the caterer to review the suggested meals generated through the proposed mathematical calculations and algorithm using the decision support system. However, the caterer retains the authority to modify the proposed meal for the day, triggering a recalculation process within the system The flow chart of the developed decision support system is illustrated in Figure 3.

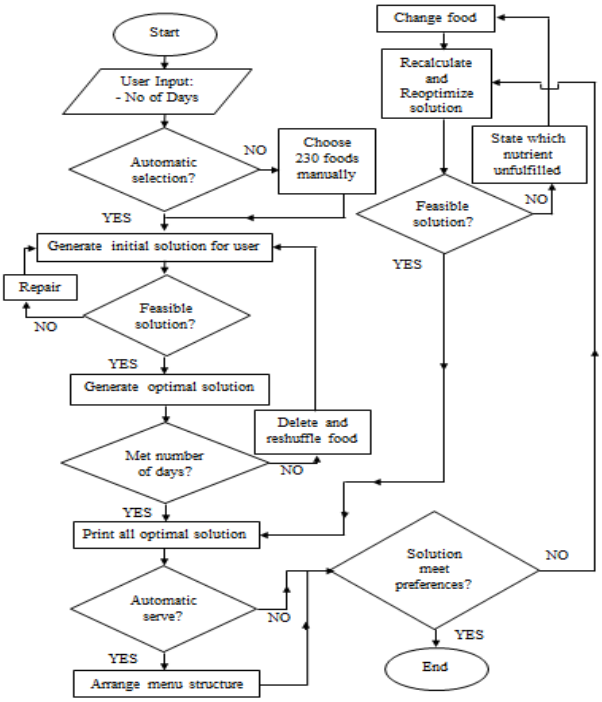

Figure 3: Flowchart of Decision Support System

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Based on the explanation, the system will:

- Generate 7-day healthy menus for secondary school children aged 13-18 in less than 3 seconds.
- Provide complete daily meal structure and requirements.
- Offer a variety of food types on a daily basis, avoiding repetition except for plain water and white rice.
- Minimize costs and find menus within the allocated budget.
- Assist customers or caterers in changing the menu even after the final and optimal menu has been generated, while ensuring it remains healthy. This will trigger a recalculation process called the Post-Optimality Process

5. RESULT & POST-OPTIMALITY PROCESS

The results for day 1 to day 7 with the proposed new algorithm are presented in Table 3. The problem was solved using the Branch and Bound method. Initially, the program selects the most affordable food options that satisfy the recommended daily allowances (RDA) and food group requirements. Consequently, the budget slightly increases each day. However, as mentioned previously, the costs for each daily menu still remain below the allocated daily budget of RM15.00 or USD3.50. Based on Table 3, it is evident that there is a 52.24% saving from the daily budget of RM15.00 or USD3.50 provided by the government. To illustrate this further, Table 5 presents a simple calculation of the annual budget for 120 secondary boarding schools, each with 1000 students. With the implementation of the system, the government has managed to save over a quarter billion Malaysian Ringgit (RM324,000,000) or more than 75.6 million US dollars (USD) annually.

Table 3: 7 Days Menu with Daily Budget RM15.00 @ USD3.50

Seven days menu	Days						
	Day1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Beverages	Orange flavoured drink, powder (B), Plain water (2 times) (T,L), Coconut water (E), Sugar cane juice D), Milo (S)	Plain water (2 times) (B, L), Syrup rose (D), Sarsi (S), Lengkong (M), Limau (E)	Milk, cow, fresh (B), Milk, UHT, low-fat, recombined (S), Plain water (2 times) (M, D), Sirap Bandung (L), Coffe & Sugar (E)	Coffee powder, instant (M), Milk, UHT, full cream, recombined (B), Plain water (2 times) (L, D), Coffee mixture, powder (E), Tea (S)	Malted milk drink, packet (M), Plain water (2 times) (L, D), Milk powder, skim (S), Tea and milk (E), Yogurt Oren (B)	Milk, UHT, chocolate flavoured (B), Plain water (2 times) (L, D), Milk, sterilized (M), Yoghurt, apricot flavor (E), Milk based diet powder (S)	Plain water (2 times) (L, E), Milk, powder, instant, full cream (M), Malted milk powder (S), Apple Juice (L) Orange Juice (B)
Cereal flour based	Biscuit soda/plain (S)	Biscuit, coconut (S)	Cookies, peanut (S)	Putu bamboo (S)	Biscuit, finger cream (S)	Biscuit peanut and coconut S)	Bread coconut (S)
Rice flour based	Kuih kasui (B)	Kuih buah Melaka (B)	Bidaran (B)	Kuih lompang (B)	Rempeyek (B)	Lor-mai-fan (B)	Tumpi (B)
Cereal meal based	Rice, chicken (L), Rice, cooked (D)	Rice, fried (L) Rice, cooked (D)	Rice, "oily" (D), Rice, cooked (L)	Rice, cooked (D), Rice coconut milk IL)	Rice, cooked (L), Noodle, rice (D)	Rice, "dagang" (L), Rice, cooked (D) (D)	Rice, cooked (L), Rice porridge, fish, instant
Meat	Chicken satay (L)	Quail egg, whole (L)	Hen egg, whole (D)	Beef satay (L)	Duck egg, whole (D)	Maw satay (L)	Chicken curry, canned (L)
Seafood	Fish unspecified, dried, salt (D)	Fish curry canned (D)	Indian mackerel fried in chilli (L)	Fish satay snack (D)	Prepared cuttlefish snack (L)	Red snapper, fried in chilli (D)	Indian mackerel, fried (D)
Vegetables	Celery(daun seladeri) (L), Mengkudu (D)	Mustard leaves, Chinese (L), Spinach (D)	Spinach onion (L), Tapioca shoots (D)	Fern shoots (L), Cekur manis (D)	Papaya shoots (L), Pegaga gajah (D)	Kesom (D), Soya bean sprout (L)	Asam gelugor, pucuk (L), Yam stalks (D)
Fruits	Guava (L), Nangka (D)	Rambutan (L), Pulasan (D)	Banana common (L), Cempedak (D)	Pineapple (L), Kismis (D)	Papaya (L), Watermelon (D)	Banana (pisang nangka (D), Binjai (L)	Mata kucing (D), Rambai (L)
Wheat flour based	Doughnut (E)	Kuih kapit (E)	Kuih ketayap (E)	Curry puff twisted (E)	Cucur udang (E)	Cake, swiss role (E)	Yau-car-kue (E)
Miscellaneous	Candy coconut (M)	Mysore pak (M)	Kuih kasturi (M)	Seaweed, agar (M)	Cucur Badak (M)	Kuih sagu (M)	Kuih kacang (M)
COST	**RM5.50**	**RM6.20**	**RM6.85**	**RM7.20**	**RM7.50**	**RM8.10**	**RM8.80**

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Based on Table 3, it is evident that there is a 52.24% saving from the daily budget of RM15.00 or USD3.50 provided by the government. To illustrate this further, Table 5 presents a simple calculation of the annual budget for 120 secondary boarding schools, each with 1000 students. With the implementation of the system, the government has managed to save over a quarter billion Malaysian Ringgit (RM324,000,000) or more than 75.6 million US dollars (USD) annually.

6. PICTURES OF PRODUCT INNOVATION

These are pictures showcasing the product innovation (refer to Figure 4).

7. THE IMPACT OF PRODUCT INNOVATION

The level of impact of the product innovation is incredibly high worldwide, and there is currently no similar system or competitors in existence. As a result, we hold the distinction of being the first and pioneering system in this field. To validate the significance of our research, we conducted a thorough analysis using Google Trends with two keywords: "school diet" and "school menu" (refer to Figure 6). Both keywords demonstrated popularity ratings ranging from 75% to 100% worldwide. This indicates that our research has had a substantial global impact and underscores its importance in the field. As mentioned earlier, our research and system have a significant impact due to the following reasons:

- There is currently no available system specifically developed for boarding or secondary school children that incorporates Malaysian or other country's food.
- The available systems mainly focus on adults without considering a specific age range.
- Existing systems lack consumer preferences and flexibility.
- Local recipes or Malaysian own recipes are not included in the available systems.
- The available systems have an incomplete number of nutrients and food groups.
- Existing systems primarily prioritize macronutrients and overlook micronutrients.
- The available systems offer a limited selection of foods.
- The nutrient boundaries are not met by the available systems.
- Existing systems are time-consuming, requiring a significant amount of time to generate menus for more than one day.
- The available systems do not account for serving different menus every day.

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8. COMMERCIALIZATION & FUTURE POTENTIAL

This system has the potential for commercialization in various sectors, including Primary Schools, Tahfiz Schools, Boarding Schools (SBP), Universities, Special Needs Children Houses, Hospitals and Nursing Homes, Ministry of Health, Ministry of Education, Ministry of Defence, Ministry of Youth and Sport, Ministry of Science and Technology, Astronaut agencies, Sports Organizations, Cancer Societies, Military etc. These sectors can benefit from implementing the system to enhance their menu planning and provide healthy and tailored meal options to their target audiences.

9. CONCLUSION

There are several contributions that can be highlighted from this research and system in terms of novelty:

- Improved memories and health among secondary school students.
- The first program that uses our very own Malaysian menu.
- The combination of optimization methods and the binary programming (BP) approach significantly contributes to solving complex problems.
- Introduces a new algorithm known as the "Sufahani-Ismail Algorithm (SIA)".
- The elimination calculation technique, in conjunction with BP and Branch and Bound, helps eliminate selected variables and reshuffle available variables for the next day's menu selection.
- This leads to better findings, faster processing time, and outperforms traditional methods.
- Implementation of the post-optimality approach.
- Development of a decision support system.
- Efficiently outperforms previous studies as there are no studies that specifically focus on these issues.

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OPTIMIZING ROYALTY PAYMENTS THROUGH MATHEMATICAL APPROACH AND HYBRID SHOOTING METHOD WITH SAPGR-ALGORITHM

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Abstract

This research focuses on maximizing the performance index of a non-standard Optimal Control problem. However, the final state value is unknown, leading to a nonzero terminal shadow value. To address this challenge, the SAPGR-Algorithm was proposed, a new modified shooting method. The continuous approximation of the hyperbolic tangent (tanh) approach was taken to encounter the royalty function's non-differentiability. The direct methods (Euler, Runge-Kutta, Trapezoidal, Hermite-Simpson approximation) served as a validation process. We anticipate that the modified shooting method will yield improved optimal results, making it a valuable contribution for researchers and academicians exploring innovative solutions to real-world problems.

Keywords: Direct Method; Optimal Control; Royalty Payment; Shooting Method.

1. INTRODUCTION

This project addresses the non-classical Optimal Control (OC) problem by applying the Spence (1981) economic model. The model incorporates a discrete form of the royalty function, which depends on the unknown final state value. We tested the royalty function using up to a seven-stage piecewise function. Royalty payment refers to compensation made by one company to the property owner for its use. We employed a new continuous approximation method using hyperbolic tangent (tanh) to overcome the challenges posed by the discrete royalty function. The problem was solved using a new modified shooting method, the SAPGR-Algorithm, which combines the Powell and Golden Section Search methods. The optimal results were validated by comparing

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them with discretization methods such as Euler, Runge-Kutta, Trapezoidal, and Hermite-Simpson approximations.

Several challenges arise during the solution of the model. Firstly, the state value at the terminal time is unknown, resulting in a nonzero final shadow value. Furthermore, the royalty function is represented by a piecewise function, which makes it non-differentiable at specific time frames. This limitation stems from the discrete nature of the royalty function.

These are the objectives of the research:

1. To maximize the performance index by using royalty payment that is in piecewise function.
2. To compute the unknown final state value, then solve optimal royalty payment by implementing the SAPGR-Algorithm.
3. To develop a new boundary condition for solving the nonzero final shadow value.
4. To investigate the appropriate approach of continuous approximation of hyperbolic tangent (tanh) for difficulty using a piecewise function.
5. To propose a new user interface design for the royalty payment system.

The Spence (1981) economic model, which is the performance index, J need to be maximized.

$$J\left[u(t)\right]=\int_{t_0}^{T}\left(a(t)u^{1-\alpha}-\left(\rho+m_0+c_0e^{-\lambda y}\right)u(t)\right)e^{-rt}dt$$

where

- ρ is the royalty
- α is the price elasticity of demand
- λ is a parameter that defines the speed of learning
- r is the discount factor
- m_0 is the asymptote of the learning curve
- c_0 is the component of unit cost that is subject to the learning curve

Several approaches have been deployed in the system, and these are the characteristics of the research and the system:

1. Producing optimal and feasible solutions.
2. Maximizing the performance index.
3. Providing a final optimal state value.
4. Setting an infinite time horizon for calculating royalty payments.
5. Developing a new modified shooting method (SAPGR-Algorithm), the combination of Powell and Golden Section Search method.
6. Generating the unknown final state value that is optimal through the SAPGR-Algorithm.
7. Developing a new boundary condition through fundamental theory proves to overcome the nonzero final shadow value.
8. Implementing a new continuous hyperbolic tangent (tanh) approach to settle the issue regarding the non-differentiable royalty function that is in the piecewise function.
9. Validating the optimal result with direct methods such as Euler, Runge-Kutta, Trapezoidal and Hermite-Simpson approximations.
10. Establishing continuous and fair royalty payments.
11. Considering the royalty in stages payment.
12. Proposing a new user interface for the royalty payment system.
13. Developing a new algorithm that reduces processing time.

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Therefore, this research has successfully improved current studies on the royalty payment problem and addressed previously unexplored issues. The system is the first of its kind in the world, and it offers the following advantages:

1. Addresses the importance of fundamental theory in solving the real economic problem.
2. Help the company to solve the royalty payment problem with a mathematical approach.
3. Easy and accurate.

2. MATERIALS AND METHODS

During the problem-solving process, several novel findings were obtained. To address the non-differentiability issue in the royalty function at certain stages, a continuous approximation using the hyperbolic tangent (tanh) function was implemented. This conversion ensured that payments could be made continuously. Following the work of Malinowska & Torres in 2010, a new boundary condition was established to address the nonzero final shadow value. The unknown terminal state value was then solved using a new modified shooting method called the SAPGR-Algorithm, which combines the Powell and Golden Section Search methods within the shooting technique. The program was developed in the C++ programming language.

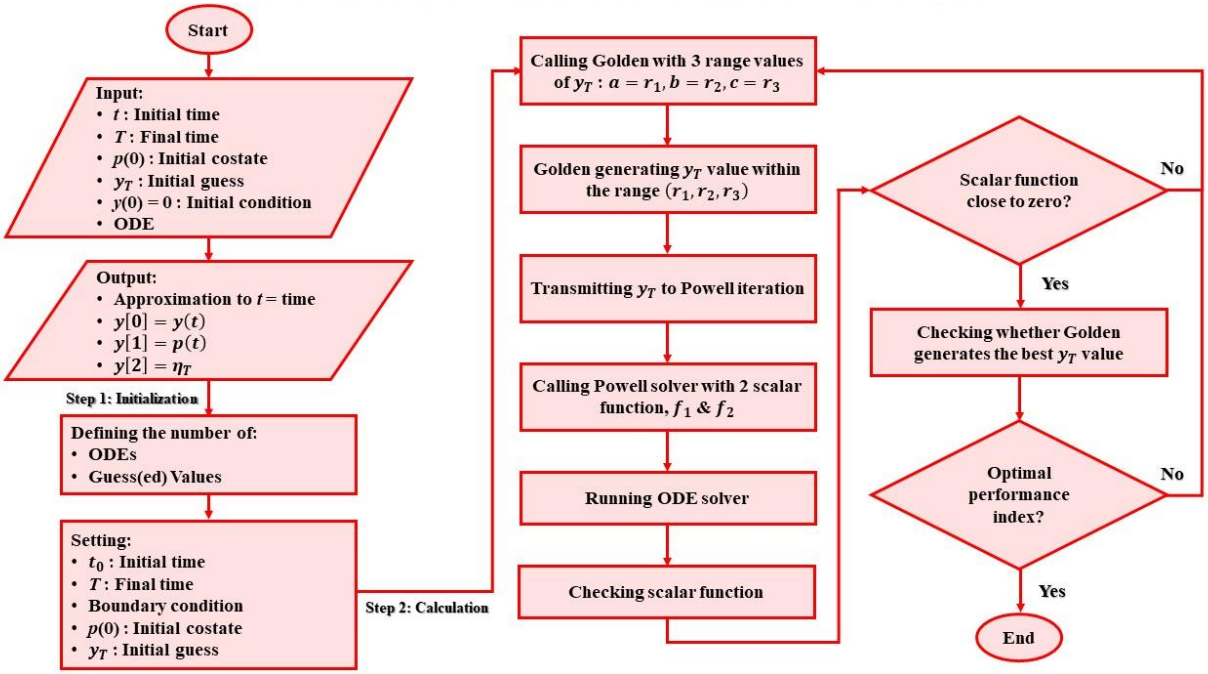

Figure 1. Flowchart of SAPGR-Algorithm

The algorithm begins by initializing the Golden Section Search method with three range values for the final state value. The generated optimal value is then passed to the Powell iteration phase. The Powell solver is invoked within this phase, and the program executes the ordinary differential equation (ODE) solver. The optimal solution is achieved when the scalar function approaches zero. Subsequently, the Golden Section Search method verifies whether the obtained final state value optimizes the performance index. If not, the program iterates again until an optimal solution is reached.

Based on the explanation, the system will:

1. Generate a performance index that is optimal and maximized.
2. Provide an optimal final state value.
3. Offer a continuous royalty payment.
4. Generate a final shadow value that is not equal to zero by using the new boundary condition.

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5. Assist researchers in solving the difficulty when using royalty payment that is in a piecewise function.

To validate the results, a discretization method using Euler, Runge-Kutta, Trapezoidal and Hermite-Simpson approximations was employed. The discretization models were implemented using the AMPL programming language with the MINOS solver.

3. RESULTS AND DISCUSSION

The optimal results were evaluated using both tabular and graphical representations.

Table 1. Optimal Solution For Shooting and Direct Method

Methods	Optimal Solution			
	Final state value, *y(T)*	**Performance index, *J* (*T*)**	**Initial shadow value, *p* (0)**	**Final shadow value, *p (T)***
SAPGR-Algorithm	0.356419	0.641990	-1.085786	-0.356795
Euler	0.319074	0.611833	-1.26011	-
Runge-Kutta	0.323087	0.612860	-1.28002	-
Trapezoidal	0.322194	0.614032	-1.28354	-
Hermite-Simpson	0.328815	0.61295	-1.25833	-

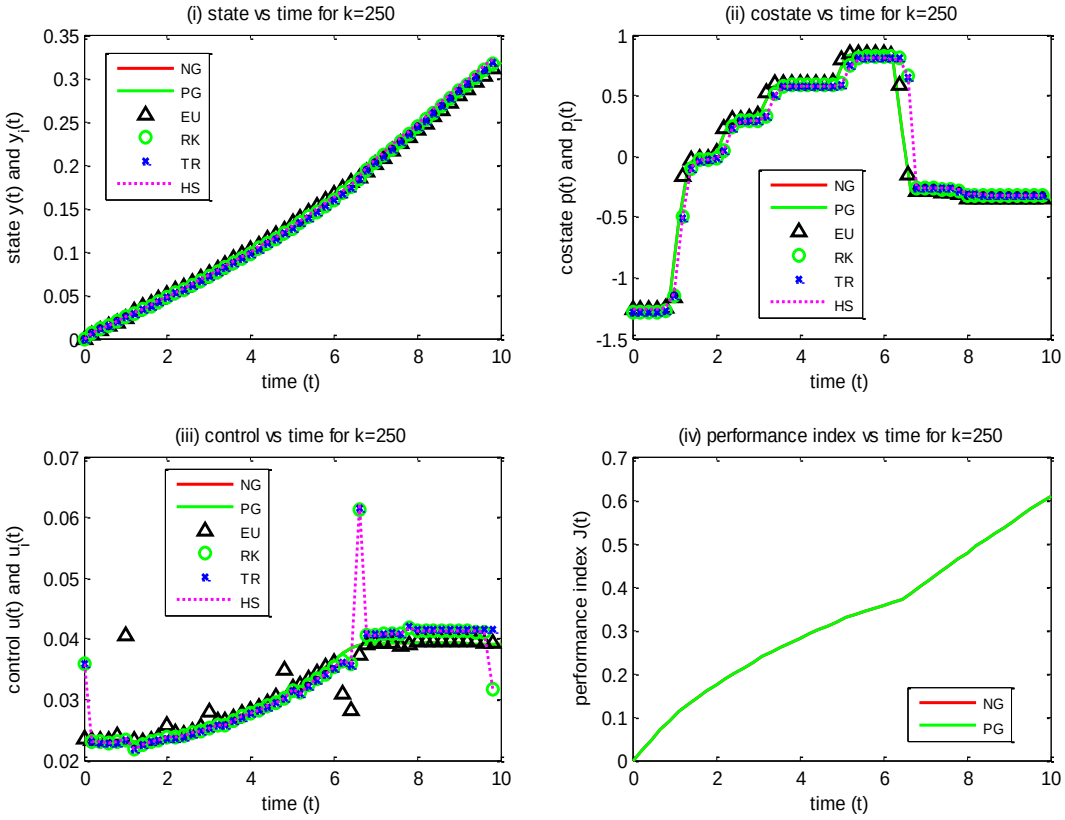

Figure 2. Optimal Result of Numerical Testing With Seven-Stage Royalty Function (EU=Euler; RK=Runge-Kutta; TM=Trapezoidal; HS=Hermite-Simpson)

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The modified shooting method produces a more precise and seamless optimal solution, allowing for differentiation at any time frame. This research successfully tackled an actual economic model, providing a solution that reduces the time required to solve royalty payment problems involving piecewise functions. Moreover, it highlights the significance of fundamental theory in addressing real-world economic challenges. Additionally, this research serves as a foundation for other researchers to explore innovative approaches to solving complex problems.

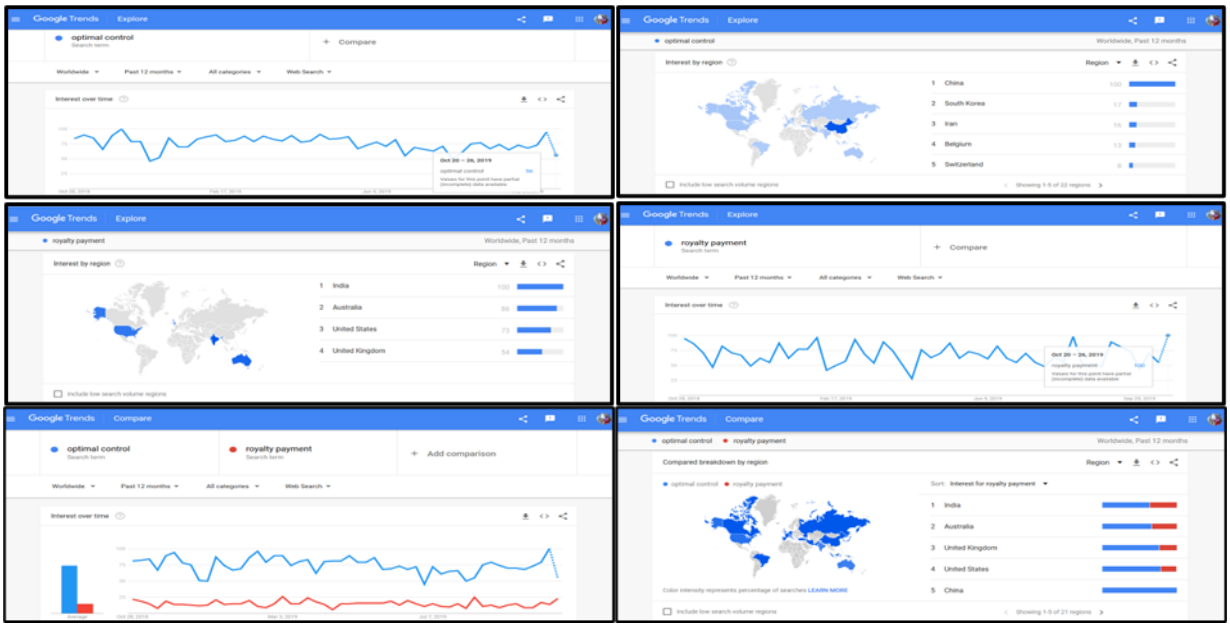

Figure 3. Due Diligent Test Through Google Trend

As mentioned earlier, our research and system have a significant impact due to the following reasons:

1. There is currently no available system specifically developed for royalty payment that simultaneously considers the final state value and final shadow value.
2. The available research findings did not consider a specific economic model considering the demand to pay the royalty.
3. Existing researchers are facing difficulty when using the piecewise function in the royalty payment problem.
4. The mathematical method used is in the traditional mode where no new method development exists in solving real-world problems.
5. The standard rate for shadow value is always considered equal to zero.

4. CONCLUSION

The difficulty in using the royalty function that is in the piecewise function is overcome by utilizing the continuous approximation of the hyperbolic tangent (tanh) approach. This ensures that the functional objective function can be differentiated at all processes. This project can be a stepping-stone for researchers and academicians to explore new approaches to solving real-world problems. The most important is, this project addressed the importance of fundamental theory in solving the untangled issue. There are several contributions that can be highlighted from this research and system in terms of novelty, usefulness, and environmental friendliness.

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Novelty:
- Introduced the new approach, the hyperbolic tangent (tanh) approach.
- Introduced new modified shooting methods with 5 new algorithms.
- Proposed new system design for royalty payment problem.

Usefulness:
- Managed to solve a real economic problem, Spence (1981) model.
- Help the company to pay royalties in a proper way.
- Preventing corruption involving royalty payment.

Environmental Friendliness:
- Reducing the time taken to solve the royalty payment problem in terms of discrete form.
- Transfer and trade-related aspects of environmental safety.

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PENGHASILAN TEKNOLOGI *AUGMENTED REALITY* (AR) NetScan DALAM PENGAJARAN DAN PEMBELAJARAN (PdP) BAGI KURSUS DFC20143 INTRODUCTION TO NETWORK

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Abstrak

Aplikasi *NetScan* merupakan satu produk penghasilan inovasi berasaskan teknologi *Augmented Reality (AR)* dalam pengajaran dan pembelajaran (PdP) yang telah dibangunkan untuk kursus *Introduction to Network* yang menfokuskan kepada topik pengenalan kepada asas perkakasan rangkaian komputer. Pembangunan bahan digital ini telah dihasilkan di dalam versi bahasa Inggeris bagi memenuhi keperluan pengajaran dan pembelajaran di Politeknik. Dalam konteks pendidikan, penggunaan teknologi *AR* dilihat mampu menyokong pembelajaran aktif di dalam kelas di samping meningkatkan motivasi dan minat pelajar. Teknologi *AR* merupakan salah satu kaedah baharu yang diterapkan dalam dunia pendidikan di mana ianya memberi pengalaman interaktif dalam persekitaran dunia nyata. Selain itu, pembangunan bahan digital ini juga adalah seiring dengan perkembangan teknologi dalam pendidikan masa kini yang memerlukan teknik pengajaran lebih kreatif, inovatif dan interaktif. Ini disokong oleh kajian Muhammad Pozi & Khalid (2017) yang menunjukkan teknologi dapat meningkatkan motivasi, minat serta pengalaman dalam pengajaran dan pembelajaran. Salah satu teknologi dalam dunia pendidikan yang mendapat perhatian dan semakin diminati adalah seperti realiti berperantaraan (*AR*). Justeru, satu aplikasi digital berbentuk *AR* telah dibangunkan untuk kursus *Introduction to Network* bagi meningkatkan keberkesanan PdP dan sebagai menyokong aktiviti pembelajaran berpusatkan pelajar. Pemilihan kursus tersebut sebagai kandungan bahan digital adalah berdasarkan kepentingan dan keperluannya mengikut sukatan yang ditetapkan di mana ia dilengkapi dengan elemen multimedia dan disertakan penerangan berkaitan topik tersebut. Inovasi PdP ini telah diuji kepada pelajar yang mengikuti kursus tersebut dengan tujuan untuk melihat keberkesanan dan pendapat pelajar mengenai penghasilan produk AR ini. Hasil kajian menunjukkan sebahagian besar pelajar memberikan tindakbalas yang positif dan menyatakan penggunaan teknologi AR sangat membantu dalam meningkatkan kefahaman dan motivasi pelajar terhadap kursus yang diajar. Penghasilan bahan inovasi ini bukan sahaja memenuhi keperluan kurikulum bagi kursus tersebut malah ianya juga secara tidak langsung akan dapat memudahkan dan meningkatkan minat pelajar untuk pembelajaran yang lebih berkesan. Kesimpulannya, dapatan kajian ini memberi gambaran untuk cadangan akan datang bagi penghasilan teknologi AR diperluaskan bagi keseluruhan topik dalam kursus tersebut.

Kata Kunci: *Augmented Reality*, inovasi, interaktif, motivasi, *Introduction to Network*

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1. PENDAHULUAN

Perkembangan bidang teknologi yang menjadi lebih pesat adalah antara kesan daripada Revolusi Industri 4.0 yang dipacu oleh teknologi kecerdasan buatan, analitik data raya dan robotik telah menjadikan penguasaan kemahiran teknologi digital menjadi semakin penting ke arah transformasi Pendidikan (Jamen et al., 2021). Perkembangan inovasi dalam teknologi berevolusi dari semasa ke semasa telah membawa kepada penggunaan teknologi yang meluas dalam pelbagai sektor termasuk sektor pendidikan yang semakin berkembang pesat di seluruh dunia. Teknologi diperlukan dalam pendidikan kerana teknologi menggalakkan pembelajaran aktif yang bergantung kepada individu dan secara tidak langsung meningkatkan perkembangan intelektual (Romainor et al., 2022). Salah satu teknologi dalam dunia pendidikan yang mendapat perhatian dan semakin diminati adalah seperti realiti berperantaraan (AR) di mana ia merupakan satu trend teknologi yang paling kerap ditekankan yang mana membolehkan interaksi antara kandungan maya dan dunia realiti. Teknlogi AR mampu menghasilkan aplikasi yang inovatif dan kreatif dalam bidang pendidikan untuk menarik minat dan meningkatkan motivasi pelajar untuk aktif dalam pembelajaran.

Justeru, satu aplikasi berasaskan *AR* iaitu *NetScan* telah dibangunkan sebagai Alat Bahan Bantu Mengajar (ABBM) di mana ia boleh meningkatkan keberkesanan pengajaran dan pembelajaran selain daripada menarik minat pelajar mengikuti kursus yang diajar di samping dapat menyokong pembelajaran berpusatkan kepada pelajar (SCL). Aplikasi ini direka khusus untuk para pelajar yang mengambil kursus DFC20143-*Introduction To Network* di Jabatan Teknologi Maklumat dan Komunikasi (JTMK) Politeknik METrO Tasek Gelugor. Skop pembangunan modul aplikasi ini lebih menfokuskan kepada subtopik berkaitan asas perkakasan rangkaian komputer di mana pelajar boleh mengimbas peralatan yang terdapat di dalam makmal menggunakan teknologi AR untuk mendapatkan informasi sama ada dalam bentuk teks, audio ataupun video berkaitan peralatan tersebut.

TEKNOLOGI AR DALAM PENDIDIKAN

Banyak kajian menunjukkan bahawa AR menyediakan kelebihan dalam pendidikan dengan kandungan digital yang ditambahkan pada imej sebenar. Pelajar dapat memahami konsep pembelajaran dengan cepat melalui paparan format 3D yang terkandung dalam AR (Templeton, 2020). AR juga berpotensi untuk meningkatkan kemahiran penyelesaian masalah, kerjasama dan komunikasi selain pengetahuan dan pemahaman konsep (Mystakidis et al., 2022). Ini dapat disimpulkan bahawa, penggunaan AR dalam pendidikan menjadikan proses pengajaran dan pembelajaran (PdP) lebih interaktif, menarik dan menyeronokkan (Macariu et al., 2020; Templeton, 2020; Yusof et al., 2022). Kepelbagaian kaedah mengajar yang diterapkan di sesuatu institusi pendidikan akan mengubah corak penyampaian serta memberi impak terhadap prestasi atau perkembangan bukan hanya kepada para pelajar malahan turut mempengaruhi inovasi dan kreativiti penyampaian tenaga pengajar itu sendiri. Pengajaran dan pembelajaran tidak setakat dipraktikkan secara konvensional di mana tenaga pengajar memfokuskan aktiviti ini di bilik kuliah semata-mata malahan sepatutnya perlu selari dengan arus perkembangan fasiliti teknologi maklumat masa kini. Pernyataan masalah yang seterusnya pengkaji ingin melihat keberkesanan penggunaan Aplikasi *Augmented Reality NetScan* berdasarkan aktiviti pengajaran dan pembelajaran dari perspektif pelajar

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2. METODOLOGI KAJIAN

Kajian ini adalah berbentuk kajian data deskriptif dan mengambil kira pandangan serta maklumbalas daripada pelajar yang mengikuti kursus tersebut. Instrumen kajian yang digunakan adalah borang soal selidik yang dibangunkan menggunakan pautan *google docs*. Seramai 30 orang pelajar terlibat dalam kajian ini di mana pelajar diminta menjawab borang soal selidik berkaitan tahap keberkesanan penggunaan aplikasi AR NetScan dalam pembelajaran kursus DFC20143. Soal selidik terbahagi kepada dua bahagian iaitu profil demografi dan tahap keberkesanan penggunaan aplikasi *Augmented Reality (AR)* dalam kalangan pelajar.

3. DAPATAN KAJIAN DAN PERBINCANGAN

Kajian ini terdiri daripada 30 orang responden dalam kalangan pelajar. Dapatan kajian bagi faktor demografi dianalisis menggunakan kekerapan dan peratusan manakala soalan responden digunakan bagi menjawab objektif kajian yang dinyatakan dalam bentuk min.

Jadual 1: Taburan Responden Berdasarkan Jantina

JANTINA	KEKERAPAN	PERATUS
Lelaki	14	46.7
Perempuan	16	53.3

Berdasarkan jadual 1, bilangan responden dari kalangan pelajar perempuan adalah lebih ramai dari pelajar lelaki sebanyak 53.3% iaitu seramai 16 orang pelajar, manakala pelajar lelaki 46.7% iaitu 14 orang pelajar. Sebanyak 5 soalan telah diberikan kepada responden berkaitan keberkesanan penggunaan aplikasi *NetScan* terhadap pengguna iaitu dalam kalangan pelajar.

3.1 Analisis Pembolehubah Keberkesanan Aplikasi NetScan Kepada Pengguna

Bahagian ini mengandungi 5 item soalan yang berkaitan dengan aplikasi PMTG *NetScan* terhadap pengguna iaitu dalam kalangan pelajar . Analisis data dibuat dengan menggunakan nilai min. Hasil dapatan kajian adalah seperti ditunjukkan dalam Jadual 2.

Jadual 2: Analisis Min Bagi Pembolehubah Keberkesanan Aplikasi *NetScan* kepada Pengguna

BIL	ITEM SOALAN	KEKERAPAN PERATUSAN				SKOR MIN	TAFSIRAN
		STS	**TS**	**S**	**SS**		
1	Saya gembira dapat menggunakan Aplikasi NetScan ini sebagai panduan pengajaran dan pembelajaran.	-	-	-	100	4.00	Tinggi
2	Aplikasi NetScan meningkatkan interaksi dan penglibatan dalam sesi pembelajaran.	-	-	10	90	3.90	Tinggi
3	Pendekatan *Augmented Reality* (AR) yang digunakan dalam Aplikasi NetScan amat membosankan	90	6.7	3.3	-	1.13	Rendah
4	Aplikasi NetScan dapat dikongsi bersama rakan-rakan secara mudah.	-	-	20	80	3.80	Sederhana
5	Aplikasi NetScan membantu pemahaman anda terhadap topik yang dipelajari	-	-	3.3	96.7	3.97	Tinggi

Dapatan kajian menunjukkan analisis bagi pembolehubah keberkesanan aplikasi NetScan kepada pengguna di mana min skor bagi setiap item soalan 1, 2 & 5 berada dalam tahap yang tinggi iaitu 3.90 hingga 4.00 manakala

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min skor bagi item soalan 4 berada dalam tahap yang sederhana iaitu 3.80. Min skor terendah adalah soalan 3 dengan nilai 1.13 sahaja. Item yang mendapat min skor tertinggi adalah item soalan 1 iaitu pada nilai 4.00. Hasil kajian menunjukkan responden bersetuju untuk menggunakan aplikasi AR NetScan sebagai panduan bahan pengajaran. Ini menunjukkan bahawa pelajar-pelajar berminat menggunakan aplikasi ini sebagai alat bantu dalam pengajaran dan pembelajaran.

4. KESIMPULAN

Hasil dapatan daripada kajian ini dapat merumuskan signifikan aplikasi *Augmented Reality* dapat memberikan impak yang positif kepada pelajar-pelajar Politeknik METrO Tasek Gelugor. Impak positif ini jika dapat diterapkan di dalam suasana pembelajaran di institusi pengajian tinggi khususnya di politeknik, semestinya dapat meningkatkan prestasi seseorang pelajar dalam semua aspek yang ingin dicapai. Penghasilan bahan inovasi ini bukan sahaja memenuhi keperluan kurikulum bagi kursus tersebut malah ianya juga secara tidak langsung akan dapat memudahkan dan meningkatkan minat pelajar untuk pembelajaran yang lebih berkesan.

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S3PTIS: INOVASI HIJAU DALAM PENGURUSAN PERKHIDMATAN TEKNIKAL ICT SEKOLAH

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Abstrak

Sistem Pengurusan Pemusatan Perkhidmatan Teknikal ICT Sekolah (S3PTIS) bertujuan meningkatkan keberkesanan pengurusan laporan teknikal ICT sekolah di setiap daerah dengan cara yang mesra alam dan efisien. Dibangunkan menggunakan platform AppSheet, S3PTIS membolehkan pengguna mencipta, mengemaskini, dan memadam laporan melalui aplikasi berasaskan web yang selamat dan mudah digunakan. Notifikasi automatik dihantar kepada penyelaras pasukan, ketua unit, dan ketua penolong pengarah di setiap daerah melalui aplikasi dan e-mel. Penggunaan S3PTIS menunjukkan peningkatan dalam kecekapan pengurusan laporan teknikal ICT, mengurangkan penggunaan kertas, meminimumkan jejak karbon, serta memberi kesan kepada penjimatan dari segi masa dan kewangan. Sistem ini memudahkan akses kepada laporan dan direktori PTIS, mempercepatkan proses komunikasi dan tindakan susulan, sekaligus mengurangkan keperluan perjalanan fizikal dan kos operasi. Untuk masa depan, kami mencadangkan integrasi dengan sistem pengurusan sekolah lain, analitik data untuk pemantauan prestasi, dan kempen kesedaran untuk penggunaan aplikasi ini di semua sekolah. Usaha untuk menambah baik aplikasi dari segi keselamatan data dan mesra pengguna akan diteruskan bagi memastikan keberkesanan jangka panjang serta sokongan kepada inisiatif kelestarian alam sekitar. Dengan S3PTIS, kami beraspirasi menyokong pengurusan ICT yang lebih hijau, mampan, dan kos-efektif di setiap daerah, negeri dan seluruh negara amnya.

Kata Kunci: Pengurusan ICT; Mesra alam; Kecekapan; Penjimatan Kos; Kelestarian.

1. PENGENALAN

Dalam era digital yang semakin berkembang pesat, pengurusan perkhidmatan teknikal ICT di sekolah-sekolah memerlukan pendekatan yang lebih sistematik dan efisien. Latar belakang keperluan ini timbul daripada keperluan untuk meningkatkan keberkesanan pengurusan laporan teknikal, memastikan data yang diuruskan lebih selamat, dan mengurangkan penggunaan sumber yang tidak lestari seperti kertas. Di Pejabat Pendidikan Daerah Baling, penyelarasan pasukan teknikal ICT sering berhadapan dengan isu-isu berkaitan pengurusan laporan yang lambat, penyebaran maklumat yang tidak cekap, dan kos operasi yang tinggi. Hal ini membawa keperluan untuk satu sistem yang bukan sahaja mampu menangani masalah-masalah tersebut tetapi juga menyokong inisiatif kelestarian alam sekitar. Penggunaan kertas yang berlebihan dan kos perjalanan fizikal untuk penyelarasan dan pengesahan laporan adalah antara cabaran utama yang memerlukan penyelesaian yang inovatif dan mesra alam. Kajian oleh Smith (2020) dan Johnson (2019) menunjukkan bahawa sistem pengurusan digital dapat mengurangkan penggunaan kertas sehingga 70%, sekali gus meminimumkan jejak karbon dan kos operasi.

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S3PTIS (Sistem Pengurusan Pemusatan Perkhidmatan Teknikal ICT Sekolah) diperkenalkan sebagai satu solusi komprehensif yang direka untuk mengatasi isu-isu ini. Dibangunkan menggunakan platform AppSheet, S3PTIS merupakan sebuah aplikasi berasaskan web yang membolehkan pengguna mencipta, mengemaskini, dan memadam laporan teknikal ICT dengan mudah dan selamat. Sistem ini juga menyediakan notifikasi automatik melalui aplikasi dan e-mel kepada pihak berkepentingan di pelbagai peringkat, termasuk penyelaras pasukan, ketua unit, dan ketua pegawai pendidikan daerah di setiap daerah. Menurut kajian oleh Brown et al. (2021), penggunaan notifikasi automatik dapat meningkatkan kecekapan komunikasi dan tindakan susulan sebanyak 50%. Selain meningkatkan kecekapan pengurusan, S3PTIS juga membawa kepada penjimatan masa dan kos kewangan yang signifikan. Sistem ini meminimumkan keperluan untuk perjalanan fizikal dan penggunaan kertas, sekali gus menyokong inisiatif hijau dan mempromosikan amalan kelestarian. Dengan integrasi masa depan yang dirancang untuk analitik data dan kempen kesedaran, S3PTIS bukan sahaja meningkatkan pengurusan ICT tetapi juga menyumbang kepada matlamat negara yang lebih hijau dan mampan.

2. MATERIAL DAN KAEDAH

Dalam usaha membangunkan Sistem Pengurusan Pemusatan Perkhidmatan Teknikal ICT Sekolah (S3PTIS), beberapa material dan kaedah telah dikenal pasti untuk memastikan kejayaan pelaksanaannya.

2.1. Material

Antara material utama yang digunakan ialah platform *AppSheet*, yang dipilih kerana kebolehpercayaannya, keselamatannya, dan kemudahan penggunaannya. AppSheet digunakan untuk membangunkan aplikasi S3PTIS yang berasaskan web, memudahkan pengguna mencipta, mengemaskini, dan memadam laporan teknikal ICT dengan mudah dan selamat. Selain itu, peranti digital seperti komputer riba dan telefon pintar juga digunakan oleh pengguna untuk mengakses aplikasi ini. Sambungan internet yang stabil adalah kritikal bagi membolehkan pengguna mengakses dan menggunakan aplikasi ini secara dalam talian tanpa gangguan. Data pengguna, termasuk maklumat seperti e-mel rasmi, peranan, dan zon penugasan, dikumpulkan dan disimpan dalam sistem untuk memastikan kelancaran operasi aplikasi. Di samping itu, sistem notifikasi elektronik digunakan untuk menghantar pemberitahuan automatik melalui aplikasi dan e-mel kepada pihak berkepentingan seperti penyelaras pasukan, ketua unit, dan ketua penolong pengarah di setiap daerah.

2.2. Kaedah

Proses pembangunan aplikasi bermula dengan perancangan reka bentuk antaramuka pengguna dan pengalaman pengguna yang mesra pengguna. Setelah reka bentuk ditetapkan, pembangunan aplikasi dilakukan menggunakan *AppSheet*, diikuti dengan fasa pengujian untuk memastikan aplikasi berfungsi dengan lancar tanpa sebarang bug atau masalah teknikal. Modul notifikasi turut dibangunkan untuk menghantar pemberitahuan automatik kepada pengguna yang berkenaan apabila laporan baru dicipta atau dikemaskini.

Pengumpulan data melibatkan pendaftaran pengguna, di mana maklumat seperti e-mel rasmi, peranan, dan zon penugasan dikumpulkan semasa pendaftaran untuk membolehkan akses dan penggunaan aplikasi. Pengguna boleh mencipta laporan baru, mengemaskini laporan sedia ada, dan memadam laporan yang tidak diperlukan melalui aplikasi ini. Semua laporan dan maklumat pengguna disimpan dalam pangkalan data yang selamat untuk memastikan integriti dan keselamatan data. Pengguna boleh mengakses laporan dan maklumat yang relevan mengikut peranan dan zon penugasan masing-masing.

Notifikasi automatik dihantar melalui aplikasi dan e-mel kepada penyelaras pasukan, ketua unit, dan ketua penolong pengarah setiap kali laporan baru dicipta atau dikemaskini. Pengguna boleh melihat notifikasi yang diterima dalam aplikasi untuk memastikan mereka tidak terlepas sebarang maklumat penting.

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Untuk menilai keberkesanan S3PTIS, data penggunaan aplikasi dianalisis untuk menilai peningkatan kecekapan pengurusan laporan serta penjimatan masa dan kos. Maklum balas daripada pengguna dikumpulkan secara berkala untuk mengenal pasti sebarang isu dan cadangan penambahbaikan.

Dengan menggunakan material dan kaedah yang dinyatakan, S3PTIS dapat menyediakan satu platform yang efisien dan mesra alam untuk pengurusan perkhidmatan teknikal ICT di sekolah-sekolah, menyumbang kepada penjimatan masa, kos, dan usaha ke arah kelestarian alam sekitar.

3. KEPUTUSAN DAN PERBINCANGAN

3.1. Keputusan

Berdasarkan penggunaan Sistem Pengurusan Pemusatan Perkhidmatan Teknikal ICT Sekolah (S3PTIS), keputusan kajian melibatkan beberapa aspek utama seperti pada Jadual 1.

Jadual 1. Aspek utama Produk S3PTIS

Bil	Aspek	Penerangan
1	Penjenamaan Semula	S3PTIS merupakan penjenamaan semula sistem pelaporan aktiviti PTIS terdahulu yang telah ditingkatkan menjadi aplikasi dan berasaskan web.
2	Ciri-ciri Utama Aplikasi	Ciri-ciri utama penciptaan laporan baru, kemas kini laporan, pemadaman laporan, dan paparan laporan di pelbagai peringkat (Zon, Daerah).
3	Automasi dan Notifikasi	Sistem ini menyediakan automasi dalam mengisi borang laporan baru dan menghantar notifikasi kepada pihak-pihak berkaitan melalui aplikasi dan email setelah laporan baru direkodkan atau dikemaskini.
4	Kemudahan Akses dan Penggunaan	Akses kepada sistem ini diberikan melalui muat turun aplikasi *AppSheet* dan S3PTIS, serta *login* menggunakan email rasmi.
5	Keselamatan dan Kepenggunaan	Menekankan aspek keselamatan dan mesra pengguna dalam aplikasi ini.

Produk S3PTIS juga menunjukkan penjimatan dari segi masa dan kos kewangan. Merujuk kepada Rajah 1, mendapati bahawa penjimatan dari segi masa melibatkan pengurangan masa daripada 20 minit (mengambil kira masa dari mula proses membuka *laptop*/komputer sehingga laporan disiapkan) kepada hanya satu minit atau kurang dalam menyiapkan laporan. Manakala dari segi penjimatan dari segi kos kewangan, dengan jumlah 12,000 laporan telah direkodkan (selama setahun) menyamai 12,000 helaian kertas A4 utk cetakan, menyamai 24 *ream* kertas A4 berharga RM288. Hal ini dapat mengurangkan kos kertas sebanyak 32.4%. Dakwat printer berharga RM200 mencetak 4000 helaian.

Oleh itu, penjimatan bagi dakwat mesin pencetak pula didapati memperoleh penjimatan sebanyak RM600 yang melibatkan pengurangan 67.6%.

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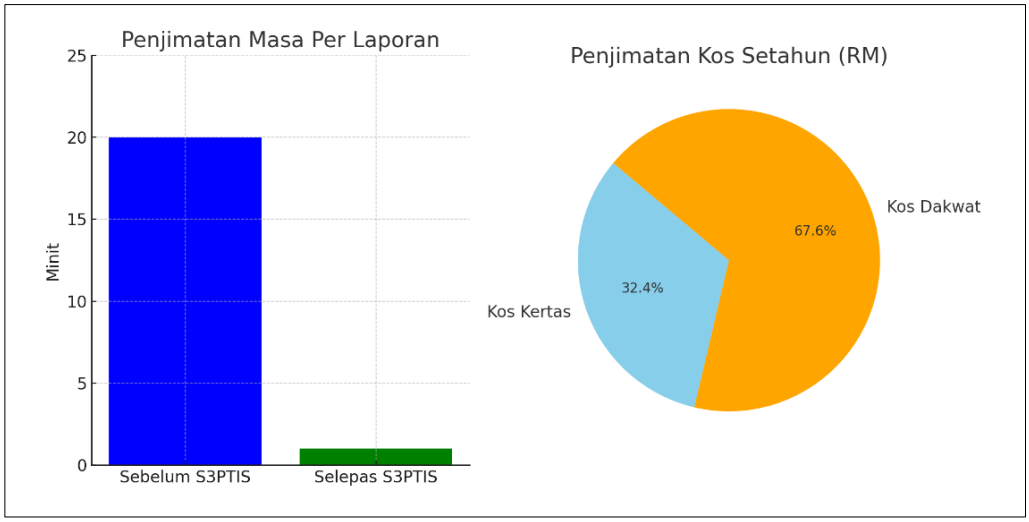

Rajah 1.

3.1. Perbincangan

S3PTIS, atau Sistem Pengurusan Pemusatan Perkhidmatan Teknikal ICT Sekolah, adalah sebuah aplikasi dan sistem web yang direka untuk memperbaiki efisiensi dalam pengurusan pelaporan aktiviti Perkhidmatan Teknikal ICT Sekolah (PTIS). Berdasarkan keputusan hasil penggunaan aplikasi ini, mendapati bahawa keunikan, kepentingannya dapat memberi impak kepada semua pihak termasuk individu, organisasi serta alam sekitar.

4. RUMUSAN

S3PTIS merupakan inovasi yang sangat penting dalam pengurusan perkhidmatan teknikal ICT di peringkat daerah khususnya dan seluruh Kedah amnya. Sistem ini tidak hanya meningkatkan keberkesanan operasi harian tetapi juga menawarkan penjimatan dari segi masa dan kewangan. Penggunaan teknologi seperti *AppSheet* mempercepatkan proses pengurusan data, sementara notifikasi dan komunikasi yang efisien memastikan semua pihak yang berkaitan sentiasa mendapat informasi terkini.

Dengan antaramuka yang mesra pengguna dan fitur yang komprehensif, S3PTIS berpotensi untuk diadaptasi oleh lebih banyak sekolah dan daerah, serta boleh menjadi model bagi sistem pengurusan perkhidmatan teknikal di sektor pendidikan lain. Inovasi ini membawa perubahan positif yang nyata dalam cara pengurusan teknikal dilaksanakan di sekolah-sekolah, menawarkan solusi yang berkesan dan moden untuk cabaran pengurusan PTIS, dan memberikan manfaat ekonomi serta ekologi melalui penjimatan masa dan sumber.

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SECTION 8

Mechanical Engineering

2024 OPEN INTERNATIONAL INNOVATION COMPETITION
Sustainable Urban Innovations for the Development of Well-being

e ISBN: 978-629-98755-4-3

SMART 3-WHEEL BIKE: TECHNICAL SUPPORT FOR DISABLED ENTREPRENEURS

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Abstract

Technology is a crucial aspect of starting a business, particularly for disabled entrepreneurs who may face additional challenges due to their disabilities. Entrepreneurship has become a preferred field of employment for disabled people, primarily due to a lack of other employment opportunities. However, the current technology available for disabled entrepreneurs is insufficient, and they may not be able to compete effectively in the business world. Compared to non-disabled individuals, disabled people have lower labor market participation rates, which limits their opportunities for employment. Running a business can be challenging for anyone, but disabled people often face additional obstacles that make it harder for them to succeed. Due to their disabilities, they may require specific technology or technical assistance to help them grow their business. The objective of this research is to developed Smart 3-Wheel Bike to provide better facilities to disabled entrepreneurs, making it easier for them to organize and operate their businesses competitively. The methodology employed is involving three phases: the analysis phase, the design and development phase, and finally the implementation and evaluation phase. In the analysis and evaluation phases, two case studies were conducted on the needs and acceptance of the prototype. The findings Performance expectancy, effort expectancy, social influence, facilitating condition and behavioral intention directly influence disabled entrepreneur usage behavior of Smart 3-Wheel Bike. Thus, from the two case studies indicated that the development of the Smart 3-Wheel Bike for disabled entrepreneurs was able to fulfil the disabled entrepreneurs' needs, and people with disabilities accept this technology in running their businesses.

Keywords: Disabled Entrepreneurs, Technology, Entrepreneurship

1. INTRODUCTION

Disabled individuals encounter significant obstacles in securing employment, largely attributed to a lack of employability skills. Statistics indicate lower labor market participation rates for disabled people, with only 0.31% employed in 2019. The concentration in lower-skilled occupations exacerbates their challenges, a situation worsened by the COVID-19 pandemic. Entrepreneurship emerges as a potential solution, offering disabled individuals greater control and financial independence. Malaysia's "National Entrepreneurship Policy" aligns with this approach, focusing on empowering disabled individuals economically and fostering inclusivity in the job market.

Supporting disabled entrepreneurs aligns with the United Nations' Sustainable Development Goals (SDGs), particularly SDG 8: Decent Work and Economic Growth, aiming for inclusive economic growth and employment. Additionally, promoting entrepreneurship contributes to SDG 10: Reduced Inequalities by narrowing the gap in employment opportunities and economic empowerment between disabled and non-disabled individuals.

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Recent studies highlight the challenges faced by disabled entrepreneurs, emphasizing their inclination toward social entrepreneurship. While facing difficulties in accessing resources, disabled entrepreneurs exhibit a propensity for innovation and risk-taking. Remote work and digital platforms also emerge as avenues for increased labor market participation among disabled individuals, promoting inclusivity. Overall, fostering an inclusive and accessible labor market is crucial for improving the employment prospects of disabled individuals.

1.1 Problem Statement

Disabled individuals often encounter additional barriers when starting or growing a business due to their disabilities, which can limit their access to resources and opportunities compared to non-disabled individuals. Research has shown that technology can be a crucial factor in enabling disabled entrepreneurs to succeed in the business world, by providing them with the necessary tools and assistance to overcome these barriers and compete effectively (Bahry et al., (2023); Sans-Bobi, M. A. et al. (2012), Rozell et.al. (2010), Norasmah (2002), and Rogoff et al. (2004)). Entrepreneurs with disabilities often face challenges in sustaining successful businesses but can benefit from technical assistance (Widoyoko et al, 2018). Assistive technology plays a crucial role in enabling people with disabilities to engage in entrepreneurship (Howard, 2017). Moreover, the use of assistive technologies has prompted technopreneurs to focus on improving services for people with disabilities in urban environments (Angelocci et al, 2008). Programs like TIPeD provide experiential learning opportunities for students to innovate in entrepreneurship and technology for individuals with disabilities, emphasizing the importance of assistive technology in driving innovation and awareness (Golsberg and Pearlman, 2012). By understanding the strategies employed by successful entrepreneurs with disabilities and providing necessary technical assistance, individuals with disabilities can overcome barriers, achieve economic independence, and contribute positively to society (Mohammadi et al, 2014). However, despite the potential benefits of technology, the current options available for disabled entrepreneurs are often insufficient. The Smart 3-Wheel Bike was developed specifically to address this gap, with the goal of providing disabled entrepreneurs with a tool that can help them to overcome the unique challenges they face and run their businesses in a more competitive and sustainable manner. By focusing on the specific needs of disabled entrepreneurs and leveraging technology to address these needs, the Smart 3-Wheel Bike has the potential to make a meaningful contribution to the broader goal of promoting inclusive entrepreneurship and sustainable economic development for all.

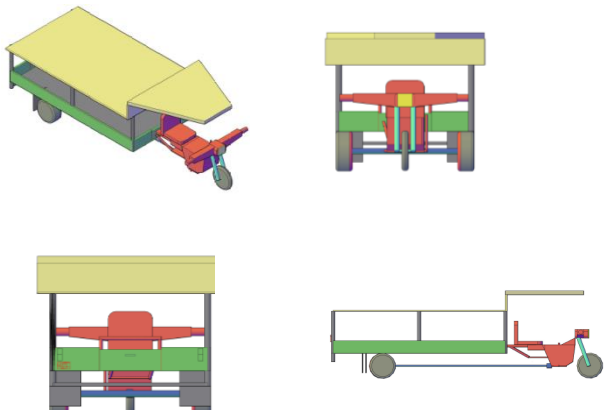
2. PRODUCT INNOVATION

2.1 Product Design

Smart 3-Wheel is designed using a modified motorcycle where it will be equipped with reverse gear transmission facilities, a large basket/place to place the sales items, roofed, and equipped safety features. As compared to the available supporting facilities for disabled people, Smart 3-Wheel Bike is more user-friendly.

2.2 Prototyping Process

Existing Facilities



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Prototype frame	Installing baskets on motorcycle	Install rear gear
Extend the gear to facilitate OKU	Install Roofed	Safety Feature

2.3 Product development

This product is a collaboration project between UMK and Deen Ironwork that is fully funded by UMK Prototype Research Grant (UMK-Pro). In December 2020, the process of analysis, design, and development has been started and already completed in January 2022 and received a patent from MyIpo.

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3. METHODS

The process of developing a Smart 3-Wheel Bike is based on three phases, the analysis phase, the design and development phase, and finally implementation and evaluation phase. In the analysis and evaluation phase, two case studies were conducted on the needs and acceptance of the prototype.

4. RESULTS AND DISCUSSIONS

4.1 Analysis Phase

In Analysis Phase the first Case Study was conducted. The purpose of this study is to examine entrepreneurs with disabilities' views on the need for technical support. The Unified Theory of Acceptance and Use of Technology (UTAUT) was used as a basic model for study. A survey method was utilized among 40 respondents in Tumpat Kelantan, Malaysia that categorize as disabled entrepreneurs to investigate their technology needed. The data obtained were analyzed using Statistical Packages for the Social Sciences (SPSS) software for descriptive statistics and regression analysis.

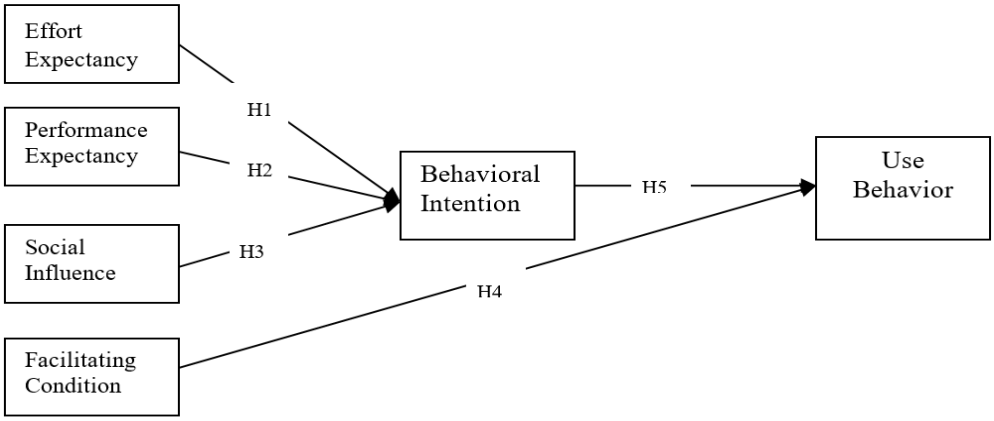

Figure 1: Research framework

Table 1: Results

Item	Coefficient	Significant
Performance expectancy	0.2561	0.0045
Effort expectancy	0.5671	0.0004
Social influence	0.1671	0.0023
Facilitating Condition	0.4671	0.0000

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Table 2: Hypothesis results

Hypothesis	Test
H1: Performance Expectancy is positively influenced behavioral intention to use Smart 3-Wheel Bike by the disabled entrepreneur.	Supported
H2: Effort Expectancy is positively influenced behavioral intention to use Smart 3-Wheel Bike by the disabled entrepreneur.	Supported
H3: Social influence is positively influenced behavioral intention to use Smart 3-Wheel Bike by the disabled entrepreneur.	Supported
H4: Facilitating condition is direct influences the use behavioral of Smart 3-Wheel Bike provided for the disabled entrepreneur.	Supported
H5: Behavioral intention directly influence disabled entrepreneur usage behavior of Smart 3-Wheel Bike.	Supported

The findings indicate the urgent need for development and supporting technology for disabled entrepreneurs. Therefore, the development of the Smart 3-Wheel Bike for disabled entrepreneurs was able to fulfill the disabled entrepreneurs' needs which had been proved based on the estimation analysis using the UTAUT model.

4.2 Implementation and Evaluation Phases

(ii) The second case study were conducted in Implementation and Evaluation Phases. The Smart 3-Wheel Bike was developed to provide better facilities to entrepreneurs with disabilities. The study will examine the factors of acceptance of technology in assisting entrepreneurs with disabilities (PWDs) through the development of the "Smart 3-Wheel Bike". Using Smart-PLS analysis and the sample size is 37 people of disability (PWDs) from Kelantan.

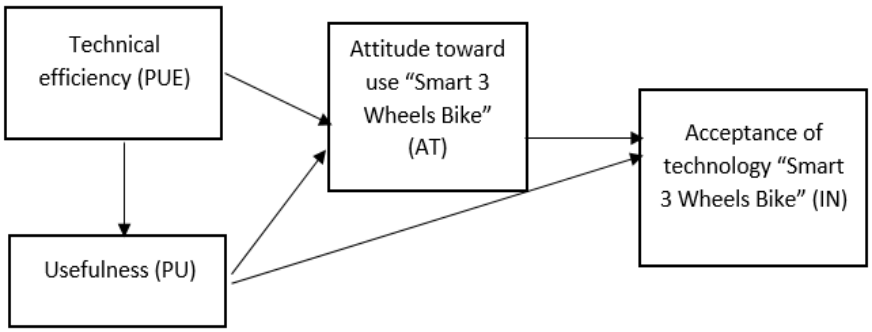

Figure 2: Research framework

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Table 3: Discriminant Validity (HTMT)

Item	AT	IN	PU	PUE
AT	0.896			
IN	0.716	0.852		
PU	0.611	0.587	0.861	
PUE	0.764	0.682	0.808	0.879

Note: AT is attitude; IN is Acceptances of technology; PU is usefulness; PUE is Technical efficiency.

Table 4: Hypothesis result

Hypothesis	Relationship	Std Beta	Std Error	t-values	p-values	f^2	VIF	Results
H1	IN → AT	0.587	0.113	5.173	0.000	1.054	1.000	Supported
H2	IN → PU	0.682	0.110	6.219	0.000	0.525	1.000	Supported
H3	IN → PUE	0.716	0.075	9.490	0.000	0.870	1.000	Supported

The results reveal that all variables such as technical efficiency, usability, and attitude to use technology influence the acceptance of the development of the "Smart 3 Wheels Bike “. Therefore, people with disabilities accept this technical assistant in running their businesses. In a conclusion, the need for technology in helping entrepreneurs with disability (PWDs) through the development of the "Smart 3-Wheel Bike" is very much needed.

5. IMPORTANCE OF PRODUCT

Smart 3-Wheel Bike will be able to facilitate disabled people in doing business and growing their business. In most cases, due to inappropriate technologies, people with disabilities have disadvantages to obtain independent individuality as well as necessary information for their business and overcoming barriers to organizing their business competitively. Thus, to strengthen the entrepreneurship of disabled people, is, therefore, essentially providing technical support to them.

5.1 Advantages

The development of the Smart 3-Wheel Bike offers several advantages for disabled individuals, significantly enhancing their mobility and independence. Firstly, the bike is designed to facilitate easy operation by disabled users, featuring a reverse gear transmission that simplifies maneuvering. Secondly, the vehicle boasts a larger storage space, providing ample room for personal belongings and other essentials. Additionally, the inclusion of a roof offers protection from various weather conditions, ensuring a more comfortable ride. The bike's design and size are optimized to be ideal for users, balancing functionality and aesthetics. Finally, it is equipped with essential safety features, which ensure the security and well-being of the rider. These attributes collectively make the Smart 3-Wheel Bike a practical and empowering solution for disabled entrepreneurs and individuals seeking greater autonomy in their daily transportation needs.

5.2 Marketability

Smart 3-wheel Bike design to fulfil the need of disabled people. Besides, this product is seen to be able to meet demand other than the disabled people, where it can be used in the small-scale agricultural sector (such as palm oil farmers, rubber, vegetables, and others), business (hawkers and petty traders) based on size, function, and as well as user-friendly.

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6. CONCLUSION

The Smart 3-Wheel Bike is the technical assistance and technology that is very much needed by disabled entrepreneurs to make their business easier and to remain competitive in their business activities.

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NOVEL CO-PYROLYTIC FUEL-BASED POLYPROPYLENE PLASTIC AS ALTERNATIVE POWER GENERATION USING THE MINI GAS TURBINE SYSTEM

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Abstract

The mini gas turbine is a combustion engine that has been adapted as a power generation system in an industrial power plant with the benefits of having a high power-to-weight ratio, portability for transportation, low capital and maintenance cost, small size, and rapid system initiations. This engine can utilise multiple types of fuels with fossil fuels being the dominant sources while alternative fuels are gaining attention for its usage. This project aims to provide a simple innovative process to produce novel co-pyrolytic (NCP) fuel-based polypropylene plastic (PP) as an alternative fuel for the gas turbine operation system. Waste PP food packaging was co-pyrolysed with the yellow grease oil (YGO) in an inert environment inside a stainless steel reaction at 450^{o}C for 150 min. About 75% of co-pyrolytic oil was successfully gained from this synthesise with further purification to become NCP. Based on the several physicochemical properties of NCP, 70.55% of this fuel are hydrocarbon compounds with the potential to become an alternative fuel for gas turbine systems, and further upgrading NCP improve the properties to fit the aviation turbine standards. This establishment will give an insight into a clean and long-term practical alternative fuel production for industrial usage.

Keywords: Alternative power generation; Co-pyrolytic fuel; Emission gases; Mini gas turbine; Polypropylene plastics.

1. INTRODUCTION

The world energy production is dominated by the use of petroleum fossil fuels (eg., coal, oil and gas) with 61% being used to generate electricity in 2022, and expected to increase as much as 48% in another 20 years due to the growing need of ever-expanding human population (EMBER, 2023; Moodley, 2021). Such projections continue to cause significant environmental problems associated with the emission of greenhouse gases (GHG) from fossil fuel combustion, with Carbon Dioxide (CO_2), Sulphur Dioxide (SO_2), Nitrous Oxide (N_2O) and Carbon Monoxide (CO) being the main gases generated. To overcome this situation while cooping the energy demand, a net zero carbon approach according to the Kyoto Protocol and Paris Agreement suggested the utilisation of biofuels especially in the heat and transportation sectors. Biofuels from waste materials have gained a lot of attention due to their abundance in large quantities, no competition with food-based feedstock and their ability to curb the environmental issues arising from the accumulation of this trash (Goh et al., 2020).

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Co-pyrolysis is one of the methods that can produce biofuel from waste feedstock in the form of char, synthetic liquid and syngas. It is a similar thermochemical method to the pyrolysis process but with the addition of a substance that increases the synthesis rate of reaction on two or more types of hydrocarbon-based materials as its feedstock. This method has the benefits of improving the fuel properties in terms of higher calorific value, is chemically stable, has low oxygen, sulphur and nitrogen content, and promotes the reduction of waste in the landfill (Abnisa & Wan Daud, 2014).

The waste feedstock for the co-pyrolysis process can be divided into three categories which are solid biomass (such as wood products), liquid biomass (such as waste cooking oil) and plastics (such as Polystyrene (PS) and PP). Suriapparao et al. (2020) stated that the best feedstock combination for the co-pyrolysis process is combining biomass with plastic as it will enhance the content of petrochemical compounds with low O/C and H/C ratios as well as reduce the formation of solid char as compared to biomass pyrolysis alone.

PP is one of the non-biodegradable synthetic polymer plastics with a composition of carbon and hydrogen atoms of 83.80% and 13.85% mostly being produced at high volume as household products but very little effort is taken to be recycled (Dwivedi et al., 2019). Yellow grease oil (YGO), is an end product of thick frying oil with a high concentration of fatty acids produced through once or several times of usage by food premises, food industries and households during the food preparation process. This oil will normally be disposed of and improper management of this process in the sewage system (as normally done by many residents and premises) can contaminate the water and further damage the environment (de Feo et al., 2020). Although both feedstocks pose a danger to the environment, it has the potential to be converted as usable synthetic hydrocarbon fuel.

The gas turbine engine is a versatile multi-fuel combustion system that is currently being used as an aircraft propulsive thruster engine and power generator to produce electricity. This combustion engine is favourable for operation due to its capability to generate huge amounts of power with low maintenance costs. The use of various types of fossil fuel according to the American Standard Testing and Materials (ASTM) D2880 specifications for gas turbine operation is very dominant. However, there is an effort to utilise alternative fuels and one of them is the pyrolysis oil. Because of the poor characteristics of this oil, the performance of the engine is reduced, and NO_X, CO, and UHC are formed more than the conventional fossil fuel (Buffi et al., 2018).

The work done by Lam et al. (2019) and Muhbat et al. (2021) has shown that co-pyrolytic oil has a composition almost similar to gasoline, kerosene and diesel fuel, with most of its properties on par with the fuel standard. Thus, this research proposed producing alternative fuel from co-pyrolytic oil liquid of PP and YGO in comparison with several gas turbine fuel specifications for potential sustainable urban power generation.

2. MATERIALS AND METHODS

PP from food packaging, drink cups and food containers and YGO was collected from the campus cafeteria and food stalls around the UTM Johor Bahru campus. Kaolin powder was utilised as the catalyst in this synthesis process, purchased from Sigma Aldrich (M) Sdn. Bhd. PP was cleaned using dish detergent to remove food waste and let it dry at room temperature for two hours. It was then shredded to 5mm x 30mm using cross-cut shredded before grinded to 3mm flakes using the high-speed grinder. As for the YGO, it was purified using the cloth filter to remove any food waste remaining and heated to a consistent 100^{o}C for one hour to remove any moisture. 150g of PP and YGO at 50:50 proportion was added inside a stainless steel reactor with 10 wt.% of catalyst. The reactor was sealed and clamped before being connected to the other conventional co-pyrolysis apparatus as shown in Figure 1. Nitrogen gas was let to flow inside the reactor at a constant flow rate to create an inert experimental condition. After that, the electric heater was left to heat until 450^{o}C for 150min, until no more vapour formed, condensed inside the condenser and collected into the flask.

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Figure 1. The conventional co-pyrolysis setup

After the co-pyrolysis process was completed and cooled down, the collected co-pyrolytic oil was purified using the atmospheric distillation method up to 270ºC, until no more vapour formed and condensed inside the collecting flask. This is shown in Figure 2. Next, the purified co-pyrolytic oil was taken for physicochemical properties analysis. Gas Chromatography Mass Spectrometry (GC-MS) was used to determine the composition of oil from each catalyst while the fuel's physical properties in terms of density at 15ºC, kinematics viscosity at 40ºC, calorific value and acid value were analysed using a pycnometer, Townson+Mercer Kinematics Viscometer, IKA C2000 Bomb Calorimeter and Titration apparatus, according to the ASTM D941, ASTM D445, ASTM D240 and ASTM D974.

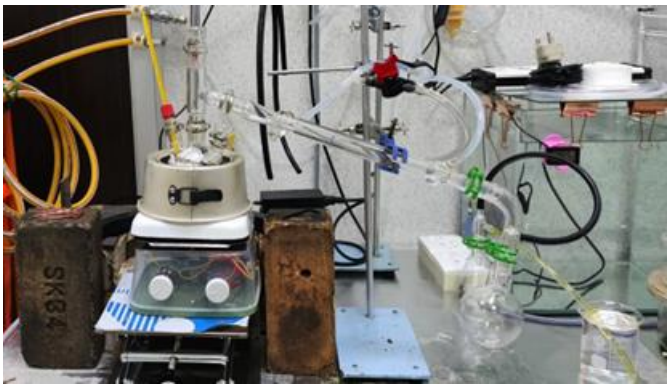

Figure 2. The atmospheric distillation setup

3. RESULTS AND DISCUSSION

The synthesis of YGO and PP generates three products of co-pyrolytic oil, syngas and coke while distilling the co-pyrolytic oil produces NCP. The percentage gain of these products is presented in Figure 3. The oil yielded 75% out of 150g PP and YGO mixture while syngas and char at 10.47% and 14.32%. As for the NCP, the percentage gained from the atmospheric distillation process is 43.2%, collected from the condensation of potential fuel compounds that are lighter than multiple heavier organic compounds inside the co-pyrolytic oil.

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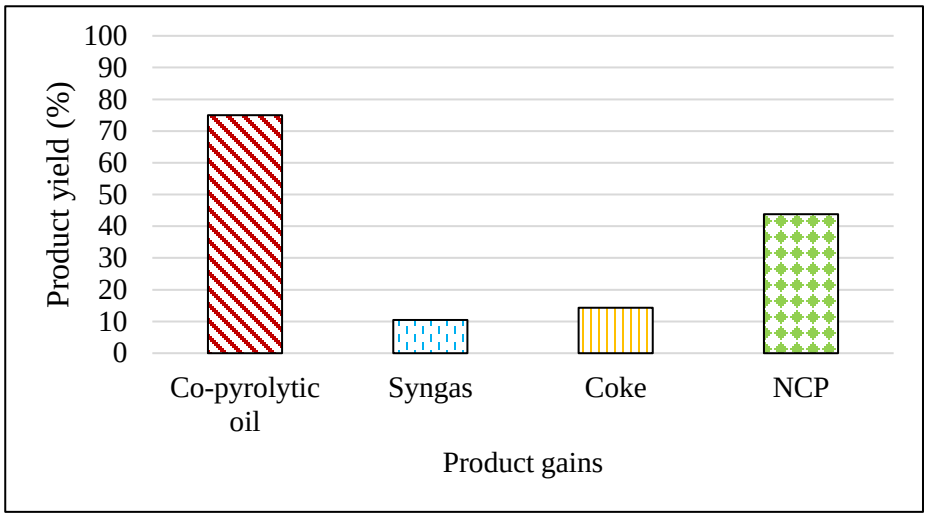

Figure 3. The percentage product yield from the co-pyrolysis process

The density, kinematics viscosity, calorific value and acid value of NCP are presented in Table 1, in comparison with No.0-GT land gas turbine fuel oil according to the ASTM D2880, JP-4 from Mil-T-5624-N and ASTM 7566. The No. 0-GT is a wide-cut distillate that contains naphtha, Jet B and other light properties hydrocarbon liquids. The closest counterpart for this fuel is JP-4, a hydrocarbon fuel with a mixture of kerosene and gasoline developed by the United States Air Force for aircraft military purposes (Dukek, 2000). The ASTM 7566 is a standard fuel specification for aviation turbines containing synthesised hydrocarbons from non-petroleum-based processes to produce synthetic paraffinic kerosene (SPK), a replacement for commercial kerosene jet fuel (Rumizen, 2021). By comparing the several fuel properties of NCP with these standards, the calorific value is very close to the typical value for No.0-GT and slightly higher than JP-4 and ASTM 7566. As for the density, it is lower than all the standards but only meets the No.0-GT requirement. The kinematics viscosity at 40ºC does meet the No.0-GT specification, while no values are mentioned for the other two standards. Lastly, the acid value of NCP is 15.01 mgKOH/g, which is higher than JP-4 and ASTM 7566. As for the No.0-GT, no specific value is set as the reference standard. Utilising fuel with high acidity can strongly corrode engine parts and fuel systems. Post-treatment can be done using esterification, hydrotreating and hydrocracking processes to reduce the acidity and further improve the fuel quality (Martins-Vieira et.al, 2023).

Table 1. The several fuel properties of NCP in comparison with three turbine fuel standards

Fuel Properties	NCP	No. 0-GT	JP-4	ASTM 7566
Density at 15ºC(g/cm^3)	0.73	<0.85	0.751-0.802	0.775-0.840
Kinematics viscosity at 40ºC (mm^2/s)	0.65	<1.3	-	-
Calorific value (MJ/kg)	43.73	44 (Typical)	≥42.8	≥42.8
Acid value (mgKOH/g)	15.01	-	≤0.015	≤0.010

The potential hydrocarbon groups and oxygenated compounds inside NCP from GC-MS analysis are presented in Figure 4 a) and b). In Figure 4 a), NCP shows to contains 70.55% of hydrocarbon, at which 1-Pentadecene ($C_{15}H_{30}$), (E)-2-Tetradecene ($C_{14}H_{28}$) and (E)-2-Dodecene ($C_{12}H_{24}$) are the dominant compounds. Another 29.45% is the organic oxygenated compounds, dominantly from n-decanoic acid ($C_{10}H_{20}O_2$) and n-hexadecanoic acid ($C_{16}H_{32}O_2$).

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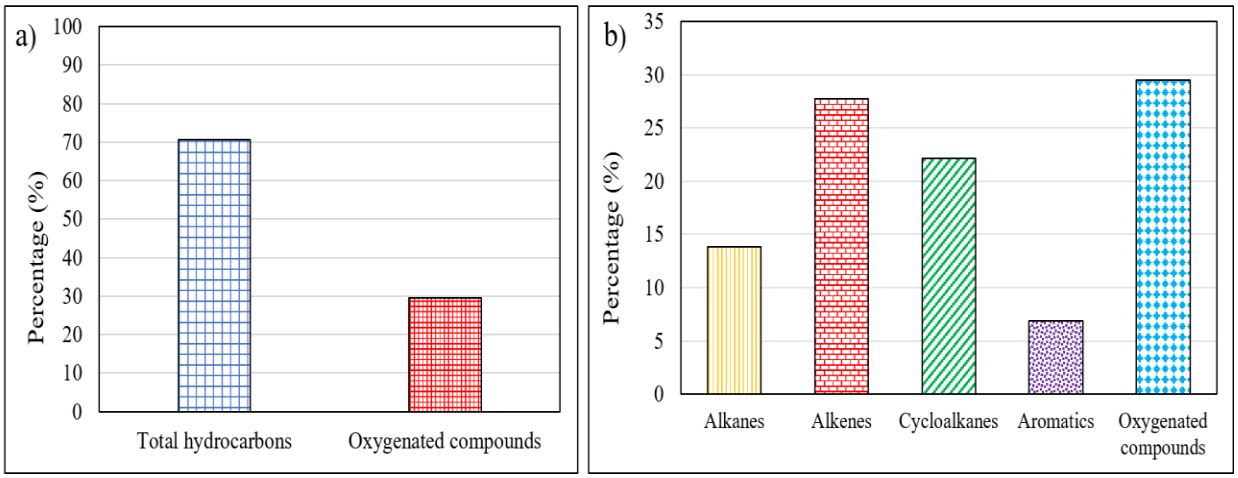
From this percentage, the co-pyrolysis synthesis reaction through cracking and deoxygenation together with the positive synergic effect between PP and YGO can produce a petrochemical-like compound fuel with a high H/C and low O/C ratios (Suriapparao et.al, 2020). As shown in Figure 4 b), the composition of hydrocarbon compounds can be divided into four categories which are alkanes (13.83%), alkenes (27.71%), cycloalkanes (22.14%) and aromatics (6.87%). Alkanes and cycloalkanes are the preferrable synthetic hydrocarbon compounds in transportation fuel especially in aircraft for clean combustion as well as having high mass-to-heat content. Alkene on the other hand require proper oxygen supply to achieve the same output. As for aromatics, it can cause the formation of soot during combustion if the value is too high (Dukek, 2000). In the context of power generation turbines, these hydrocarbon categories are not the main issue due to the flexibility of the gas turbine itself which can utilise multiple types of fuel (including gaseous fuel) but seek the ability to provide maximum energy output per operational cost (Dukek, 2000). By referring to the high calorific value of NCP and fuel compositions (containing a low percentage of aromatics), it has great potential to be utilised as an alternative fuel for power generation.



(a) (b)

Figure 4. The percentage of hydrocarbon and oxygenated compounds. (a) in NCP and (b) Different hydrocarbon categories and oxygenated compounds

4. CONCLUSION

The growing need for energy demand together with the concern about GHG impact on the environment has urged the development of biofuel that is sustainable and eco-friendly. Co-pyrolysis is one of the methods to produce biofuel from solid and liquid biomass and plastics have been given attention, giving the beneficial attention of reducing waste to the environment. YGO and PP are among the waste that can be utilised to synthesise into co-pyrolytic oil for industrial purposes. NCP as the alternative fuel for gas turbine power generation systems has been developed through this process and purified for enhanced appearance and properties. The physicochemical properties of NCP are then analysed according to the established standards. The density, kinematics viscosity, calorific value and acid value show to fit as an alternative fuel for No.0-GT, while further upgrading and treatment of NCP has the potential to improve the properties of the fuel to fit the aviation turbine standards. As for the fuel composition, NCP majorly contains hydrocarbon compounds with different percentages of alkanes, alkene, cycloalkanes and aromatics. As the gas turbine system has wide fuel flexibility, NCP with such hydrocarbon proportions has a high potential to be utilised as an alternative fuel for sustainable power generation in the future.

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2024 OPEN INTERNATIONAL INNOVATION COMPETITION
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POFA-PET INCORPORATED CONCRETE (WPIC) FOR SHIELDING GAMMA RAY

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Abstract

Gamma-ray shielding research is critical in industries ranging from medical radiography to nuclear power, where high-energy gamma radiation poses serious health concerns and practical obstacles. Traditional insulation materials such as lead are effective but often have disadvantages. Recent research has concentrated on producing novel materials that provide excellent gamma ray attenuation and have increased sustainability and economic benefits. This study looks into combining Palm Oil Fuel Ash (POFA) and Polyethylene Terephthalate (PET) waste into concrete mixtures to create a new, environmentally friendly gamma ray shielding material. By including these industrial and post-consumer waste items, the project hopes to improve the shielding qualities of concrete while also addressing environmental waste disposal challenges, providing a dual advantage of radiation protection and trash management. This study aimed to evaluate the feasibility of adding POFA-PET to concrete mixtures. The concrete mixer with POFA-PET integration was expected to outperform traditional concrete in strength, density, and radiation attenuation efficiency. The findings of this research could be applied to the development of low-cost radiation shielding materials because PET polymer and palm oil fuel ash (POFA) are abundant in many developing nations.

Keywords: POFA; PET; Concrete; Shielding; Gamma-Ray

1. INTRODUCTION

Radiation shielding is essential in many industries, including medical, industrial, and nuclear applications, to protect persons and the environment from damaging ionising radiation (Knoll, 2010). Gamma rays, ionising radiation with a high penetration rate, pose significant health dangers due to their ability to permeate live tissue and induce cellular damage (Attix, 2004). To reduce the intensity of these rays and ensure safety in gamma radiation-contaminated situations, effective shielding materials must absorb or attenuate them. Traditional shielding materials such as lead and concrete are widely utilised but have drawbacks, including environmental problems and structural constraints (Lambert, 2006). As a result, developing novel materials that provide improved shielding capabilities while resolving these constraints is critical.

Concrete has traditionally been the chosen material for radiation shielding due to its availability, cost-effectiveness, and high mass density (Neville, 2011). However, the search for more efficient shielding methods has led to the investigation of modified concrete compositions using a variety of industrial by-products and waste materials (Siddique, 2011). One such invention is using Palm Oil Fuel Ash (POFA) and Polyethylene Terephthalate (PET) in concrete. Incorporating POFA and PET into concrete creates a composite material that increases gamma ray attenuation and promotes sustainability by recovering industrial waste (Alsubari, 2016).

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2. MATERIALS AND METHODS

This study uses ordinary Portland cement (OPC), fine and coarse aggregates, and POFA-PET as a concrete addition. The study aims to assess the effectiveness of gamma-ray shielding by embedding POFA and PET into concrete and analysing its density and water absorption. New concrete would be subjected to the slump test, while cured concrete would be evaluated for density, water absorption, and gamma-ray shielding performance.

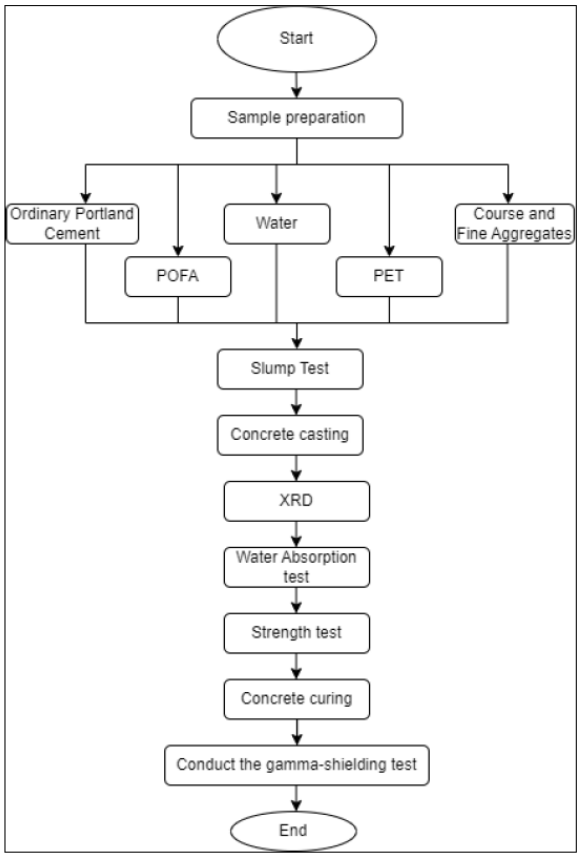

Figure 1. Workflow chart for this research investigation

3. RESULTS AND DISCUSSION

Different percentages of PET and weight of PET were utilized in this study to compare the results achieved after 28 days. All 30 concrete cubes have already been testified using the slump test method. Gamma-ray shielding, water absorption, and Density tests were performed on 20 samples, respectively. The physical properties of POFA-PET incorporated concrete are anticipated to show notable improvements in density, homogeneity, and compatibility with existing concrete matrices. Including PET flakes is expected to reduce the overall weight of the concrete, while POFA should enhance the binding properties, leading to a uniform distribution of materials. These changes will likely contribute to better workability and ease of mixing, making POFA-PET concrete a viable option for construction applications.

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The effectiveness of POFA-PET concrete in gamma-ray shielding is expected to be comparable or superior to traditional concrete mixes. Through radiation shielding calculations, it is predicted that the linear attenuation coefficients and transmission ratios of POFA-PET concrete will demonstrate significant gamma-ray absorption, potentially outperforming standard concrete. This is due to the high density and effective distribution of POFA and PET within the concrete matrix, which enhances the material's ability to attenuate gamma radiation.

Adding POFA and PET to concrete is expected to affect its durability and mechanical strength positively. The research anticipates that POFA, a pozzolanic material, will improve long-term strength and durability by enhancing the concrete's resistance to chemical attacks and reducing permeability. PET flakes are expected to provide added toughness and flexibility, potentially reducing the occurrence of cracks and improving impact resistance.

4. CONCLUSION

Overall, POFA-PET concrete should maintain sufficient radiation shielding while exhibiting enhanced mechanical properties, making it a robust and durable material for construction applications.

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SECTION 9

Sciences

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TI:DE

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Abstract

TI:DE is a newly generated product used to absorb oil on the sea's surfaces, which is harmful to the marine environment. It is made fully from eco-friendly products, which are banana peels and coconut husks. This material can be obtained in the natural environment. As the name of our product implies, it is made by focusing on reducing oil pollution in the ocean. Oil pollution refers to the introduction of petroleum-based substances into the environment, primarily the marine and coastal ecosystems, resulting in adverse effects on the natural habitat, wildlife, and human activities. This type of pollution encompasses a wide range of oil products, including crude oil, refined petroleum products (such as gasoline, diesel, and lubricants), and by-products. As a result, conventional oil spill treatment methods are costly. We solve the problem by developing a low-cost, ecologically friendly product. Our product contains banana peels and coconut husks. Banana peels can absorb oil efficiently due to their unique structure and chemical composition. **Banana peels can absorb oil more efficiently**. These fruit peels have microporous structures and heterogeneous, rough surfaces with crater-like pores that have the ability to absorb oil. Banana peels also contain cellulose, hemicellulose, and lignin. These fibrous materials have good adsorption properties, allowing them to bind and hold onto oil molecules. Coconut husks also help absorb oil. The surface of coconut husk fibers contains various functional groups, such as hydroxyl and carboxyl groups, which can interact with oil molecules through hydrogen bonding and van der Waals forces, enhancing their oil adsorption capacity. Hence, this innovation could be worth creating—a changing innovation that leads to a healthy environment and an eco-friendly environment.

Keywords: Oil, Absorb, Eco-friendly

1. INTRODUCTION

Nowadays, cases of oil pollution are increasing. Statistics show that Malaysia has faced 130 oil spill cases from 2014 until 2022, as reported by the Department of Environment (DOE). On average, 10–11 oil spill cases happen each year. Numerous negative consequences for the economy, human health, and environment can result from oil pollution.

Thus, we created an innovation of oil absorbent ball which is more effective and eco-friendlier to the environment and free from those harmful chemicals using the banana skin. In order to make sure that this product works well, we did 3 methodologies including 2 experiments after a long study and discussion. We divided the procedures into two. For procedure one, firstly, we made a preparation of providing the necessary materials. To make the extract, we dried the skin and form the dried skin in powder. Secondly, we did an experiment to test effectiveness of this innovation extraction towards oil in the ocean. The next experiment we did is an experiment to get the best. We made few samples banana skin with different ratio of size and the weight. The objective is to test what ratio is best and effective towards oil before we form it into sphere sharp. Both experiments showed

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a good and positive results. The reason why we made it round and light so that it floats easily on the surface of the water. In layman's term, this can be made easily and is believed to help reducing oil pollution.

All methodologies have been done with proper procedures and guided by teachers. By commercialising this product, the use of can be reduce. At last, the produce of this product is beneficial in improving human health and save the environment. (Rashid, M., Samad, S.A., Gafur, M.A. and Chowdhury, A.M.S., 2015)

2. MATERIALS AND METHODS

2.1 METHODOLOGY

Procedure 1

1. Gather all the needed materials, including banana peels and coconut husks, which are the main materials for this product.
2. Experiment to test the effectiveness of banana peel and coconut husk absorbance toward oil. The experiment showed a good result, which proved that this product works very well as aabsorption agent.
3. Several experiments are conducted to get the best results. A few samples of banana peels and coconut husks with different quantities of these materials. This experiment was conducted to identify the quantity of banana peel and coconut husks that should be used for more effective oil absorption before the product will be formed.
4. Partical Application;

- To use banana peels for oil absorption, they are typically dried and ground into a powder.
- This powder can then be spread over the oil spill, where it will adsorb the oil.
- After sufficient time for adsorption, the oil-saturated banana peel powder can be collected and disposed of or treated appropriately.

3. RESULTS AND DISCUSSION

3.1. Description on our respondent

Figure 1 shows the selection of absorbent agents. Based on the survey form that has been conducted in the study area. There are three types of absorbent agents selected, namely coconut husk, banana peels and peat moss.

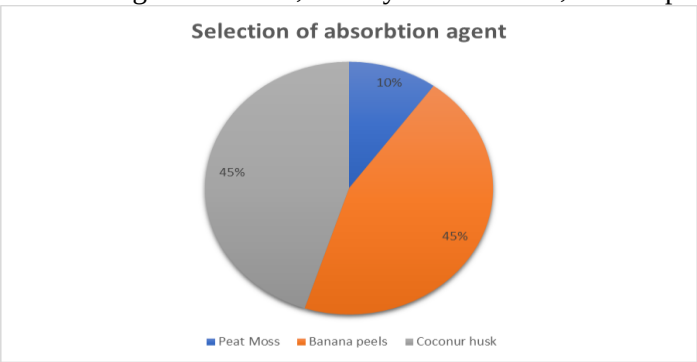

Figure 1: Selection of absorbtion agent

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3.2. Description on our respondent

Table 1. Descriptive on Background of Respondent

RESPONDENT	GENDER	CHOICE
1	MALE	Banana peels
2	FEMALE	Peat moss
3	FEMALE	Banana peels
4	MALE	Coconut husk
5	FEMALE	Coconut husk
6	MALE	Banana peels
7	MALE	Peat moss
8	MALE	Banana peels
9	FEMALE	Coconut husk
10	MALE	Banana peels
11	FEMALE	Coconut husk

3.3 Discussion

The results of this survey show that most respondents choose banana peels and coconut coir as natural materials that can be absorbent agents. This TI:DE works as a material that can absorb liquids such as oil. Liquids such as oil in the sea will be naturally absorbed by this absorbent material. Once the liquid has been absorbed it will decompose along with the banana peel or coconut husk. Its main purpose is to help in cleaning the river area that has been polluted by the waste of the factory which is oil.

4. CONCLUSION

The data obtained show a preference for absorbent items that can absorb over absorbent items that are not natural materials. The surveyed areas show significant demand for oil waste solutions, with an emphasis on practicality and efficiency. Although absorbent materials appear to be the preferred choice, there are instances where non-natural absorbent materials are a special need or aesthetic consideration. Some study areas face challenges in dealing with this pollution problem as a result of several factors.

These findings emphasize the importance of tailoring solutions to pollutants to meet needs. The implications of activities in disposing of liquid waste that cause pollution can be effectively overcome and encourage the community in efforts to keep the river clean.

In conclusion, this study highlights the importance of absorbent materials used in effectively addressing the needs of liquid waste management. Recommendations include widespread use of absorbent items in various commercial settings, accompanied by awareness campaigns to encourage responsible waste disposal habits.

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MEDMATHEMATICA: A COMPUTER-AIDED CANCER SEGMENTATION SYSTEM

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Abstract

Cancer is an abnormal tissue growth that can metastasize, forming new tumors in different parts of the body. Early cancer detection is crucial for improving patient outcomes and survival rates. However, accurately identifying and segmenting cancer in medical images is challenging due to low contrast, subtle indicative features, and varying intensity levels within the same image. This study aims to enhance cancer detection, diagnosis, and treatment through the development of MedMathematica. This system utilizes a novel mathematical variational level set model to selectively segment various cancer abnormalities in both color and grayscale medical images. The system has been tested on 30 color and 30 grayscale images with different types of cancer and achieved an average Dice accuracy of 93.32% with a processing time of 0.9483 seconds. The findings demonstrate that MedMathematica significantly improves the detection and segmentation of cancerous tissues, leading to better patient outcomes and overall improvements in healthcare quality and efficiency. Future research will focus on extending the system to evaluate cancer segmentation accuracy and efficiency in three-dimensional color and grayscale images. This study highlights the potential of advanced mathematical models in enhancing cancer detection and treatment, contributing to the broader goal of improving healthcare outcomes and efficiency.

Keywords: Cancer Detection; Image Segmentation; Mathematical Modeling; Medical Images; Variational Model

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1. INTRODUCTION

According to the International Agency for Research on Cancer (IARC), cancer remains a leading cause of mortality worldwide, with 19,976,499 new cases and 9,743,832 deaths reported globally in 2022. In Malaysia alone, 51,650 new cases and 31,633 deaths were recorded that same year (Bray et al., 2024). Early detection is crucial for improving patient outcomes and survival rates, as it allows for timely and effective intervention. Neglecting early detection can lead to fatal consequences. One of the methods to help radiologists in detecting cancer is image segmentation. Image segmentation is the process of separating abnormal tissue (region of interest) from healthy tissue (background) in an image. The best segmentation approach is manual segmentation. However, it is time-consuming and subject to inter-rater variability due to differences in interpretation and judgment among evaluators (Azam et al., 2023). Therefore, developing efficient automatic or semi-automatic computer-aided cancer segmentation systems with high accuracy and fast processing times is imperative for cancer detection.

Accurately detecting and segmenting cancerous tissues in medical images poses significant challenges. Cancer images often exhibit intensity inhomogeneity and low contrast, making it difficult to distinguish between cancerous and healthy tissues (Azam et al., 2023). These difficulties can lead the radiologist to spend more time detecting cancer cells. Various computer-aided detection (CAD) systems have been explored to improve cancer detection and segmentation (Ramaekers et al., 2024; Malek et al., 2020; Yasiran et al., 2020). While CAD-based deep learning models have shown promise, they have practical limitations, such as substantial data requirements, storage needs, extended running times, and the necessity for diversified datasets to train on various cancer types, which makes them inflexible (Azman et al., 2024). Additionally, many existing CAD will convert color cancer images into grayscale before the segmentation process, resulting in a loss of data dimensionality and reducing segmentation accuracy (Azam et al., 2023). According to Embong et al. (2017), the analysis of color cancer images yields a more comprehensive portrayal of image elements, featuring nearly 10% more edge information compared to grayscale counterparts.

This study aims to develop a robust CAD system capable of accurately and efficiently segmenting various types of cancerous tissues in two-dimensional color and grayscale cancer images. To achieve this objective, we introduced MedMathematica, which employed a novel mathematical variational level set model known as Selective Local Image Fitting (SLIF) model to selectively segment various cancer abnormalities in both grayscale and color medical images. The selective approach was chosen because it offers precise, localized segmentation and greater control over the process, making it well-suited for handling the variability and complexity of medical images compared to other segmentation methods (Azman et al., 2024). The subsequent portions of this work are organized as follows: Section 2 outlines the material and methodology employed in this study, whilst Section 3 showcases the experimental results and subsequent discussion. Section 4 concludes and offers recommendations.

2. MATERIALS AND METHODS

MedMathematica is tested on 60 medical images (30 color and 30 grayscale) with different types of cancer abnormalities obtained from various image databases: 10 grayscale breast cancer mammogram images (Moreira et al., 2012), 10 grayscale breast cancer ultrasound images (Rodtook et al., 2018), 15 color melanoma skin cancer dermoscopic images (Buda et al., 2019), 10 grayscale brain meningioma magnetic resonance images (MRI) (Cheng, 2017) and 15 color brain Low Grade Glioma (LGG) MRI (Codella et al., 2018). Their benchmarks which contained the segmented regions and have been validated by experts were obtained from the same database. These benchmarks were used to compare with the segmentation output from our CAD system to measure the segmentation accuracy of the system. Furthermore, the selection of all datasets is due to their convenient accessibility and immediate availability.

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All 30 images were resized to 128×128 pixels to enhance computational efficiency. The implementation is carried out using MATLAB R2021a software. The central processing unit (CPU) processor used was an AMD Ryzen 7 7735HS with Radeon Graphics, operating at a frequency of 3.20 GHz and accompanied by 16 GB of installed memory (RAM)

2.1. Segmentation using Selective Local Image Fitting (SLIF) Model

MedMathematica utilized a novel mathematical variational level set model known as the Selective Local Image Fitting (SLIF) model, to selectively segment the cancer abnormalities in color and grayscale images. This SLIF model was introduced by the first and second authors of this paper and the journal related to the SLIF model has been published (Azam et al., 2023). The SLIF model incorporates the concept of the local image fitting energy from the Local Image Fitting (LIF) model, proposed by Zhang et al. (2010), and the distance fitting term from the Distance Selective Segmentation 2 (DSS2) model, proposed by Ghani and Jumaat (2022), into a variational energy functional. In addition, the SLIF model used the gradient descent method and a Gaussian function to solve the minimization energy functional and regularize the level set function, which makes the SLIF model efficient. Figure 1 shows the Graphical User Interface (GUI) of our MedMathematica for segmenting brain abnormalities in color brain LGG MRI images.

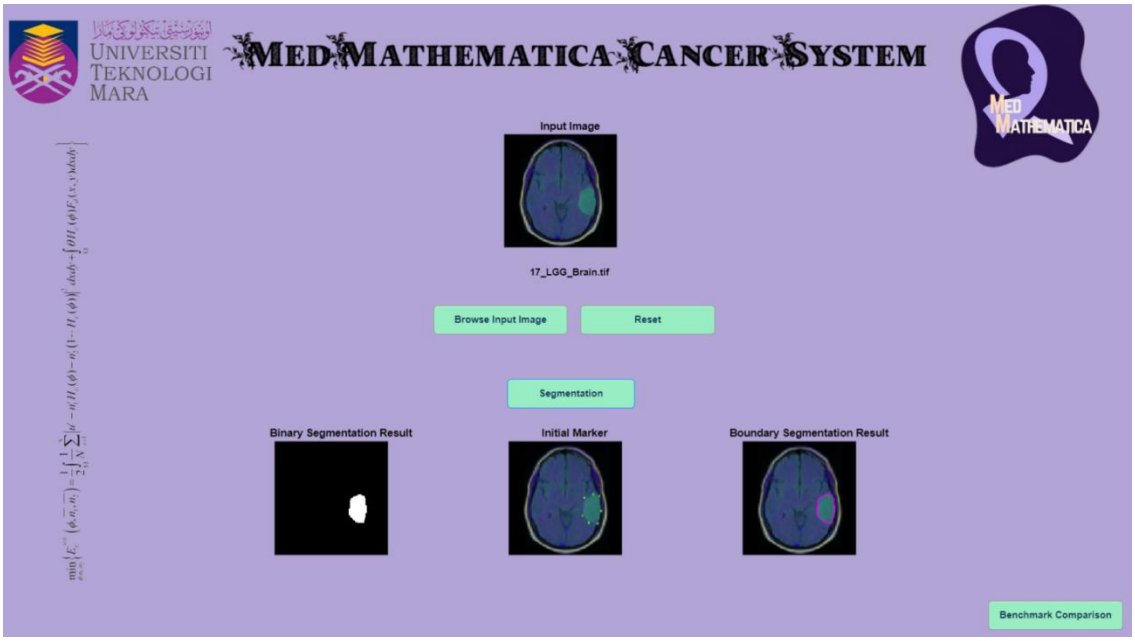

Figure 1. Segmentation Results for Color Cancer Images using MedMathematica

Based on Figure 1, the user first needs to click the 'Browse Input Image' button to select an input image. After clicking the 'Segmentation' button, the user should place a set of initial markers around and close to the cancer region's boundary by left-clicking the mouse. This step is necessary for the initialization process, as the SLIF model is a selective type of level set model. Once this is completed, the user should right-click to create a mask, where the initial markers will connect to form an initial polygon mask. After the initialization process, the initial contour will evolve until it segments the region of interest. The output, including the binary image and boundary of the segmentation results, will be displayed as shown in Figure 1. For comparison purposes, the user needs to click the 'Benchmark Comparison' button to compare MedMathematica's output with a benchmark image validated by an expert. Figure 2 illustrates the Graphical User Interface (GUI) of MedMathematica during this comparison with the expert-validated benchmark image.

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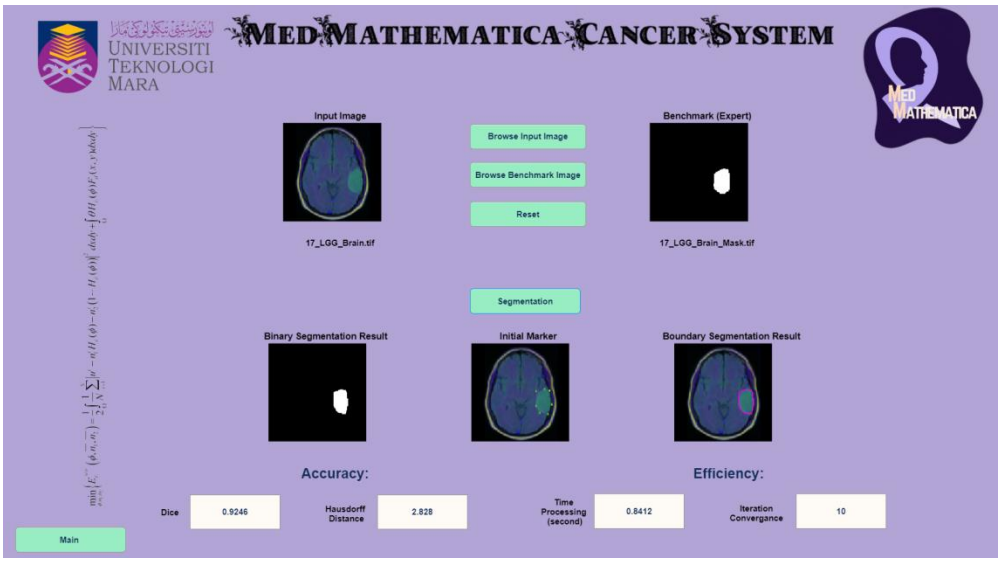


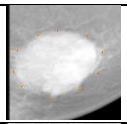
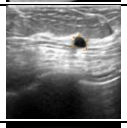
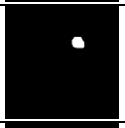
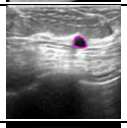
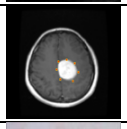
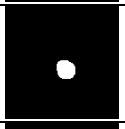
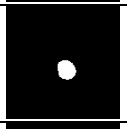
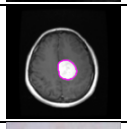
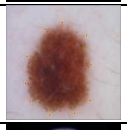
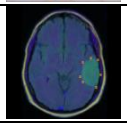
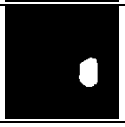
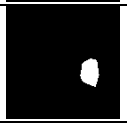
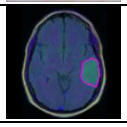
Figure 2. Comparison with the Expert-Validated Benchmark Image using MedMathematica

As shown in Figure 3, the MedMathematica will also display the numerical results of the accuracy (Dice similarity coefficient and Hausdorff distance) and efficiency (time processing and iteration). Further details about the mathematical formulation and the algorithm implementation of the SLIF model can be found in the paper of Azam et al. (2023).

3. RESULTS AND DISCUSSION

This section discusses the overall segmentation outcomes for our MedMathematica in segmenting cancer in medical images. Table 1 shows five examples of segmentation results when using MedMathematica.

Table 1. Segmentation Results of Five Cancer Images using MedMathematica

Type of Cancer Images	Medical Image with Initial Markers	Benchmark (Validated by Expert)	Binary Segmentation Result	Boundary Segmentation Result
Grayscale Breast Cancer Mammogram				
Grayscale Breast Cancer Ultrasound				
Grayscale Brain Meningioma MRI				
Color Melanoma Skin Cancer Dermoscopic				
Color Brain LGG MRI				

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As illustrated in Table 1, the binary and boundary segmentation results generated by MedMathematica are shown in columns four and five, respectively. By visual inspection, MedMathematica appears to segment all types of abnormalities well in both color and grayscale medical images, despite the presence of intensity inhomogeneity. The SLIF formulation utilizes local averages within a Gaussian window to estimate the average inner and outer intensities of the contour, effectively handling variations in intensity across the images (Azam et al., 2023). In addition to visual observation, the average segmentation accuracy and efficiency of the MedMathematica were provided as well as shown in Table 2.

Table 2. Average Accuracy and Efficiency Segmentation Results

Average Dice Similarity Coefficient	Average Hausdorff Distance	Average Time Processing	Average Number of Iterations
0.9332	**3.0810**	**0.9483**	**22**

Based on Table 2, we may conclude that our MedMathematica demonstrates high performance in segmenting cancer images.

4. CONCLUSION

The MedMathematica system, using the Selective Local Image Fitting (SLIF) model, effectively addresses cancer segmentation challenges with high Dice accuracy (93.32%) and fast processing (0.9483 seconds). It demonstrates that MedMathematica can manage intensity inhomogeneity and segment various types of cancer abnormalities. However, issues with manual initialization may affect accuracy. This work's novelty lies in applying the SLIF model for precise segmentation in color and grayscale images, setting a benchmark for future models. Practically, it enhances cancer detection and diagnosis, improving healthcare outcomes. Future efforts should focus on extending the system to three-dimensional imaging and refining automatic initialization.

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SECTION 10

Social Sciences

2024 OPEN INTERNATIONAL INNOVATION COMPETITION
Sustainable Urban Innovations for the Development of Well-being

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WORKPLACE MENTAL HEALTH INNITIATIVE

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Abstract

Fostering an environment at universities is crucial, for creating an academic setting. This piece presents methods to support the well-being of university staff and faculty. The Higher Education Mental Health App offers a range of features tailored to settings including a hub, online counselling sessions and educational modules. It also incorporates mood check ins, personalized content and interactive elements to boost engagement. Through the Mental Health Mentorship Program staff members can receive guidance from mentors through meetings and specialized training along with tools for tracking progress. The Mental Health Awareness and Education Platform provides workshops on stress management. Achieving work life balance along with opportunities for learning and community engagement, through forums. Anonymous mental health evaluations are conducted via surveys that generate reports, data analyses and personalized support feedback. The Peer Support Network creates a community where peer mentors lead interaction and support sessions following training and evaluation to ensure effectiveness. By adopting these strategies universities can foster an atmosphere that enhances productivity while reducing stress levels and prioritizing the well-being of faculty members and staff.

Keywords: Mental Health; Mentoring Program; Awareness Platform, Stress Management

1. INTRODUCTION

Fostering a supportive environment at universities is essential for creating a thriving academic setting. The Workplace Mental Health Initiative is designed to support the well-being of university staff and faculty through various innovative methods. This initiative includes the development and implementation of the Higher Education Mental Health App, the Mental Health Mentorship Program, the Mental Health Awareness and Education Platform, and the Peer Support Network. By integrating these components, the initiative aims to reduce stress levels, enhance productivity, and prioritize the mental health of faculty and staff.

1.1. Problem Statement

University staff and faculty face significant mental health challenges due to the demands of their roles, including high workloads, the pressure to balance professional and personal lives, and the competitive nature of academia. Despite the availability of mental health resources, there is often a lack of cohesive, easily accessible support tailored to their specific needs. The absence of such support can lead to increased stress, burnout, and decreased productivity (Smith et al., 2018; Johnson et al., 2019).

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1.2. Objectives

The project has five main objectives: (1) Develop and implement the Higher Education Mental Health App to provide accessible online counseling, mood check-ins, educational modules, and personalized content. (2) Establish the Mental Health Mentorship Program to offer guidance, specialized training, and progress tracking tools for staff members. (3) Create the Mental Health Awareness and Education Platform to conduct workshops on stress management and provide opportunities for learning and community engagement. (4) Conduct anonymous mental health evaluations through surveys to generate reports, analyze data, and provide personalized support feedback. (5) Launch the Peer Support Network to build a community where peer mentors lead interaction and support sessions, ensuring continuous evaluation and effectiveness.

2. MATERIALS AND METHODS

2.1. Methodology

The methodology includes four key steps. First, a needs assessment will be conducted through surveys and focus groups with university staff and faculty to identify key stressors and mental health needs (Brown & Lee, 2018). Existing mental health resources will be analyzed to identify gaps in support. Second, the development phase will involve designing and developing the Higher Education Mental Health App with features such as mood check-ins, online counseling, and educational modules. The structure for the Mental Health Mentorship Program, including training materials and progress tracking tools, will also be created. The Mental Health Awareness and Education Platform will be developed with workshops and forums for stress management and community engagement, and anonymous mental health evaluations will be designed using validated survey tools. Third, the implementation phase will pilot the Higher Education Mental Health App with a selected group of staff and faculty to gather feedback and make necessary adjustments, launch the Mental Health Mentorship Program, Awareness and Education Platform, and Peer Support Network, and conduct mental health evaluations to tailor support interventions. Finally, the evaluation phase will collect and analyze data from app usage, mentorship feedback, workshop attendance, and peer support sessions, conduct follow-up surveys to assess the impact on stress levels, productivity, and overall well-being (Nguyen et al., 2020), and adjust and improve the programs based on feedback and data analysis.

2.2. Materials / Prototypes

The initiative includes the development of several prototypes: (1) Higher Education Mental Health App: A user-friendly interface with mood check-ins, online counseling sessions, and educational modules. Personalized content recommendations based on user interactions and feedback. (2) Mental Health Mentorship Program: Training modules for mentors and progress tracking tools to monitor mentee development. (3) Mental Health Awareness and Education Platform: Interactive workshops on stress management and forums for community engagement and knowledge sharing. (4) Anonymous Mental Health Evaluations: Online survey tools that ensure anonymity and automated report generation for personalized feedback. (5) Peer Support Network: An online community platform for peer mentor interactions and scheduling tools for support sessions.

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2.3. Benefits

The initiative aims to achieve several benefits. Enhanced well-being will result from improved mental health support, leading to reduced stress levels and better work-life balance for staff and faculty (Miller & Smith, 2019). Increased productivity will be achieved by creating a supportive environment that boosts engagement and productivity among university employees (Jones et al., 2019). Community building will be fostered through the Peer Support Network and community forums, creating a sense of belonging and mutual support. Data-driven insights will be gained from anonymous evaluations and data analyses, providing valuable insights into the mental health needs of staff and faculty and allowing for tailored interventions. A sustainable support system will be created by integrating various support mechanisms into a cohesive system, ensuring continuous mental health support for university staff and faculty.

3. EXPECTED RESULTS

The implementation of these strategies has led to significant improvements in the mental health and well-being of university staff and faculty. Initial pilot results were expected to increased engagement with the Higher Education Mental Health App, with 75% of users reporting regular usage of mood check-ins and online counseling sessions. Participants in the Mental Health Mentorship Program have expected to provide positive feedback, with 80% of mentees reporting improved guidance and support. There also expected to have high attendance and satisfaction rates for stress management workshops that will be conducted through the Mental Health Awareness and Education Platform. Insightful data from anonymous mental health evaluations will led to personalized support interventions that have been well-received by staff and faculty. Strong community connections could be formed through the Peer Support Network, with active participation in support sessions and forums.

4. CONCLUSION

In conclusion, the Workplace Mental Health Initiative has the potential to significantly improve the mental health and well-being of university staff and faculty, fostering a supportive and productive academic environment. By prioritizing mental health, universities can create a more harmonious and effective workplace, ultimately benefiting the entire academic community.

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THINKTANK: ENHANCING PRACTICAL-BASED LEARNING

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Abstract

Integrating technology into education has determined how educators enhance their teaching and learning experiences. **ThinkTank** is a platform to serve better practical-based learning environments in which it reflects students' practical experiences, ensuring comprehensive feedback for educators. 39 final year degree students at a Public University in Sarawak completed one of the projects from their Environmental Management in Developing Countries course. ThinkTank is utilized to value students' feedback on how effective their previous activity was in facilitating their learning process through hands-on activities. In this 3R Project (Reduce, Reuse, Recycle), students reviewed this project as an engaging activity that connects environmental issues and students' experiences in real life settings. This innovation can be considered to be expanded to other educational levels or professional training programs.

Keywords: Formative feedback; practical-based learning; ThinkTank; students'.

1. INTRODUCTION

Communication needs to be fast and facilitated between students and educators. The integration of technology helps to enhance students' engagement and practical skill development. As technology evolves each day, there is an increasing demand for tools to facilitate practical-based learning, connecting students with theoretical knowledge and real-world application.

In response to this demand, ThinkTank was developed to provide formative feedback, helping educators in creating better practical-based learning environments. Goldin et. al. (2017) stated that formative learning is well-known as a key factor in influencing learning. This way of learning demands students reflects their understanding of a particular subject through written communication, and this is seen to simultaneously help improve learners' learning in academic settings (Mahmud, N. F. F., Mahmud, N., & Sahari, S. H., 2023).

The necessity of understanding teaching effectiveness through student feedback to improve educational outcomes is crucial for curriculum development and the overall student experience in learning and professional skills (Sharp, D. L., Karadzhov, D. D., & Paterson, D. H., 2022). However, traditional feedback methods often failed to engage students meaningfully, resulting in assessments being perceived as barriers in achieving final grades rather than opportunities for educational learning growth (Wolstencroft, P., & de Main, L., 2021).

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ThinkTank addresses these challenges by providing a platform that emphasizes formative feedback and practical experiences or in other words, words from students help improve educators' teaching delivery. This tool aims to transition from static to generative feedback processes, fostering deeper understanding and engagement among students (Laici, C., & Pentucci, M., 2023).

The implementation of ThinkTank in a project i.e., 3R Project (Reduce, Reuse and Recycle) for final-year Environmental Management students at one of the public universities in Sarawak demonstrated its potential to connect theoretical knowledge with real-world applications effectively. Here, the students were given a task to produce products by using recycled items and demonstrate them in the class. Despite the positive outcomes, the applicability of ThinkTank can be broadened and explored across different educational levels and professional training programs.

The two main objectives of developing ThinkTank are:

i. To evaluate the effectiveness of ThinkTank platform in enhancing practical-based learning and student engagement within the context of Environmental Management course.
ii. To summarize students' feedback based on the practical based learning within the context of Environmental Management course.

2. MATERIALS AND METHODS

2.1. Participants

The respondents of this project were 39-degree students from the Faculty of Administrative Science and Policy Studies at UiTM Sarawak. They were in Semester 6, taking an Environmental Management in Developing Countries course.

2.1. Tasks

Students participated in practical-based learning activities in which they had to innovate their 3R projects based on the topic given. They had to showcase their project in class and then provide feedback via the ThinkTank template distributed through Google Form. In this template, short and long-answer questions were designed to integrate a reflective learning experience.

2.3 Survey

The questions in ThinkTank were reflective and subjective in nature. These allowed students to give their feedback regarding their project. The ThinkTank consisted of ten questions formulated by the lecturer based on a discussion with other lecturers' teachings of the subject. The data were treated qualitatively to get a comprehensive summarization of the specific feedback given by the students. The ten questions were written in Table 1 as below:

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Table 1: List of questions formulated for the students.

No.	Questions	Explanation on the questions
1	What is your email address?	This field collects the respondent's email address for follow-up or further contact, if necessary. It ensures that the responses can be attributed to specific participants and enables communication regarding their feedback.
2	What was the name of your innovation?	This question identifies the specific innovation being evaluated. Knowing the name allows for a clear association between the feedback and the project or initiative.
3	Save a picture of your innovation here:	This section allows participants to upload a visual representation of their innovation. A picture can provide a clearer understanding of the project and its environmental impact.
4	How effective do you believe the initiative has been in promoting awareness about environmental issues among participants?	This question measures the success of the initiative in raising awareness about environmental issues. It gauges how well participants feel the project has educated them or others about environmental challenges and solutions.
5	To what extent do you think the initiative has influenced participants to adopt more sustainable practices in their daily lives or work routines?	This question assesses the practical impact of the initiative on participants' behaviour. It looks at whether the project has encouraged participants to implement more sustainable practices in their everyday activities or work.
6	How well do you feel the initiative integrated eco-friendly measures, such as reduced waste, energy efficiency, or conservation efforts?	This question evaluates how well the initiative incorporated environmental practices. It considers aspects like waste reduction, energy efficiency, and conservation efforts, reflecting the project's commitment to eco-friendly measures.
7	To what extent did the initiative align with broader environmental goals, such as reducing carbon footprint or promoting biodiversity?	This question looks at the bigger picture, determining how well the initiative aligns with global or national environmental goals. It checks if the project contributes to reducing carbon emissions, promoting biodiversity, or other significant environmental objectives
8	How satisfied are you with the eco-friendly practices introduced or emphasized through the initiative, considering factors like convenience and overall impact?	This question measures participant satisfaction with the eco-friendly practices promoted by the initiative. It considers the convenience and effectiveness of these practices, providing insight into their practical implementation.
9	Share your future goal in sustaining the environment via the 3R (Reduce, Reuse, Recycle) project.	This open-ended question invites participants to discuss their future goals related to the 3R principles. It encourages them to reflect on how they plan to continue supporting environmental sustainability through reducing, reusing, and recycling.
10	Share your expression in learning this syllable via the 3R project.	This question encourages participants to share their individual experiences and reflections on what they learned through the 3R project. It captures their sentiments and the impact of the learning experience on their attitudes and behaviors.

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Each of the questions serves to collect comprehensive feedback on various aspects of the environmental initiative, from effectiveness and impact to participant satisfaction and future goals. The insights gathered can help in assessing the initiative's success, identifying areas for improvement, and planning future projects.

3. RESULTS AND DISCUSSION

The results of the survey were analyzed qualitatively, and they indicated that almost all 39 respondents found the 3R project to be a useful tool for raising awareness about environmental issues. The data collected showed in the Table 1, a significant increase in the students' awareness and their involvement with environmental sustainability.

Table 2: Average Rating for the Effectiveness of ThinkTank Platform in Enhancing Practical-based Learning and Student Engagement within the Context of Environmental Management Course.

Category	Average Rating
Effectiveness in Promoting Environmental Awareness	4.49
Perceived Impact on Sustainable Practices	4.44
Integration of Eco-friendly Measures	4.41
Alignment with Environmental Goals	4.31
Participant Satisfaction with Eco-friendly Practices	4.46

All in all, results have significantly shown an increase in students' awareness and involvement with environmental sustainability topics. Results in Questions 4–8 from the survey were critical in helping the students understand their projects' contributions to sustaining the environment. This formative feedback process allowed students to reflect on their learning and understand the importance of these issues in a real-world context. Thus, it helps the educators improve their way of teaching, particularly in practical-based learning classes.

Table 3: Findings on Students' Feedback based on the Practical-based Learning within the Context of Environmental Management Course.

No	Key Themes	Goals
1	Promotion and Normalization of 3R Practices	A significant number of responses emphasize the importance of integrating 3R practices into daily routines and making them a standard aspect of behavior, particularly within educational settings like campuses. This includes making the 3R project mandatory or a habitual practice for students and the broader community.
2	Education and Awareness	Many respondents highlight the need to increase awareness and educate communities about the importance of 3R and environmental sustainability. This is seen as crucial for empowering individuals to adopt eco-friendly habits and for ensuring that future generations are better in taking care of the environment.

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3	Sustainable Materials and Products	Several responses mention the goal of promoting the use of sustainable materials and reducing the reliance on non-recyclable or non-degradable products. There is also a focus on creating and encouraging the use of eco-friendly products and alternatives that minimize environmental impact.
4	Community Engagement and Policy Implementation	There is a strong emphasis on engaging with communities and establishing policies that support environmental sustainability. Respondents aim to implement eco-friendly campus policies and foster a culture of responsible consumption and waste management through community involvement.
5	Waste Reduction and Recycling Efforts	Respondents express a commitment to reducing waste, particularly plastics, and enhancing recycling efforts. This includes specific initiatives such as reusing items, recycling tissue boxes, and creating products like the "Smart Go Table Desk" from recycled materials.
6	Long-term Environmental Impact	The overarching goal across the responses is to contribute to a healthier environment by reducing the ecological footprint, promoting sustainability, and ensuring that these efforts lead to long-term positive outcomes for the planet.

The expressions of students learning through the 3R project highlight a mixture of excitement, creativity, and a growing sense of responsibility towards environmental sustainability. Many students found the project engaging and inspiring, especially because it provided hands-on experience in reducing waste and promoting eco-friendly practices. The process of creating products from recyclable materials not only enhanced their understanding of sustainability but also fostered a sense of accomplishment and innovation. Students also appreciated the practical aspect of the project, which allowed them to see the immediate impact of their actions on the environment. Overall, the 3R project has been a positive and enlightening experience for students, encouraging them to integrate these principles into their daily lives and future endeavors.

Results in the Table 3 above reflected a strong collective intent to advance the 3R project by embedding sustainable practices into everyday life, educating and empowering communities, and driving significant reductions in waste through innovative and collaborative approaches. All this feedback from the students is crucial in aiding educators' way of delivering lectures in future lessons as it integrates students' experiences while making it more effective in a practical-based learning class. The formative feedback process is instrumental in enhancing their learning experience and engagement, especially in their project-based learning. Overall, the ThinkTank platform demonstrated positive outcomes in enabling students to continuously reflect on and improve their learning experiences.

4. CONCLUSION

In conclusion, students agreed that the 3R projects done in their Environmental Management in Developing Countries course are essential for introducing environmental issues and enhancing their knowledge through practical projects. ThinkTank is an effective mechanism to be used by the educators to improve their teaching delivery in the following lecture session, particularly after they receive feedback from the students. With this platform, educators will be able to empower students to become active participants in the pursuit of a cleaner and greener planet, ultimately ensuring the sustainability of 3R initiatives and broader environmental efforts. ThinkTank is also a great tool for emphasizing students' practical experiences. This way of learning acknowledges the effort made by the teacher, especially in improving their way of teaching delivery, thereby enhancing educational outcomes, especially for practical-based learning courses. Through ThinkTank, educators are able to create an environment that supports continuous learning and improvement.

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DEVELOPING A COMPREHENSIVE FRAMEWORK FOR ASSESSING THE IMPACT OF POPULATION AGING ON THE ENVIRONMENT IN MALAYSIA

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Abstract

This study presents a framework that utilizes the Material Balance Model to analyze the influence of population aging on the environment in Malaysia. A review of past studies has established a conceptual framework that expands the Material Balance Model to include population aging in both the consumption and production sides. The results emphasize the impact of demographic shifts on environmental processes through economic activities. The residues generated from economic activities involving the elderly were found to either improve or worsen ecological degradation. Policymakers should be advised to assess the impact of population aging on the environment, taking into account both the benefits and drawbacks by developing sustainable plans that address the demands of the aging population by comprehending the impact of an aging population on consumption patterns and resource utilization. This work adds to the discussion on demographic changes and environmental sustainability, offering a foundation for further investigation and developing policies in this field.

Keywords: Population aging; environment; demographic shifts; material balance model.

1. INTRODUCTION

Environmental degradation has become an everlasting issue on a global scale, affecting nations universally from the hazards associated with it. Human activities play a significant role, particularly the combustion of fossil fuels, deforestation, and industrial emissions, in contributing to higher greenhouse gases (GHG) (Romero-Muñoz et al., 2021). Developing countries are responsible for global carbon dioxide (CO_2) emissions due to the rapid development and industrialization processes taking place toward becoming developed nations. Rapid urbanization and industrialization in Malaysia pose challenges in managing and reducing CO_2 emissions. According to the World Resource Institute's CAIT Climate Data Explorer, Malaysia is one of the developing countries experiencing a steady increase in GHG emissions and ranked 20th as emitter globally in 2022. In 2021, Malaysia ranked 24th globally for CO_2 emissions from fossil fuel combustion, and its CO2 emissions per capita income was 31st globally. This indicates that Malaysia relies more on carbon-intensive consumption and production.

Demographic shifts play a vital role in determining factors of environmental degradation. One of the factors of higher GHG is population growth, which leads to higher demand for resources and energy consumption (Dong et al., 2018). As the population increases, several significant environmental consequences become apparent and affect the environment. However, nowadays, most countries are experiencing a decline in fertility rate while the increase in life expectancy contributes to the aged society.

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Based on the United Nations projections, Malaysia will become an aging nation by 2030, with 15 percent of its population comprising those aged 60 and above (The United Nations, 2023). Numerous studies have highlighted the impact of population aging on environmental degradation based on the changes in consumption patterns. For example, Kim et al. (2020) discovered that CO_2 decreases as the population ages because the elderly tend to travel less and participate less in daily activities. On the contrary, Yu et al. (2020) identified that the elderly spend more time at home, the residential consumption will increase, and the electricity usage will rise. Due to the inconclusive impact of population aging on the environment, it is worthwhile to explore this issue more to guide the government and policymakers in formulating an effective strategy to face these issues in the future. Therefore, the Material Balance Model is a valuable model to be utilized in forming a comprehensive framework regarding population aging and environmental degradation. This study will propose a modified Material Balance Model framework for population aging, which will be beneficial for policymakers in deciding appropriate measures for society and the nation.

2. LITERATURE REVIEW

Another prevalent model that explains the explicit relationship between economic activity and the natural environment is the Materials Balance Model, advocated by Kneese, Ayres, and D'Arge (1970). This approach was an innovative contribution developed based on the fundamental principle known as the Material Balance Principle (MBP). The MBP was developed based on the first law of thermodynamics on the notion that matter can neither be created nor destroyed. The extended version of the material balance model presented the circular flow model inside a wider schematic to demonstrate the linkages between economic decision-making and the natural environment (Callan and Thomas, 2013).

Due to many countries have experienced significant demographic shifts, with populations moving towards aging population while the fertility level started to decline. These changes have significantly altered the age structure, making population aging an important consideration in policy discussions. In the context of Malaysia, the aging population in Malaysia significantly impacts the dependence ratio of those aged 65 and above (Nor & Ghazali, 2021). By using percentage of the elderly population in relation to the total population in Malaysia as the measure of the elderly population, the study identified that an elevated dependence ratio might reduce total energy demand and an increased proportion of non-renewable energy sources due to income inequality. Older individuals, who have less understanding of the environment, have a greater preference for non-renewable energy sources over renewable energy sources. Consequently, this preference increases carbon emissions (Lu et al., 2021). This is corroborated by Yuan et al. (2024), who found that older individuals had a greater propensity to use energy-intensive goods and services that result in increased carbon emissions, mostly due to their extended periods of time spent at home. Therefore, the effects of population aging in Malaysia are uncertain, highlighting the need for further research.

On the other hand, Liu and Zhang (2022) discovered a positive correlation between the age dependence ratio, economic growth, and the demand for both renewable and non-renewable energy. A larger reliance ratio might result in reduced total energy demand and an increased proportion of non-renewable energy sources, mostly owing to income inequality. The demand for non-renewable energy among older individuals is greater than that for renewable energy due to their limited understanding of clean energy. The aging population in Malaysia will increase the elderly dependence ratio, resulting in a higher demand for non-renewable energy. This, in turn, would have a negative influence on the environment. As supported by Kusumawardani and Dewi (2020), a rise in the dependence ratio will increase carbon emissions.

Based on the above discussion, it is evident that population dynamics significantly impact carbon emissions and serve as a crucial indicator for assessing environmental impact. Several studies have found that an increase in the elderly population may lead to a decrease in carbon emissions due to reduced energy demand and consumption of carbon-based products.

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3. CONCEPTUAL FRAMEWORK

As shown in Figure 1, population aging will influence consumption and production activities. Firstly, population aging leads to a decrease in the supply of resources to the firm because the employment of human and capital resources stops once they retire. Secondly, the demand for goods and services will have a combined effect on the elderly. The elderly tend to consume more energy and health while consuming less for food, clothing, and transportation. We assume that the overall consumption of the elderly will be lower than that of younger people because older people are more than younger people, and the demand for overall goods and services will decline. Thirdly, as the overall consumption declines, so does production, which leads to a decline in economic activities. Thus, the residue from the consumption and production activities will also be reduced, and the environmental problems will be resolved.

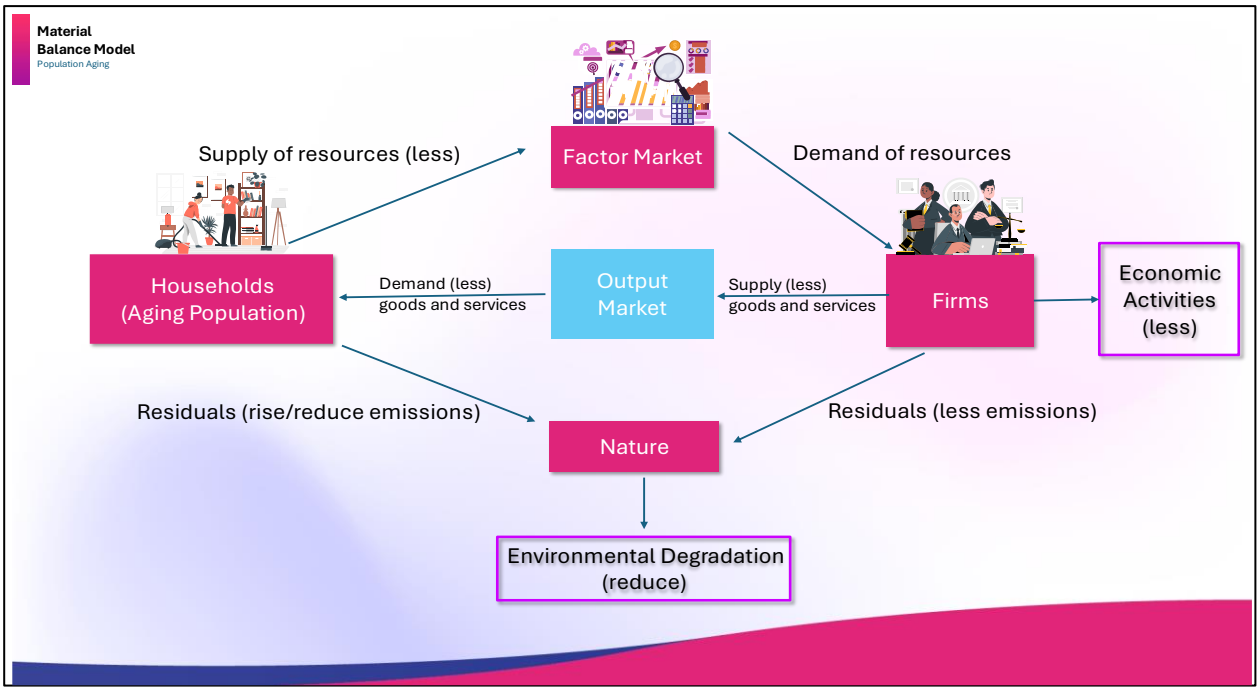

Figure 1. The modified version of the Material Balance Model

4. CONCLUSION

In summary, this study emphasizes the pivotal influence of population aging on environmental degradation. The comprehensive framework developed based on the Material Balance Model provides a nuanced understanding of how population aging affects the environment and offers a tailored approach for policymakers. Understanding the consumption pattern of the elderly, which later decreases firms' production, yields an effective way of marginalizing the reduction of economic activities. The potential outcome to the environment based on the residues produced from the economic activities enables a more effective policy intervention to optimize the existence of population aging on environmental sustainability in Malaysia.

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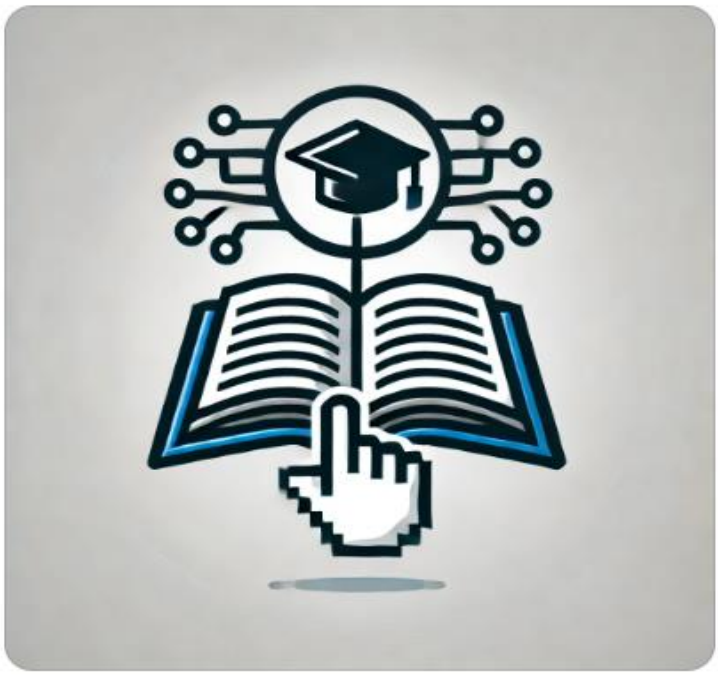
SECTION 11

Technology in Education



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METAVERSE ENGINEERING LAB FOR MECHANICS DYNAMICS

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Abstract

The concept of Metaverse has emerged as a collective virtual shared space for any form of interaction, promising immersive digital experiences that transcend traditional boundaries. In this innovation, a Metaverse Engineering Lab dedicated to Mechanics Dynamics was developed and tested with engineering students. Mechanics Dynamics forms the backbone of physical interactions, governing the behavior of objects and systems in motion. In the context of the Metaverse, understanding and simulating Mechanics Dynamics is crucial for creating realistic virtual environments and enhancing user experiences. The Metaverse engineering lab can simulate complex Mechanics Dynamics scenarios with unparalleled realism and activities. The integration of Mechanics Dynamics into the Metaverse lab enables students to interact with virtual objects and systems in a manner that closely mirrors real-world physics and enhances the authenticity and engagement of virtual experiences. The growing demand for immersive digital experiences and the expanding Metaverse ecosystem present beneficial opportunities for the commercialization of Metaverse Engineering Lab creating a productive market for innovative solutions. The motivation for developing the Metaverse engineering lab was to overcome the limitations of interactive tools for learning. These sorts of labs are poised to revolutionize how we interact with virtual environments and shape the future of digital experiences.

Keywords: Metaverse; engineering; interaction; experience; lab

1. INTRODUCTION

Engineering Education 4.0 emphasizes integrating Information and Communication Technology (ICT) to enhance student-centered learning (Low et al., 2023). The metaverse, a shared virtual space, has emerged as a transformative tool, particularly in mechanical engineering. Beyond gaming and socializing, the metaverse offers a dynamic platform for visualizing, testing, and refining engineering concepts in real time. This shift allows mechanical engineers to approach projects more innovatively and collaboratively.

In mechanical engineering education, the metaverse facilitates virtual learning and simulation. Students can interact with detailed 2D and 3D models of structures, machinery, and materials, enabling immersive project visualization and problem-solving (Wang et al., 2022). Simulations in the metaverse help examine material behaviors, evaluate structural integrity, and predict environmental impacts, streamlining the design process and reducing errors and costly revisions.

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Traditional mechanical engineering education involves complex student collaboration and multiple design proposals. The metaverse simplifies this by enabling real-time, global collaboration in a virtual setting (Kye et al., 2021; Lee et al., 2021; Won et al., 2022; & Chen 2022). This improved interaction promotes clearer communication, better decision-making, and more effective project outcomes.

Sustainability is a critical focus in mechanical engineering, especially given today's environmental challenges. The metaverse supports sustainable development by integrating renewable energy sources, optimizing resource use, and reducing environmental impact. Virtual simulations allow engineers to assess material energy efficiency, refine transportation systems to lower carbon emissions, and explore alternative materials and design techniques, thus prioritizing sustainability in engineering solutions (Zhang et al., 2022). A practical application of the metaverse in education is a virtual problem-solving lab for engineering students, particularly those struggling with Mechanics Dynamics a core mechanical engineering subject. Students have difficulty visualizing dynamic motion and complex calculations, expressing a preference for step-by-step problem-solving (Didem et al., 2022). Studies show ICT technologies enhance student engagement and learning through simulations (Fang & Tajvidi, 2018). The metaverse lab aligns with active learning principles, enabling students to engage actively with educational content rather than passively listening, thereby improving educational outcomes. Therefore, the metaverse offers a promising platform for mechanical engineering education, promoting active interaction, enhancing learning efficiency, and supporting sustainable engineering practices.

2. BACKGROUND

The concept of the metaverse, originating in the 1990s, gained significant traction when Mark Zuckerberg introduced 'Meta' (Auerbach, 2023). This sparked a surge of interest in various sectors, combining technologies like augmented reality, virtual reality, mixed reality, artificial intelligence, blockchain, and 3D virtual environments into a cohesive platform.

The metaverse is still in its research phase but promises to revolutionize education by connecting students globally. Beyond remote learning, it opens up numerous possibilities. In engineering education, which is foundational for many technological advancements, the integration of the metaverse represents a shift from traditional teaching methods to more technologically enhanced approaches. Engineering education fosters cognitive abilities, logical reasoning, problem-solving skills, and creative thinking (Doulougeri et al., 2024). Modern educational technologies, such as artificial intelligence and e-learning platforms, play a crucial role in enhancing these skills by tailoring content to individual needs and providing global access to education (Annuš, 2024).

The potential of the metaverse to enhance immersive learning in higher education is under extensive research across various fields. Some institutions have embraced this technology, yielding significant results. For example, Universiti Tenaga Nasional (UNITEN) has developed and tested an innovative engineering metaverse learning platform. This platform aims to provide supplemental learning, problem-solving, and visualization tools, enhancing the educational experience for engineering students. The metaverse learning platform at UNITEN is based on constructivism learning theory, which emphasizes active knowledge construction through reflection and interaction. This theory posits that knowledge is constructed, not passively absorbed, and that learning is an active, socially constructed process. This approach encourages students to build on existing knowledge, ask questions, and engage in discussions, thereby fostering a deeper understanding and retention of material.

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3. METHOD

For this innovation, we adopted Gather Town™ (GT) for developing the virtual engineering lab. The aim was to facilitate the engineering students' learning process especially in problem solving and visualization for the mechanics dynamics course. GT is an interactive digital environment designed to mimic real-world and face-to-face interactions. Combining the core features of web conferencing tools like Google Meet or Zoom with the visual aesthetics of classic 8-bit video games such as Pokémon, Mario, and Legend of Zelda, GT offers a unique twist on the concept of the metaverse. It is often described as a low-resolution metaverse, diverging from the typical high-definition virtual worlds. While many virtual learning environments are criticised for lacking genuine connection and the joy of physical presence, GT addresses this by transforming synchronous events into captivating, immersive experiences. Participants navigate through virtual spaces using customisable 2D avatars, reminiscent of video game characters. This approach fosters a sense of presence similar to being physically close to someone, promoting genuine and meaningful human connections.

In GT, as your avatar approaches another participant, you hear their voice and see their video feed, simulating a real-life encounter. Participants can even interact by bumping into each other and engaging in spontaneous conversations within the GT environment. This innovative blend of technology and nostalgia creates a space where virtual interactions feel surprisingly authentic and engaging from start to finish. Figure 1 depicts the navigation of the metaverse engineering lab that utilizes GT, which various features such as pictures, videos, communication medium such as voice, video and chat to create an interactive environment for students to collaborate and work together. This facilitates a better learning experience and understanding of complex materials that require visualization and diagrams to solve questions and exercises. As for the survey, Google Forms was used in the creation and distribution of the questionnaire in order to streamline data gathering. The surveys were disseminated online via goggle form. Forty-one replies were gathered over the course of around one week, from December 28, 2023, to January 3, 2024, when data collecting took place. Students needed an average of 30 minutes to finish the questionnaire. By selecting appropriate tools and techniques, this pilot research aimed to improve the process's quality and efficiency before the real data gathering began. The 66-item survey was used to collect data on preference of use of Metaverse platform and students perception after experiencing the Metaverse Engineering Lab.

Figure 1. Metaverse engineering lab

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3. FINDINGS AND DISCUSSION

As mentioned earlier, this study aimed to apply the innovation learning pedagogy, low-resolution metaverse approach to conduct a learner-centered learning environment in Mechanics Dynamics course. A research study was conducted in order to collect the response of the students after using the initial design of the system. Pilot study has been done on 41 students from Universiti Tenaga Nasional Malaysia (UNITEN) who took the Mechanics Dynamics course before. For this study, Descriptive statistical analysis was used to assess the data once it was collected, and the results are described in the sections that follow.

3.1 Results

The perception/ preference of students who used the metaverse platform as shown in Table I found that majority were willing to explore learning through virtual platforms that extend into metaverse application (61%), accepted to attend lecture sessions (60.9%), tutorial sessions (56.1%) through virtual platforms that extend into metaverse application, agreed have discussion with lecturer via metaverse application (51.2%), accepted to browse through the learning materials in different format (e.g., text, graphics audio, and video) through metaverse application (65.9%), were willing to explore the use of 2-D animation (63.4%)/ 3-D animation (70.7%) to illustrate the concept of mechanics dynamics through metaverse application.

Table 1. Perception/Preference of use of Metaverse platform

ITEMS	1 n (%)	2 n (%)	3 n (%)	4 n (%)	5 n (%)
I am willing to explore learning through virtual platforms that extend into metaverse application.	1 (2.4)	3 (7.3)	12 (29.3)	9 (22.0)	16 (39.0)
I accept to attend lecture sessions through virtual platforms that extend into metaverse application.	1 (2.4)	2 (4.9)	13 (31.7)	14 (34.1)	11 (26.8)
I accept to attend tutorial sessions through virtual platforms that extend into metaverse application.	3 (7.3)	0 (0)	15 (36.6)	16 (39.0)	7 (17.1)
I agree to discuss with my lecturer via metaverse application.	2 (4.9)	2 (4.9)	16 (39.0)	16 (39.0)	5 (12.2)
I accept to browse through the learning materials in different format (e.g., text, graphics audio, and video) through metaverse application.	1 (2.4)	2 (4.9)	11 (26.8)	18 (43.9)	9 (22.0)
I am willing to explore the use of 2-D animation to illustrate the concept of mechanics dynamics through metaverse application.	1 (2.4)	1 (2.4)	13 (31.7)	13 (31.7)	13 (31.7)
I am willing to explore the use of 3-D animation to illustrate the concept of mechanics dynamics through metaverse application.	1 (2.4)	0 (0)	11 (26.8)	15 (36.6)	14 (34.1)
I am willing to explore the use of virtual reality (VR) to engage with the mechanics dynamic contents in metaverse application.	1 (2.4)	0 (0)	11 (26.8)	15 (36.6)	14 (34.1)
I am willing to explore the use of augmented reality (AR) to engage with the mechanics dynamic contents in metaverse application.	1 (2.4)	0 (0)	14 (34.1)	13 (31.7)	13 (31.7)
I am willing to explore the use of collaboration tools to engage with my course mates for online discussion on mechanics dynamic contents in metaverse application.	1 (2.4)	0 (0)	16 (39.0)	11 (26.8)	13 (31.7)
It is interesting to create an avatar (virtual character) that represents me as a learner identity to perform learning activities on metaverse platform.	1 (2.4)	2 (4.9)	13 (31.7)	12 (29.3)	13 (31.7)
Various online learning activities integrated in the metaverse platform provide flexibility for me as a learner for engineering mechanics dynamics.	1 (2.4)	2 (4.9)	15 (36.6)	10 (24.4)	13 (31.7)
I prefer to explore the metaverse platform for learning by following the step-by-step approach.	1 (2.4)	1 (2.4)	13 (31.7)	14 (34.1)	12 (29.3)
I prefer to explore the metaverse platform for learning by the guidance of instruction in a systematic way.	1 (2.4)	2 (4.9)	13 (31.7)	17 (41.5)	8 (19.5)
I prefer to explore the metaverse platform for learning by exploring the virtual contents myself before asking for clarification.	1 (2.4)	4 (9.8)	12 (29.3)	15 (36.6)	9 (22.0)
I prefer to explore the metaverse platform for learning by trial-and-error method to discover what is happening in the virtual world regarding the learning contents.	2 (4.9)	2 (4.9)	12 (29.3)	18 (43.9)	7 (17.1)
I prefer to explore the metaverse platform by following the first-person shooter (FPS) interaction style for learning.	0 (0)	5 (12.2)	9 (22.0)	17 (41.5)	10 (24.4)
I prefer to explore the metaverse platform by following the 360-degree view interaction style for learning.	0 (0)	2 (4.9)	10 (24.4)	17 (41.5)	12 (29.3)
I prefer to explore the metaverse platform by following explanation by coaching style for learning.	2 (4.9)	2 (4.9)	10 (24.4)	15 (36.6)	12 (29.3)
I prefer to explore the metaverse platform through reasoning/ justification to clear my understanding before the problem-solving exercise.	0 (0)	4 (9.8)	9 (22.0)	18 (43.9)	10 (24.4)
I prefer to explore the metaverse platform through self-efforts rather than team work.	2 (4.9)	3 (7.3)	13 (31.7)	13 (31.7)	10 (24.4)
I prefer to explore the metaverse platform for learning as a team work.	1 (2.4)	2 (4.9)	12 (29.3)	16 (39.0)	10 (24.4)
I prefer to learn through the metaverse platform that provides with the necessary assistive tools (e.g., scientific calculator, notes taking, tips for formula, e-notes etc.)	0 (0)	2 (4.9)	12 (29.3)	17 (41.5)	10 (24.4)
I prefer to have good connection with the course instructor for online coaching through the metaverse platform.	0 (0)	4 (9.8)	8 (19.5)	15 (36.6)	14 (34.1)
I prefer to have the Chabot feature for the metaverse platform to assist my learning.	0 (0)	5 (12.2)	8 (19.5)	19 (46.3)	9 (22.0)
I believe that the metaverse application for learning mechanics dynamics can replace the traditional face to face learning.	1 (2.4)	4 (9.8)	18 (43.9)	14 (34.1)	4 (9.8)
I believe that the metaverse application for learning mechanics dynamics can be an assistive platform for traditional face to face learning.	1 (2.4)	3 (7.3)	12 (29.3)	15 (36.6)	10 (24.4)
I believe that the metaverse application for learning mechanics dynamics can co-exist parallel with the traditional face to face learning.	0 (0)	4 (9.8)	12 (29.3)	12 (29.3)	13 (31.7)
I expect to have the training before the use of metaverse platform to support the teaching and learning activities.	1 (2.4)	3 (7.3)	9 (22.0)	14 (34.1)	14 (34.1)
Currently my Internet connection is stable to perform the online activities for media rich contents in metaverse platform.	2 (4.9)	4 (9.8)	10 (24.4)	18 (43.9)	7 (17.1)
Currently my mobile phone / laptop / tablets are sufficient to view media rich contents such as 2-D and 3-D animation, video, games and collaboration tools such as ZOOM / MS Teams etc.	0 (0)	3 (7.3)	10 (24.4)	15 (36.6)	13 (31.7)
I welcome the new idea of using metaverse application to support the teaching and learning activities for engineering mechanics dynamics.	0 (0)	3 (7.3)	10 (24.4)	15 (36.6)	13 (31.7)
I am willing to participate in the use of metaverse application for learning mechanics dynamics in near future.	1 (2.4)	2 (4.9)	12 (29.3)	15 (36.6)	11 (26.8)

where 1- strongly disagree, 2-disagree, 3-neither disagree or agree, 4-agree, 5-strongly agree

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Table 2. Students Perception after experiencing the Metaverse Engineering Lab

	Very Poor	Poor	Acceptable	Good	Very Good
Overall, I think my level of knowledge for this course is better after using this supporting platform.	0 (0.0%)	0 (0.0%)	2 (4.9%)	26 (63.4%)	13 (31.7%)
Overall, I think my exposure (learning experience) for the learning using Metaverse approach is very good after using this supporting platform.	0 (0.0%)	0 (0.0%)	7 (17.1%)	24 (58.5%)	10 (24.4%)

Table 2 shows the result of the students perception after using the system. The result of the pilot study shows that more than 95.1% of the students had a positive experience after using the metaverse engineering lab. Particularly, 63.4% and 31.7% of the students think their level of knowledge for this course are good and very good after using this supporting system. 58.5% and 24.4% of the students think their exposure (learning experience) for the metaverse are good and very good.

3.2 Discussion

Information and Communication Technology (ICT) often plays a crucial role in engineering education, particularly as a supportive tool to enhance students' learning processes. According to the student responses in Table 2, the results showed that 63.4% had a good understanding and 31.7% had a very good understanding after using the Metaverse engineering platform. The Metaverse engineering platform, integrated with a constructivist approach, offers students an active learning platform with step-by-step problem-solving and visualisation modules. These findings from the pilot study align with those of other scholars. Fang's research asserted that effective visualisation and demonstration tools can aid students' comprehension and help prevent misunderstandings (Fang & Tajvidi, 2018). Furthermore, Low's study indicated that incorporating animation and video as supportive tools in the engineering classroom can also enhance students' learning motivation (Low et al., 2023). Additionally, data in Table 1 revealed that the majority of students' experiences with the Metaverse engineering lab, using the constructivist approach, were positive, with 57.1% rating it as good and 28.6% as very good. Integrating the learning system with the Metaverse engineering lab can facilitate higher-quality classroom interactions and teamwork among students (Zhao, 2024).

4. CONCLUSION

In this innovative system design, we presented the results and findings concerning the use of the Metaverse engineering lab system integrated with a constructivist approach. The findings demonstrated positive learning outcomes, including understanding levels and learning experiences, following the use of the Metaverse engineering lab platform. Future research will concentrate on a larger sample size to further investigate the effectiveness of the immersive Metaverse engineering lab system combined with a constructivist approach in engineering education.

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2024 OPEN INTERNATIONAL INNOVATION COMPETITION
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E-FORCE: A WEB APPLICATION FOR STUDENTS

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Abstract

The Engineering Science course (DBS10012) at Sultan Salahuddin Abdul Aziz Shah Polytechnic (PSA) encompasses six (6) fundamental topics, including the concept of Force, which holds paramount importance for semester 1 students pursuing a diploma in engineering. This topic delves a push and pull action which will change the state of rest or uniform motion of an object. Traditionally, the course employs face-to-face instruction, utilizing the comprehensive resources provided in the Engineering Science for Polytechnic module book and the Analysis of Final Examination Question book, offering students a compilation of previous final year questions. Recognizing the evolving landscape of education and the need for innovative pedagogical tools, the course instructor has developed e-Force web application. This online platform serves as a dynamic supplement to traditional instruction, providing students with a multifaceted learning experience. The web application features an overview of force principles, interactive calculator for computing force and momentum developed using Microsoft Excel, and an engaging interactive exercise accessible via both computer and mobile device. By integrating cutting-edge technology into the classroom environment, e-Force web app not only enhances student comprehension but also fosters a deeper appreciation for the principles of Science, Technology, Engineering, and Mathematics (STEM). Moreover, its versatility enables educators to customize learning experiences and cater to diverse learning styles, ultimately cultivating a more interactive and effective learning environment.

Keywords: Force; web application; e-Force; gaming; online calculator; STEM-based innovation; engineering education.

1. INTRODUCTION

STEM education can improve students' abilities in problem solving, to be innovators, to be independent, and able to connect what was learned with daily activities (Zubaidah & Malang, 2018). Implementation of STEM in science and mathematics learning is considered important in order to improve the quality of learning activities (Shahali et al., 2017). The evaluation instrument developed has a positive effect on cognitive learning outcomes for students of class X IPS MA As'adiyah Ketapangkaten Banyuwangi, which is evidenced by a good response with a score of 96% (Very Good) and an increase in student learning outcomes using the results of the N-Gain trial with a result of 44% in the high category, 50% in the medium category and 18.6% in the low category. The average N-gain test result is 0.6 in the medium category (Wayan Mertha & Mahfud, 2022). Multimedia designed for learning refers to the process of building mental representation from words and pictures in different contexts.

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They are designed to assist learning with tools which can be used in presentations, class room or laboratory learning, simulations, e-learning, computer games, and virtual reality, thereby allowing learners to process information both in verbal and pictorial forms (Ecenaz Alemdag, 2018). Additionally, students are encouraged to be proactive, try new ways, and repeat tasks if they want to while remaining anonymous and reducing their fear of failure (Al-Azawi et al., 2016). Gaming elements are the main gamification tools that affect students' motivation, engagement, and learning experiences (Werbach, 2014; Sailer et al., 2017).

The use of interactive learning media that emphasizes how to learn independently will make students easily achieve appropriate learning outcomes because learning independently prioritizes the self-control of each student. It is related to the achievement of learning outcomes after the learning process. Learning outcomes are the acquisition of values in the form of letters or numbers obtained by students at the end of learning (Reich. 2015).

Therefore, this study aims to serve as a dynamic supplement to traditional instruction, providing students with a multifaceted learning experience. By integrating cutting-edge technology into the classroom environment, researches intention is that e-Force web app not only enhances student comprehension but also fosters a deeper appreciation for the principles of Science, Technology, Engineering, and Mathematics (STEM) by gaining feedback through qualitative survey using questionnaire. Moreover, its versatility enables educators to customize learning experiences and cater to diverse learning styles, ultimately cultivating a more interactive and effective learning environment.

2. MATERIALS AND METHODS

2.1. Participants

The participants of this study comprised first-semester diploma in engineering students at Sultan Salahuddin Abdul Aziz Shah Polytechnic (PSA), specifically from the Department of Civil Engineering. The total number of participants was 38, with a demographic distribution of 60.6% male (23 students) and 39.4% female (15 students). The participants were selected randomly to ensure a representative sample of the student population in the Engineering Science course (DBS10012).

2.2. Survey Instrument

Data collection involved a quantitative method. Surveys were administered to gather demographic information, user satisfaction, and feedback on the application's usability and effectiveness. The total number of items to measure user feedback towards E-Force Web Application was 9 items which students responded by selecting one of five options ranging from "1" representing "Excellent" to "5" representing "Poor". The Cronbach's alpha for the measure of user feedback towards E-Force Web Application was found to be 0.90, indicating a high level of reliability.

3. RESULTS AND DISCUSSION

3.1. Demographic Background

The distribution of male respondents consists of 23 individuals, equivalent to 60.6%. Meanwhile, the distribution of female respondents consists of 15 individuals, equivalent to 39.4%. The selection of respondents was done randomly. The figure is as shown as Figure 1 below.

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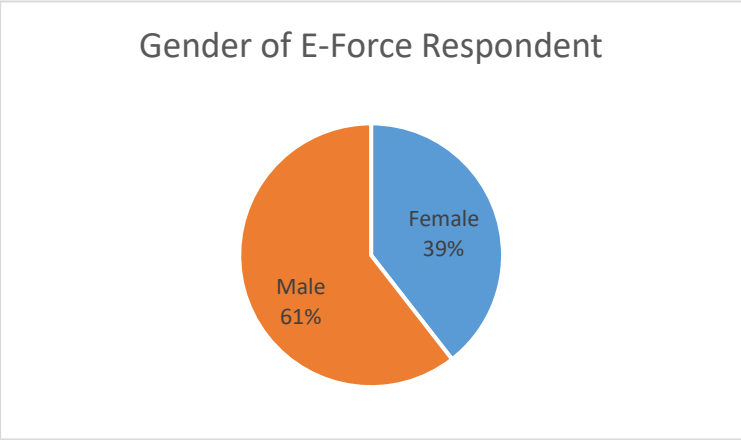

Figure 1. Descriptive Statistics on Background of E-Force Respondent

3.2. Close-Ended Data Analysis

Table 1. User Feedback and Evaluation Data for e-Force Web Application

VARIABLE	ITEM	MEAN	S.D.
Usefulness	The significance of how students utilized the application when it understands of force principles	1.53	0.69
User-Friendliness	The level of simplicity in navigating through an application	1.50	0.69
Interface Design	How the students viewed this application's visual and interactive design	1.50	0.69
Usability	Overall ease and effectiveness in using an application	1.45	0.65
Features and functionalities	Assessment on particular tools as well as resources provided by the application	1.47	0.69
Experience	General satisfaction with respect to software	1.50	0.65

The analysis of Table 1 reveals that the e-Force web application received predominantly positive feedback from users across several key variables, with mean scores ranging between 1.45 and 1.53 on a 5-point scale, indicating high satisfaction levels. The mean score for usefulness was 1.53, suggesting that students generally found the application valuable. User-friendliness and interface design both received mean scores of 1.50, reflecting a favorable perception of the application's ease of use and aesthetic appeal. Usability was rated slightly higher at 1.45, indicating strong user approval of the application's functionality. Features and functionalities had a mean score of 1.47, suggesting that students appreciated the tools and options provided by e-Force. The overall user experience was rated at 1.50, highlighting the application's effectiveness in enhancing learning engagement. Standard deviation values ranged from 0.65 to 0.69, indicating consistent feedback among users. These results underscore the application's success in delivering a user-friendly, effective, and engaging educational tool. In conclusion, the analysis of the data in Table 2 reveals that users perceive the e-Force web application as having very low to low levels of effectiveness across various dimensions, including usefulness, user-friendliness, interface design, usability, features and functionalities, and overall user experience. This feedback indicates significant areas for improvement, highlighting the need for a comprehensive redesign and enhancement to meet user expectations and improve satisfaction.

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Based on the item of usefulness, a majority of people use this application for different purposes but however, some customers are not finding it usefully enough to address their concerns in regards to its usefulness in general. As for user-friendliness, this application is largely deemed as friendly towards them and this proves that its usability is high enough. Nonetheless, fluctuations indicate there are certain aspects within the user interface or experience which can be better suited to suit every user. The fact that interface design has implications for engagement and satisfaction rates given that it is responsible for their interaction with the tool's functionality and content. A consistent feedback on user-friendliness implies that although the design supports usability effectively, there could be areas where it needs targeted improvement. Usability is a crucial aspect to be improved on. The close-to-low mean score suggests some constraints or challenges faced by users of the application when interacting with it.

4. CONCLUSION

In this regard, the overall achievement of the application is demonstrated by the homogeneity of positive responses on all fronts, with people appreciating its usefulness, user friendliness, and good design, which are important for retention and satisfaction. Nonetheless, the slightly lower mean score together with the moderate variability in usability calls for focused improvements. User testing sessions can provide actionable insights into an application's performance when accompanied by qualitative feedback and usability studies. The average deviations however show that there are differing segments of users such as demographic categories, level of technical expertise or usage patterns thereby enabling a customization of app features to meet each specific group thus enhancing overall satisfaction levels. This will enable monitoring and evaluation to track how changes made after improvement have impacted on the needs of users; it will also ensure that consumers continue receiving what they desire from the software. There should be a way for users to make contributions regarding problems and solutions hence mitigating obsolescence.

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GRAPHICA3D: LEARN 3D GRAPHS INTERACTIVELY WITH GEOGEBRA

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Abstract

Multivariable calculus is foundational for many degree programs in the sciences and engineering. A key topic in this field is multiple integrals, which involve integrating functions of more than two variables over 2-dimensional (2D) and 3-dimensional (3D) regions. The visualization of functions in multiple dimensions, a key aspect of understanding multiple integrals, often poses a challenge for students. Unfortunately, most teaching materials for multivariable calculus do not fully leverage technology for 3D graph visualization. GeoGebra, an educational mathematics application, offers an interactive learning environment for geometry, algebra, statistics, and calculus. It allows students to plot and view various 2D and 3D graphs. To enhance the interactive learning of multiple integrals, a module named Graphica3D has been developed. This module includes concise notes on 3D graphs and a GeoGebra applet that enable students to view various 3D graphs and their projections onto coordinates planes. The ease of use and practicality of Graphica3D can help students improve their ability to visualize 3D graphs. It is hoped that this well-designed interactive module with GeoGebra can positively impact students' mathematical understanding of multiple integrals.

Keywords: Multivariable calculus; multiple integrals; GeoGebra; 3-dimensional graphs; interactive learning

1. INTRODUCTION

Multivariable calculus is compulsory for many degree programs in the sciences and engineering. One of the key topics in multivariable calculus is multiple integrals. Multiple integrals are widely applied in mathematics and calculus, enabling the determination of plane areas, mass and volume calculations, moments of inertia, and surface areas for 3D objects (Milenković & Vučićević, 2024). These integrals involve integrating functions of more than two variables over 2D and 3D regions. However, students often encounter challenges when dealing with multiple integration in calculus courses. Beyond applying integration procedures correctly, they must engage in decision-making processes—identifying integration domains, evaluating strategies, and choosing the most convenient methods (Alessio et al., 2022). Determining the integration domains for triple integrals involves visualizing and sketching graphs in 3D, along with their 2D projections on appropriate coordinate planes. The inability to visualize and sketch the graphs of two-variable functions in 3D has been identified as a significant barrier hindering students' understanding and problem-solving abilities in multiple integrals (Kashefi et al., 2010; Yeni et al., 2022).

In recent years, dynamic software development has expanded the availability of engaging, well-prepared materials designed to visualize mathematical concepts. One such tool, GeoGebra, integrates seamlessly into teaching materials, bridging technology and pedagogy (Hohenwarter et al., 2008). GeoGebra is an interactive geometry, algebra, statistics, and calculus application designed for teaching and learning mathematics, science, and engineering (Ziatdinov & Valles, 2022). Being open-source, GeoGebra provides free access to its features and serves as a practical alternative to Matlab and Mathematica (Septian et al., 2021). Notably, Milenković and

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Vučićević (2024) observed that incorporating GeoGebra for the visualization of multivariable functions in the online learning environment successfully improved student achievement in solving multiple integrals.

A well-designed instructional approach utilizing such dynamic software applications for teaching and learning can produce positive impacts on students' mathematical understanding. GeoGebra provides a medium that can easily be integrated into teaching materials. Several studies have observed positive impacts on students' achievements and motivation from incorporating GeoGebra software into teaching materials for mathematics and basic calculus (Saputra & Fahrizal, 2019; Septian et al., 2021; Yeni et al., 2022). However, teaching modules related to multivariable calculus, especially those focused on visualizing 3D graphs, rarely integrate dynamic software like GeoGebra. Noticing the need to create a module that helps students learn multiple integrals interactively, a module named Graphica3D has been developed. Graphica3D is an interactive module that provides concise notes on various 3D graphs, such as planes, cones, cylinders, paraboloids, spheres, and hemispheres. It also includes a GeoGebra applet to help students visualize these 3D graphs and understand their projections onto 2D coordinate planes. The primary goal of this module is to enhance students' ability to visualize 3D graphs, ultimately benefiting their understanding of multiple integrals.

2. MATERIALS AND METHODS

The development of the Graphica3D module involves three phases, as shown in Figure 1. It began with identifying the key challenges students face in visualizing and understanding 3D graphs and multiple integrals. Based on feedback from lecturers and students, we outlined the essential features and functionalities required in the module. These include interactive 3D graph visualization, concise explanatory notes, and easy accessibility across various devices. The module is designed and arranged systematically that allows students to learn independently.

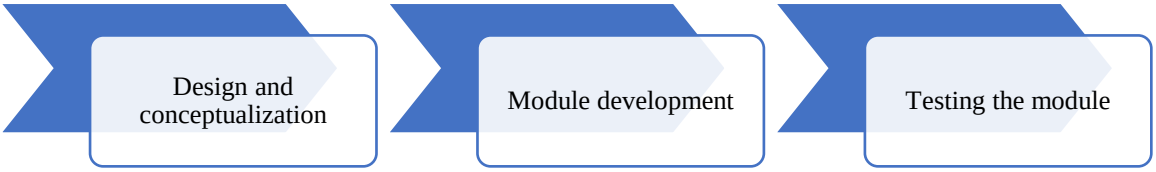

Figure 1. The Development of the Graphica3D Module

The second phase involved the actual development of the module. Graphica3D is designed as a module that provides concise notes on 3D graphs, but what sets it apart is the inclusion of a dynamic environment – the GeoGebra applet. We utilized GeoGebra, a free open-source mathematical software, to create interactive applets for the Graphica3D module. This interactive feature allows students to explore and visualize various 3D graphs, such as planes, cones, cylinders, paraboloids, spheres, and hemispheres, in an engaging way. Each applet includes a feature that enables students to view the 2D projections of these 3D graphs on the coordinate planes, including the xy-plane, xz-plane and yz-plane. Each applet is paired with concise notes explaining the mathematical functions of the 3D graphs. The interactive environment encourages experimentation and exploration, fostering a deeper understanding of the spatial relationships and properties of 3D graphs. Figure 2 displays a few pages of the Graphica3D module.

Graphica3D is designed as a flipbook module, making it easily accessible for students. They can conveniently access the module using laptops, tablets, or smartphones. This flexibility ensures that students can learn 3D graphs anytime, anywhere, at their own pace. The flipbook format combines the benefits of traditional textbooks with the interactivity of digital media, providing an intuitive and user-friendly interface. Students can easily navigate through the pages, access embedded GeoGebra applets, and review notes on-the-go. This accessibility not only supports diverse learning environments but also caters to different learning styles and preferences.

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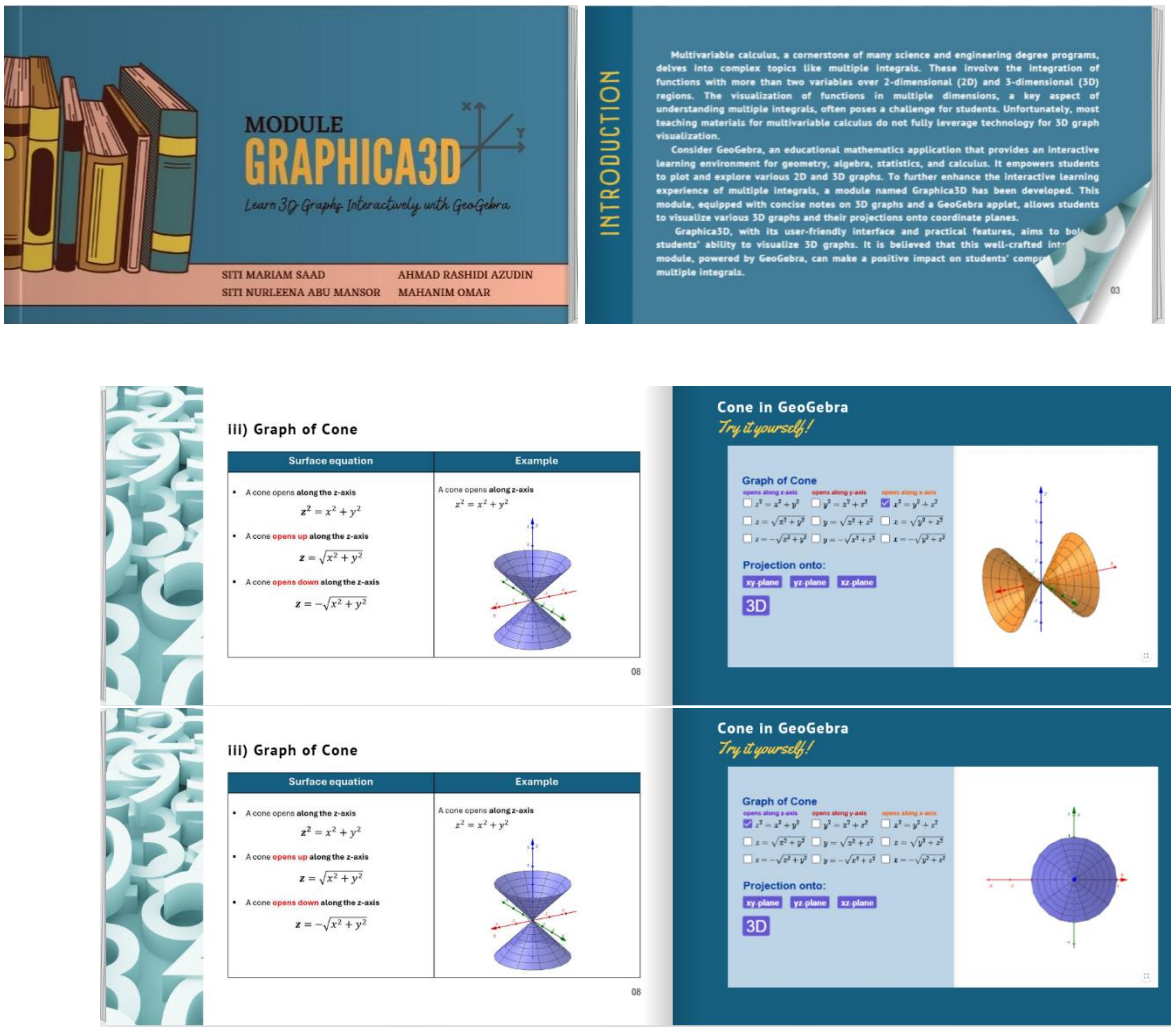

Figure 2. The Graphica3D Module

The final phase was testing the module. For this study, a random sample of 37 students enrolled in Further Calculus for Engineers course was selected among engineering students at Universiti Teknologi MARA, Cawangan Pulau Pinang. A survey with 4 Likert's scales (1- Strongly disagree, 2- Disagree, 3- Agree, 4- Strongly agree) was distributed on assessing their feedback regarding the module effectiveness in assisting students with sketching 3D graphs (Table 1).

Table 1. The Evaluation of the Effectiveness of Using Graphica3D Module

No	Questions
1	I am skilled at sketching 3D graphs.
2	I can sketch 3D graphs without the lecturer's help, every time I answer a graph question.
3	Graphica3D module helps me understand how to sketch 3D graphs for various surface equations.
4	Graphica3D module helps me in sketching 3D graphs from the given surface equations.

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3. RESULTS AND DISCUSSION

3.1. Respondent Background

The Graphica3D module was administered to facilitate practical application among students enrolled in the Further Calculus for Engineers course. These students were then asked to complete a survey regarding their usage of the module. As shown in Figure 3, there were 37 respondents participated in the survey, comprising 10 males (27%) and 27 females (73%). Majority of them were civil engineering students, 17 (45.9%). Additionally, 14 students (37.8%) were chemical engineering students, and the remainder were studying electrical engineering.

(a) Gender (b) Programme

Figure 3. Summary of Students According to Gender and Programme Study

3.2. Students' Skill and Graphica3D Module Usage Feedback

The survey results reveal several insights into students' perceptions and experiences with sketching 3D graphs and using the Graphica3D module as a learning tool. Results in Figure 4 indicate that more than half of the students (54.1% agree and 5.4% strongly agree) consider themselves skilled at sketching 3D graphs. However, 40.5% admitted their inability in sketching 3D graphs. Even though there is a significant portion of the students acknowledges their ability to handle spatial representations and mathematical visualization, which are crucial skills in fields such as engineering and sciences, a high percentage (48.6%) who are not confident in doing so without guidance from lecturers. This gap between self-assessed skill and self-reliance highlights a potential area for further support or training to empower students in independent graph sketching.

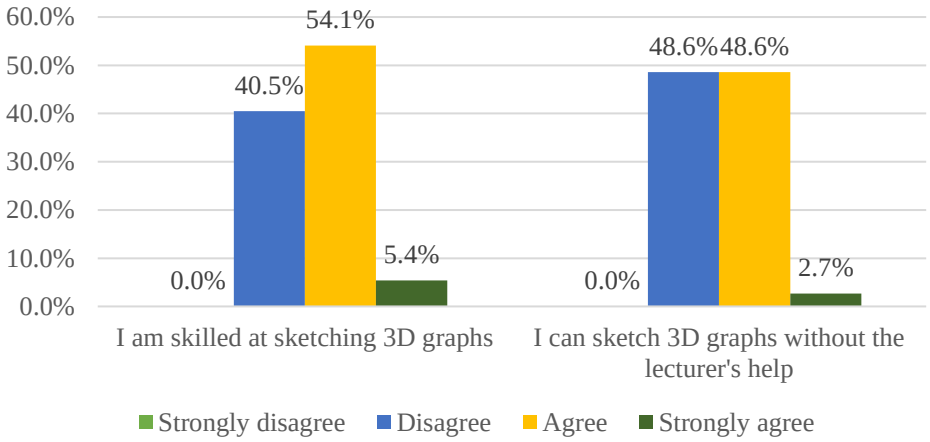

Figure 4. Students' Skill Before Introducing the Graphica3D

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All students, with 70.3% choosing the 'strongly agree' scale as displayed in Figure 5, recognize the importance of having skill in sketching 3D graphs to solve problems related to multiple integrals.

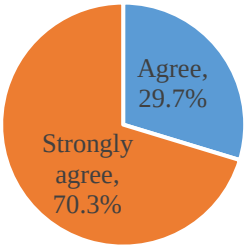


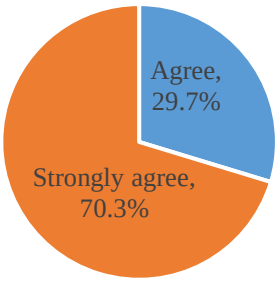
Figure 5. Students' Opinion on the Importance of Having Skills in Sketching 3D Graphs

Feedback on the Graphica3D module (Table 2) as a learning tool was positive: all respondents either agreed (43.2%) or strongly agreed (56.8%) that the module helped them understand how to sketch 3D graphs. The notes and GeoGebra applet contained in the module aided them in recognizing the surface equations, enabling them to sketch the corresponding graphs. This indicates that the interactive module enhances their understanding of 3D graph sketching. The high satisfaction rate underscores the module's effectiveness as a supplementary learning resource, potentially filling gaps in traditional classroom instruction by providing interactive and visual learning experiences.

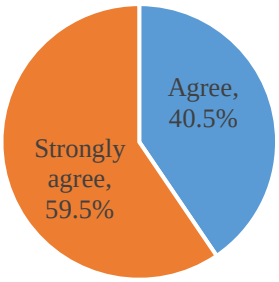
Table 2. Students' Feedback on the Usage of the Graphica3D Module

	Agree	**Strongly agree**
Graphica3D module helps me understand how to sketch 3D graphs for various surface equations	43.2%	56.8%
Graphica3D module helps me in sketching 3D graphs from the given surface equations	54.1%	45.9%

As displayed in Figure 6, a significant majority found the module to be excellent (29.7% agree and 70.3% strongly agree) and would recommend it to others (40.5% agree and 59.5% strongly agree). This endorsement highlights its potential as a widely accepted tool for enhancing spatial visualization skills among students.



(a) The Graphica3D module is very good



(b) I will recommend the Graphica3D module to my friends

Figure 6. Students' Opinion on the Graphica3D

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4. CONCLUSION

In conclusion, the introduction of the Graphica3D module has shown positive results in enhancing students' abilities to visualize and sketch 3D graphs, which are essential for understanding multiple integrals. While students generally feel competent in sketching 3D graphs, the Graphica3D module supports and enriches their learning experiences by fostering greater self-reliance and understanding. The positive reception of the module suggests that its continued integration and development could further benefit educational outcomes in understanding multivariable calculus, particularly multiple integrals, making it a valuable supplement to traditional teaching methods.

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TEACHING MATERIAL AIDS BY USING DROPBOX PLATFORM

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Abstract

In Malaysia, technological advancements have significantly improved the efficiency and effectiveness of educational tasks for lecturers and students, especially since COVID-19 began. Traditional learning allows students to ask lecturers questions directly, but lengthy sessions may make students lose focus. Lecturers are also pressured to complete the syllabus within a certain timeframe. If students cannot attend class sessions, the lecturer cannot repeat the lesson because it would disrupt the planned learning schedule. These factors cause some students to fall behind. Thus, we aim to provide a new learning method to overcome the limitations of traditional learning. Dropbox has been used as a platform to upload all the learning materials in video form. Lessons can be recorded by lecturers on short videos following the syllabus. The lecturers will provide face-to-face classes according to the syllabus while offering online learning materials that students can access anywhere and anytime. Students can access these learning aids by clicking on the links provided by the lecturer on WhatsApp. Through this method, students who cannot attend the class can study the lesson online and feel like they are listening to a live lecture. Additionally, this learning platform provides flexible and repetitive learning opportunities.

Keywords: Teaching Aids; Technology Aids; Educational Platform; Dropbox

1. INTRODUCTION

The COVID-19 pandemic prevented face-to-face teaching methods from being used, so online education is the only option. During lockdown, technology advancements enable the educational process to continue smoothly, and lecturers and students can complete their tasks effectively and efficiently. However, some students cannot adapt to the online teaching environment, and some may have certain issues with their internet connection, which makes them unable to follow the online classes. These issues resulted in some students struggling to keep up and being left behind. This situation impacts the learning process in the post-pandemic COVID-19 period. After the pandemic, face-to-face teaching continues as usual. However, it becomes a challenge for lecturers and students. Students who are used to online instruction become bored within 2-3 hours of face-to-face instruction. Teaching material aids like PowerPoint slides are famous among lecturers for helping students revise outside class sessions. However, without verbal explanation, PowerPoint slides make it hard for students to understand, especially subjects related to calculation and problem-solving. Previously, researchers suggested that PowerPoint slides with audio or video recordings may enhance online learning (Bringula et al., 2021; Muthuprasad et al., 2021). Several studies have suggested that courses offering practical or skill-oriented information should employ a blended or hybrid curriculum that combines face-to-face and online instruction (Atwa et al., 2022; Muthuprasad et al., 2021). Traditional classroom teaching combines online elements as part of blended learning, resulting in a more flexible learning environment (Walid, 2023). Past

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studies have found that e-resources provide flexibility regarding when and where learning occurs, allowing students to progress at their own speed and review materials when necessary (Usman et al., 2023).

Cloud computing services such as Dropbox store and share files, music, documents, videos, and pictures for free. Users can edit files without downloading them through the group workspace, which is useful for collaborative projects. The user-friendly interface and accessibility of Dropbox make it a good choice for teachers and lecturers, according to Chisega & Kraft (2020). Therefore, this study utilized self-made videos to complement face-to-face instruction. The lecturer will upload these videos to Dropbox after the face-to-face teaching session.

2. MATERIALS AND METHODS

Lecturers need paper and pens to write notes and calculations, as well as a smartphone and a tripod stand to record videos. Lecturers record their teaching videos in detail for about 90 seconds or less for each sub-topic. Videos were recorded in short segments as the researchers explained the topic in detail, part by part. This technique prevents students from being bored and makes it easier to find which topic they want to look at. Depending on the chapter, there can be up to twelve video segments for a single topic. While recording, the lecturer needs to ensure that her voice is clear and there are no distractions from her surroundings. After recording the teaching videos, the lecturer uploads them to Dropbox. Other teaching materials, such as PowerPoint slides, exercises, assignments, and other documents, can also be uploaded by the lecturer. Once the class sessions have ended, the lecturer shares the Dropbox link through a WhatsApp group. By clicking the link, students will be directed to the Dropbox official site to access the teaching videos. Diploma and Degree students taking Business Mathematics courses were introduced and exposed to this teaching method.

3. RESULTS AND DISCUSSION

The following figures illustrate the Dropbox link shared by the lecturer via WhatsApp and the Dropbox site with video teaching materials.

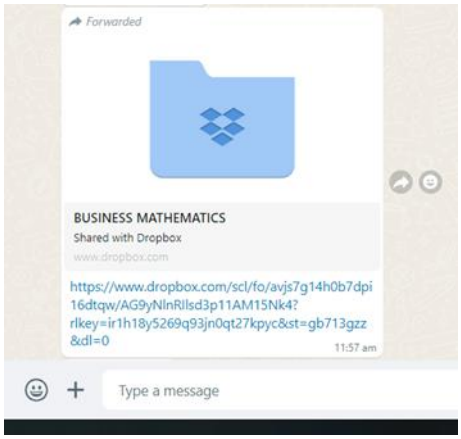

Figure 1. Link of the Dropbox shared through WhatsApp application

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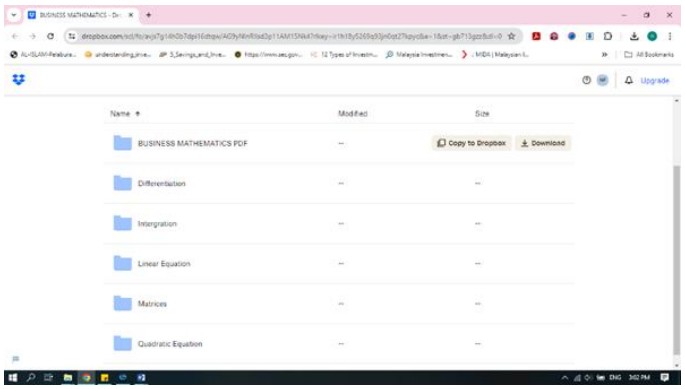


Figure 2. Dropbox's Offical Site with Video Teaching Materials

This allows students to revise according to their preferences, encouraging self-study outside of lecture sessions. Lecturer video presentations can be particularly effective for teaching since they provide a familiar and engaging experience for students. With video teaching, students can learn outside the classroom while feeling connected to their lecturers. The previous researchers also created an online tutorial video to help students access and utilize the content at their own pace (Adofina, 2022). As a result, they can perform well on quizzes, group assignments, and final exams.

Diagram 1. Grades Comparison of Degree Students for Midterm and Final Exam

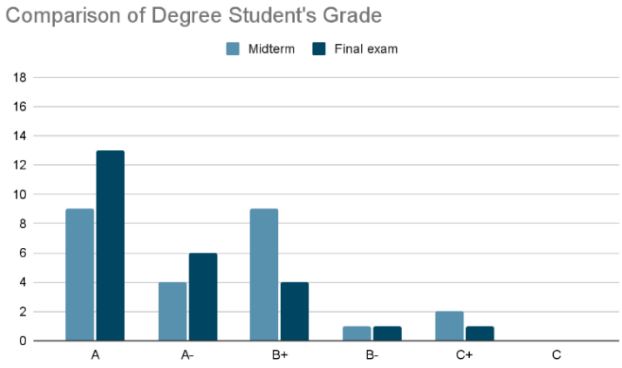
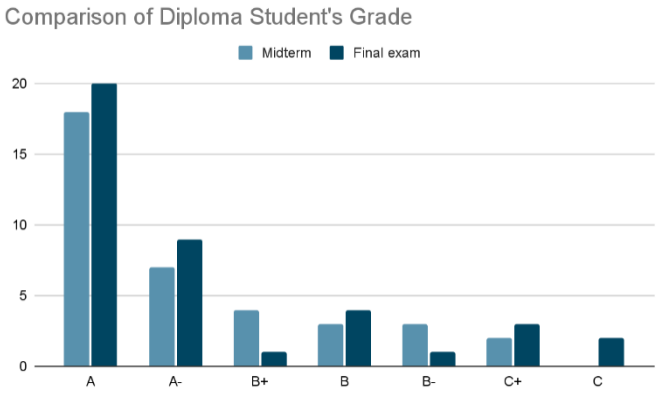


Diagram 2. Grades Comparison of Diploma Students for Midterm and Final Exam



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Compared to the results of 43 Degree students in midterm and final exams, about 25 (58.14%) students managed to maintain and upgrade their grades in Business Mathematics after using this teaching method. In addition, as a result of using this teaching method, about 35 out of 62 Diploma students maintained and upgraded their grades in Business Mathematics. It has been proven that blended learning, combining face-to-face and online teaching methods, such as self-made video teaching, effectively improves students' performance. In line with the study by Adofina (2022), self-made video tutorials are an effective tool for improving mathematics skills and competencies.

According to assessments of the teaching course, most Diploma and Degree students were satisfied with the method used by the lecturer. Interesting teaching methods can help students become more engaged in the learning process and increase self-study motivation. By providing students with various learning models, they are more likely to be enthusiastic about learning and achieve better learning outcomes (Tong et al., 2023; Zuhriyah et al., 2022).

4. CONCLUSION

As a result, this study can be summarized as follows. First, combining video teaching aids with face-to-face instruction can increase teaching effectiveness. This blended learning approach combines traditional classroom interaction with multimedia resources to produce a more comprehensive and accessible learning experience. Secondly, lecturers can use this method to address and improve upon the weaknesses of traditional lectures by using videos to provide additional content and context. Furthermore, it assists students in improving their understanding and skills, as they can review and interact with the material at their own pace, supporting better learning outcomes, performance, and academic achievement. To support the findings of this research, quantitative data should be provided using a statistical approach to evaluate the acceptance of this teaching method. Additionally, conducting interviews with students who have experienced this teaching method will offer qualitative insights into their perspectives and experiences. Furthermore, this method can be adapted to other courses to demonstrate its generalizability and relevance across various subjects.

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ORAL PRESENTATION THROUGH SELF-REFLECTION: A GUIDE TO TEACHING AND LEARNING STRATEGY VIA OPEN LEARNING TO IMPROVE ORAL PERFORMANCE

***Mimi Rita @ Aishah Binti Tajuddin[1], Aizan Binti Yaacob[2], Faizahani Ab. Rahman[3], Abd Aziz Hassan @ Yahya[4], Umazah Omar[5], Janice Koay Min Yee[6]**

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Abstract

Oral presentation is a requirement for users to fulfil their responsibilities as effective presenters. However, they encounter oral presentation anxiety (OPA) and practice self-efficacy (SE) to overcome OPA; therefore, to investigate the users' characteristics of poor and excellent oral performances using Open Learning website. The Open Learning website uses observation through the checklists by Cavanagh et al. (2014) and Gibbs (1988) reflective cycles. They were requested to do oral presentations through Open Learning website using their own recorded videos and upload to get YouTube links for three times and self-checked with the instruments provided. The research objective is to investigate the users' enhancement in oral presentation via video observation and self-reflection. The underpinning theories are the Social Constructivism (Vygoysky, 1978), Oral Presentation Anxiety (Horwitz & Cope, 1986) and Self-Efficacy (Bandura, 2006) Theories. Data was obtained through a qualitative case study research design administered to students in higher institutions. Findings show the users' performances were poor in the first presentation and they gradually enhanced in the second presentation. In the last presentation, they made excellent improvement in the oral presentation even though they had poor use of humour throughout their presentations from the data observation using the two checklists by Cavanagh et al. (2014) and Gibbs (1988) reflective cycles. The users showed significant enhancement in the oral presentation from the first to the third presentation. The implications of the study show that The Oral Presentation Strategy through Open Learning website assisted in viewing the users' enhancement in oral presentation skills. This contributes to helping the instructor to guide the users using the website to assist them in enhancing their oral presentation in the future.

Keywords: Oral Presentation Anxiety; Self-Efficacy Practice; Observation Checklists; Self-Reflection; Oral Presentation Strategy.

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1. INTRODUCTION

Oral presentation is a requirement for users to fulfil their responsibilities as future presenters. However, they encounter oral presentation anxiety (OPA) and practice self-efficacy (SE) to overcome OPA; therefore, to investigate the users' characteristics of poor and excellent oral performances using Open Learning website. The Open Learning website uses observation through the checklists by Cavanagh et al. (2014) and Gibbs (1988) reflective cycles. They were requested to do oral presentation through Open Learning website using their own recorded videos YouTube links for three times and self-checked with the two instruments provided.

The research objective is to investigate the users' enhancement in oral presentation via Open Learning Web Page which has a few features such as Interactive Media, accessibility, Enhanced Education, Flexibility in Presentation Style Self-Paced Learning, Peer Review, Analytics and Feedback Data-Driven Insights, Individualization and Customizing Personalized Learning Paths

2. METHODS AND MATERIALS

This is a qualitative case study methods with the materials used as below:

2.1. The Observation Checklists

The checklists for observations were adapted from Cavanagh et al. (2014). To assist the users using the observation checklists while watching their oral presentation videos. The first checklist focuses on the qualities of poor and excellent oral performance for the modes of communication, including body language, voice, words, and alignment; the second checklist, developed by Cavanagh et al. (2014), examines the qualities of poor and excellent oral performance for the constructed impressions of communication, including confidence, clarity, engagement, and alignment.

2.2 Gibb's reflective cycle

The written self-reflection instrument used for the users is from Gibbs (1988) because the written self-reflection from Gibb's reflective cycle is a guide for the students to write their self-reflection. After all, it is appropriate as the instrument to investigate the users' anxiety and self-efficacy phenomena.

This is a qualitative case study method with the implementation steps below:

1. **Designing the Web Page:**
   Designing a web page involves two key aspects: creating a user-friendly interface with clear navigation and utilizing a content management system (CMS) for easy content updates.

2. **Content Creation:**

   In the process of content creation for educational purposes, two critical components include developing high-quality multimedia content and creating supplementary materials with interactive elements.

   By administering an open learning web page, presenters can create a dynamic and interactive environment that enhances the traditional oral presentation, making it more engaging and effective for a diverse audience.

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3. RESULTS

The results for oral presentation anxiety and self-efficacy practice are deliberated below:

3.1 Oral Presentation Anxiety

3.1.1 Test Anxiety

Scholars have offered numerous definitions of anxiety. Test anxiety (TA) is the primary form of anxiety linked to anxiety during oral presentations. Spielberger et al. (1972) conducted a study on test anxiety and characterized it as a complicated emotional response triggered in an individual who perceives a particular scenario as threatening or hazardous. This research was conducted over 50 years ago. This definition is still widely applied today. Test anxiety was first described as the fear of being evaluated by Horwitz et al. (1986), almost forty years ago.

> *In my presentation, I covered various psychological and emotional impacts that bullying has on individuals, including anxiety, depression, and loss of self-esteem. Before the presentation, I felt nervous but also prepared because I had thoroughly researched the topic. During the presentation, I felt a mixture of confidence and anxiety. (Seow, SRS 1)*

3.1.2 Fear of Negative Evaluation

The fear of negative evaluation (FNE) is the second element that contributes to anxiety during oral presentations. Horwitz et al. (1986) defined "apprehension about others' evaluations, avoidance of evaluative situations, and the expectation that others would evaluate oneself negatively" (p. 128) as the definition of dread of negative evaluation. Fear of receiving a poor grade has a broader application since it can arise in any social setting, not just when taking a test (Horwitz et al., 1986). For instance, students may experience terror in response to peer and instructor evaluations. The present study centers on the students' self-reflections concerning their oral presenting scenarios as a means of examining their anxiety about negative judgment.

> *Before the presentation, I felt nervous but also prepared because I had thoroughly researched the topic. During the presentation, I felt a mixture of confidence and anxiety. (Seow, SRS1)*

3.1.3 Communication Anxiety

This section showed that research on oral presentation anxiety related to communication anxiety or communication anxiety in the second language, was carried out in many countries (Bilal, Tariq, Rashid, Adnan, & Abbas, 2013; Horwitz et al., 1986; Koba, Ogawa, & Wilkinson, 2000). In their papers, all the reviewed researchers mentioned communication anxiety as one of the issues of their research studies. Although a series of research on communication anxiety was administered and explored by McCroskey (1995, 2009); McCroskey et al. (2014), the current study freshly encountered communication anxiety in terms of the users who were experiencing the communication anxiety.

> *So like I said just now we were planning to do it on 10 am clock infront of the library.But fortune was not in our side because while we went there were lot of people infront of library in that morning.I felt little bit sad because we were already planning to do there but it was fine.My friends were really tried to calm me and gave some adviced, SRS 2)*

3.1.4 Topic and Content Anxiety

Learners may also have anxiety related to topics and content (TCA) when giving oral presentations. The concern and typically negative emotional response elicited when learning a second language is referred to as topic and content anxiety (TCA) (MacIntyre, 2007). A few research participants described the subject as

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a crucial component. The MacIntyre (2007) study's participants made a strong point on how the subject matter may affect their willingness or unwillingness to utilize English in class.

> *When sir told us that we had to do a talkshow about the topic that we had choosing it make me quite worried.The reason is I'm not really good in English.I remembered when I in secondary school I couldn't speak English well and also I weaked at vocabulary.When I think that it make my anxious came because I scared that I would be a burden to my group members. (Amir, SRS 1)*

3.2 Self-Efficacy Practice

3.2.1 Intentionality

According to Bandura (2006), the first theme is "intentionality," which refers to the agentic quality that characterizes people's intentions to carry out their plans of action and tactics. The users' practical commitment is called intentionality. For example, Natrah committed to completing the objective of presenting a slide show in a realistic manner.

> *So like I said just now we were planning to do it on 10 am clock infront of library. But fortune was not in our side because while we went there were lot of people infront of library in that morning. I felt little bit sad because we were already planning to do there but it was fine. My friends were really tried to calm me and gave some adviced. It makes me felt better. (Amir, SRS 2)*

3.2.2 Forethought

Plans of action that serve as a model for a future course of action that will be presented are at the heart of intention. It is a practical commitment to bringing about future acts rather than just an expectation or prediction of them. According to Bandura (2001), acts taken to achieve one goal can result in entirely distinct outcomes. To put it succinctly, the essential component of human agency is the ability to initiate activities for specific goals.

3.3.3 Self-Reactiveness

A presenter needs to be a motivator and self-controller in addition to being organized and forward-thinking. The presenter cannot just wait for the right performance to happen after deciding on an intention and an action plan (Bandura, 2006). This means that giving an oral presentation requires the capacity to control one's performance. A few sets of cycles of self-reflection guide the self-regulation of practice and preparing. These include using self-guidance and correcting self-reactions to practice and prepare the presentation.

> *Example, when I was at the secondry school, I was really actived when it came to arabic discussion in google meet. When think that,These things make me remembered again a good memory with old friend and it really touched my heart.(Amir, SRS 2)*

3.3.4 Self-Reflectiveness

Reflectiveness on Oneself in Bandura (2006) People, it was believed, are both self-examiners of their own functioning and agents of action. Unquestionably, another fundamentally human aspect of the agency is the metacognitive capacity to evaluate one's own ideas and behaviors.

> *By focusing on and addressing specific areas of weakness, I was able to enhance the overall quality of my presentation. I will maintain regular practice sessions focusing on body language, facial expressions, and vocabulary, and continue recording and reviewing my presentations to identify areas for further improvement. (Seow, SRS 3)*

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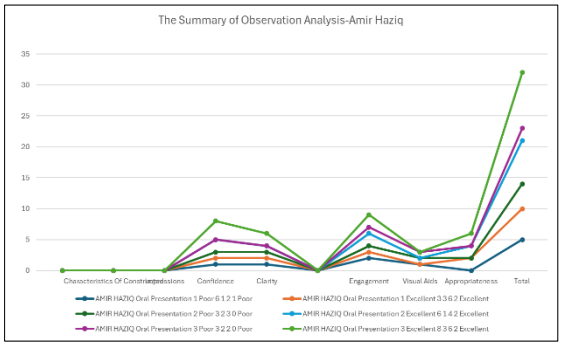
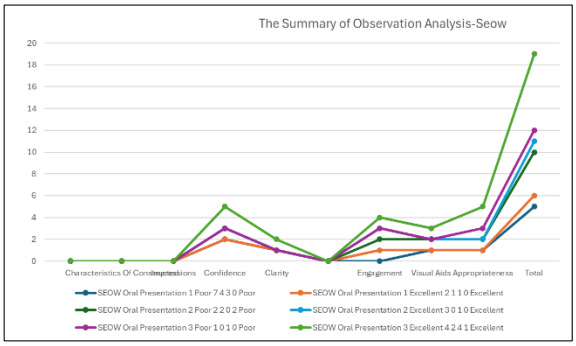
3.3.5 Self-Enhancement

A previous study on improving oneself (Hepper et al., 2010) concentrated on achieving, optimizing, and controlling positive self-perceptions. They developed an integrated method that provided valuable insights into the composition of self-enhancement. Next, socially desirable response (SDR) was one of the five pillars of self-protection and self-enhancement that Sedikides and Alicke (2018) examined.

> *Practicing with a focus on specific weaknesses proved to be beneficial. I realized that even moderate practice can lead to noticeable improvements. This experience reinforced the importance of targeted practice and self-assessment in enhancing presentation skills. (Seow, SRS 2)*

3.2 Observation Checklists





4. DISCUSSION

The observation employed in this study showed that the users' self-efficacy practice has improved in oral presentations and that their anxious sensations are being overcome. The specific experience of their human agency overcame their feeling of anxiety brought on by a few things. Participants who had linguistic anxiety matched the study's findings of oral presentation anxiety, as validated by Horwitz et al. (1986, 2010). Intentionality, planning, self-reactivity, and self-reflection—human agency as defined by Bandura (2006) were indeed components of the users' self-efficacy to enhance their oral presentations.

5. CONCLUSION

The users developed confidence as a result of self-efficacy practice. The innovation will assist lecturers or instructors in shaping the direction of oral presentation skills in the future. The SRS guidelines are available online through the Open Learning website and can be practiced globally among ESL learners. The problem arises when there is no internet connection. Theoretical Implications by Horwitz and Cope (1988) explored the concept of "communication apprehension" in the context of language learning, which includes oral presentation anxiety. Their work highlighted the psychological barriers that individuals face when speaking in public or a foreign language. Meanwhile, Bandura's (2006) theory of self-efficacy, which refers to an individual's belief in their ability to succeed in specific situations, has significant theoretical implications building self-efficacy in oral presentation is achieved through targeted training and practice with the use of technology. Future innovators can administer self-reflection together with assessment in oral presentation. Multiple contents with other courses like the oral presentation for practice in seminars and viva presentations. This is among the best innovation that contribute to society and well-being especially in higher institutions where presentations are important that assists to boost self-confidence to perform oral presentation effectively.

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INTEGRATION BY PARTS: A DIGITAL MNEMONIC SQUARE DIAGRAM LIATE APPROACH

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Abstract

This project introduces an innovative digital tool designed to enhance students' understanding and efficiency in applying the Integration by Parts method using a mnemonic square diagram based on the LIATE approach. The LIATE method, representing Logarithmic, Inverse Trigonometric, Algebraic, Trigonometric, and Exponential functions, is a well-known strategy for selecting u and dv in integration by parts. The digital tool simplifies the learning process by converting the traditionally abstract method into an engaging visual tool. The mnemonic square diagram visually represents these function categories and their relationships, aiding students and educators in understanding and applying integration by parts more effectively. This innovation includes digital QR-guided instructional videos, interactivity, and visual clarity, providing significant advantages over traditional textual methods. Studies showed a significant improvement in students' understanding and application of the integration by parts method. Feedback indicated that the tool made the learning process more engaging and interactive, enhancing the socio-educational landscape. This tool has potential for commercialization to educational institutions, online learning platforms, and individual learners.

Keywords: Mnemonic Square Diagram; Integration by Parts; LIATE; Digital Learning Tool

1. INTRODUCTION

Integration by parts is a crucial technique in calculus, particularly for evaluating integrals of product functions. This method essentially reverses the product rule for differentiation and is often necessary when integrating functions that are the product of two or more other functions. As a result, calculus is one of the subjects with high failure rates at the university level (Coronado-Hijón, 2017). Mastery of both integration and differentiation is fundamental for advanced mathematics. Therefore, a strong foundation in mathematical content and memorization skills is essential for successfully applying this knowledge. Without a solid base in basic mathematics, students will struggle with problem-solving (Steve, 2019).

Many students make errors in integration by parts because they find it difficult to remember the technique and lack basic integration and differentiation skills (Maisurah et al., 2015). A poor understanding of basic concepts affects the strategies students use to solve mathematical problems. To assist students, the Digital Mnemonic Square Diagram LIATE Approach was developed. Integration by parts has been extensively studied, with various pedagogical methods designed to facilitate its teaching. Previous research has highlighted the benefits of mnemonic devices in enhancing memory retention and understanding of mathematical concepts (Smith, 2019). Recent studies emphasize the importance of the LIATE rule in simplifying integration by parts. Cuemath (2023) demonstrated that the ILATE rule aids in the systematic selection of functions, which is crucial for solving complex integrals. Texas Tech University (2024) explored both the LIATE method and tabular

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integration by parts, finding that these approaches streamline the integration process, especially for repetitive integrations. The advancement of digital tools has revolutionized educational practices, offering interactive and engaging ways to learn complex topics (Brown, 2018; Green, 2021). However, there is limited research on the use of digital mnemonic diagrams specifically for teaching integration by parts.

The Digital Mnemonic Square Diagram LIATE Approach aims to address this gap by enhancing students' memorization skills and understanding of the integration by parts technique. Technology-assisted self-learning is an effective way to promote independent learning (Weng, 2022). This project evaluates the effectiveness of the diagram in improving students' comprehension and performance and analyzes their perceptions after using the tool. Designed using PowerPoint and featuring a QR code linking to instructional videos and interactive exercises in GeoGebra, this tool visualizes the LIATE rule and the integration by parts process. The goal is to boost the cognitive performance of calculus students, encourage lifelong learning, and support simple and effective self-learning strategies. The implementation for calculus students showed positive feedback and performance improvements.

2. MATERIALS AND METHODS

This study designed the Digital Mnemonic Square Diagram LIATE Approach by converting a traditionally abstract process into an engaging visual tool. The project aims to make the integration by parts technique more accessible, intuitive and manipulate the mnemonic diagram directly. The Digital Mnemonic Square Diagram LIATE Approach makes use of digital technology to improve calculus students' cognitive performance, promote lifelong learning, and assist easy-to-use self-learning techniques. We used this digital tool to monitor the performance and feedback of our calculus students while we implemented this diagram. 25 engineering students enrolled in a Calculus 2 course at Universiti Teknologi MARA (UiTM), Pulau Pinang, were chosen for this study. The study implemented a pre-test and post-test design, with an intervention conducted between the two, in addition to a survey to collect students' feedback.

2.1. Development Process

Development Process

The Digital Mnemonic Square Diagram LIATE Approach is designed to simplify the process of integration by parts. By following a structured development process, this tool enhances students' understanding and application of the integration by parts method. Figure 1 depicts the flowchart outlines five key steps: identifying the integral, using the mnemonic square, following instructional videos, applying the formula, and verifying through interactive exercises.

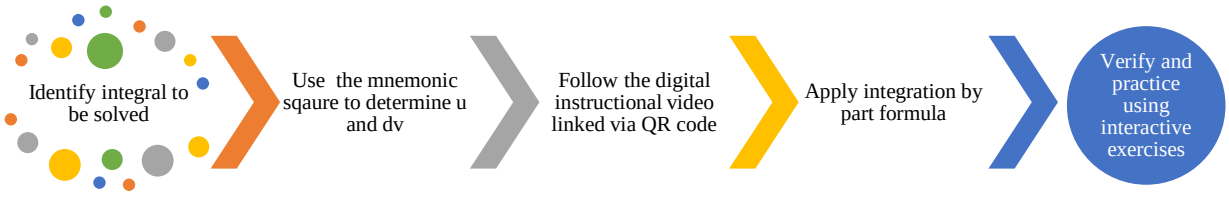

Figure 1. Development Process of The Digital Mnemonic Square Diagram LIATE Approach

To begin, students must identify the integral that needs to be solved. This step involves analyzing the integral and understanding its components. Next, the mnemonic square diagram, based on the LIATE rule (Logarithmic, Inverse Trigonometric, Algebraic, Trigonometric, Exponential), helps in selecting u and dv. By following this hierarchy, students can effectively determine which functions to differentiate and integrate. Students then access a digital instructional video via a QR code. This video provides step-by-step guidance on using the mnemonic

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square and applying the integration by parts method. The visual and interactive elements of the video enhance understanding and make the learning process more engaging.

With u and dv identified, students apply the integration by parts formula: $\int udv = uv - \int vdu$. They substitute the chosen functions into the formula, perform the necessary differentiation and integration, and simplify the resulting integral. Finally, students verify their understanding through interactive exercises provided by the digital tool. These exercises offer instant feedback, allowing students to learn from mistakes and refine their skills. Continuous practice with varied integrals helps students become proficient in using the integration by parts method.

Square Diagram Components

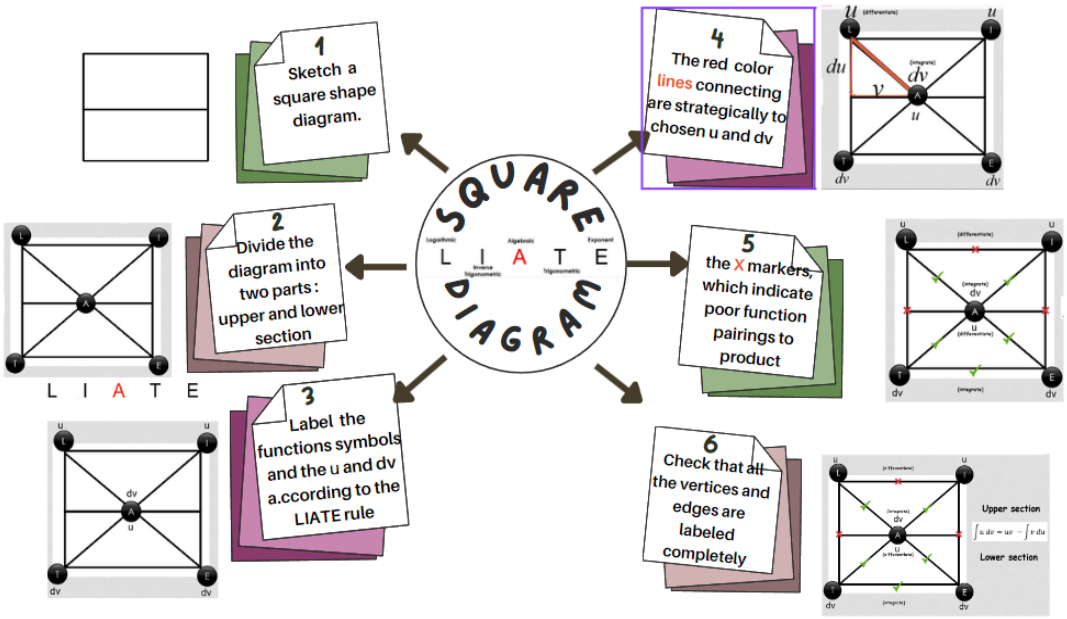

Figure 2. User Manual of the Square-shaped Diagram Development Process

The square shape of the diagram is used to establish basic integration and differentiation relationships as a method to help students remember the technique to solve integration by part more easily. Figure 2 depicts the square-shaped diagram development process. The construction steps of the diagram technique are clearly shown. This diagram includes all the functions, namely L (Logarithmic functions), I (Inverse trigonometric functions), A (Algebraic functions), T (Trigonometric functions) and E (Exponential functions). The mnemonic square diagram is divided into an upper section and a lower section, each representing different types of functions. The diagram includes lines connecting different sections, indicating the proper pairings of u and dv according to the LIATE rule. These pairings are strategically chosen to lead to more straightforward integrals. The diagram also includes X markers, which indicate combinations of u and dv that should not be used together. These markers help avoid overly complicated integrals that can arise from poor function pairings. By highlighting these special cases, the diagram guides students where standard integration by parts needs to be adapted or repeated, and where special techniques may be necessary to achieve a solution.

A Digital Mnemonic Square Diagram LIATE Approach

The Digital Mnemonic Square Diagram LIATE Approach is developed using GeoGebra, an interactive mathematics software. This innovative tool is designed to visualize the LIATE rule and the integration by parts technique, making it easier for students to learn and apply these concepts. As shown in Figure 3, the Digital Mnemonic Square Diagram interface provides a user-friendly platform for mastering this essential calculus technique.

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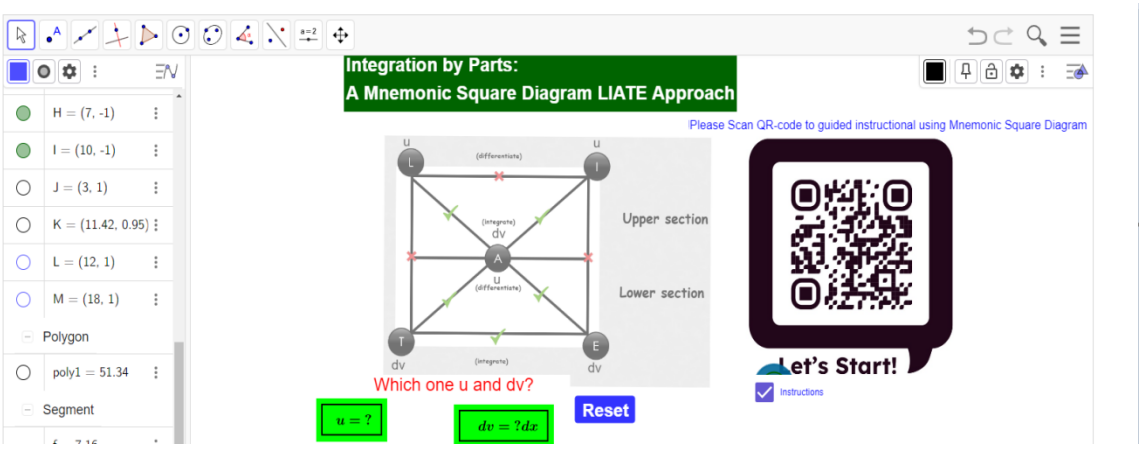

Figure 3. A Digital Mnemonic Square Diagram Interface

Here is a detailed explanation of the functionality of this interactive tool. By visualizing the LIATE rule and providing interactive practice, it supports students in mastering this essential calculus technique. The integrated QR code links to a video tutorial, offering step-by-step instructions for using the tool and applying the integration by parts technique. The GeoGebra tool includes interactive exercises where students can practice integration by parts method. Immediate feedback helps them refine their skills and deepen their understanding. By inputting integrals into the tool, students can see the step-by-step application of the integration by parts formula, enhancing their comprehension of the method. For example, consider a section in GeoGebra where students can input an integral to be evaluated. Once the integral is entered, the tool helps students select u and dv, apply the integration by parts formula and visualize the steps involved in the process. This dynamic visualization, as shown in Figure 4, illustrates how the digital tool simplifies the integration by parts technique using the Mnemonic Square Diagram.

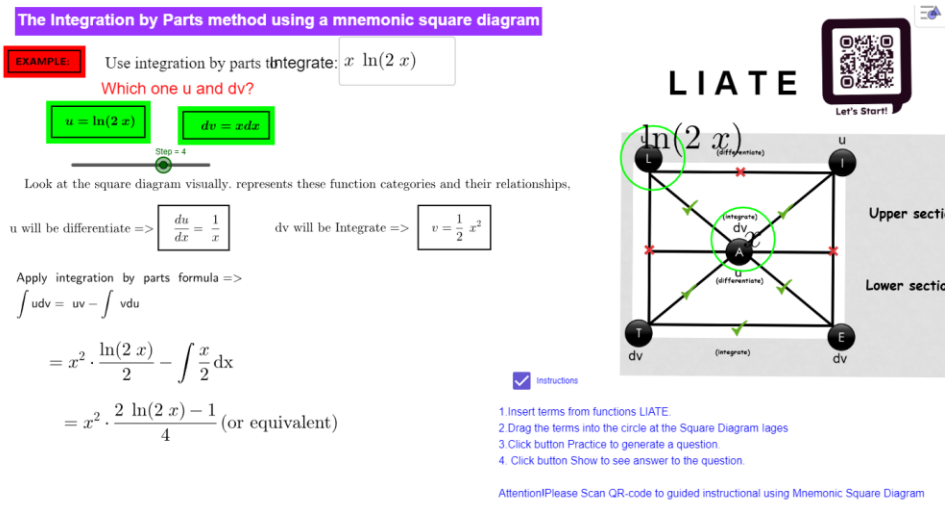

Figure 4. Sample of Screenshot from the GeoGebra Tool showing the Interactive Interface

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3. RESULTS AND DISCUSSION

During the first week, a pre-test consisting of 10 questions on basic integration by parts was developed and administered through Google Forms. All 25 students completed the pre-test to establish their baseline understanding and skills. In the second week, the students were introduced to the Digital Mnemonic Square Diagram through a detailed tutorial session. The features of the digital tool, including the interactive interface, and step-by-step solution guidance, were demonstrated. They were provided with additional integration by parts problems to practice with the tool. In the fourth week, an identical post-test to the pre-test was administered, again through Google Forms. This measured the improvement in students' understanding and skills after using the Digital Mnemonic Square Diagram. Surveys were conducted to evaluate students' satisfaction with digital tools. The pre-test and post-test scores were compared to determine the effectiveness of the digital tool.

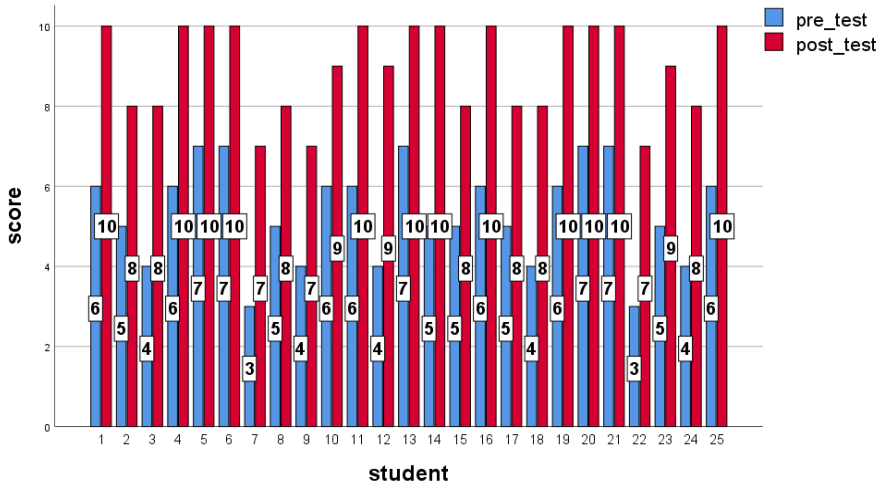

Figure 5. Bar Chart Score of Pre and Post-test

The following bar chart illustrates the pre-test and post-test scores of 25 students on a 10-question exam that was developed to assess the effectiveness of a Digital Mnemonic Square Diagram aid in the instruction of the Integration by Parts method. The digital tool's implementation resulted in a significant improvement in student performance, as evidenced by the blue pre-test scores and the red post-test scores. In contrast to the pre-test, in which no students achieved the maximum score, numerous students achieved faultless scores of 10 in the post-test. This represents a substantial improvement.

This evidence underscores the digital tool's efficacy in improving students' comprehension and application of the Integration by Parts method. The observed increase in scores indicates that the instrument not only enhanced the accessibility of the material but also facilitated a more engaging learning experience. These findings are further supported by positive feedback from students, which suggests that the tool has significant potential for integration into educational contexts to improve learning outcomes.

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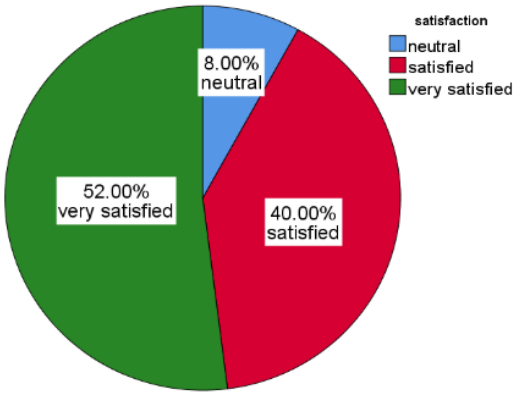

Figure 6. Students' Satisfaction with the Digital Mnemonic Square Diagram

The pie chart illustrates the satisfaction levels of students with the Digital Mnemonic Square Diagram on a scale from 1 to 5. Most respondents, 52%, rated their satisfaction as "very satisfied" (5), while 40% rated it as "satisfied" (4). Only 8% of respondents felt neutral (3) about the tool. No respondents rated their satisfaction as "dissatisfied" (2) or "very dissatisfied" (1), indicating an overall positive reception of the tool. The results of this study are by the previous literature, which emphasizes the efficacy of mnemonic techniques in enhancing mathematical learning. However, the Digital Mnemonic Square Diagram LIATE Approach is unique in that it integrates digital interactivity and visualization, which significantly improves both comprehension and performance in integration by parts. The advantages of visual learning aids in mathematics have been emphasized in previous research, such as those conducted by (Scruggs & Mastropieri, 2000; Fernandes & Speer, 2002).

4. CONCLUSION

This study shows that the Digital Mnemonic Square Diagram LIATE Approach is an effective tool for improving students' understanding and performance in integration by parts. The tool provides a visual and interactive approach that facilitates understanding and memory retention of concepts and increases student interest and interactivity in learning. The educational implications of this study are that using digital tools such as the Digital Mnemonic Square Diagram LIATE Approach can help students better understand complex concepts and improve their academic performance. This tool can also make it easier for lecturers to convey complex concepts, making the teaching and learning process more effective.

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We would like to express our deepest gratitude to the individuals and organizations who have supported this project. Special thanks to our colleagues for their invaluable cooperation and ideas throughout the development of this tool. We also extend our appreciation to the Mathematics Department for providing the necessary resources and facilities. Finally, we are grateful to the students who participated in the testing and provided valuable feedback. Their contributions have been instrumental in refining and improving the tool.

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