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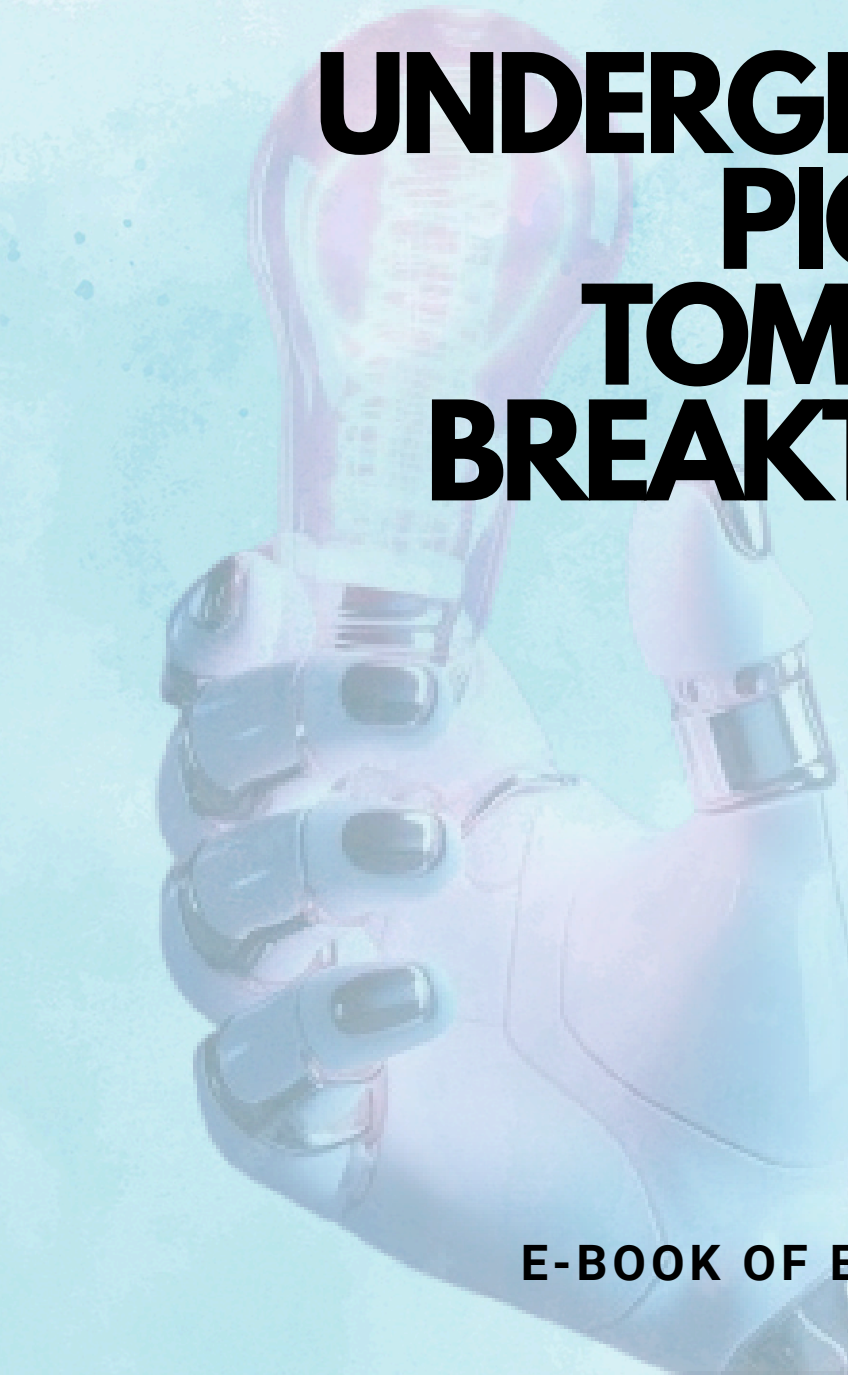
I-URID 2025

INTERNATIONAL UNDERGRADUATE RESEARCH INNOVATION, INVENTION AND DESIGN

UNDERGRADUATES PIONEERING TOMORROW'S BREAKTHROUGH



E-BOOK OF EXTENDED ABSTRACTS

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Universiti Teknologi MARA Cawangan Negeri Sembilan,
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PREFACE

It is with great pleasure that we present this e-book of extended abstracts for the International Undergraduate Research, Innovation, Invention and Design (IURIID) organized by Universiti Teknologi MARA (UiTM) Cawangan Negeri Sembilan. Guided by the theme “Undergraduates Pioneering Tomorrow’s Breakthrough,” this publication reflects the energy, creativity, and determination of undergraduate students who are stepping forward as active contributors to knowledge, innovation, and design. The works showcased here represent a wide spectrum of disciplines and highlight the ability of young scholars to address real-world challenges, propose novel solutions, and demonstrate resilience in the pursuit of meaningful ideas. Each abstract captures not only academic effort but also the spirit of exploration, collaboration, and the courage to move beyond conventional boundaries. This collection further illustrates the importance of nurturing undergraduate research as a foundation for future breakthroughs and as a catalyst for personal and professional growth. We extend our heartfelt appreciation to the students for their dedication, the supervisors and mentors for their invaluable guidance, the reviewers for ensuring quality, and the organizing committee for their commitment in making this event a success. It is our hope that this e-book will serve as an inspiration to readers, encouraging continued innovation and affirming the vital role of undergraduates in pioneering tomorrow’s breakthroughs.

Editors

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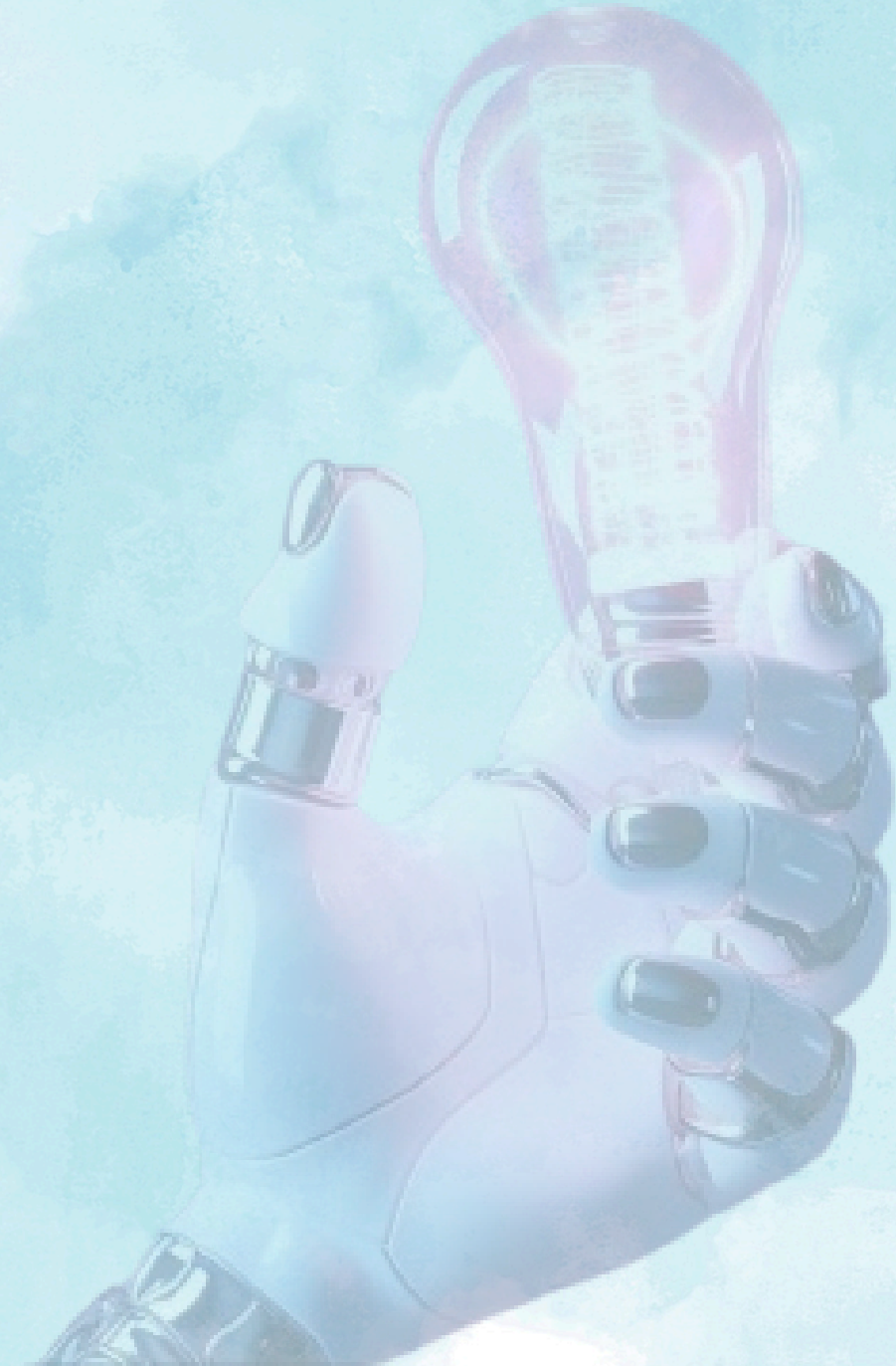

INFLUENCE OF DIFFERENT ANTI-REFLECTIVE COATING ON SILICON SOLAR CELLS IN PVLIGHT HOUSE

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ABSTRACT

Crystalline silicon (c-Si) is the most commonly used material in solar photovoltaics (PV) due to its stability and availability. However, its high surface reflectivity causes significant optical losses, reducing overall solar cell efficiency. This study evaluates the effectiveness of five single-layer anti-reflective coating (ARC) materials (Silicon nitride, Silicon dioxide, Titanium dioxide, Aluminium oxide, and Zinc oxide) applied on planar c-Si surfaces with thickness of 200 μm. Using the Wafer Ray Tracer by PV Lighthouse, optical behavior was simulated, and the maximum photocurrent density (J_{max}) was calculated. Among all tested materials, ZnO achieved the lowest reflection and highest J_{max} of 35.84 mA/cm², representing a 40.05% enhancement from the reference c-Si. The results show that ZnO is the most effective ARC in improving light trapping and enhancing solar cell performance.

Keywords: Crystalline silicon, anti-reflective coating, ray tracing, simulation, solar cell efficiency

INTRODUCTION

The need of clean and renewable energy has become an urgent matter as climate change is become worse and potential limitation of fossil fuels. Solar energy has become an alternative because it is widely available, low environmental impact, and rapid technological improvement (Vadiyala, 2020; Behrani, 2023). Among various solar technologies, crystalline silicon (c-Si) remains the most commonly used material due to its abundance, maturity, and stability in photovoltaic (PV) applications (Wang, 2022). According to the International Energy Agency (IEA, 2024), solar PV are predicted to provide 80% to dominate renewable energy expansion, generating nearly 80% of all renewable energy generation capacity by 2030. This shows the importance in improving solar cell performance in order to meet future energy demands. However, silicon surface actually suffers high reflectivity due to its nature of silicon causing up to 30% of sunlight to be reflected instead of absorbed (Kumaragurubaran & Anandhi, 2014). This optical loss, limit the power output of solar cells. Anti-reflective coatings (ARC) are widely used to tackle optical problem, minimise reflection and improve light trapping. Choosing the best ARC material and configuration is still difficult, despite the fact of numerous materials and coating methods have been researched.

This study uses Wafer Ray Tracer, an advanced ray-tracing modelling tool made by PV Lighthouse, to describe light interacts with c-Si solar cells. Ray-tracing simulations provide a lot of data on light behaves optically, allowing to accurately measure reflection, absorption, and transmission without having to do physical experiments. A few researchers have used ray tracing for evaluation of ARC, which making it a reliable and widely accepted approach. The wafer ray tracer simulator uses a thickness of 200 μm c-Si in order to perform the task of ray tracing in silicon solar cells. Five ARC materials such as Silicon nitride (Si_3N_4), Silicon dioxide (SiO_2), Titanium dioxide (TiO_2), Aluminium oxide (Al_2O_3) and Zinc oxide (ZnO), each with a thickness of 75 μm, applied on a planar surface of c-Si. This analysis of the optical properties of solar cells will involve using the wavelength range that runs between 300 and 1200 nm and the AM1.5G solar spectrum at zero incidence angle.

To determine the optical performance of each ARC, the maximum photocurrent density (J_{max}) is calculated using Equation (1):

$$J_{max} = q \int \quad EQE(\lambda).S(\lambda)\, d\lambda \qquad (1)$$

where q = 1.6 x10^{-19} is the electron charge, EQE is the external quantum efficiency and S(λ) is the standard spectral irradiance of sunlight for AM1.5 G spectrum. The carrier collection is assumed to be one (i.e. internal quantum, IQE = 1).

The J_{max} enhancement (%) is calculated using Equation (2):

$$J_{max}\ \ enhancement\ (\%) = \frac{(J_{max}\ scheme - J_{max}\ ref)}{J_{max}\ ref} \times 100\% \qquad (2)$$

where J_{max} scheme represents the maximum potential of photocurrent density of the light trapping scheme which has to be added to the c-Si substrate while J_{max} ref is refers to photocurrent density of the standard silicon wafer without enhancements.

The simulated values of reflection, photocurrent density (J_{max}), and J_{max} enhancement are analysed to find the most effective ARC material to improve the optical performance of c-Si solar cells.

RESULTS AND DISCUSSION

This part highlights the results obtained from the simulation and numerical analysis of anti-reflective coatings (ARC) for silicon solar cells using Wafer Ray Tracer by PV Lighthouse simulation. The materials ARC used are SiN_4, SiO_2, TiO_2, Al_2O_3, and ZnO, which each Each parameter is written as Scheme I to Scheme V in the graph. A reference c-Si without ARC and planar surface is also presented for comparison. Based on Figure 1 shows among all ARC materials, Scheme V (ZnO) and Scheme I (SiN_4) demonstrated the lowest reflection in the visible range (400–700 nm). ZnO achieved nearly 0% reflectance at 580 nm, while Si_3N_4 reached as low as 0.0028 at 560 nm. This significant reduction is attributed to their optimal refractive index of ZnO (~2.0) and SiN_4 (~2.0)—which act as effective cushion between air (n ≈ 1.0) and silicon (n ≈ 3.5), minimising front-surface light loss (Muhi, 2018; Lai et al., 2020). In contrast, Scheme II (SiO_2) exhibited the highest reflection across the spectrum, with reflection exceeding 30% at many wavelengths due to its lower refractive index (~1.45), resulting in poor optical matching and increased surface reflection (Zahid et al., 2020).

Although absorption and transmission graphs are not shown, the simulation trends indicate that schemes with lower reflection such as ZnO and Si_3N_4 which related with stronger photon absorption in the active solar spectrum (visible range), while higher transmission beyond 960 nm suggests optical losses in the infrared region, where silicon's ability to absorb photons declines (Zambree et al., 2023). These optical behaviours are supported by the calculated photocurrent density (J_{max}) values in Table 1. Scheme V (ZnO) achieves the highest J_{max} of 35.84 mA/cm², representing a 40.05% improvement compared to reference scheme (25.59 mA/cm²). Scheme I (Si_3N_4) follow closely with 39.58% enhancement, while Scheme III (TiO_2) achieves 37.71%. Meanwhile, Scheme II (SiO_2) produces the lowest J_{max} of 20.02 mA/cm², which confirming its inefficiency due to high reflection. Another study by Jamaluddin et al. (2024) also investigates the efficiency of silicon solar cells using various ARC materials and demonstrates a similar trend, where ZnO and SiN_4 show the highest overall performance, with values that are very close to each other. These results confirm the exceptional performance of ZnO as the ideal ARC material, making it the preferred choice for optimizing solar cell efficiency.

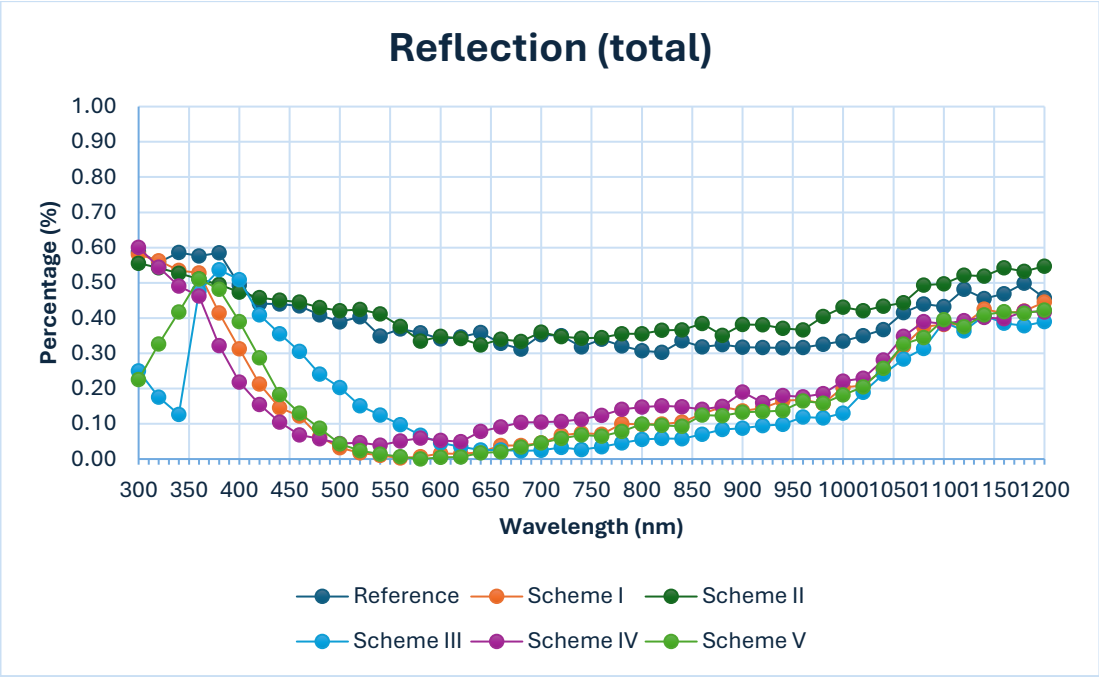

Figure 1: Reflection curve for c-Si with different ARC material on the c-Si solar cell

Table 1: The simulation data of LT Schemes with the J_{max} enhancements

LT Scheme	J_{max} (mA/cm^2)	J_{max} enhancement (%)
Reference c-Si scheme with thickness 200µm	25.59	-
Scheme I: Planar surface Silicon Nitride ARC with thickness of 75 µm	35.72	39.58
Scheme II: Planar surface Silicon Dioxide ARC with thickness of 75 µm	20.02	21.76
Scheme III: Planar surface Titanium Dioxide ARC with thickness of 75 µm	35.24	37.71
Scheme IV: Planar surface Aluminium Oxide ARC with thickness of 75 µm	35.05	36.98
Scheme V: Planar surface Zinc Oxide ARC with thickness of 75 µm	35.84	40.05

CONCLUSION

This study demonstrates that the choice of anti-reflective coating (ARC) material significantly affects the optical performance and photocurrent generation of crystalline silicon (c-Si) solar cells. Among the five materials tested, Zinc Oxide (ZnO) exhibits the best overall performance, achieving the highest J_{max} (35.84 mA/cm²) and lowest reflection in the visible spectrum. Its refractive index provides excellent matching between air and silicon, leading to 40.05% enhancement in photocurrent compared to uncoated silicon. Silicon Nitride (Si_3N_4) closely follows with similarly low reflection and J_{max} enhancement (39.58%), making it another viable ARC option, especially due to its industrial compatibility. Meanwhile, Silicon

Dioxide (SiO_2) showed the poorest performance, highlighting the importance of selecting materials with appropriate optical properties. In conclusion, ZnO is identified as the most effective single-layer ARC material for enhancing light trapping and boosting silicon solar cell performance in this study. These findings can help guide the development of high-efficiency, low-cost photovoltaic devices using numerical ray tracing methods.

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STUDENTS' ACADEMIC PERFORMANCE PREDICTION USING DECISION TREE

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ABSTRACT

Academic performance is a key indicator of both institutional quality and student development. High dropout rates negatively affect the university's reputation, making early identification of at-risk students crucial. While many researchers have developed prediction models for academic performance, but this remains a challenge due to the large number of influencing factors. This makes it harder to identify students at-risk and give them effective support. This study develops an accurate predictive model for students' academic performance using a Decision Tree Classification algorithm. This study begins with the preliminary studies and then continues with the data acquisition, data preprocessing, prediction model development and the web-based prototype development. The best model achieved an accuracy of 90.14% using 10-fold cross-validation with a precision of 90.73%, recall of 90.14%, and specificity of 97.74%. These results show the model's potential to assist educators and administrators in identifying at-risk students and taking timely action to support their academic success.

Keywords: Prediction, Academic Performance, Decision Tree, Classification

INTRODUCTION

Student academic performance is a crucial indicator of both institutional quality and individual development. The students who perform well will graduate, while those who do not, are at risk of dropping out. High dropout rates are major concern for university administration as they can affect the reputation and resource allocation (Roslan et al., 2024). Depending on the study's nature and the higher education provider, dropout rates might be influenced by a variety of factors, including academic performance, health, family, and personal reasons.

Early academic performance prediction is crucial for students, educators and institution. Students who have been denoted to have a bad grade will receive extra session and additional material from the educator (Ouyang, 2024). Educators can identify students who are at risk to do poorly and implement the required interventions to improve the learning process. Furthermore, understanding the factors affecting performance helps in designing strategies to enhance academic outcomes (Karmagatri et al., 2023). The factors which affect the performance of the students could also be discovered through the use of an accurate prediction model. In this manner, the educational institutions will identify the underperforming students early enough to provide support to them (Sagala et al., 2022).

However, predicting students' performance is complex due to the wide range of influencing variables, including psychological traits, educational background, personal characteristics, and demographics. Although various predictive models have been proposed, many fail to account for all relevant factors or lack interpretability. Therefore, this study aims to develop an accurate and interpretable predictive model for student academic performance using the Decision Tree algorithm. Decision Tree is an interpretable and

transparent machine learning approach for classification problems which representing the decision process as a sequence of simple, intuitive rules. Specifically, each node in a decision tree corresponds to a feature and a decision threshold, and the path from the root to a leaf node represents a series of decisions based on the feature values (Mienye and Jere, 2024). It is well known that decision trees are simple to understand. The intuitive structure of decision tree algorithm is based on the tree-like model of decisions, gives clear and active insights and thus is appropriate for prediction and analysing pattern in educational data.

This study intents to produce a prediction of student academic performance model which involves using both historical and current data to project outcomes in the future. Data mining and machine learning techniques have been employed to identify at-risk students and support timely interventions that enhance overall academic success. The prediction model will also help identify the most influential features contributing to student success or underperformance.

RESULTS AND DISCUSSION

The predictive model for students' academic performance was developed using data from the UC Irvine Machine Learning Repository, containing 4,424 student records with 36 features related to demographics, socio-economic status, academic history, and performance in the first two semesters. Using a Decision Tree Algorithm, the model was evaluated using a few metric measurements before the deployment phase. The following presents and discusses the model's performance and key findings derived from the dataset.

Experiments were performed with the goal of obtaining the best model performance using Decision Tree while comparing a model produced using a full attribute and a subset of attributes using feature reduction. In addition, 10-Fold Cross Validation and 5-Fold Cross Validation were tested to get the best model. The performance of the model was evaluated using accuracy, precision, recall and specificity. The table 1 belows show the result of the experiment.

Table 1: Experiment Results Using Different Approaches

Method	K-Fold Cross Validation	Accuracy	Precision	Recall	Specificity
Full Attributes	5 Folds	0. 8873	0.8898	0.8873	0.9532
	10 Folds	0.8895	0.8926	0.8895	0.9576
After Reduct	5 Folds	0.9008	0.9064	0.9008	0.9755
	10 Folds	0.9014	0.9073	0.9014	0.9774

For the full set attributes, the model performed consistently well across all folds and all metrics. 10-fold cross validation shows slightly better performance as compared with 5 folds cross validation with an accuracy of 0.8895 than 0.8873 for 5 folds which indicates the model more reliable due to better generalization. Meanwhile, the precision and recall were balanced, meaning that the model can accurately identify both dropout and graduate performance cases. The specificity metric consistently above 0.95 indicates strong ability to identify students who are not at risk.

Meanwhile, the experiment after reduction process shows the performance improve across all metrics. The accuracy increases over 90% for both 5 folds and 10 folds showing that the model become more efficient and accurate with fewer attributes. The values for precision and recall also increase which indicate consistency in predicting at-risk students. Specificity values increase significantly for both 5 folds and 10 folds which around 0.9774, showing the stronger capability in identifying not at risk students correctly.

From this observation, it shows that feature reduction approaches improve all the result in all metrics which indicated that removing irrelevant features help the model to focus on the most impactful attributes thus enhancing accuracy and model interpretability. Besides that, the models produce from all k-fold techniques are stable because they are not highly sensitive to the splitting technique. The balance between precision and recall is important because it can avoid from both false positive and false negative cases.

After developing the best model using the Decision Tree algorithm, a web-based prototype was created for end users. The website integrates the prediction model, allowing users such as students, educators, and

administrators to make academic performance predictions. Figure 1 below shows the web prototype interface.

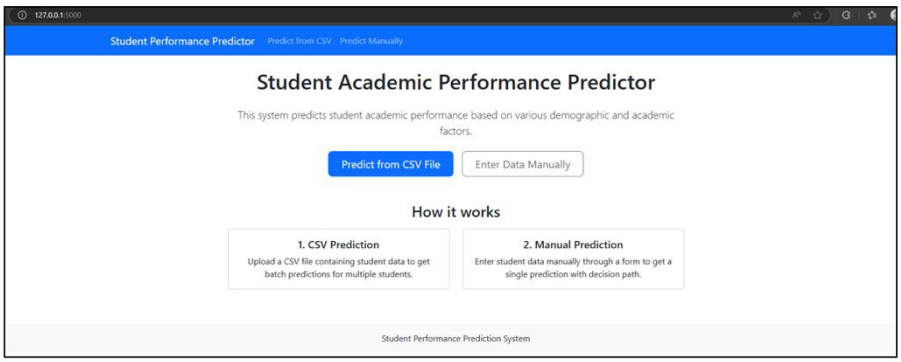

Figure 1: Web Prototype Interface

Users can interact with the Student Academic Performance Predictor system through two simple pathways depending on their specific needs as shown in Figure 1. For educators or administrators who need to analyse multiple students in a cohort, they would click the "Predict from CSV File" button and upload a CSV file with the student demographic and academic information for their class, cohort, or students. For the academic advisors, counsellors, or educators who are gaining insights for a specific student directly in a meeting or advisement session, they can click the "Enter Data Manually" button, which opens a form interface where they enter information sourced from the individual student including their grades, attendance, demographic factors of relevance, and other academic indicators. The single-student result provides not just a single prediction, but a prediction that includes the decision path, helping the user understand the most contributory factors influencing the prediction as shown in Figure 2 belows.

Prediction Result

Predicted Performance: Graduate

Decision Path:

1. "Curricular units 2nd sem (approved)" is greater than 3.00
2. "Tuition fees up to date" is greater than 0.00
3. "Curricular units 2nd sem (approved)" is greater than 4.00
4. "Curricular units 2nd sem (evaluations)" is less than or equal to 9.00
5. "Curricular units 1st sem (credited)" is less than or equal to 8.00

Top Important Features:

Feature	Importance Score
Curricular units 2nd sem (approved)	0.7817
Tuition fees up to date	0.1007
Curricular units 1st sem (enrolled)	0.0491
Curricular units 2nd sem (evaluations)	0.0205
Curricular units 1st sem (approved)	0.0100

Figure 2: Sample Output

CONCLUSION

This study successfully developed a predictive model for students' academic performance using the Decision Tree algorithm. They demonstrated strong predictive capability for academic performance, especially after feature reduction. With an accuracy of 90.14% and high precision, recall, and specificity, it offers a practical and interpretable solution to support educators in monitoring and improving student outcomes in real academic environments and enabling timely interventions.To enhance practical application, a web-based prototype was also developed, integrating the prediction model for use by

students, educators, and administratrors. This system allows users to input relevant student data and receive predictive insights, enabling early intervention and informed decision-making. Overall, the proposed solution not only supports academic monitoring but also contributes to reducing dropout rates and improving student outcomes.

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POTENTIAL OF *SYZYGIUM AROMATICUM* (CLOVE) AS A NATURAL ANTIBACTERIAL AND ANTIOXIDANT REMEDY

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ABSTRACT

Syzygium aromaticum (Clove) is a species of the Myrtaceae family, also known as Cengkih in Malaysia. Chemical compounds in clove have been discovered to have a lot of potential metabolites to cure many diseases and illnesses such as colds, eye sties, bronchitis, sinus conditions, cough and asthma. The research focused on the extraction, phytochemical analysis and bioactivity properties of *S.aromaticum*. The extraction process used different polarity solvents such as petroleum ether, chloroform and methanol. Phytochemical screening was performed using several chemical tests, and the presence of alkaloids, flavonoids, tannins, saponins, steroids and phenols in crude extracts of clove was successfully detected. The antibacterial activity against *Bacillus cereus*, *Staphylococcus aureus*, *Escherichia coli* and *Salmonella typhi* was determined in this study. The methanol crude extracts displayed the highest antibacterial activity against *B. cereus* with an inhibition zone of 12 mm. The antioxidant activity of *S. aromaticum* extract was carried out using the DPPH method. The petroleum ether extract showed strong DPPH radical scavenging activity with an IC_{50} value of 59.59 µg/mL. This study shows that the extracts of *S.aromaticum* contain medicinally bioactive compounds and have the potential as antibacterial and antioxidant agents that may benefit human health.

Keywords: Syzygium aromaticum, Myrtaceae, Phytochemical, Antibacterial, Antioxidant

INTRODUCTION

Natural product is substances that originate from animals, plants and microorganisms. New therapeutic compounds have come from nature due to the tremendous chemical diversity found in various species of plants. Since the beginning of the 20th century, the extraction or powder of medicinal plants has been used as the main active ingredient in medicinal products because they are considered a powerful source of drugs that have no side effects when applied to patients (Brown et al., 2010). *Syzygium aromaticum* is a tropical evergreen plant from the Myrtaceae family that has been commonly used as a spice for human nutrition and a flavouring agent since ancient times. It is also used for treating several illnesses in folk medicine such as colds, eye sties, bronchitis, sinus conditions, cough and asthma (Cortés-Rojas et al., 2014). Clove buds are believed to be an effective antioxidant and antibacterial herbal because they contain the phenolic compounds, eugenol. This compound was reported to be the major constituent present in the clove oil, which is responsible for its biological activity (El-maati et al., 2016). In this study, the phytochemical screening was done on *S.aromaticum* extracts to detect the presence of secondary metabolites and demonstrate their biological activities (antioxidant and antibacterial).

OBJECTIVE

This study aims to extract phytochemicals from the *S.aromaticum* buds using different polarities of solvents such as petroleum ether, chloroform and methanol. Phytochemical screening has been done to identify the presence of phytochemicals from the extracts of *S.aromaticum*. Besides, the antioxidant and antibacterial

activities of *S.aromaticum* extracts were also demonstrated using the DPPH (2,2-diphenyl-1-picrylhydrazyl) and disc diffusion methods, respectively.

METHODOLOGY

Plant Extraction

The buds of *S.aromaticum* were dried and ground into fine powder. It has been weighed and extracted sequentially with petroleum ether, chloroform and methanol. The extracts were filtered through a filter paper and concentrated using a rotary evaporator to obtain the crude extract.

Phytochemical Screening

Chemical tests for the screening and identification of bioactive chemical constituents such as alkaloids, flavonoids, tannins, saponins, steroids and phenols on *S.aromaticum* extracts were carried out by using a standard procedure (Khan et al., 2022).

Antioxidant Assay

DPPH radical scavenging assay was utilised to determine the antioxidant activity of *S.aromaticum* with some modifications (Ghadermazi et al., 2017). Each sample (1.0 mg) was dissolved in methanol (1 mL) to obtain a stock solution with a concentration of 1000 µg/mL. A series of diluted solutions was prepared from the stock solution with methanol starting from 1000, 500, 250, 125, 62.5, 31.3,15.63 and 7.81 µg/mL. The sample solutions with various concentrations (0.2 mL) were mixed with 3.8 mL of methanolic DPPH solution (50 µM). The mixture was incubated for 30 minutes at room temperature in the dark. After 30 minutes, the absorbance of the reaction mixture was recorded at 517 nm.

Antibacterial Assay

The antibacterial activity of the crude extracts of *S.aromaticum* was determined using the disc diffusion method with slight modification (Saikumari et al.,2016). The activity was tested against two Gram-positive bacteria, *B. cereus* and *S.aureus* as well as two Gram-negative bacteria, *E. coli* and *S. typhi.*

RESULTS AND DISCUSSION

Extraction of the sample

The crude extracts of *S.aromaticum* from the extraction process were weighed using an analytical balance. The percentage and yield of each extract were calculated. Table 1 below shows the results of the sample extraction of different solvents. Methanol demonstrated the highest percentage yield at 10.83%, indicating effective extraction of a diverse range of polar compounds. Chloroform exhibited moderate efficiency with a percentage yield of 7.23%, while petroleum ether showed a relatively lower yield of 5.57%, suggesting lower solubility of non-polar compounds in this solvent.

Table 1: Result of sample extraction

Extract	Weight of ground sample (g)	Weight of crude extract (g)	Percentage yield (%)
Petroleum Ether	400.00	22.27	5.57
Chloroform	362.75	26.24	7.23
Methanol	341.59	36.99	10.83

Phytochemical screening of S.aromaticum

S.aromaticum has been reported to contain many active compounds. In this study, phytochemical screening was carried out to detect the presence of secondary metabolites in petroleum ether, chloroform and methanol. Moreover, phytochemical screening confirmed the presence of various bioactive compounds in clove, including alkaloids, flavonoids, saponins, tannins and phenols. These compounds contribute to the potential health benefits associated with clove. Table 2 shows the result of the phytochemical analysis of those extracts.

Table 2: Phytochemical screening of *S.aromaticum*

Test	Crude extract			Observation
	Pet. ether	Chloroform	Methanol	
Alkaloid	-	+	+	Reddish brown
Flavonoid	+	+	+	Light yellow
Phenol	+	+	+	Dark green
Steroid	+	+	+	Red color
Saponin	-	-	+	Frothing
Tannin	-	-	+	Dark Green

Key: presence (+), absence (-)

Antioxidant Activity

The DPPH radical scavenging assay was employed to evaluate the antioxidant properties of *S.aromaticum.* The data on the DPPH radical scavenging activity of petroleum ether, chloroform, and methanol extracts from *S.aromaticum* leaves, along with the standard antioxidant, ascorbic acid, is presented in Table 3. Petroleum ether extract demonstrated strong radical scavenging activity with an IC_{50} value of 59.59 µg/mL. The chloroform extract exhibited significant DPPH radical scavenging activity, with an inhibition rate of 91.47% at 1000 µg/mL with a corresponding IC_{50} value of 66.75 µg/mL. Methanol extract was presented the lowest IC_{50} value in this experiment with 71.70 µg/mL.

Table 3: DPPH radical scavenging of the extract of S.aromaticum

Extract	% Inhibition at 1000µg/mL	IC_{50} (µg/mL)
Petroleum ether	83.88 ± 0.36	59.59 ± 0.58
Chloroform	91.47 ± 0.22	66.75 ± 0.79
Methanol	90.59 ± 0.57	71.70 ± 0.88
Ascorbic acid	97.18 ± 0.02	57.23 ± 0.14

Data present mean ± standard deviation of three replicate experiments.

Antibacterial Activity

The diameter of the inhibition zone for each extract was measured. Table 4 showed the bacterial activity of *S.aromaticum* extract against selected bacteria, with a diameter inhibition in the range of 7.0 to 12.0 mm. The methanol crude extract displayed the highest antibacterial activity against *B. cereus* with an inhibition zone of 12.0 mm compared to other extracts. In contrast, there is no inhibition zone (6.0 mm) observed for the methanol extract against *S.typhi*.

Table 4: Antibacterial activity of S. aromaticum extracts

Extract	Diameter of Inhibition Zone (mm)			
	B. cereus	***S. aureus***	***E. coli***	***S. typhi***
Petroleum ether	9.0	8.0	8.0	7.0
Chloroform	7.0	10.0	8.0	8.0
Methanol	12.0	11.0	11.0	6.0
Streptomycin[a]	20.0	18.0	16.0	15.0

Inhibition zone diameter (mm) including diameter of disc 6 mm; [a]Positive control

CONCLUSION

The phytochemical screening has revealed the presence of various secondary metabolites in *S.aromaticum* extract, including alkaloids, flavonoids, saponins, phenols, tannins, and steroids. An antibacterial study was conducted using the disc diffusion method against *B. cereus*, *S. aureus*, *E. coli* and *S. typhi.* In addition, the result showed that the methanol extract displayed the highest antibacterial activity against *B. cereus* with an inhibition zone of 12 mm. This result was supported by the study of Ajiboye and team (2016). Meanwhile, the antioxidant study revealed that the petroleum ether extract demonstrated strong radical scavenging activity with an IC_{50} value of 59.59 µg/mL, followed by chloroform extract (IC_{50} 66.75 µg/mL)

and methanol extract (IC_{50} 71.70 µg/mL), respectively. The results showed that the extract of *S.aromaticum* has potential as an antibacterial and antioxidant agent for pharmaceutical purposes (Shekhar et al, 2018).

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UniVent: AN AI-ENHANCED SMART PLATFORM FOR UNIVERSITY EVENT MANAGEMENT AND STUDENT ENGAGEMENT

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ABSTRACT

University life involves more than just academic learning. Participating in campus events plays an important role in helping students develop soft skills, expand their networks, and enrich their educational experience. At UiTM Seremban, many students struggle to stay informed about campus events due to scattered announcements, manual registration processes, and a lack of centralized tracking tools. To address these issues, our team created UniVent, a smart platform designed to simplify how students and organizers manage university events. UniVent allows students to explore events, register with ease, receive timely reminders, scan attendance via QR codes, track merit points, and download digital certificates. For organizers, the platform provides tools to create events, manage participants, monitor statistics, and gather feedback through an integrated dashboard. Automated features such as real-time notifications, attendance recording, and certificate generation help save time and reduce paperwork. What makes UniVent unique is its use of artificial intelligence to recommend events based on each student's interests, academic background, and participation history. This personalised approach encourages higher engagement and supports better decision-making for students. By combining multiple event-related functions into one platform, UniVent supports UiTM's digital transformation efforts and promotes sustainable practices in line with Sustainable Development Goals, particularly Goal 4 (Quality Education) and Goal 9 (Innovation and Infrastructure). The system was developed by students to solve real campus challenges and is ready for integration with tools such as iStudent and Google Calendar. UniVent has strong potential to scale across campuses and foster a more connected, active student community.

Keywords: Smart Campus, Event Management System, Student Engagement, Artificial Intelligence, Digital Transformation

INTRODUCTION

Co-curricular involvement is an essential part of student life, helping learners grow beyond academics. However, many students at UiTM Seremban still face challenges in keeping up with university events. Much of this is due to disjointed communication, manual event processes, and the absence of a central system to manage event attendance or achievements. Commonly used platforms like WhatsApp or Telegram are helpful but not ideal for managing structured information. This often causes students to miss important announcements or lose track of event schedules (Zhao, 2024).

When students lack timely access to information or the ability to monitor their own participation, they may miss out on valuable learning experiences (Akour & Alenezi, 2022). On the other hand, organizers also experience difficulties, particularly in handling registrations, tracking attendance, managing payments, and collecting feedback (ELSHAPASY & Mohamed, 2024). These recurring issues prompted the development of UniVent—a student-centered mobile platform aimed at streamlining the way events are promoted, tracked, and experienced on campus. With built-in intelligent features and a clean, user-friendly design, UniVent encourages more active participation and smoother event management.

OBJECTIVE

The main goal of UniVent is to redefine how students and event organisers interact with university programs. It does this by offering a centralized solution that resolves common pain points such as scattered announcements, repetitive registrations, and delayed communication (Seitbatkalova et al., 2023). Rather than asking students to hunt for information or submit repetitive forms, UniVent provides a comprehensive portal listing all events with full details. Whether it's a seminar, sports day, or academic workshop, each listing is updated in real-time and linked to a smooth registration and payment system (Amin & Paiman, 2022). This helps students register with fewer steps and receive instant confirmation.

Another aim is to improve engagement using real-time notifications, reminders, and personalised dashboards. These dashboards allow students to view their past participation, earned merit points, and downloadable certificates. For organizers, the platform offers a dashboard to monitor registrations, view demographic breakdowns, and collect feedback in a structured way. By combining these goals, UniVent aligns with UiTM's push toward digital transformation while also improving the campus experience for all parties involved (Mutizwa et al., 2023).

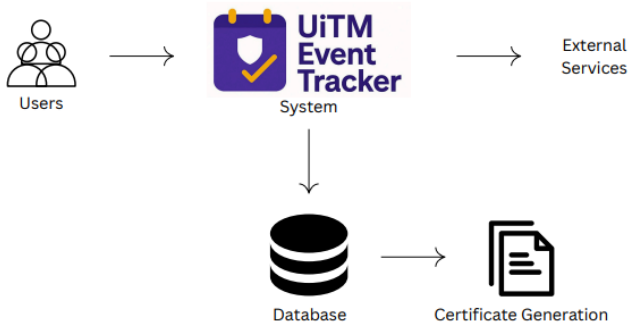

Figure 1: UniVent System Architecture

DESCRIPTION

UniVent is a mobile-first application, built specifically for UiTM students and staff. The interface is designed with simplicity in mind—students can browse upcoming events using filters like event type, faculty, or date, while event pages clearly display key information such as location, time, fees, and benefits (Phuengrod et al., 2023). If payment is required, students can complete it securely using online options and receive immediate confirmation. Push notifications ensure that students stay informed about changes or reminders. One of UniVent's most useful tools is its personal dashboard. This feature helps students track event attendance, merit points, and access downloadable certificates for past events.

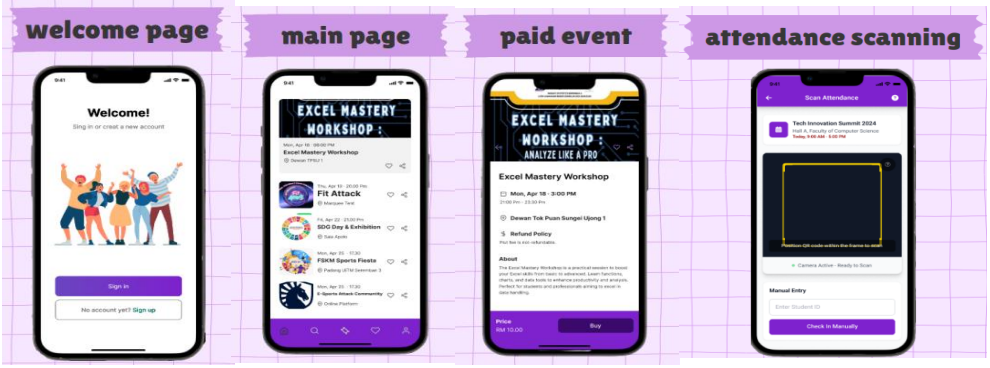

Figure 2: Student Dashboard UI

For event organizers, UniVent offers a back-end dashboard that supports event creation, real-time registration tracking, and automated QR-code-based attendance. Organizers can also upload posters, manage participant limits, and view live analytics. Feedback is gathered through built-in forms and displayed using graphs that summarise participant satisfaction, attendance, and faculty representation. Data is securely stored on the cloud, providing continuous access and protection for both students and staff. All these features are designed to reduce paperwork, streamline communication, and provide better data for decision-making on campus.

Figure 3: Organizer Dashboard Analytics

NOVELTY

What makes UniVent stand out is its ability to bring everything together in one platform. Unlike typical form-based systems or external tools like Eventbrite, UniVent was built from scratch to serve the unique needs of universities. Students no longer have to juggle multiple apps or links just to sign up, pay, check in, and later download certificates (Thinh, 2024). A key innovative feature is the use of artificial intelligence for personalised recommendations. Based on students' faculty, interests, and event history, the system suggests relevant future events. This makes it easier for students to discover meaningful activities and increases the likelihood of participation (Li et al., 2024).

For organisers, automation is at the heart of the platform. QR codes link directly to each student's profile, eliminating manual attendance sheets (Bsisu et al., 2024). Feedback is gathered automatically and presented in simple visual reports. These tools make it easier for faculty and student groups to organize impactful events without getting overwhelmed by logistics. Even more importantly, UniVent is built with scalability in mind. While it was initially developed for UiTM Seremban, the platform can be connected to tools like iStudent or Google Calendar for broader use across other campuses. It supports UiTM's digital transformation roadmap and promotes sustainability by reducing paper usage and manual work. Ultimately, UniVent represents a smart, future-ready system that benefits everyone in the campus community.

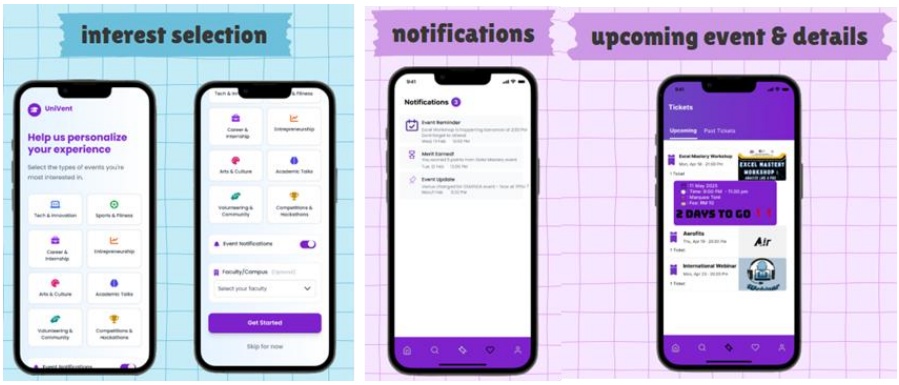

Figure 4: AI for Personalized Recommendations

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COMPACT CAR SELECTION USING ANALYTIC HIERARCHY PROCESS

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ABSTRACT

Malaysian car buyers frequently encounter significant challenges in selecting the optimal compact car, primarily due to the multitude of criteria that demand careful consideration. The effectiveness of this decision-making process hinges critically on the accurate identification and prioritisation of these diverse factors. While Multi-Criteria Decision-Making Methods (MCDM) have been applied in various consumer choice scenarios, no prior research has specifically utilized the Analytic Hierarchy Process (AHP) to address the complex problem of optimal compact car selection. This study bridges this significant methodological gap by proposing and implementing a novel framework for compact car selection using AHP. Key evaluation criteria, including safety, price, fuel efficiency, performance, and brand, were identified as the primary factors influencing buyer preferences. The AHP method, renowned for its ability to structure complex decisions by breaking them down into a hierarchy, was systematically applied to rank four prominent compact car alternatives in the Malaysian market which are Perodua Myvi, Perodua Axia, Proton Iriz, and Honda City Hatchback, based on the established criteria. The findings of this research revealed that the Honda City Hatchback emerged as the most preferred compact car among the evaluated alternatives, demonstrating the robust effectiveness of AHP in solving intricate selection problems within the automotive sector. This pioneering application of AHP provides a valuable, structured approach for consumers and stakeholders in the compact car market. For future research, this AHP framework can be expanded to incorporate additional criteria and a wider range of alternatives, further enhancing its comprehensive decision-making capabilities.

Keywords: Compact car, AHP, Criteria, Alternatives, Multi-Criteria Decision Making, Analytic Hierarchy Process (AHP)

INTRODUCTION

In Malaysia, choosing the right compact car is a significant decision for many people, especially for undergraduates and young graduates (Kowang et al., 2018). However, this choice is difficult due to many similar models available and the need to weigh multiple criteria at once such as price, safety, fuel efficiency and performance (Korhonen et a1., 1992; Luqman et a1., 2015; Abu-Alkeir et al., 2020).

While other Multi Criteria Decision Making (MCDM) methods exist, this study proposes Analytic Hierarchy Process (AHP) by being the first to apply to the specific problem of selecting a compact car brand in Malaysia. The AHP developed by Thomas Saaty in the 1987s, is a powerful tool for making complex decisions. It helps to systematically translate subjective judgments into a quantifiable ranking of alternatives. This study uses the AHP to provide a clear and structured method for consumers to evaluate and select the best compact car brand that aligns with their needs and priorities.

METHODOLOGY

The AHP methodology was applied to determine the most preferred compact car in Malaysia. The methodology involves a clear, step-by-step approach to turn subjective judgments into a quantifiable ranking. First a three-level hierarchical structure was created in which the top level defined the overall goal which is to choose the most preferred compact car. The middle level is five criteria for decision-making which are safety, price, fuel efficiency, performance and brand. These five criteria are considered as the most important criteria as referring to literature. The bottom level listed the four car alternatives being considered are Myvi, Perodua Axia, Proton Iriz and Honda City hatchback. To get expert opinion, a survey was given to eight experts. Using a pairwise comparison method, they were asked to compare each criterion against the others and each car against the others using 1-9 scale to rank their relative importance. The steps in AHP are explained as follows:

Step 1: Construct a pairwise comparison matrix
Then the criterion's scale is calculated using Equation (1), where a is the scale of the first criteria, and b is the scale for the second criteria.

$$P_{ij} = \begin{cases} |a-b|+1 & \text{it is important than y} \\ \dfrac{1}{|a-b|+1} & \text{otherwise} \end{cases} \quad (1)$$

Step 2: Synthesizing the pairwise comparison.
The elements are placed inside the matrix denoted by P according to their degree.

$$P = \begin{bmatrix} 1 & c_{1,2} & \cdots & c_{1,n} \\ \dfrac{1}{c_{1,2}} & \ddots & \cdots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ \dfrac{1}{c_{1,n}} & \dfrac{1}{c_{2,n}} & \cdots & 1 \end{bmatrix}$$

The normalised elements are denoted as P_j where $P_j = \sum_{i=1}^{n} P_{ij}$ and $v_{ij} = \frac{P_{ij}}{P_j}$. The process of normalisation is repeated for every row and column of the elements and placed in a new matrix as N.

$$N = \begin{bmatrix} v_{11} & \cdots & v_{1n} \\ \vdots & \ddots & \vdots \\ v_{1n} & \cdots & v_{nn} \end{bmatrix}$$

Next, the elements within the normalized matrix are summed between the other elements within the same row and it is divided by the number of elements of the matrix. The purpose of this is to find the criteria's weightage which is denoted by W. Criteria with highest weightage value is the most important criteria.

$$W_i = \frac{1}{n}\left(\sum_{i=1}^{n} v_{ij}\right)$$
$$W = [W_1, W_2, W_3, W_4, W_5] \quad (2)$$

Step 3: Perform the consistency matrix
There is one standard way of testing consistency in AHP, which is by calculating the maximum eigenvalue, The consistency matrix is considered valid if: $PW^T = NW^T$, where P is the pairwise comparison matrix and W is the weight vector. The data is considered logically consistent and reliable if the consistency ratio (CR) is less than 0.1. To find consistency ratio, the maximal latent root is denoted by ρ_{max} as Equation (3),

$$\rho_{max} = \frac{1}{n}\sum_{i=1}^{n} \frac{PW_i^T}{W_i}_{max} \quad (3)$$

Consistency indicators, CI by substitutes Equation (4),

$$CI = \frac{\rho_{max} - n}{n-1} \quad (4)$$

The Random Index (RI) is standard value to assess the consistency of judgments in AHP methods. The value of the RI depends on the number of elements being compared, denoted by n. Table 2 shows the standard ratio index.

Table 2: Standard ratio index

n	0	1	2	3	4	5	6	7	8	9	10
RI	0	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

To find the Consistency Ratio (CR), divide the CI by RI as Equation (5). The CR value must be less than 0.1 for the judgments to be considered logically consistent and acceptable.

$$CR = \frac{CI}{RI} \quad (5)$$

Step 4: Step (4-6) are performed for criteria
The construction of pairwise comparison synthesising the pairwise and consistency test are repeated for each criterion.

Step 5: Develop overall priority ranking
The collection of consistency value will be used to develop the overall priority ranking. Weightage of Alternatives:
By using the same pairwise comparison matrix method in order to calculate the weightage of alternatives based on criteria as:

$$\begin{aligned} WA_{c_1} &= \left[WA_{c_{11}}, WA_{c_{12}}, WA_{c_{13}}, WA_{c_{14}}, WA_{c_{15}}\right] \\ &\vdots \\ WA_{c4} &= \left[WA_{c_{41}}, WA_{c_{42}}, WA_{c_{43}}, WA_{c_{44}}, WA_{c_{45}}\right] \end{aligned} \quad (6)$$

The overall priority weight of the alternatives is calculated as:

$$WA_i^T = \sum_{j=1}^{n} W_{c_j} \times WA_{c_i}^T \quad (7)$$

RESULTS AND DISCUSSION

This section presents the findings from the AHP used to determine the most preferred compact car brand. Based on an average pairwise comparison metrices from eight experts, the result shows that Performance was considered the most important criterion, followed by price, fuel efficiency, safety and brand.

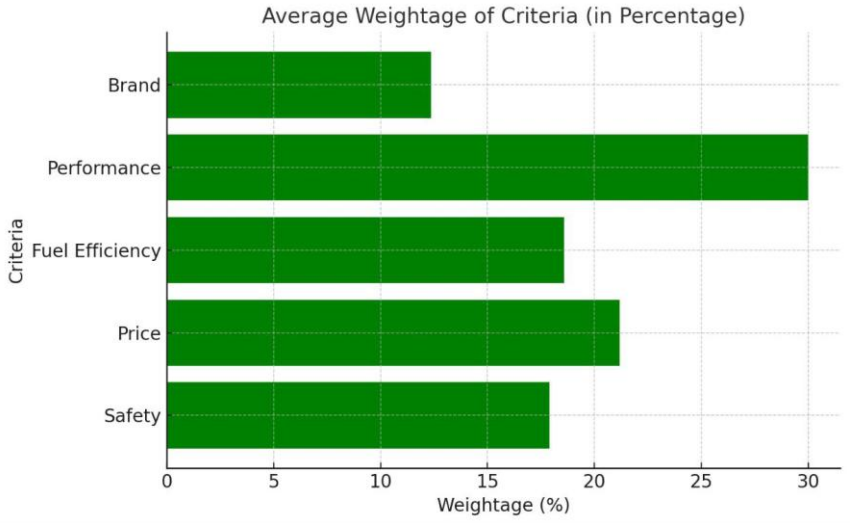

Figure 1: Percentage of Average Weightage of Criteria

Next, each car alternatives were evaluated against these criteria. The overall priority weights were then computed by multiplying the local weight of each car alternatively by the corresponding criterion's weight. The final ranking of the compact cars is presented in Table 3.

Table 3: Final Ranking of Compact Car Alternatives

Alternatives	Average weightage	Rank
Perodua Myvi	0.2436	2
Perodua Axia	0.2387	3
Proton Iriz	0.0853	4
Honda City Hatchback	0.4093	1

Based on Table 3, Honda City Hatchback is the most preferred compact car among the alternatives, with the highest preferences score. This is attributed to its strong performance and favourable ratings across other criteria. The Perodua Myvi and Perodua Axia ranked closely behind, primarily due to their affordability and fuel efficiency, which were highly valued by the experts. In contrast, Proton Iriz was the least preferred option, receiving the lowest score in this study. These findings demonstrate that the AHP is an effective and structured decision-making tool that can assist consumers in making a choice based on multiple criteria. The results also offer valuable insights for car manufacturers and marketers regarding the preferences of Malaysian consumers in the compact car market.

CONCLUSION

This study successfully demonstrates the effectiveness of applying the Analytic Hierarchy Process (AHP) to solve the complex problem of selecting a compact car. While AHP has been used in various fields, this study's key contribution is its pioneering application of this method to the specific preferences of Malaysian consumers in the compact car segment. The final rankings confirmed the model's validity, with the Honda City Hatchback emerging as the most preferred option due to its strong performance and favourable ratings across all criteria. In contrast, the Proton Iriz was identified as the least preferred alternative. The high rankings of the Perodua Myvi and Axia further highlight the importance of affordability and fuel efficiency to consumers. In conclusion, the AHP proved to be an invaluable, structured decision-making tool for consumers facing multi-criteria evaluations. The results also provide car manufacturers and marketers with crucial insights into the key preferences that drive consumer choice in the Malaysian compact car market.

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FORECASTING STOCK PRICES AND EVALUATING PORTFOLIO OF OIL AND GAS COMPANIES IN MALAYSIA: A GEOMETRIC BROWNIAN MOTION MODEL

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ABSTRACT

Forecasting stock prices is crucial in guiding investors, especially in volatile industries such as oil and gas. This study employs the Geometric Brownian Motion (GBM) model to simulate short-term stock price movements of 30 oil and gas companies listed on Bursa Malaysia. The companies were categorised into five portfolios using Altman Z-scores to reflect financial stability. Historical daily closing prices over two months were analysed and forecast accuracy was validated using Mean Absolute Percentage Error (MAPE), Mean Square Error (MSE), and Mean Absolute Deviation (MAD). The results show that Portfolio 5 achieved the highest projected return of 18.01%, making it the most suitable for investment, while Portfolio 1 recorded a negative return of –7.38%. Forecast accuracy validation further revealed that Portfolio 2 produced the most reliable results with the lowest error values, while Portfolio 5, despite its profitability, exhibited weaker accuracy due to the volatility of certain stocks. These findings demonstrate that the GBM model is an effective tool for short-term forecasting and portfolio evaluation, supporting better risk-informed decision-making in Malaysia's oil and gas sector.

Keywords: Geometric Brownian Motion, Stock Forecasting, Portfolio Evaluation, Altman Z-Score, Oil and Gas Sector

INTRODUCTION

The stock market serves as a vital platform for investors to generate returns, however, its inherent volatility poses substantial risks, especially within the Malaysian oil and gas sector, which is highly sensitive to global shocks (Rahim & Liwan, 2024). Due to mitigate these risks, investors rely on effective forecasting and portfolio management strategies (Dai, 2021). While traditional methods like ARIMA and exponential smoothing have been used widely, they are often not great at capturing the random behaviour of volatility stock prices (Mallikarjuna & Rao, 2019).

The Geometric Brownian Motion (GBM) model has become a standard tool in financial mathematics (Abidin & Jaafar, 2012). The GBM model captures both the predictable drift and the random volatility of stock prices, making it very effective for short term forecasting. However, there is a lack of research that applied the GBM model to forecast the collective performance of a portfolio rather than just an individual stocks.

This study addressed this gap by introducing a novel, two step approach, by first using the Altman Z -score to classify 30 oil and gas companies into five portfolios based on their financial stability. Second, applying the GBM model to forecast the future returns for each of these constructed portfolios. This integrated methodology allows this study to evaluate not only which portfolio is likely to yield the highest future

return, but also to analyse the relationship between financially stable portfolios and evaluate both profitability and forecast accuracy.

METHODOLOGY

Daily closing prices of 30 oil and gas companies listed on Bursa Malaysia were collected over a period of two months. Financial ratios required for Altman Z-score calculation were also obtained from company financial statements. The Altman Z-score model was employed to classify the stocks into five groups as portfolio. The Z-score is calculated as follows (Singh & Singla, 2019):

$$Z = 1.2X_1 + 1.4X_2 + 3.3X_3 + 0.6X_4 + 1.0X_5 \quad (1)$$

where X_1 is working capital per total assets, X_2 is retained earnings per total assets, X_3 is EBIT per total assets, X_4 is market value equity per total liabilities, and X_5 is sales per total assets. Stocks were then assigned to five portfolios representing varying levels of financial stability.

For stock price forecasting, the GBM model was applied. GBM assumes that stock prices follow a stochastic differential equation (SDE), where S_t represents the the stock price at time t, μ is the drift rate (expected return), σ is the volatility, and W_t is a Wiener process.

$$dS_t = \mu S_t dt + \sigma S_t dW_t \quad (2)$$

The analytical solution of this SDE is:

$$S_t = S_t \, exp\left(\left(\mu - \frac{1}{2}\sigma^2\right)t + \sigma W_t\right) \quad (3)$$

Forecast accuracy was measured using three error metrics. Mean Absolute Percentage Error (MAPE) was computed as,

$$MAPE = \frac{100}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right| \quad (4)$$

Meanwhile Mean Square Error (MSE) and Mean Absolute Deviation (MAD) were defined as

$$MSE = \frac{1}{n}\sum_{t=1}^{n}(A_t - F_t)^2 \quad (5)$$

$$MAD = \frac{1}{n}\sum_{t=1}^{n}|A_t - F_t| \quad (6)$$

where F_t is the price of a stock at time, t and A_t is actual stock price at time .

RESULTS AND DISCUSSION

The results indicate substantial variation in the performance of the constructed portfolios. Table 1 presents the percentage increment in stock prices as projected by the GBM model. Portfolio 5 achieved the highest return of 18.01%, making it the most attractive for investment, while Portfolio 1 showed a decline of 7.38%, signalling poor performance. Portfolios 2, 3, and 4 displayed stable and moderate growth with gains ranging from 5.02% to 7.22%.

Table 1: Forecast percentage increment of each portfolio based on GBM model.

Portfolio	Sum of Percentage Increment (%)	Remark
1	-7.38	Loss
2	5.07	Profit
3	7.22	Profit
4	5.02	Profit
5	18.01	Best Profit

Forecast accuracy was assessed for all stocks in the portfolios using MAPE, MSE, and MAD. For instance, PETRON achieved a MAPE of 14.05%, an MSE of 0.0285, and a MAD of 0.0295, reflecting reasonably accurate forecasts with some short-term deviations at Table 2. Other stocks in the portfolios displayed similar patterns: more stable stocks had lower error values, indicating higher reliability, whereas stocks experiencing higher volatility showed larger MAPE and MAD values, highlighting less predictable performance. Consequently, portfolios with predominantly stable stocks demonstrated stronger overall forecast accuracy, while portfolios containing more volatile stocks experienced reduced reliability in their predictions.

Table 2: MAPE, MSE, and MAD values for Petron.

ERROR	VALUE
MAPE	0.1405
MSE	0.0285
MAD	0.0295

The comparison between actual and forecasted values for PETRON, shown in Figure 1, offers additional insight into the performance of the GBM model. Over the two-week horizon, the model closely tracked actual prices, demonstrating its effectiveness in capturing short-term dynamics. However, deviations became more noticeable over longer horizons, indicating that GBM is better suited for short-term forecasting, particularly in highly volatile sectors like oil and gas.

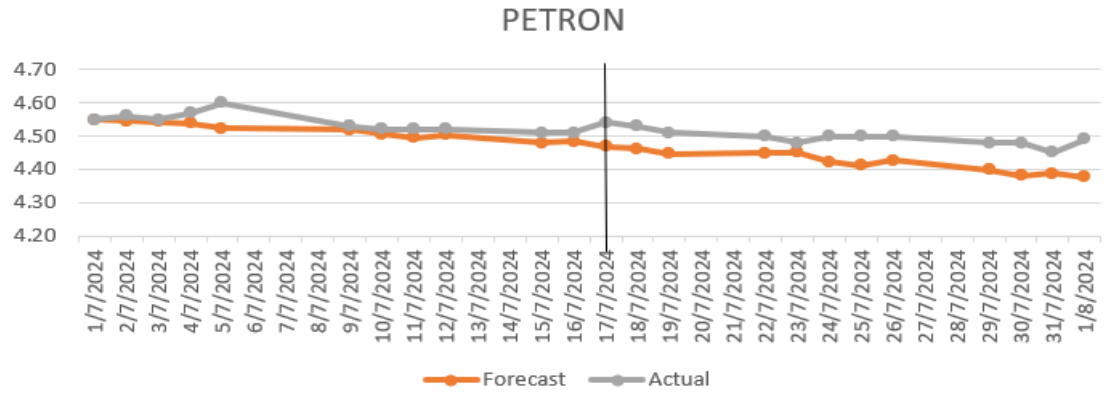

Figure 1: Actual vs. forecast stock prices for PETRON using the GBM model.

Collectively, these findings reveal a trade-off between profitability and accuracy. While Portfolio 5 offered the highest returns, it was also characterised by high volatility. In contrast, Portfolio 2 demonstrated strong accuracy, indicating that investors seeking reliability should prioritise financially stable firms, even if the expected returns are modest.

CONCLUSION

This study successfully demonstrates a novel approach to portfolio evaluation by integrating the Geometric Brownian Motion (GBM) model with the Altman Z-score. While the GBM is standard tool for forecasting individual stock prices, this study uniquely applies it to group of stocks and evaluates the results based on predefined financial stability in which this method is not explored in previous studies. The findings show

that the GBM model is a reliable approach for short-term stock price forecasting and portfolio evaluation in Malaysia's oil and gas sector. Portfolio 5, emerged as the most profitable, while Portfolio 2 was the most accurate. This demonstrates that investors should consider both potential returns and forecast reliability when making decision, particularly in volatile sectors like oil and gas. These results suggest that investors should balance profitability with forecast reliability. Future research, it is recommended to compare the performance of the GBM model with other forecasting tools to improve robustness.

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PERFORMANCE EVALUATION OF BANKS IN MALAYSIA USING INTEGRATED ENTROPY-FUZZY VIKOR MODEL

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ABSTRACT

Evaluating bank performance is crucial for identifying institutional strengths and weaknesses, and for safeguarding the stability of the national economy, given the banking sector's central role in monetary affairs. While various multi-criteria decision-making (MCDM) methods have been employed for this purpose, no prior research has utilised the integrated Entropy and Fuzzy VIKOR methods to assess bank performance. This study addresses this significant methodological gap by proposing and applying this novel combination to evaluate selected Malaysian banks. To overcome challenges related to the diverse nature of financial indicators and inherent data uncertainties, a comprehensive set of liquidity and profitability ratios were first selected through a meta-analysis of past research. Subsequently, the integrated MCDM approach was applied in which the entropy method objectively determined criteria weights, assigning higher importance to indicators with lower entropy, while the Fuzzy VIKOR method addressed data imprecision and ranked banks based on their performance scores. A case study was conducted on nine major Malaysian banks over a five-year period, with financial data collected via the Eikon Refinitiv DataStream application. The findings reveal notable differences in bank performance, with some consistently demonstrating higher profitability and lower liquidity compared to others. Specifically, the highest-ranked banks exhibited the lowest VIKOR indices (Q_i), while the lowest-ranked banks had the highest Q_i values. This pioneering study provides insightful information for stakeholders, including investors, regulators, and bank management, facilitating more informed strategic decision-making and fostering continuous development within the Malaysian banking industry.

Keywords: Bank Performance, Entropy Method, Fuzzy VIKOR, Multi-Criteria Decision-Making, Malaysian Banks

INTRODUCTION

The banking sector has undergone significant transformations due to globalisation and technology that allowing institutions to provide good quality services without opening new physical entities (Uwuigbe & Fakile, 2012). Increasing competitive, evaluating bank performance have become essential for ensuring efficiency, productivity and profitability while minimising risks to stakeholders (Aduba, 2022). This evaluation is often conducted using profitability, liquidity and leverage such as Return on Equity (ROE), Return on Assets (ROA), Current Ratio (CR), Debt-to-Equity ratio (DER), and Debt-to-Asset ratio (DAR) (Abdel-Basset et al., 2020). Managing liquidity is essential critical, as its deficiency can negatively impact profitability and overall financial health of a bank (Hasmiana et al., 2022).

To enhance decision-making process, various Multi-Criteria Decision-Making (MCDM) methods, including BWM-TOPSIS and the Fuzzy AHP, along with integrated fuzzy-based methods have been employed (Aziz et al., 2023; Nguyen, 2021; Taylan et al., 2021). However, a notable gap in existing research is the limited application of Entropy and Fuzzy VIKOR for measuring bank performance. This study addresses this gap by proposing a novel Entropy Fuzzy VIKOR approach to evaluate Malaysian

banks. This integrated method provides a unique and powerful way to assess performance by first determining the objectives weights of financial criteria using Entropy method and then ranking the banks using the fuzzy VIKOR approach.

METHODOLOGY

This study uses a unique Entropy Fuzzy VIKOR approach to evaluate the performance of Malaysian banks. First, a decision matrix $D = [x_{ij}]$ is built with banks as alternatives (i) and financial ratios as criteria (j) (Chen et al., 2022). This matrix is then converted into a fuzzy decision matrix where (L_{ij}, M_{ij}, U_{ij}), represented by Triangular Fuzzy Number (TFN). The TFN has three values where, L_{ij}, M_{ij} and U_{ij} as low, an average and a high value respectively, which helps handle the uncertainty in the data (Shapiro & Koissi, 2017). The decision matrix is as follows:

$$D = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix}$$

The fuzzy decision matrix is normalised using the Min-max normalisation method, $D \rightarrow [0,1]$ which the value is between 0 to 1 (Rodrigues & Agra, 2022). After normalization, the fuzzy numbers are converted back into a single value through defuzzification using method of Mean-max membership as Equation (1), where $x_k = a_{ij} + b_{ij} + c_{ij}$, and n is a number of triangular fuzzy number.

$$\tilde{x}_{ij} = \frac{\sum_n^{k=1} x_k}{n} \tag{1}$$

The proportion value of alternatives under criteria n, p_{ij} as Equation (2), where $i = 1,2,\cdots,m$ and $j = 1,2,\cdots,n$.

$$p_{ij} = \frac{\tilde{x}_{ij}}{\sum_{i=1}^{m} \tilde{x}_{ij}} \tag{2}$$

The entropy value e_j for each criterion n is used to objectively determine the weight of each financial indicators where the constant of k, $k = \frac{1}{lnln\,(m)}$, ensures that the entropy values are between 0 and 1 (Lam et al. 2021) calculated using Equation (3).

$$e_j = -k \sum_{i=1}^{m} p_{ij} \cdot ln(p_{ij}) \tag{3}$$

The weight of the financial indicators, w_j, using the entropy approach as Equation (4) where $d_j = 1 - e_j$.

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j}$$

Then, $x_{ij} \times w_j$ and produce the decision matrix criterion with respect to alternatives.

$$F = \begin{bmatrix} f_{11} & \cdots & f_{1n} \\ \vdots & \ddots & \vdots \\ f_{m1} & \cdots & f_{mn} \end{bmatrix}$$

The best f_j^+ and worst f_j^- values for each criterion are determined. Next two key indices are calculated for each bank which are the utility (S_i) using Equation (4),

$$S_i = \sum_{j=1}^{n} \frac{w_j(f_j^+ - f_{ij})}{f_j^+ - f_j^-} \tag{4}$$

and Regret (R_i) using Equation (5),

$$R_i = max\left(\frac{w_j(f_j^+ - f_{ij})}{f_j^+ - f_j^-}\right) \tag{5}$$

which S_i represents the maximum group utility and R_i indicates the individual regret. Finally, the VIKOR index (Q_i) is computed. This index represents a compromise and is used to rank the banks from best to worst, where v denotes the strategy of maximum group utility weight, while $1 - v$ signifies the individual regret weight using $v = 0.5$ following Lam et al., (2021). The Q_i is as Equation (6), where $S^+ = (S_i)$, $S^- = (S_i)$, $R^+ = (R_i)$ and $R^- = (R_i)$.

$$Q_i = v\left(\frac{S_i - S^+}{S^- - S^+}\right) + (1 - v)\left(\frac{R_i - R^+}{R^- - R^+}\right) \tag{6}$$

RESULTS AND DISCUSSION

In this study, a literature was conducted to identify the most suitable financial measures for estimating a bank's performance from the period of 2019 to 2023. This led to the selecting of five key financial indicator which are ROE, ROA, DER, DAR, and CR. To achieve the research objective, the banks's performance was evaluated using an Integrated Entropy Fuzzy VIKOR model. This method reduces bias and eliminates uninformed human judgment, ensuring the final decision is based on solid inputs underlie decision-making. The final weights of each indicator are shown in Figure 1.

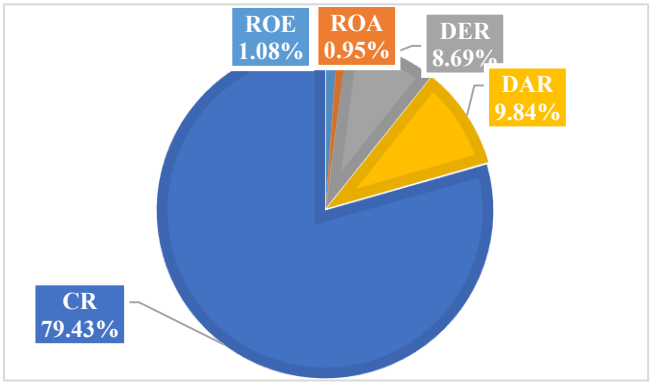

Figure 1: The Weightage of the Importance of Criteria

The analysis shows that CR holds the highest weight at 0.7943, making it the most significant factor in assessing banks' ability to manage its short-term debts and build stakeholder trust. The DAR and DER follow as the next most important criteria, with weights of 0.0984 and 0.0869 respectively. In contrast,

ROA and ROE are found to be the least influential factors, with weights of 0.0095 and 0.0108. The VIKOR index (Q_i), which derived from Utility (S_{ij}) and Regret (R_{ij}) values, is then used to rank the banks. As shown in Table 1, the bank with the smallest Q_i value is considered the closest to the ideal solution, making it the preferred choice.

Based on Table 1, Hong Leong Bank is the most preferred bank with lowest Q_i of 0.0000. Ammb Bank Holding follows with a Q_i of 0.5560, and Malayan Banking is next with 0.6577. Affin Bank Berhad has the lowest rank with a $Q_i$value of 0.9977, which suggests it has the poorest overall performance and is the farthest from the ideal bank.

Table 1 Rank and Q_iValue for Each Alternative

Banks	**Vikor indices Q_i**	**Rank**
Hong Leong Bank	0.0000	1
Bank Islam Malaysia	0.8825	5
Cimb Group Holdings	0.9353	6
Malayan Banking	0.6577	3
Public Bank	0.7319	4
Rhb Bank Bhd	0.9354	7
Affin Bank	0.9977	9
Ammb Holdings	0.5560	2
Alliance Bank Malaysia	0.9508	8

CONCLUSION

This study successfully identified and applied a set of pertinent financial measures used to gauge the performance of banks, with the current ratio (CR), the return on equity (ROE), the return on assets (ROA), debt to equity ratio (DER), and debt to asset ratio (DAR) as a few of the standards to consider. The study achieved its objectives by using the Integrating Entropy-Fuzzy VIKOR model. Objective weights were first determined using the Entropy method to eliminated bias and the fuzzy VIKOR model was then used to rank the banks based on their overall performance. The results clearly showed that Hong Leong Bank was the top-ranked bank, followed by AMMB Holdings, Malayan Banking, Public Bank, and finally Bank Islam Malaysia. The model's effectiveness was confirmed by the lower rankings of the other banks in the comparison. In conclusion, the Integrated Entropy-Fuzzy VIKOR model has proven to be a valid and effective tool for assessing and comparing the performance of Malaysian banks.

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TRANSPORTRIX-SHIPMENT MANAGEMENT SYSTEM

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ABSTRACT

Transportrix is a web-based shipment application system that facilitates Sustainable Development Goal (SDG) 9, which advocates for resilient infrastructure, promotes inclusive and sustainable industrialisation, and fosters innovation. This system will enhance the existing manual shipping management system of MSF Maju Global. The manual method utilises WhatsApp applications to manage customer shipment orders and assign lorry drivers. This will result in human errors, including order inaccuracies, duplicate driver signings, and delays. This product employs the waterfall development technique, which comprises five phases: requirements, design, implementation, verification, and maintenance. The functions provided by Transportrix are: 1) enable customers to place shipment orders online, 2) administrators can view and update the order's status, 3) assign a lorry driver and truck to fulfil the shipment, and 4) generate reports. This program is a highly beneficial solution that will enhance the company's efficiency by conserving management time and resources through streamlined planning, execution, and tracking of shipment orders.

Keywords: Web-Based Application, Shipment Management System

INTRODUCTION

The growth of logistics and transportation management corresponds with Sustainable Development Goal (SDG) 9: Industry, Innovation, and Infrastructure. This target underscores the development of resilient infrastructure, the advancement of sustainable industrialisation, and the encouragement of innovation (United Nations, 2015). In a more digital business environment, firms like MSF Maju Global must implement digital shipping management systems to maintain competitiveness and improve operational efficiency. These technologies modernise infrastructure, augment industrial capacity, and guarantee dependable delivery services by automating processes and diminishing reliance on outdated human methods. This clearly corresponds with the goals of SDG 9.

Presently, MSF Maju Global uses a manual system utilising the WhatsApp application to receive customer shipment requests and allocate lorry drivers. This method is readily accessible; nonetheless, it is susceptible to errors and operational inefficiencies. Common issues include incorrect order details, reassigning drivers to the same task, and delivery delays, all of which diminish service quality and client satisfaction. This deficient communication system hinders the organization's growth by impairing its capacity to manage additional orders and address logistical challenges. These issues underscore the necessity of a structured and automated approach that mitigates risks and ensures seamless operations.

The concept for the Transportrix Shipment Management System was inspired by the success of Lalamove, a logistics platform that employs technology to allocate drivers and monitor orders in real time, revolutionising last-mile delivery (Lalamove, 2021). Transportrix employs automation and intuitive interfaces to enhance freight management for MSF Maju Global, grounded in these innovative concepts. The project employs the Waterfall development model, a recognised methodology wherein system requirements, design, implementation, testing, and deployment are executed sequentially (Balaji, S., & Murugaiyan, 2012). This ensures that the development process is structured and methodical. This strategy ensures clarity in developmental stages and minimises errors by delineating deliverables.

The Transportrix Shipment Management System has four primary objectives: (i) to automate the acquisition of shipment orders from customers, (ii) to facilitate the assignment of lorry drivers and trucks, (iii) to provide users with a straightforward method for real-time shipment status tracking, and (iv) to expedite the processing of shipment orders. Transportrix aims to deliver a comprehensive solution that addresses the operational requirements of MSF Maju Global by rectifying the deficiencies of the manual system and implementing optimal practices in digital logistics. Ultimately, the process facilitates the generation of innovative concepts for businesses while ensuring that shipping is executed promptly, precisely, and to the satisfaction of the consumer.

RESULTS AND DISCUSSION

This system has three levels of users, which are Administrator, Driver and Customer. The section below will be discussed based on the user's type.

Administrator

Figure 1 shows the main page for Administrator as the highest level of user. The administrator is allowed to add, update, delete and view information of the administrators, truck drivers, orders, shipments and trucks. And also, can print the receipt for each order.

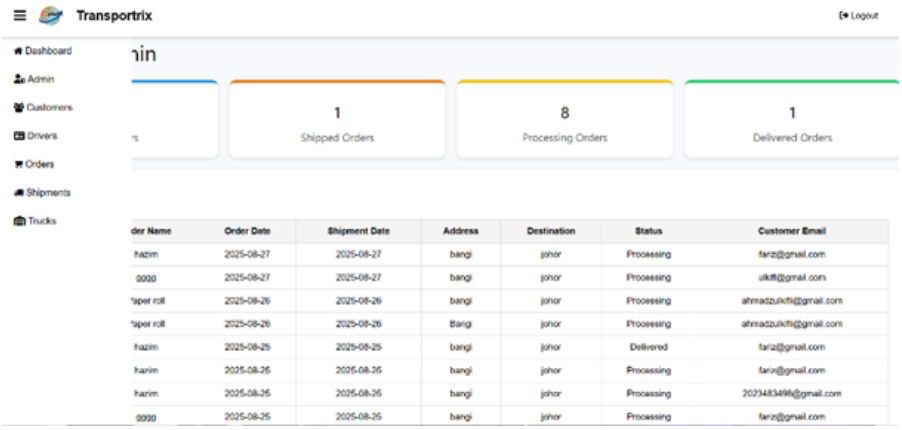

Figure 1: Main Page for Administrator

Figure 2 shows the page to update the truck driver's details when the administrator chooses the driver tab.

Figure 2: User interface – update the truck driver's details

As mentioned earlier, the administrator is allowed to assign the driver for the shipment order. Figure 3 shows the page to add a new shipment order for the driver. The administrator should insert the customer and order details, and also which truck driver is assigned to accomplish the task.

Figure 3: User interface – add new shipment order

Driver

Then, the second level of user is the driver. Figure 4 shows the main page for the driver. The driver is allowed to update and view the shipment order assigned to the driver, and can also update their availability, either available or not.

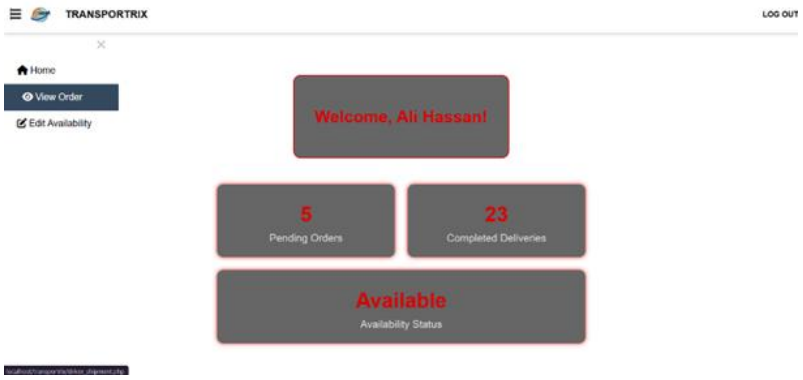

Figure 4: Main Page for Drivers

Figure 5 shows the order page assigned to the driver. This page will display after the driver chooses the View Order button.

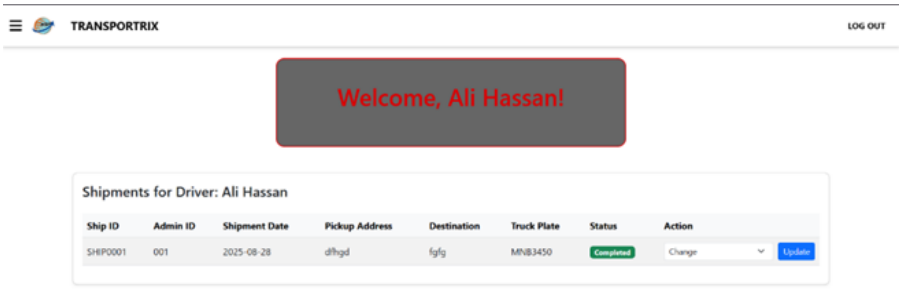

Figure 5: Order Page for Drivers

Customer

Figure 6 shows the main page for the customer. The customer is allowed to: 1) create and view an order, 2) update the customer's profile, 3) view About Us (details of the founder), and 4) view Contact Us (details to contact MSF Maju Global).

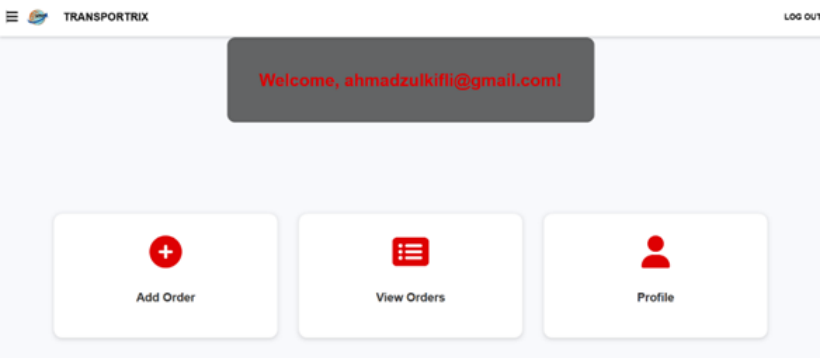

Figure 6: Main Page for Customer

This system provides advantages to both the firm personnel and the clients in comparison to the manual system. However, for future enhancements, the system might be developed as a mobile application. This is due to the system's enhanced accessibility. Ultimately, everyone today possesses a cell phone for communication purposes.

CONCLUSION

The development of the Transportrix Shipment Management System signifies a notable improvement in overcoming the operational constraints of conventional manual logistics methods. The implementation of a structured web-based platform improves accuracy, decreases redundancy in driver assignments, and mitigates delays that previously compromised service quality. The application's primary functions—order placing, driver and vehicle allocation, real-time status updates, and receipt generation—enhance logistics management by increasing openness and accountability. In accordance with Sustainable Development Goal (SDG) 9, Transportrix enhances resilient infrastructure and sustainable industrialisation by implementing digital innovations that improve organisational efficiency and customer happiness.

Moreover, the initiative demonstrates the potential for scalability and enduring significance within the logistics industry. Future improvements, including mobile application development, may enhance accessibility for consumers and drivers, promoting a more responsive and user-focused service. The technology offers MSF Maju Global rapid operational enhancements and equips the company to respond to evolving industry trends influenced by digital transformation. Transportrix exemplifies how technology innovation in shipping management may yield sustainable solutions, improve competitiveness, and facilitate overarching goals of digital industrial progress.

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PERFUME PREFERENCES BY GENDER: COMPARATIVE ANALYSIS OF PURCHASE FREQUENCY, AVERAGE SPENDING AND PURCHASING DECISIONS

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ABSTRACT

This study aims to determine whether there is a significant association between gender on perfume preferences, focusing on purchase frequency, average spending, and purchasing decisions between local and international brands in Petaling District, Malaysia. Despite the growing competition in the perfume industry, gender-based studies in consumer behavior remain underexplored. A structured online survey was conducted, collecting data from 485 respondents aged 18 to 40. Using chi-square tests of independence and crosstabulation, the results revealed that gender significantly associates with purchasing decisions when it comes to choosing local or international brands. In purchasing decisions, females gravitate toward international brands, while males show a preference for local brands, influenced by price sensitivity. However, no significant associations between gender were found in purchase frequency and average spending. These findings highlight the role of gender in shaping perfume choices and offer practical implications for both local and international brands to tailor their marketing strategies to appeal to gender-specific preferences.

Keywords: Average Spending, Gender, Local vs International Brands, Perfume Preferences, Purchase Frequency, Purchasing Decisions

INTRODUCTION

The perfume industry today represents more than just a marketplace for fragrances; it embodies individuality, lifestyle, and social identity. Consumer preferences are shaped by cultural values, psychological motivations, and social expectations, with gender emerging as one of the most influential factors in purchasing behavior. In Malaysia, religious values and cultural norms strongly influence consumption patterns (Yusoff, 2019). However, the ways in which men and women interact with perfume products remain relatively underexplored.

Perfume is often perceived as an extension of self-expression, where purchasing decisions are influenced not only by personal preference but also by gender roles, social image, and brand perception. Previous studies suggest that factors such as perceived value, personal motivation, and habitual behavior significantly affect consumer loyalty and brand selection (Abror et al., 2023). Despite the global growth of the perfume industry, limited research has examined gender-based differences in consumer behavior within the Malaysian context.

Recognizing these gender-specific dynamics is vital for brands aiming to connect meaningfully with local consumers. Research has shown that demographic variables frequently reveal distinct behavioral patterns (Januri et al., 2017), providing marketers with valuable insights to anticipate trends and refine strategies. In this light, the present study focuses on the Petaling District, analyzing gender associations with spending behavior, purchasing decisions between local and international brands, and overall engagement with perfumes. Specifically, this study aims to determine whether there is a significant association between

gender and perfume preferences, focusing on purchase frequency, average spending, and purchasing decisions between local and international brands.

METHODOLOGY

This study employed a quantitative cross-sectional design to investigate gender-based associations in purchase frequency, average spending, and purchasing decisions between local and international brands in Petaling District, Malaysia. The sample consisted of 485 respondents aged 18–40, selected using convenience sampling. Participants were approached in urban locations like shopping malls and retail outlets within the Petaling District.

Data collection was conducted using a self-administered online questionnaire distributed via Google Forms, consisting of multiple-choice questions on demographic details, purchase frequency, average spending, and purchasing decisions. The survey allowed for efficient data gathering and a broad representation of the target demographic.

Statistical analysis was performed using Chi-square tests of independence and crosstabulation to examine the relationships between gender and the variables of interest: purchase frequency, average spending, and purchasing decisions. The test is suitable for analysing categorical data and determining statistically significant differences in the distribution of responses between genders. According to Rana & Singhal (2015), the chi-square statistic is calculated as;

$$\chi^2 = \Sigma \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \quad (1)$$

where O_{ij} denotes the observed frequency and E_{ij} denotes the expected frequency. If the p-value is less than 0.05, the null hypothesis is rejected, indicating that there is enough evidence of a significant association between gender and perfume preferences and vice versa. In addition, crosstabulation was used to present the frequency distribution of responses across categories, offering a visual understanding of gender differences in perfume preferences and spending behavior (Rana & Singhal, 2015).

RESULTS AND DISCUSSION

Demographic Information

The demographic profile of respondents is summarized in Table 1. The total number of valid respondents was 485.

Table 1: Summary of Demographic Information

Variable	Category	Frequency	Percentage
Gender	Male	190	39.2
	Female	295	60.8
Age	18-24 years old	155	32.0
	25-31 years old	168	34.6
	32-39 years old	162	33.4
Income Level	Below RM 2,000	161	33.2
	RM 2,000 - RM 5,000	165	34.0
	RM 5,001 - RM 10,000	116	23.9
	Above RM 10,000	43	8.9

Frequency of Perfume Purchases by Gender

The crosstabulation results showed a gender difference in purchase frequency. The distribution of responses is presented in Table 2. Since the chi-square test yielded a non-significant result (p-value = 0.934 > 0.05), the null hypothesis failed to be rejected, indicating no statistically significant association between gender and purchase frequency. Gender did not significantly impact the frequency of perfume purchases, with both

male and female consumers reporting similar purchasing patterns. Most respondents bought perfume every three months, suggesting a regular cycle influenced by usage rate and budget availability. This indicates that perfume purchasing behavior is largely influenced by personal habits rather than gender-specific tendencies. For local brands, aligning promotional campaigns with quarterly buying cycles could help target consumers during high-repurchase periods, improving sales and relevance.

Table 2: Crosstabulation between Gender and Purchase Frequency

Purchase Frequency		Rarely	Once a Year	Every 6 Months	Every 3 Months	Once a Month	Total
Gender	Male	22	39	42	54	33	190
		11.6%	20.5%	22.1%	28.4%	17.4%	
	Female	39	60	70	82	44	295
		13.2%	20.3%	23.7%	27.8%	14.9%	
Total		61	99	112	136	77	485
		12.6%	20.4%	23.1%	28.0%	15.9%	

Average Spending on a Perfume Bottle by Gender

The distribution of average spending on a perfume by gender is shown in Table 3 below:

Table 3: Crosstabulation between Gender and Average Spending

Average Spending		Below RM50	RM50 - RM150	RM151 - RM300	RM301 - RM500	Above RM500	Total
Gender	Male	21	50	43	50	26	190
		11.1%	26.3%	22.6%	26.3%	13.7%	
	Female	29	94	76	63	33	295
		9.8%	31.9%	25.8%	21.4%	11.2%	
Total		50	144	119	113	59	485
		10.3%	29.7%	24.5%	23.3%	12.2%	

Since the chi-square test showed no significant results (p-value = 0.457 > 0.05), the null hypothesis failed to be rejected, suggesting that gender does not significantly associate with average spending on a perfume.

Although not statistically significant, the results suggest that females generally spend slightly more on perfumes compared to males, especially in the higher spending categories. This points to a higher likelihood of female consumers being willing to spend more on perfumes that fit their preferences. Local brands could consider offering a variety of price points, ensuring they cater to both budget-conscious consumers and those seeking higher-end options. By enhancing the perception of quality, local brands could more effectively compete with international brands in the local market.

The Purchasing Decisions of Consumers by Gender

The crosstabulation for purchasing decisions by gender is shown in Table 4 below:

Table 4: Crosstabulation between Gender and Purchasing Decisions

Purchasing Decisions		Local	International	Total
Gender	Male	49	141	190
		25.8%	74.2%	
	Female	104	191	295
		35.3%	64.7%	
Total		153	332	485
		31.5%	68.5%	

Since the chi-square test for this variable was significant (p-value = 0.029 < 0.05), the null hypothesis is rejected, indicating that there is a statistically significant association between gender and purchasing decisions.

Gender influences were more prominent in purchasing decisions. Females were more likely to make independent purchasing decisions, with 64.7% reporting they were the primary decision-makers. In contrast, a larger proportion of males (35.3%) relied on others for purchasing decisions. This highlights the importance of targeting female consumers with marketing that emphasizes empowerment, personal preference, and product quality. For male consumers, campaigns leveraging external recommendations or endorsements may be more effective in influencing purchase behavior.

CONCLUSION

This study provides valuable insights into the role of gender in shaping perfume preferences within the Petaling District, Malaysia. While gender does not significantly influence purchase frequency or average spending, it has a notable impact on purchasing decisions between local and international brands. Female respondents were more inclined toward international products, whereas males showed stronger support for local brands, often influenced by price considerations. These findings highlight opportunities for brands to adopt gender-sensitive marketing strategies. Local brands can emphasize affordability and authenticity to appeal to male consumers, while international brands may focus on quality, prestige, and emotional connection to attract female consumers. Overall, incorporating gender as a key factor in marketing and product development can strengthen brand competitiveness in Malaysia's evolving perfume market.

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SMART WASTE COLLECTION: OPTIMIZING RECYCLING ROUTES WITH GRAPH COLORING AND MTZ-TSP

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ABSTRACT

Global waste generation continues to rise, making efficient recyclable waste management crucial. This study focuses on optimizing recyclable waste collection in Rasah, Negeri Sembilan by addressing two key challenges: proper separation of recyclables and efficient routing of collection vehicles. A graph coloring algorithm is applied to cluster collection locations based on compatible materials, ensuring contamination-free recycling. The MTZ-TSP (Miller-Tucker-Zemlin Traveling Salesman Problem) model is then used to design optimal routes that minimize travel distance and costs. This framework improves efficiency, reduces environmental impact, and directly supports SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production).

Keywords: Graph Colouring, MTZ-TSP, Recycling, Collection

INTRODUCTION

As the global population continues to grow, waste generation is increasing at an alarming rate. The most common method of waste disposal is landfilling (Gueboudji et al., 2024), yet the method is highly unsustainable due to limited space, rising operational costs, and severe environmental impacts. One powerful way to reduce reliance on landfills is through recycling, which allows waste to be given a second life by turning it into new products (Bandh et al., 2024). Recycling helps save natural resources, reduce pollution, cut greenhouse gas emissions, and drive progress toward a sustainable circular economy. In Malaysia, recycling efforts have shown steady progress. The national recycling rate has improved from 30.7% in 2020 to 37.9% in 2024 (Aufa Mardhiah (2025); BERNAMA (2021); Lee (2025)). However, despite this growth, more than 80% of recyclable materials still end up in landfills due to poor separation practices and inefficient collection systems (Baba-Nalikant et al., 2023. A major challenge lies in the fact that recyclables consist of diverse materials such as paper, plastics, glass, metal, and e-waste which must be properly separated to prevent contamination. When recyclables are mixed, their value decreases, and the recycling process becomes inefficient or even unfeasible.

To address these issues, this project introduces a smart recyclable waste collection framework that combines clustering of collection locations with optimised routing. Two main approaches were applied to address recyclable waste collection. First, a Graph Coloring Algorithm is used to cluster recyclable collection locations based on the type of materials. Second, the Miller-Tucker-Zemlin Traveling Salesman Problem (MTZ-TSP) model is applied to design the most efficient collection routes. The framework was tested in Rasah Jaya, Seremban, as a case study. Since the area had limited real recyclable containers, hypothetical collection locations were created to simulate diverse conditions, with each location randomly assigned one or more recyclable types. In this project, five types of recyclables were considered: paper, plastics, glass, metal, and e-waste. For instance, Collection Location 1 handles paper and e-waste, while Collection Location 2 collects glass, plastics, and metal. The type of material collected is randomly assigned. Figure 1 illustrates the graph network of the hypothetical recyclable collection locations, consisting of 14 points in total. To apply the MTZ-TSP model, the distances between these locations were obtained using Google Maps.

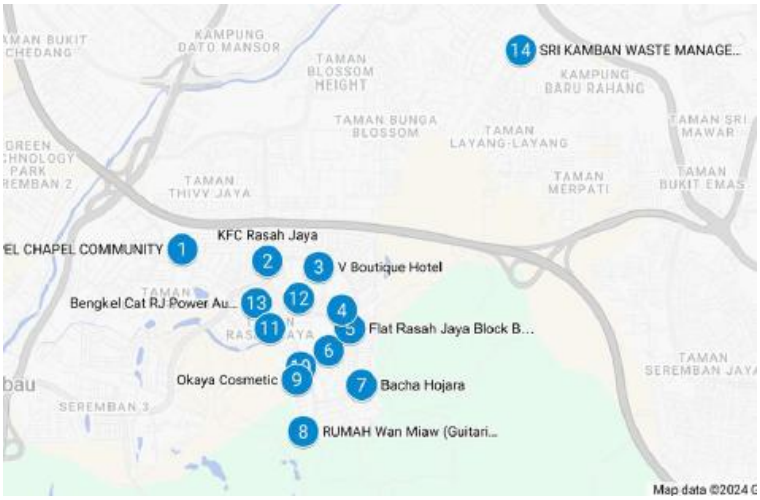

Figure 1: Distribution of hypothetical recyclable collection locations in Rasah Jaya

RESULTS AND DISCUSSION

Using Graph Colouring Algorithm, three clusters were formed: Cluster 1 (paper, plastics, and glass), Cluster 2 (metal), and Cluster 3 (e-waste). Figure 2 illustrates the clustered collection locations in Rasah Jaya. As seen, Location 14 appears in all three clusters, as it accommodates paper, metal, and e-waste. Each cluster's collection route was then optimized using the MTZ-TSP model. Figure 3 presents the routing plan for Cluster 1 as an example. From Figure 3, the journey within Cluster 1, which includes paper, plastic, and glass, follows an extensive route covering the most nodes: 14→1→12→4→9→10→11→5→7→6→3→2→14.

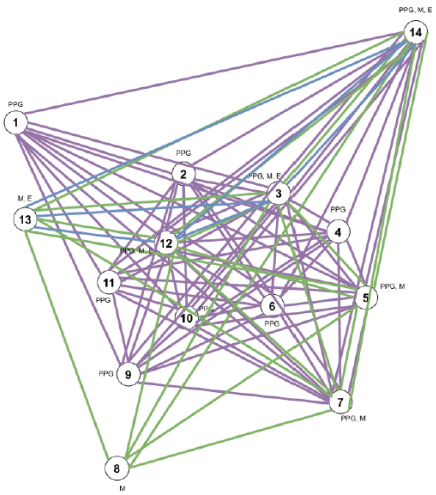

Figure 2: Clusters of recyclable materials across 14 collection locations

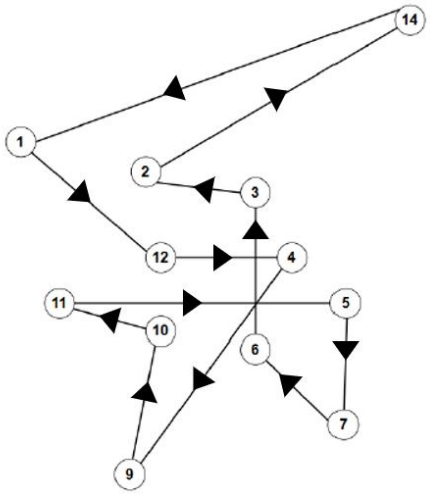

Figure 3: Routes between collection locations for Cluster 1

This overview highlights the differences in route complexity and time requirements across waste types and provides a comprehensive view of the collection efficiency for the entire waste management operation.

CONCLUSION

This study demonstrates how combining graph coloring for clustering and MTZ-TSP for routing can transform recyclable waste collection systems. By ensuring cleaner separation, optimising routes, and reducing operational costs, the framework supports sustainable waste management practices. Most importantly, it contributes directly to SDG 11 and SDG 12, making cities cleaner, smarter, and more responsible in their consumption and production cycles.

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SELECTING RENTAL HOUSES AMONG YOUNG ADULTS USING INTEGRATED ENTROPY FUZZY VIKOR MODEL

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ABSTRACT

The demand for rental houses is increasing since property prices continue to rise. Hence, it is difficult to become an owner of a house, especially for young adults. In Malaysia, numerous young adults face financial difficulties, which often lead them to rent a house. Identifying the crucial criteria that influenced their rental decisions is important. Hence, the decisions they make will correspond with their preferences and requirements. In this study, criteria such as price, location, accessibility, security, and amenities were the inputs that were used to establish a framework for determining rental decisions. By applying the Integrated Entropy Fuzzy-VIKOR Model, it tackled the issue of selection for rental house preferences among young adults and provided a significant impact on decision-making. The entropy method was used to avoid subjectivity in the selection process. Then, the Fuzzy-VIKOR method was applied to determine the rank of rental house alternatives, which were the apartment, double-story house, terrace, and bungalow, according to these weighted criteria. The findings of this study showed that security received the highest prioritised criteria by implementing the entropy method, and apartment was the most preferred alternative among young adults using the Fuzzy-VIKOR model.

Keywords: Rental House, Young Adults, Fuzzy-VIKOR, Entropy

INTRODUCTION

In Malaysia, young adults face challenges when choosing a preferred rental house despite the availability of various housing options. Understanding their preferences and decisions on rentals is essential to understanding their needs when selecting a rental house. Since there are many criteria involved, younger adults often face difficulties in making rental decisions. Hence, Multi-Criteria Decision-Making (MCDM) is the relevant method to be used in determining a suitable house for rent.

MCDM is one of the decision-making methods that was designed to structure and address decision and planning challenges that involve the consideration of multiple criteria simultaneously (Aruldoos et al., 2013). The VIseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) method, also known as the Fuzzy VIKOR method, is one of the MCDM methods that has been implemented in numerous areas to solve complex decision problems. This model is crucial in identifying a compromise solution that is farthest from the Negative Ideal Solution (NIS) and closest to the Positive Ideal Solution (PIS) with the ability to rank preferential decision alternatives (Khan et al., 2020).

In addition to that, the entropy weight method introduced by Shannon is significant for decision-making as it measures the level of uncertainty and amount of information related to decision criteria (Deng et al., 2020). Shannon incorporated entropy into information theory to measure uncertainties in information sources, making the entropy weight method a reliable tool for measuring uncertain information (Siew et al., 2021). The objective of this study is to identify the critical criteria rental housing preferences. With that, this study aims to implement the MCDM model, specifically the Integrated Entropy-Fuzzy VIKOR model, to analyse and rank the most preferred rental housing option among young adults.

METHODOLOGY

The fuzzy rating for ith alternative for jth criterion based on kth decision maker is set as $\tilde{x}_{ijk} = \left(x_{ijk1}, x_{ijk2}, x_{ijk3}, x_{ijk4}\right)$. The importance of weight is set as $\tilde{w}^s_{jk} = \left(w^s_{jk1}, w^s_{jk2}, w^s_{jk3}, w^s_{jk4}\right)$. Then, the fuzzy rating was aggregated. The importance of weight for each jth criterion based on kth decision maker also was aggregated as Equations (1) and (2), where $i = 1,2,\cdots,m$, $j = 1,2,\cdots,n$ and $k = 1,2,\cdots,t$.

$$\text{Aggregated importance of weight for each criterion} = \begin{cases} w^s_{j1} = \min\limits_k \left\{w^s_{jk1}\right\} \\ w^s_{j2} = \dfrac{1}{k}\sum\limits_{k=1}^{k} w^s_{jk2} \\ w^s_{j3} = \dfrac{1}{k}\sum\limits_{k=1}^{k} w^s_{jk3} \\ w^s_{j4} = \max\limits_k \left\{w^s_{jk4}\right\} \end{cases} \tag{1}$$

$$\text{Aggregated importance of weight for each criterion} = \begin{cases} x_{ij1} = \min\limits_k \left\{x_{ijk1}\right\} \\ x_{ij2} = \dfrac{1}{k}\sum\limits_{k=1}^{k} x_{ij2} \\ x_{ij3} = \dfrac{1}{k}\sum\limits_{k=1}^{k} x_{ij3} \\ x_{ij4} = \max\limits_k \left\{x_{ij4}\right\} \end{cases} \tag{2}$$

Based on Equations (1) and (2), the decision matrix $\tilde{D}$ and the subjective matrix, $\tilde{W}^s$ can be expressed as $\tilde{D} = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix}$ and $\tilde{W}^s = \begin{bmatrix} \tilde{w}^s_1 & \tilde{w}^s_2 & \cdots & \tilde{w}^s_n \end{bmatrix}$. Defuzzification of the $\tilde{D}$ and $\tilde{W}^s$ was calculated using Equation (3) where a is minimum value, b is value in the centre but less than c, and d is the maximum value.

$$Z^* = \frac{\left(c^2 + d^2 + cd\right) - \left(a^2 + b^2 + ab\right)}{3\left[(c+d) - (b+a)\right]} \tag{3}$$

The decision matrix should be normalized for each criterion $C_j\left(j = 1,2,\cdots,n\right)$ by using the calculation of the projection value of each criterion called P_{ij} of the index value of alternative m under criterion n.

$$P_{ij} = \frac{x_{ij}}{\sum\limits_{i=1}^{m} x_{ij}} \tag{4}$$

The entropy value e_j for each criterion. The k constant, $k = \dfrac{1}{\ln(m)}$, is calculated to ensure that the entropy values lies between 0 and 1 as Equation (5).

$$e_j = -k \sum_{i=1}^{m} p_{ij} \cdot \ln\left(p_{ij}\right) \tag{5}$$

Next, the calculation of weights, w_j^s as Equation (6).

$$w_j^s = \frac{1 - e_j}{\sum_{j=1}^{n}\left(1 - e_j\right)} \tag{6}$$

The normalisation of decision matrix ensures that each criterion is limited between 0 and 1, allowing for comparability among the criteria. The cost criteria, $x_{ij4}^{-} = \max\left\{x_{ij4}\right\}, C_j \in B$ represent the disadvantage criteria, while benefit criteria, $x_{ij4}^{+} = \max\left\{x_{ij4}\right\}, C_j \in B$, relate to criteria that has significant when selecting the rental houses, where u_{ij} is the new fuzz number for alternatives under criteria C_j, B is the benefit criteria and C is cost criteria as Equation (7).

$$u_{ij} = \left(\frac{x_{ij1}}{x_{ij4}^{+}}, \frac{x_{ij2}}{x_{ij4}^{+}}, \frac{x_{ij3}}{x_{ij4}^{+}}, \frac{x_{ij4}}{x_{ij4}^{+}}\right), C_j \in B \quad u_{ij} = \left(\frac{x_{ij1}}{x_{ij4}^{-}}, \frac{x_{ij2}}{x_{ij4}^{-}}, \frac{x_{ij3}}{x_{ij4}^{-}}, \frac{x_{ij4}}{x_{ij4}^{-}}\right), C_j \in C \quad u_{ij} = \frac{x_j^{+} - x_{ij}}{x_j^{+} - x_j^{-}} \tag{7}$$

The x_j^{+} is the best values and x_j^{+} is the worst value. Calculation of overall performance evaluation using Equation (8).

$$u_{ij} \times w_j^s \tag{8}$$

Defuzzification of the Decision Matrix Criterion with Respect to Alternatives. The formula of defuzzification is the same as in Equation (3). The best f_j^{+} and worst f_j^{-} values for each criterion are determined (Siew et al., 2021). Next two key indices are calculated for each bank which are the utility $\left(S_i\right)$ using Equation (9),

$$S_i = \sum_{j=1}^{n} \frac{w_j^s\left(f_j^{+} - f_{ij}\right)}{f_j^{+} - f_j^{-}} \tag{9}$$

and Regret $\left(R_i\right)$ using Equation (10),

$$R_i = \max\left(\frac{w_j^s\left(f_j^{+} - f_{ij}\right)}{f_j^{+} - f_j^{-}}\right) \tag{10}$$

which S_i represents the maximum group utility and R_i indicates the individual regret. Finally, the VIKOR index $\left(Q_i\right)$ is computed. This index represents a compromise and is used to rank the banks from best to worst, where v denotes the strategy of maximum group utility weight, while $1 - v$ signifies the individual regret weight using $v = 0.5$ following Lam et al., (2021). The Q_i is as Equation (11), where $S^{+} = \min\left(S_i\right)$, $S^{-} = \max\left(S_i\right)$, $\mathrm{R}^{+} = \min\left(R_i\right)$ and $R^{-} = \max\left(R_i\right)$.

$$Q_i = v\left(\frac{S_i - S^+}{S^- - S^+}\right) + (1-v)\left(\frac{R_i - R^+}{R^- - R^+}\right) \tag{11}$$

RESULT AND DISCUSSION

In this study, a literature was conducted to identify the most suitable criteria for rental house and found that amenities, security, price, location and accessibility as the important criteria. The Integrated Entropy-Fuzzy VIKOR model was implemented for identifying rental housing options. Figure 1 shows the weight of the importance assigned to each criterion using the entropy method.

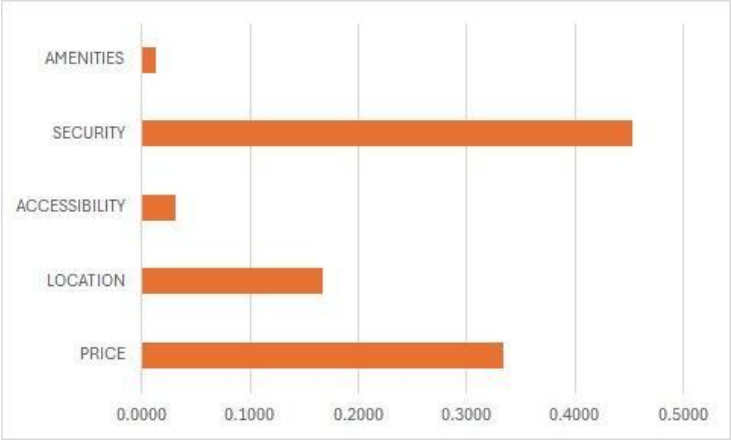

Figure 1: The Weightage of the Importance of Criteria

The analysis showed that security had the highest weight at 0.4530, making it the most important factor in a young adult's choice of a rental house. Price was the next most important at 0.3341, followed by location at 0.1678. In contrast, accessibility and amenities had the lowest weights at 0.0317 and 0.0133 respectively. These findings indicate that young adults prioritise safe living conditions. Table 1 shows the Fuzzy VIKOR method result.

Table 1. Rank and Q_i Value for each Alternative

Houses	Q_i	Rank
Two-storey	1.0000	4
Bungalow	0.5230	2
Terrace	0.8690	3
Apartment	0.0000	1

Based on Table 1, the Apartment is the most preferred rental house with a Q_i value of 0.0000. It represents the optimal compromise across all criteria. The second most preferred option is the bungalow with Q_i value of 0.5230. The terrace and two-storey house ranked lower with Q_i values of 0.8690 and 1.0000. The final ranking shows that the apartment is the most preferred choice for young adults likely due to its security, amenities and accessibility.

CONCLUSION

This study successfully met its objectives by proposing an Integrated Entropy Fuzzy VIKOR model for evaluating rental housing preferences among young adults. The study's two-stage approach proven to be

valid tool for making complex decisions. In the first stage, the entropy method was used to objectively determine the weights of each criterion, avoiding any personal bias. The analysis showed that security was the most important factor in a young adult's choice of a rental house while amenities were the least important. In the second stage, the Fuzzy VIKOR model was used to rank the rental housing options based on the previously determined weights. The findings revealed that the apartment received the lowest Q_i index indicating it was the most preferred options. It was followed by the bungalow, terrace and two-storey house.

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BOOMOKI STOCK MANAGEMENT SYSTEM (BSMS)

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ABSTRACT

The service industry, such as cooked food provided by the restaurant, café or hotel, is a very important industry. Many food providers use manual cooking raw stock materials tracking that will lead to inaccurate inventory counts, increased food waste from spoilage and overstocking, and the risk of stockouts, which negatively impact profitability. Boomoki Stock Management System (BSMS) is aligned with the United Nations' Sustainable Development Goal (SDG) 12, which mentions responsible consumption and production to halve per capita global food waste at the retail and consumer levels and reduce food losses in the production and supply chains. The development of BSMS uses the waterfall development technique, which comprises five phases: requirements, design, implementation, verification, and maintenance. BSMS has three users, which are the kitchen staff, administrator and manager. Functions included in this system are updating the stock quantity, low stock alert, restock request and approval, raw material usage logging (daily tracking of consumed items), supplier management (detail and assign item) and report generating by week. This system leads to reduced food costs and waste, improved operational efficiency by preventing stockouts, minimises overstocking, helps in accurate pricing, and provides valuable data for better decision-making and optimised resource management.

Keywords: Food Service Industry, Stock Management System, Web-Based Application

INTRODUCTION

The service sector, especially culinary services provided by restaurants, cafés, and hotels, is essential for fostering economic growth and satisfying consumer needs. Nonetheless, numerous food suppliers persist in utilising manual techniques for monitoring raw stock materials, frequently leading to issues such as erroneous inventory counts, food deterioration, overstocking, and the potential for stockouts. These inefficiencies elevate operating expenses while adversely impacting profitability and customer satisfaction.

The Boomoki Stock Management System (BSMS) was created to facilitate ethical consumption and production, aligning with the United Nations' Sustainable Development Goal (SDG) 12. This objective highlights the necessity of diminishing global food waste at retail and consumer levels, alongside reducing food losses throughout production and supply chains (United Nations, 2015). The BSMS was developed utilising the waterfall model, which consists of five systematic phases: requirements, design, implementation, verification, and maintenance, hence assuring a structured and reliable development process (Balaji, S., & Murugaiyan, 2012).

The BSMS caters to three user categories: kitchen personnel, administrators, and managers. The primary functionalities encompass stock quantity updates, low-stock notifications, refill requests and approvals, daily monitoring of raw material use, supplier management, and weekly report generation. Through the integration of these elements, BSMS offers a novel solution to enhance inventory precision, reduce food waste, and improve overall efficiency in the food service sector.

RESULTS AND DISCUSSION

The BSMS can be used by three types of users, which are: administrators, kitchen staff, and managers. This section will discuss based on the type of system's users.

Administrators

BSMS allows the administrators to perform the stated functions: 1) Approve restock requests by kitchen staff, 2) Supplier management, 3) Assigning Supplier to specific items and 4) Manage the users of the system. Figure 1 shows the main interface for the administrator.

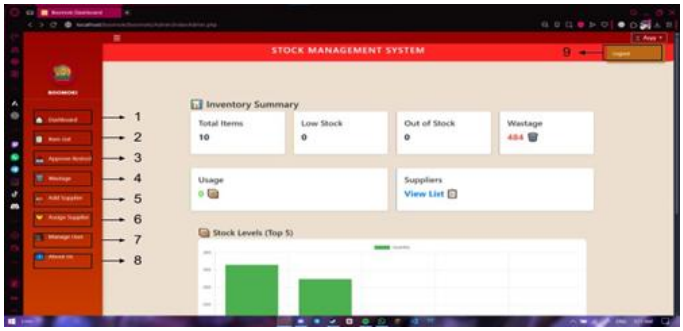

Figure 1: Main Page for Administrator

On the administrator's main page, the user can view the inventory summary, the graph of stock levels and 9 buttons that represent: 1) Dashboard, 2) Item List, 3) Approve Restock, 4) Wastage, 5) Add Supplier, 6) Assign Supplier, 7) Manage User, 8) About Us and 9) Logout. Figure 2 shows the interface for button number 3, which is Approve Restock. The administrator can approve the restock of raw material for cooking by kitchen staff or reject the restock request based on a certain situation.

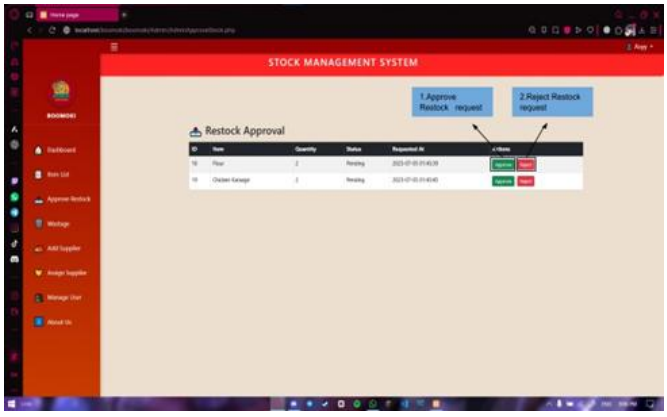

Figure 2: Approve Restock Interface

The raw material supplier is a crucial stakeholder in the cooked food industry; thus, Figure 3 illustrates the interface for adding a new supplier, while Figure 4 depicts the interface for assigning specific raw materials or items to that supplier. The administrator has the authority to remove the supplier's assignment and reassign it to a different supplier. This function is crucial for ensuring that the record of supplier details is organised and can be synchronised with the things they provide.

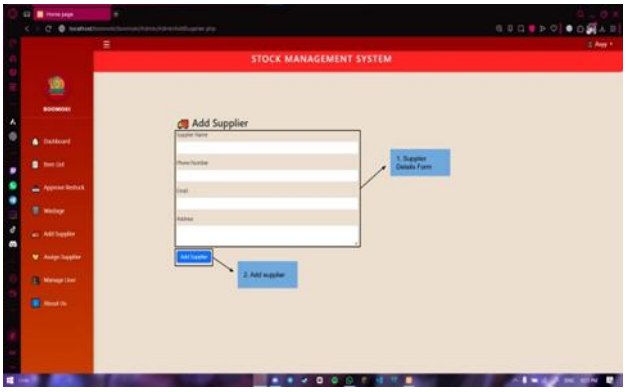

Figure 3: Add New Supplier Interface

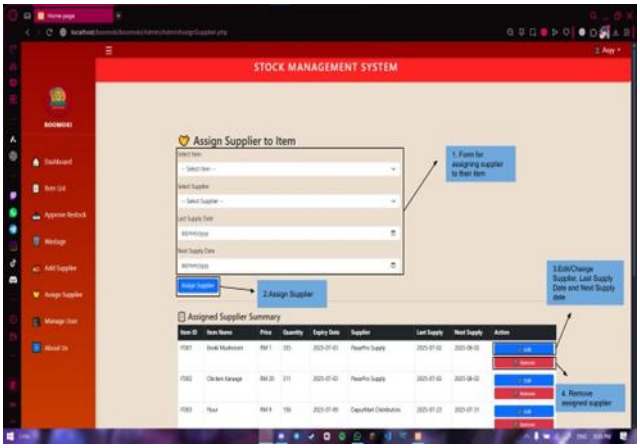

Figure 4: Assign Supplier to Item Interface

Kitchen Staff

The secondary users of the BSMS are kitchen personnel, who are responsible for food preparation. Figure 5 illustrates the primary interface for culinary personnel. The kitchen personnel are capable of 1) managing stock (adding/updating/deleting goods), 2) seeing low-stock alert notifications, 3) submitting restock requests, 4) receiving approval for restock requests, 5) reviewing wastage records, and 6) monitoring usage logs (daily tracking of consumed raw materials). To utilise the item, kitchen personnel must document the usage facts as illustrated in Figure 6.

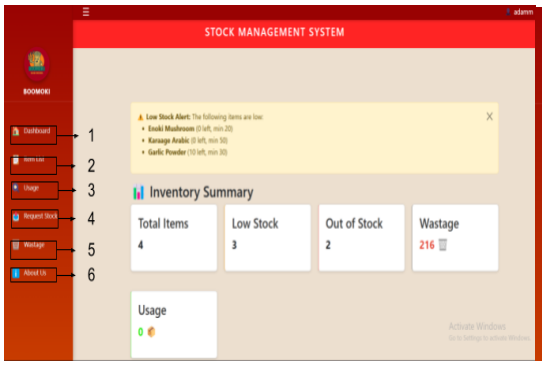

Figure 5: Kitchen Staff Main Interface

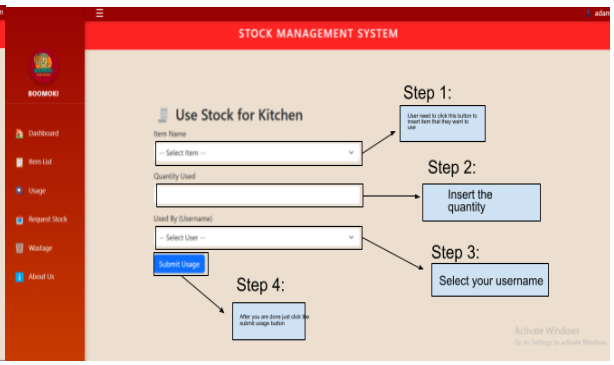

Figure 6: Usage Stock Interface

Manager

The third category of BSMS users is the manager. Managers have very minimal function in the usage of BSMS. The system can provide automated general and weekly reporting for the manager. Figure 7 shows the main interface for the manager. The button represent: 1) Dashboard(back to dashboard), 2) Report(view report) and 3) About Us(view the system's developer detail).

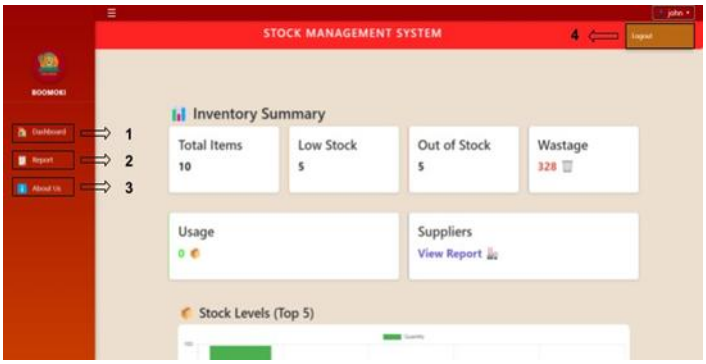

Figure 7: Manager Main Interface

The system can be beneficial for the cooked food service provider by easing the stock and supplier management. In addition, this system can have a positive impact on environmental conservation by tracking the wastage of the material.

CONCLUSION

The Boomoki Stock Management System (BSMS) exemplifies a pragmatic and inventive solution to the inefficiencies in raw material monitoring in the food service sector. By incorporating functionalities such as inventory amount tracking, low-stock notifications, restock request authorisations, supplier allocation, and daily consumption recording, the system guarantees precise inventory management while reducing waste and averting stock shortages. The systematic development approach utilising the waterfall model enhances the system's reliability, rendering it appropriate for implementation by restaurants, cafés, and hotels that depend significantly on effective stock management to sustain profitability and customer pleasure.

In addition to operational advantages, BSMS supports wider sustainability goals by conforming to the United Nations' Sustainable Development Goal (SDG) 12 regarding responsible consumption and production. By minimising food waste and facilitating optimal resource utilisation, the system not only decreases expenses but also fosters environmentally sustainable practices within the culinary industry. BSMS serves as an essential instrument that integrates technology, efficiency, and sustainability, enhancing decision-making capacities for food service operators and offering enduring competitive advantages.

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PHARMAFLOW SALES & INVENTORY MANAGEMENT SYSTEM

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ABSTRACT

The *PharmaFlow Pharmacy Sales and Inventory Management System* has been developed to address inefficiencies in manual transaction and stock control processes. The existing manual system was time-consuming, error-prone, and lacked real-time tracking of sales, customer records, and inventory. The Database Life Cycle (DBLC) is used to design, implement, and manage the system efficiently. Microsoft Access has been chosen to automate data organization, transaction processing, and inventory monitoring. The system integrates customer, staff, supplier, drug, stock, and transaction data into a centralized database, enabling accurate, secure, and easily retrievable records. The sequential query language (SQL) was implemented to generate real-time reports on sales, stock levels, supplier deliveries, and customer transactions. Results show significant improvements in operational efficiency, stock accuracy, and financial reporting. Automated stock updates, expiry date alerts, and secure staff logins enhanced data reliability and reduced administrative workload. This system ensures timely restocking, prevents the sale of expired drugs, and strengthens data privacy, ultimately improving service quality and supporting better decision-making for the pharmacy.

Keywords: Database Life Cycle (DBLC), Microsoft Access, Sales Tracking, Inventory Control, SQL Queries

INTRODUCTION

Pharmacy is a retail establishment, also known as a drug store, where medicines and health-related products are sold, dispense prescribed medications, and offer advice on their safe and effective use. Pharmacy welcomes any individuals that require medicines prescription and granting patient training and education on health from our experienced and licensed pharmacists (KareXpert, n.d.). The pharmacists provide prescriptions based on the customer's condition and presenting symptoms. Pharmacy offers a wide range of medications, catering to all age groups, from baby to elderly care medications. The medications are organized according to their name, type and functions, making it more accessible for our customers.

The sales and inventory management systems that PharmaFlow currently uses is not efficient as it relies heavily on a manual system. . It requires the pharmacist to manually monitor each drug that is available in the pharmacy. Pharmacy management has kept paper records in filing cabinets. Managing a very large pharmacy with records on papers will be tedious and difficult to keep track of inventories with regards to the drugs in the store, expiry date, quantity of drugs available based on the categories (Rathnayake, 2021). Therefore, PharmaFlow has decided to build the management system for drugs by using Microsoft Access. Microsoft Access can make the inventories and sales data for the pharmacy more organised and easier to track.

The main objective of developing the PharmaFlow Pharmacy Sales and Inventory Management System is to create an efficient, accurate, and secure database-driven solution that streamlines pharmacy operations. Specifically, the system is designed to capture and record all sales transactions and payment methods to ensure proper financial tracking and reporting. It aims to monitor drug inventory in real time, prevent stock shortages, and provide alerts for expired medications to maintain safe dispensing practices. Additionally,

the system organizes and safeguards customer, staff, supplier, and drug data, ensuring that sensitive information is accessible only to authorized personnel. By automating these processes, the system reduces manual workload, minimizes human error, and enables the generation of precise reports for operational analysis. Ultimately, these objectives work together to enhance productivity, improve customer service, support timely decision-making, and elevate the overall professionalism of PharmaFlow Pharmacy.

PharmaFlow Pharmacy has improvised the dispensing and inventory management of medications and services provided by our pharmacy. Our database inventory manages stocking and inventory of the pharmaceuticals health products such as recording the quantity supplied by the supplier and unit of medications sold to customers. Furthermore, our inventory maintains accurate records of medications storage compliance such as expiry date and proper labelling for each medication. This reduces the risk of dispensing outdated medicine to customers. Our pharmacy also records medicine dispensing history that includes date of purchase and dose given to customers to keep track of the medications sold to customers.

In addition, our business database manages the financial and sales flow in the pharmacy. The system handles sales tracking, billing procedure and insurance claims made by the customer as well as medicine sales and appointment related costs. Moreover, financial records including cash flow with corresponding transaction time and date as well as payment method are documented precisely in the sales database. Along with that, the pharmacy's total sales, specific sales contributed by each customer can be calculated accurately.

METHODOLOGY

Database Life Cycle (DBLC) was chosen for our pharmacy system development. DBLC is a structured development process because it provides a step-by-step framework which are planning, design, implementation and more. DBLC also improved data accuracy and consistency by following normalization and design standards (*Avenga,* 2024) and DBLS also can provide better identification problems and solutions because the analysis stage highlights weaknesses in existing systems and ensures the new system addresses them effectively.

Firstly, the phase database planning is to identify the need for a reliable sales and inventory system to replace manual processes. Planning involved defining project goals such as reducing errors, ensuring data security, and enabling real-time tracking of sales and stock. Secondly, the system definition phase is to define the system scope including managing customers, staff, suppliers, drugs, stock, and transactions. Thirdly, requirements collection and analysis phase is to analyze the original system problems, rrequirements were collected to ensure the new system could generate transaction reports, track expiry dates, and manage supplier data. Next, the database design phase included creating an Entity Relationship Diagram (ERD), normalizing data up to Third Normal Form (3NF), and building relational schemas. Tables such as *Customers, Staff, Drugs, Stocks, Supplier, Transactions,* and *Pharmacy_Transactions* were defined**.**

Furthermore, Microsoft access was chosen as the DBMS platform due to its accessibility, ease of use, and suitability for academic-level system development. Next, in the implementation phase, tables, relationships, and queries were created in MS Access. SQL queries were designed to produce outputs like total pharmacy sales, customer transaction histories, supplier stock reports, and stock balances. Forms and reports were also developed to simplify user interaction. Then, in the testing and evaluation phase, queries and reports were tested with sample data to ensure the system produced accurate outputs. Functionality such as secure login, expiry date tracking, and transaction recording was evaluated to confirm objectives were met. Lastly, in the operation and maintenance phase, the system is intended to be used daily by staff for recording transactions and tracking stock. Maintenance includes updating drug information, supplier details, and ensuring staff accounts remain secure (Engineering LibreTexts, 2023).

RESULTS AND DISCUSSION

The development and implementation of the *PharmaFlow Pharmacy Sales and Inventory Management System* successfully addressed the inefficiencies of the previous manual processes. The new database-driven system, developed using Microsoft Access, integrates customer, staff, supplier, drug, stock, and transaction records into a centralized platform. This integration has significantly improved data accuracy, reduced human error, and allowed for real-time monitoring of stock levels and sales transactions.

The SQL queries designed within the system produced accurate and meaningful reports that support decision-making. Examples include generating total pharmacy sales, tracking the quantity of drugs supplied by each supplier, listing drugs with stock levels exceeding a set threshold, and providing detailed customer transaction histories. Automated calculations of stock balances after sales ensured precise inventory control, while expiry date tracking prevented the sale of outdated medications. Secure login functions further enhanced data privacy by restricting access to authorized staff. Figure 1 shows the example of SQL command for sales tracking and figure 2 shows the output of sales tracking query.

```
SELECT C.CustName, D.DrugName, PT.Quantity, D.DrugPrice, Quantity*DrugPrice AS TotalPriceEachCustomer, TranscDate, TranscTime
FROM CUSTOMERS AS C, PHARMACY_TRANSACTION AS PT, DRUGS AS D, [TRANSACTION] AS T
WHERE C.CustID=T.CustID
AND PT.DrugCode=D.DrugCode
AND T.TranscID=PT.TranscID;
```

Figure 1: SQL Command for sales tracking

Q2ListCustNameQuantityDrugPrice

CustName	DrugName	Quantity	DrugPrice	TotalPriceEachCustomer	TranscDate	TranscTime
Faizal Zainal	Prednisone	6	RM0.60	RM3.60	1/5/2025	10:15 AM
Nur Aisyah Rahman	Salbutamol	4	RM0.90	RM3.60	1/5/2025	2:05 PM
Lim Wei Jian	Pantoprazole	3	RM1.50	RM4.50	2/5/2025	9:43 AM
Siti Mariam Bt. Zakaria	Clopidogrel	3	RM3.00	RM9.00	2/5/2025	11:32 AM
Arvin Kumar A/L Rajan	Naproxen	2	RM1.20	RM2.40	2/5/2025	4:20 PM
Aiman Zulkifi	Glimepiride	2	RM1.20	RM2.40	3/5/2025	12:45 AM
Nur Aliya Abu	Cetirizine	4	RM0.80	RM3.20	3/5/2025	1:01 PM
Jonathan Lim	Atorvastatin	2	RM1.20	RM2.40	3/5/2025	3:55 PM
Siti Mariam Ismail	Paracetamol	3	RM1.00	RM3.00	5/5/2025	8:27 PM
Harith Danial	Erythromycin	2	RM3.00	RM6.00	5/5/2025	5:39 PM
Chloe Tan	Metroformin	4	RM0.50	RM2.00	6/5/2025	10:58 AM
Faiz Ahmad	Montelukast	2	RM2.80	RM5.60	1/5/2025	9:00 AM
Lee Mei Yin	Levothyroxine	2	RM0.80	RM1.60	6/5/2025	1:49 PM
Priya Nair	Ibuprofen	3	RM0.80	RM2.40	6/5/2025	11:21 AM
Amirul Hakim	Omeprazole	3	RM1.00	RM3.00	5/5/2025	8:37 PM
Farah Nadia Halim	Cetirizine	3	RM0.80	RM2.40	4/5/2025	4:30 PM
Hafiz Ramli	Amlodipine	2	RM0.80	RM1.60	4/5/2025	12:40 AM
Lee Zia Jee	Amoxicillin	2	RM1.00	RM2.00	4/5/2025	3:10 PM
Aina Sofea Zainal	Azithromycin	3	RM2.50	RM7.50	7/5/2025	10:29 AM
Zulkarnain Mohd Noor	Cetirizine	3	RM0.80	RM2.40	7/5/2025	11:14 AM
Brenda Chua	Naproxen	2	RM1.20	RM2.40	7/5/2025	9:05 PM
Faizah Rosli	Salbutamol	4	RM0.90	RM3.60	8/5/2025	4:27 PM
Azhar Karim	Glimepiride	4	RM1.20	RM4.80	8/5/2025	7:50 PM
Kelly Ng	Ranitidine	2	RM1.00	RM2.00	8/5/2025	2:10 PM
Shafiq Hadi	Losartan	2	RM2.00	RM4.00	9/5/2025	10:55 AM
Alia Aziz	Erythromycin	5	RM3.00	RM15.00	9/5/2025	10:17 AM
Daniel Yap	Paracetamol	3	RM1.00	RM3.00	9/5/2025	4:40 PM
Huda Nazira	Loratadine	2	RM1.00	RM2.00	10/5/2025	11:23 AM
Ikhwan Saleh	Naproxen	3	RM1.20	RM3.60	10/5/2025	3:10 PM

Figure 2: Output for sales tracking

Operationally, the system has streamlined workflow by automating record-keeping, reducing administrative workload, and enabling faster service delivery to customers. Staff can now easily retrieve drug information, update sales records, and monitor stock movements without manual counting or cross-checking. The enhanced reporting capabilities also allow management to track performance trends, identify restocking needs, and maintain compliance with audit requirements. Overall, the system demonstrates how a well-structured Database Management System can transform pharmacy operations into a more efficient, secure, and data-driven process.

CONCLUSION

PharmaFlow Pharmacy is an advanced retail or community pharmacy that utilizes advanced system technology to enhance the sales and inventory management operations. Our pharmacy aims to deliver high-quality pharmaceutical care, prioritizing accuracy and customer satisfaction by providing quick and efficient service as well as to serve as reliable medical guidance and easily accessible healthcare for the Seremban 3 community.

The auto-calculation of stocking quantity such as quantity of stock supplied by the supplier company and amount of stock sold to the customer is one of our pharmacy advantages. Furthermore, the incorporation of a centralised database has made the organization of medications easier according to their price and corresponding supplier company. Medication recognition becomes more efficient as each drug is allocated with their unique ID. In addition, personalized user staff accounts have greatly enhanced the quality of service provided by the staff, allowing fast and efficient customer service. Staff can monitor the medications availability as well as checking the expiry date before dispensing to customers. Lastly, maintaining medication inventory and managing sales operations.

Improvement is needed in development to increase accuracy, efficiency, data security, and scalability. Other than that, ultimately ensuring that the database system remains relevant and valuable to the pharmacy's operations. For example, the improvement can be made to improve the accessibility that will allow access via web or mobile apps for user flexibility. In addition, improve the user experience enhancements, provide a simple dashboard with KPIs such as top sales and medicine that is expiring soon.

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FLORAGUARD: A CNN-BASED FUNGAL DETECTION SYSTEM FOR SMART HORTICULTURE

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ABSTRACT

Fungal diseases represent one of the most damaging threats to ornamental plant productivity and economic value, particularly in nursery and horticultural sectors. Traditional detection methods rely heavily on manual inspection, which is inefficient, inconsistent, and inaccessible to non-specialists. This project introduces FloraGuard, a novel lightweight detection system powered by Convolutional Neural Network (CNN) architecture using MobileNet-V2, designed to automate the identification of four common fungal diseases—powdery mildew, black spot, rust, and botrytis blight—from leaf images. A curated dataset of 568 labelled images was preprocessed through normalization, augmentation, and filtering to enhance model robustness. The final trained model demonstrated 95.73% accuracy, with high F1-scores across all classes, and was integrated into a user-friendly GUI accessible via web or mobile interface. FloraGuard has potential to reduce fungicide overuse, minimise losses, and democratise plant disease management for small-scale growers. Its relevance aligns with SDG Goals 2 and 12 and provides a scalable foundation for commercial and academic extensions.

Keywords: Fungal Detection, MobileNet-V2, Image Classification, Smart Agriculture, Sustainable Horticulture

INTRODUCTION

The global ornamental plant industry, valued at over USD 50 billion, is driven by increasing demand for high-quality flowering plants in landscaping, interior design, and therapeutic horticulture (González-Briones et al., 2025). However, fungal infections pose major challenges, leading to visible damage, premature senescence, and reduced marketability. Common diseases such as powdery mildew, rust, black spot, and botrytis blight are widespread. Recent studies report that up to 70% of flowering plants are susceptible to fungal pathogens, resulting in significant yearly yield losses and financial impacts (Qiu et al., 2024). Despite these risks, disease detection in nurseries and small-scale operations largely relies on manual visual assessments, printed leaf catalogues, or informal consultations—methods that are often slow, unreliable, and inaccessible to rural or amateur growers (Nwaneto & Yinka-Banjo, 2025).

To address this limitation, there is a clear need for scalable, automated detection systems accessible to non-experts. This study proposes a lightweight image classification tool that uses Convolutional Neural Networks (CNNs), specifically the MobileNet-V2 architecture, for fungal disease detection in flowering plants. The tool is designed for real-time use on mobile and low-cost devices, supporting early diagnosis and timely intervention in varied cultivation settings. This research also contributes to the United Nations Sustainable Development Goals, particularly Goal 2 (Zero Hunger) and Goal 12 (Responsible Consumption and Production), by reducing fungicide overuse and encouraging sustainable plant health practices (Assaf et al., 2025; Prabhu & Dilip, 2024).

OBJECTIVES

This study was conducted with the following objectives:

i. To design and train a CNN model using MobileNet-V2 to automatically classify disease types from leaf images.
ii. To develop an intuitive, user-friendly interface (GUI) that allows users to upload and analyze images for real-time fungal detection.
iii. To evaluate the model performance using key classification metrics and benchmark it against conventional detection methods.

METHODOLOGY

The FloraGuard fungal detection system was developed through a structured eight-phase methodology. Figure 1 shows the diagram for FloraGuard fungal detection methodology.

The first phase involved a comprehensive literature review and problem identification, focusing on gaps in current plant disease detection methods and justifying the use of lightweight CNN models for real-time diagnosis. In the second phase, a curated dataset of 568 labelled images depicting four common fungal infections—powdery mildew, black spot, rust, and botrytis blight—was acquired from RoboFlow, ensuring sufficient diversity and annotation quality. The third phase, data preprocessing, applied several enhancements including normalisation, image augmentation, blur filtering using Laplacian variance, bounding box cropping, and label harmonisation to prepare the dataset for training. The fourth phase centred on model development, where MobileNet-V2—a lightweight convolutional neural network—was adapted using transfer learning, with custom classification layers added to fine-tune the model for the specific fungal classes.

In the fifth phase, model training and validation were performed using a 70/15/15 split for training, validation, and testing datasets respectively, and optimised using the Adam optimiser and categorical cross-entropy loss function. The sixth phase focused on GUI development and integration, where a user-friendly interface was built using Streamlit and Flask to allow non-experts to upload images and receive real-time predictions, designed especially for mobile and low-resource environments. In the seventh phase, performance evaluation was conducted using metrics such as accuracy, precision, recall, and F1-score, and the system achieved 95.73% accuracy with an inference time of less than two seconds per image. Finally, the eighth phase involved system deployment and documentation, where the trained model was saved, the application was packaged for demonstration, and technical documentation was prepared for potential IP filing, user dissemination, and future scalability.

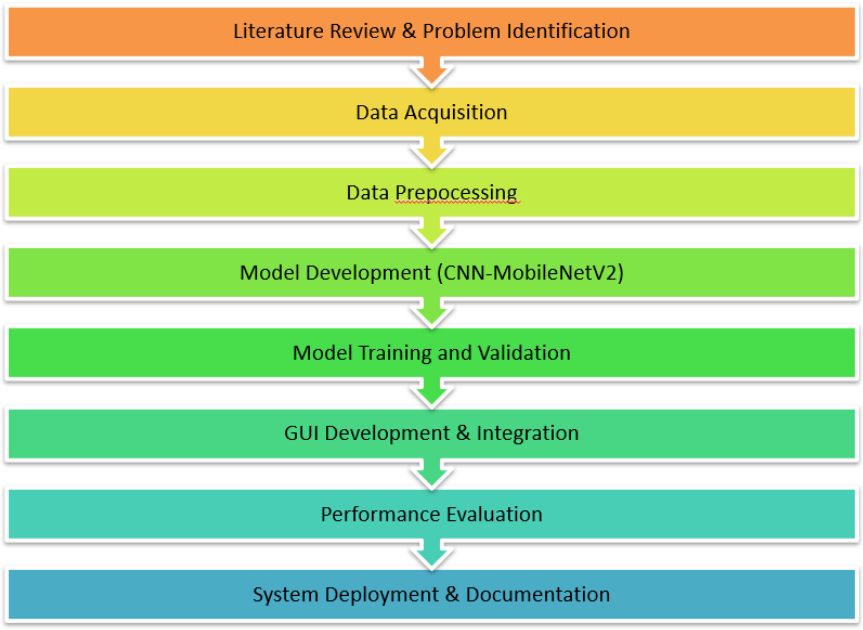

Figure 1: FloraGuard fungal detection methodology

RESULTS AND DISCUSSION

The results of the FloraGuard system demonstrate high model effectiveness and practical usability. The MobileNet-V2 CNN model achieved an overall accuracy of 95.73%, confirming its ability to correctly classify a wide range of fungal leaf diseases. The model's average recall score of 95.0% highlights its sensitivity in correctly identifying actual cases of disease, while an average precision of 96.2% indicates a low false-positive rate. The F1-score, which balances precision and recall, was recorded at 94.8%, validating the model's consistency across all four disease categories. As summarized in Table 1, the system also exhibited a low inference time of under 2 seconds, making it suitable for real-time deployment. Notably, powdery mildew and rust achieved the highest recall rates at 99%, reflecting exceptional model accuracy for these classes. Despite being underrepresented in the dataset, botrytis blight still attained an 87% recall, indicating robust generalization. When benchmarked against traditional machine learning classifiers such as Support Vector Machines (SVM) and Random Forests, FloraGuard's CNN model delivered up to a 20% improvement in F1-score, underscoring its superior adaptability to image-based classification tasks. Informal user testing further revealed that non-technical users found the graphical interface intuitive and efficient, appreciating its visual feedback, simplicity, and compatibility with low-spec devices. These findings confirm that FloraGuard is not only accurate in detection but also highly usable and ready for broader implementation. Table 1 shows exceptional classification performance.

Table 1: Exceptional classification performance

Metric	Value
Accuracy	95.73 %
Recall (Avg)	95.0 %
Precision (Avg)	96.20 %
F1-Score (Avg)	94.80 %
GUI Inference Time	< 2 seconds

CONCLUSION

In conclusion, the FloraGuard system presents a practical and innovative solution to the long-standing challenge of fungal disease detection in flowering plants, particularly within the ornamental horticulture sector. By leveraging the MobileNet-V2 CNN architecture and integrating it into a user-friendly graphical interface, the system successfully bridges the gap between advanced artificial intelligence and accessible

agricultural technology. The model achieved high accuracy and robust performance across multiple metrics, proving its reliability for real-time classification. Furthermore, the system's low computational demand and ease of use make it highly applicable for small-scale growers, educators, and community gardening programs. Beyond technical performance, FloraGuard aligns with sustainability goals by promoting early disease intervention and reducing excessive fungicide use. With its strong foundation in research, demonstrated usability, and potential for commercialization, FloraGuard represents a scalable, socially relevant, and forward-looking innovation in the field of smart agriculture.

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UNIDASH: STUDENT-TO-STUDENT CAMPUS RIDE SERVICE

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ABSTRACT

UniDash is an intelligent mobile app designed to provide a safe, affordable, and convenient experience for both drivers and passengers. Students often pay high fares when using commercial ride-hailing apps, and sometimes raise safety concerns, as they may have to travel with unknown drivers, which can lead to discomfort and potential risk. Currently, there is no centralised platform connecting students who offer and seek affordable transportation services. Hence, many rely on informal communication through instant messaging apps or the university's confession pages, which causes inefficiency and lacks proper tracking and scheduling. Therefore, UniDash aims to offer affordable and convenient rides to students and implement a verification standard for safety purposes. The verification system enhances the sense of community and safety, as students know they are only interacting with peers from the same institution. The app employs a client-server architecture, where the mobile application itself serves as the client and the communication medium to the centralized cloud server, which processes requests and manages data. It also supports real-time communication via WebSocket or push notification services to ensure immediate updates for both passengers and drivers, which builds trust and enhances the sense of security among users. The uniqueness of UniDash lies in its exclusive focus on the student community. Students who need a ride can browse available drivers, compare prices, and book a ride that suits their needs. Contributing to decision support, UniDash helps students make better ride choices based on available data. Before accepting or offering a ride, students can view the driver's profile, ratings, ride histories, and passengers' reviews. Through its smart technology and thoughtful design, UniDash stands out as a meaningful and innovative solution in the campus transportation landscape.

Keywords: mobile apps, intelligent system, e-hailing, students

INTRODUCTION

Transportation has become one of the challenges for university students, as they need to move from one location to another, both on campus and in the surrounding areas. While ride-hailing services like Grab are widely available, the fare can sometimes be expensive for students, and safety concerns associated with traveling with unknown drivers further add to the discomfort. Despite the growing demand for student-friendly transportation solutions, there is currently no platform specifically designed to address these issues, connecting students with trustworthy and affordable rides. To bridge this gap, UniDash has been developed as a mobile application tailored to meet the students' transportation needs. UniDash connects students with peer drivers, providing a safe, cost-effective, and reliable way to travel.

The main objective of UniDash is to provide a centralis.ed platform where students can easily book affordable rides that will ensure an accessible transportation option suitable for their budget. The platform also aims to foster trust among users by adding student verification and review systems, allowing students to make informed decisions based on feedback from their peers. UniDash also offers a safer and more reliable transportation solution by implementing advanced safety features such as real-time tracking, emergency alerts, and limiting rides to students only, creating a secure environment for users to travel with peace of mind. Figure 1 shows the flowcharts for both types of users: customers and drivers. Users need to

sign up upon using the application and use their student credentials to ensure it is exclusively for students, and then proceed to the next process, either to book or offer the ride-hailing service.

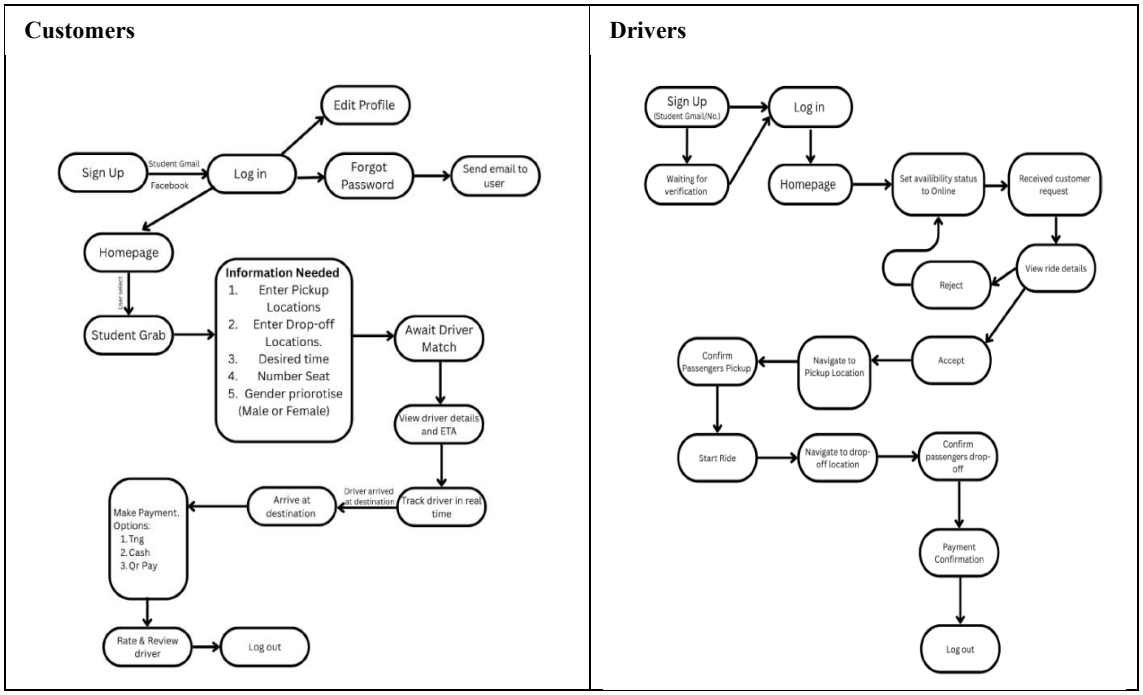

Figure 1: Flowcharts of UniDash for Customers and Drivers

UNIDASH FEATURES

The app runs on a client-server setup, where the mobile app acts as the client and connects to a central cloud server to handle requests and manage data. It also supports real-time communication through WebSocket or push notifications, allowing passengers and drivers to receive instant updates. This quick response helps build trust and gives users a stronger sense of safety. UniDash incorporates several advanced and intelligent technologies to provide a reliable and secure transportation experience tailored specifically for university students. One of the key technologies used in UniDash is real-time GPS tracking with a built-in map system. Unlike apps that rely on third-party navigation, UniDash offers its own map interface, displaying routes, estimated arrival times, and pick-up or drop-off points directly within the app. This makes the experience smoother since users don't need to switch between different apps. It also provides better control over the interface and allows for more flexibility in customising features (Ding et al., 2007). This feature enables users to view the live location of their driver or rider throughout the journey, ensuring transparency and fostering trust among users. By allowing users and campus security to monitor trips, it can reduce safety concerns. GPS tracking in mobile apps has become an increasingly important feature, enhancing users' trust and operational transparency (Zhang et al., 2020). UniDash also allows family members or campus security to monitor the ride if necessary, adding an extra layer of safety.

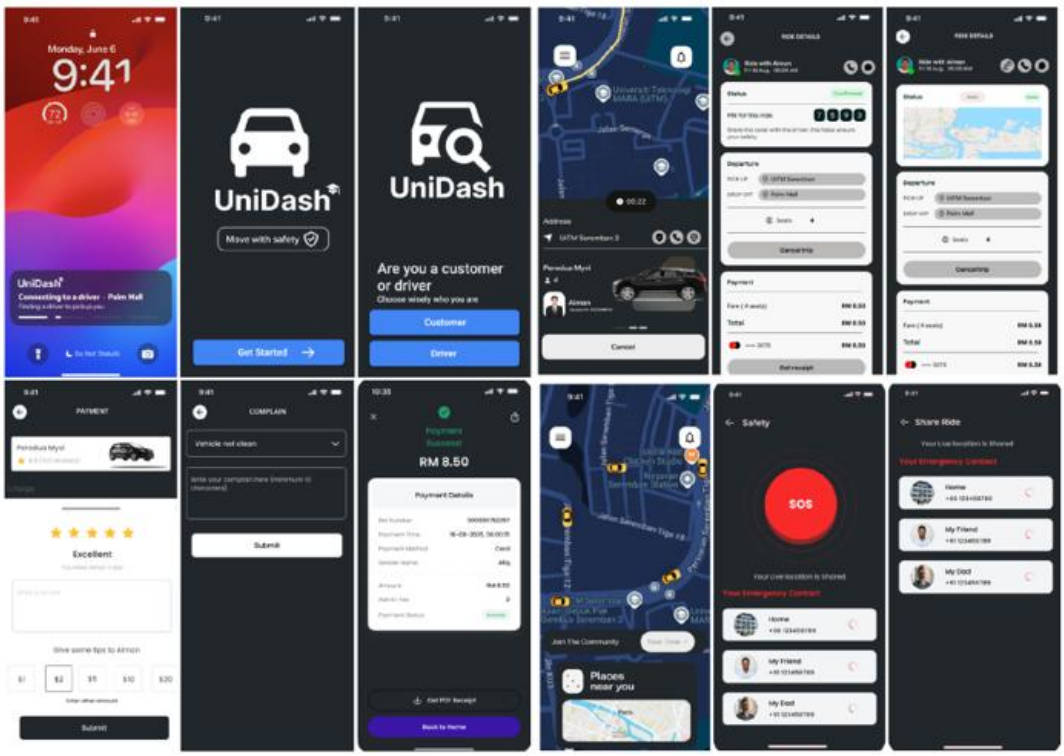

Figure 2: User Interface for UniDash Mobile Application

The primary users of UniDash are university students who require a safe, affordable, and convenient way to travel by connecting them with trusted student drivers from the same campus community. With features such as real-time tracking, community channels, emergency alerts, and rides that are restricted to students only, UniDash ensures a secure and supportive transportation experience while fostering a sense of community among students. The application includes a smart notification system that alerts users at every stage of the ride process. The system that provides automatic alerts sent to users regarding ride confirmation, arrival, start, and completion is to improve user satisfaction and engagement (Habermann et al.,2016). Figure 2 displays some user interfaces of UniDash for students who want to book a ride-hailing service.

PROJECT NOVELTY AND SIGNIFICANCE

The UniDash mobile application provides a solution to the challenge of finding a single platform that offers more affordable and safer transportation for university students. In the decision-making process, UniDash is integrated with intelligent features that help users make better ride choices based on available data. For instance, students can view a driver's profile, which includes their ratings, ride history, and user reviews, before accepting or offering a ride. Intelligent decision support system tools have proved to enhance operational efficiency and user satisfaction in transportation apps (Seng et al., 2023). The strength of UniDash lies in its exclusive focus on the student community. Unlike typical ride-hailing apps, all UniDash users are required to verify their status as a student by scanning their student card. By having this feature, it will build trust and enhance the sense of security among users. Additionally, it allows students to generate side income by becoming drivers themselves, further enriching the student experience.

UniDash offers additional features that distinguish it from other platforms. These include live tracking of rides, an emergency alert button, and a community system that automatically prompts in any emergency. These features are included for a safer, more convenient, and enhanced user-friendly experience, thus significantly improving the daily transportation options for students. Through its smart technology and minimalist design, UniDash stands out as a meaningful and innovative solution in the campus transportation landscape.

CONCLUSION AND FUTURE WORKS

UniDash was initially designed to address the common transportation challenges faced by students, such as high fares, difficulty in finding available rides around campus, and safety concerns. Offering a smarter, more affordable solution, UniDash moves forward by providing students with extra convenient features such as live ride tracking, emergency alerts, and the option to choose the driver's gender, enhancing comfort and security. As a forward-thinking innovation, UniDash is designed to significantly benefit students by offering a reliable and accessible transportation solution. To bring UniDash to another level, it is recommended to expand its user base by incorporating partnerships with universities and student organisations. Offering interesting promotions or incentives for new users could further encourage adoption. Additionally, integrating more advanced safety features, such as in-app video calls or driver background checks, could increase user confidence and safety. Expanding the app's features to include multi-destination rides or group bookings could also improve its usability for students with varying needs.

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The authors would like to thank the subject lecturer, evaluation panels, and project supervisor for their guidance and constructive feedback throughout the development of this project. Appreciation is also extended to the Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, for the support and resources provided throughout the completion of the ISP688: Intelligent Decision-Making Support System course.

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GO-SERVE: A SMART VOLUNTEER REGISTRATION AND EVENT HUB

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ABSTRACT

Go-Serve, a smart application for volunteer registration and event hub, is designed to support the growing awareness and attention of volunteerism in the community. Charity events and activities hosted by non-profit organisations, student clubs, and community organisations catch people's interest to be part of as volunteers. However, aspiring volunteers have difficulties finding suitable events due to the dispersed channels of information for different events. Same goes for the organizers of the events, as they don't have a centralised platform to advertise their upcoming events and recruit potential volunteers due to limited communication, access, and visibility. Therefore, Go-Serve aims to bridge the gap between organisations and volunteers by offering a centralised platform that delivers solutions, utilising the latest mobile application technology. The app provides features that connect volunteers to the events that suit their interests, knowledge, skills, and location. Main features included in the app, such as in-app registration, user profiles, calendars, reminders, and activity tracking, are presented with a clean and easy navigation user interface. Additional smart features, such as real-time event listings, an analytic dashboard, location-based recommendations, a feedback mechanism, and in-app messaging services, enhanced the accessibility and encouraged continuous involvement for future activities. A cloud-hosted NoSQL database, Firebase Realtime Database utilises the real-time data captured by the app, and with integration to a Google machine learning framework, TensorFlow Lite achieves higher personalisation and smart responsiveness. With a systematic and visible platform, Go-Serve may significantly foster volunteerism events and activities, thus contributing a positive impact on the community.

Keywords: mobile apps, intelligent system, volunteer, community

INTRODUCTION

Volunteerism plays a critical role in addressing social issues, enhancing community resilience, and fostering civic engagement. It encompasses a range of activities where individuals contribute their time and effort without financial remuneration, aiming to support community needs or address social issues. Volunteerism involves individuals or groups dedicating their time and skills for the benefit of others, often in non-profit organizations or community service initiatives (Clary et al., 1998). Nowadays, the awareness and enthusiasm of the young generation towards volunteerism are increasing, aligned with the advancement of technology that enables information to be more accessible and reachable. The reasons for the soaring attention in these noble efforts are attributed to the media exposure and experience-sharing by the organisers and volunteers involved. However, the number of potential upcoming volunteers would be hindered from growing if communities are not provided with an appropriate and centralised platform. Currently, there are a huge number of websites that promote volunteerism projects. Nonetheless, scattered and sometimes outdated information on various websites failed to attract the participation of volunteers in the program.

Thus, this project, called Go-Serve, is designed to make volunteering easier and more meaningful for everyone. First, it focuses on building a simple mobile app that helps students and community members find opportunities that match their skills, interests, and location, while also giving organisations a convenient way to share events and recruit volunteers. Second, it aims to make the whole process smoother

with features such as quick sign-ups, reminders, activity tracking, personalised suggestions, and real-time updates so that communication between volunteers and organisations feels natural and engaging. Lastly, the project aims to inspire individuals to remain engaged in community service over the long term by recognising their efforts, highlighting their impact, and making volunteering a rewarding and enjoyable experience.

GO-SERVE DESIGN AND FEATURES

Go-Serve offers core features that support the functional flow of volunteering, from event planning to interaction with participants. Every functionality has been specially designed to perform tasks with minimal effort, generating efficient and smooth user experience. It is also integrated with Firebase Realtime Database. It is a cloud-based NoSQL database that lets apps capture and update data instantly. When connected to Google's machine learning tool, TensorFlow Lite, apps can provide more personalised experiences and respond more intelligently to users' needs. Volunteers are presented with a comprehensive event browsing interface that allows them to browse available opportunities by category, interest, date, or location. The app is equipped with a smart matching event system that suggests programs to users based on their past attendance, selected interests, skills, and location. For the organisation, it analyses trends to suggest program types likely to succeed in a specific location. Figure 1 displays the user interface for volunteers in the Go-Serve application.

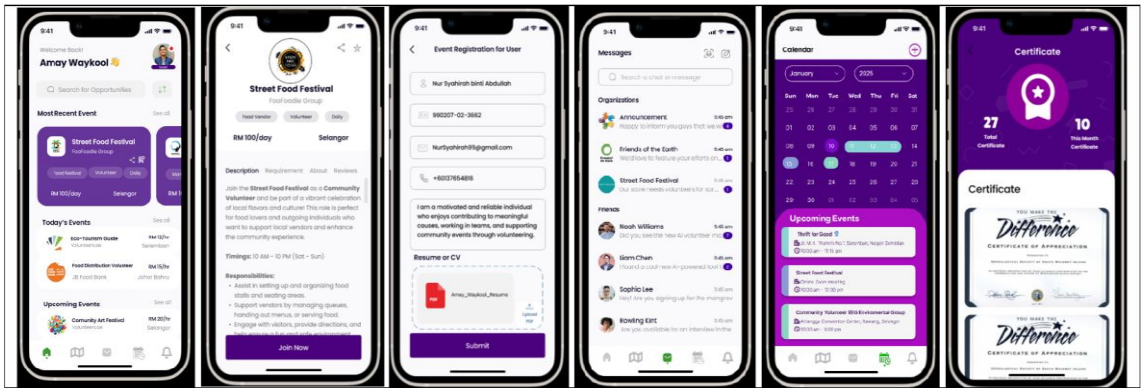

Figure 1: User Interface for Go-Serve mobile application (Volunteer Page)

The app features a range of tools to make volunteering more organised and enjoyable. Volunteers and organisations will receive real-time push notifications about event updates, approvals, feedback requests, and deadlines, ensuring no one misses important information. Attendance is made simple with a QR code scanner, allowing volunteers to check in quickly at events while their hours and records are updated automatically. To facilitate communication, the app features an in-app messaging system that supports both individual and group chats, promoting teamwork without the need for external apps. Additionally, visual dashboards provide volunteers with a clear view of their total events, certifications, and participation history, while organisations can track attendance, event performance, and feedback to inform future planning. Figure 2 shows the organisation's user interface in the application.

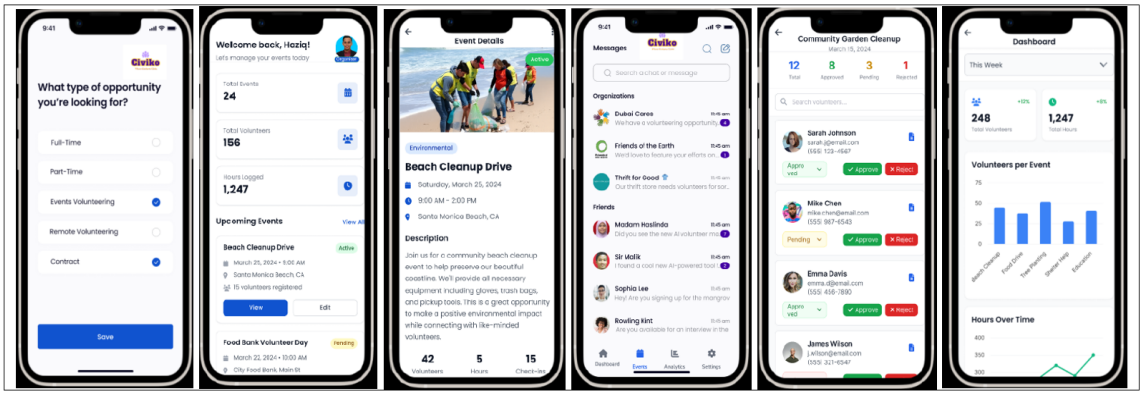

Figure 2: User Interface for Go-Serve mobile application (Organization Page)

PROJECT NOVELTY AND STRENGTHS

Go-Serve is a volunteer management platform that makes things easier and smarter for both volunteers and organisers. Go-Serve has a dual interface that gives volunteers and organizers their own dashboards, making it easier to use and less confusing. It also comes with a smart event matching tool that recommends the most suitable events for volunteers based on their interests and location, while helping organisers plan better using trend-based suggestions. The app keeps events updated automatically in real time, so full or expired events disappear without anyone needing to do extra work. In urgent situations, the emergency mobilisation feature lets organisers quickly send instant notifications to gather volunteers right away.

CONCLUSION

In conclusion, Go-Serve shows how technology can make volunteer management easier, smarter, and more effective. With its dual interface, smart event matching, real-time automation, and emergency mobilisation, the app helps solve the common problems found in traditional systems and creates a smoother experience for both volunteers and organisers. For the future, it is suggested that Go-Serve include features like gamification, such as badges or point-based rewards, to keep volunteers motivated and engaged. Adding social media integration would also help reach more people and encourage stronger community involvement. With these improvements, Go-Serve has the potential to become a leading platform for long-term volunteer engagement and management.

ACKNOWLEDGEMENT

The authors would like to thank the subject lecturer, evaluation panels, and project supervisor for their guidance and constructive feedback throughout the development of this project. Appreciation is also extended to the Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, for the support and resources provided throughout the completion of the ISP688: Intelligent Decision-Making Support System course.

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EcoWise: WEB-BASED INTELLIGENT SUSTAINABILITY EVALUATION USING TOPSIS (WISE-T)

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ABSTRACT

EcoWise: WISE-T is a free web-based tool that helps users evaluate and rank sustainability projects by considering environmental, economic, and social factors. It is designed for students, researchers, policymakers, and organisations that may not have access to expensive commercial software. The system uses the Technique of Order Preference by Similarity to Ideal Solution (TOPSIS) method, a common approach in multi-criteria decision-making (MCDM). Users first set up a decision matrix with alternatives and criteria. EcoWise then normalizes the data, applies weights to each criterion, and calculates the distance of each alternative from the best and worst solutions. Based on this, the tool produces a ranked list of options. EcoWise's novelty lies in its lightweight, easy to use, and runs directly in a web browser without installation. It provides clear visual outputs such as weighted matrices and ranking charts, making the decision-making process more transparent, flexible, and aligned with the United Nations Sustainable Development Goals (SDGs).

Keywords: Sustainability Evaluation, Multi-Criteria Decision-Making (MCDM), TOPSIS, Decision Support System, Web-Based Tool

INTRODUCTION

The growing focus on sustainable development has increased the demand for transparent, data-driven tools to evaluate environmental, economic, and social initiatives. Yet, organisations, policymakers, and sustainability managers often face conflicting criteria, subjective judgments, and a lack of standardised frameworks, which hinder effective decision-making. These challenges frequently result in inconsistent or biased evaluations, especially in contexts where decisions rely on manual assessments rather than structured methods (Mardani et al., 2015).

Multi-Criteria Decision-Making (MCDM) techniques, such as the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), offer a structured approach by ranking alternatives based on their distance to an ideal solution. Originally proposed by Hwang and Yoon in 1981, TOPSIS has since been widely applied in socioeconomic research, scientific studies, and policy analysis (Zhang et al., 2017). Its popularity stems from its simplicity, interpretability, and effectiveness in handling conflicting criteria (Behzadian et al., 2012). However, current sustainability assessment tools are limited in scope, often static, and lack interactivity or transparent visualization, reducing user trust and flexibility (Cinelli et al., 2014).

To overcome these gaps, this study presents EcoWise (WISE-T), a free, web-based platform that applies the TOPSIS method to rank sustainability alternatives. The system integrates MCDM principles with interactive web technologies to deliver a user-friendly, transparent, and scalable solution for multi-dimensional sustainability assessment.

The objectives of this project are to develop a decision framework using the TOPSIS method to evaluate sustainability performance across multiple criteria, compare and rank sustainability initiatives to identify the most sustainable alternatives, enhance transparency through step-by-step outputs and sensitivity

analysis, and support data-driven decisions aligned with the United Nations Sustainable Development Goals (SDGs).

RESULTS AND DISCUSSION

EcoWise (WISE-T) is an interactive web-based decision support tool designed to simplify sustainability decision-making through the TOPSIS method. Developed in Python and deployed via Streamlit, the system runs directly in a browser without installation, making it accessible to users across academic, corporate, and policy settings. The workflow in Figure 1 begins with dataset upload in Excel or CSV format, followed by definition of criteria as benefit or cost, assignment of weights, and automatic construction of the decision matrix. The system then performs normalisation, weighting, identification of benchmark solutions, Euclidean distance calculations, and closeness coefficient computations. These results are displayed step by step, ensuring full transparency. Figure 2 shows the integrated interface where users can view the uploaded dataset, intermediate calculations, and bar chart rankings in real time. This design allows dynamic weight adjustments, interactive outputs, and clear visualisation of sustainability rankings, making EcoWise a practical and user-friendly decision-support platform. The website is accessed through the link: https://ecowise-fiqhley.streamlit.app/.

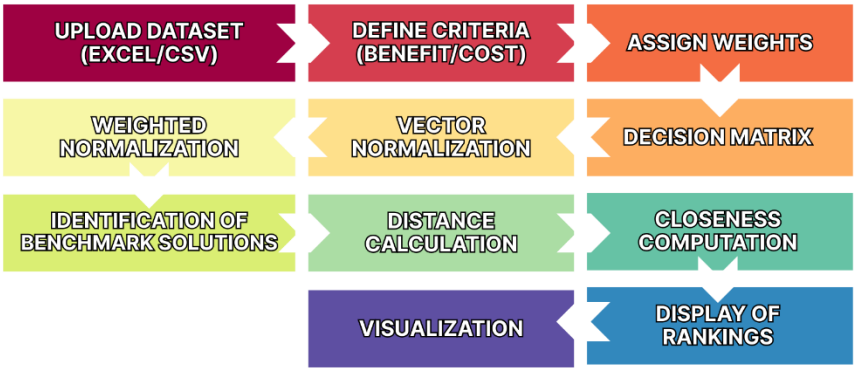

Figure 1: Flowchart of EcoWise: WISE-T.

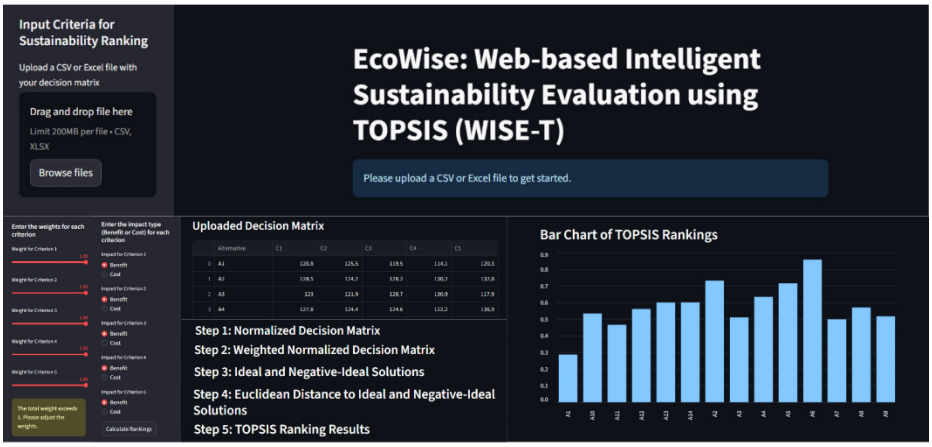

Figure 2: EcoWise: WISE-T input interface, output matrix and ranking chart.

The novelty of EcoWise lies in its ability to transform an academic MCDM method into a fully operational, transparent, and interactive web platform. Unlike manual TOPSIS calculations or static spreadsheet models, EcoWise provides an automated workflow that minimises errors and improves efficiency. Each stage of the TOPSIS process is visualized, fostering user trust and offering methodological clarity rarely found in conventional tools. Its adaptability to handle large datasets with multiple alternatives and criteria enhances scalability, while its browser-based design ensures accessibility without additional software costs. EcoWise also incorporates flexible weight adjustments, allowing users to test different decision scenarios instantly.

This level of interactivity and transparency distinguishes EcoWise from subscription-based tools such as D-Sight, making it an open and inclusive solution. By bridging scientific strictness with practical usability, EcoWise delivers value not only for sustainability consultants and policymakers but also as an educational tool for universities and training institutions.

CONCLUSION

EcoWise (WISE-T) transforms the TOPSIS method into a transparent, user-friendly, and adaptable web-based decision support tool for sustainability evaluation. By simplifying normalisation, weighting, benchmark identification, distance computation, and ranking, it eliminates the complexity and errors of manual calculations. Its interactive interface enables users to adjust weights dynamically, visualise intermediate steps, and generate clear ranking outputs, encouraging trust and adaptability in decision-making. Unlike conventional or subscription-based tools, EcoWise is freely accessible, lightweight, and capable of handling diverse datasets across corporate, governmental, and academic contexts. Aligned with the United Nations Sustainable Development Goals (SDGs), it empowers stakeholders to make data-driven, responsible choices that advance sustainable development. Future improvements may include integration of hybrid MCDM methods, expanded visualisation options, and exportable reports to further strengthen its practical and educational impact.

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SCHOLARSHIP SELECTION REINVENTED: A FUZZY INFERENCE APPROACH TO ASSESSING OVERSEAS STUDY CANDIDATES

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ABSTRACT

Scholarship selection is a critical process that determines access to higher education opportunities, yet conventional methods often suffer from subjectivity, rigidity, and bias. This project introduces a fuzzy inference system (FIS) as an innovative approach to assessing overseas scholarship candidates. The system integrates four key criteria—CGPA, parents' income, co-curricular activeness, and number of siblings—using trapezoidal membership functions and a rule base of 81 fuzzy rules. By applying MATLAB's Fuzzy Logic Toolbox, the model transforms crisp input values into fuzzy sets, evaluates them through inference rules, and defuzzifies the results into clear eligibility outcomes. This method captures uncertainties in candidate profiles and provides nuanced decisions beyond binary acceptance or rejection. The novelty lies in its fairness, transparency, and flexibility in handling borderline cases, offering a scalable framework adaptable to diverse scholarship schemes. Ultimately, the system ensures more equitable opportunities for students pursuing overseas education.

Keywords: Fuzzy Inference System, Scholarship Selection, MATLAB, Decision-Making

INTRODUCTION

Scholarship programs play a vital role in ensuring equitable access to higher education, especially for students aspiring to pursue studies abroad. Traditionally, scholarship selection processes rely heavily on fixed eligibility criteria or subjective evaluations by committees. While such approaches are widely used, they often face challenges including ambiguity in requirements, inconsistency in candidate evaluation, and susceptibility to bias (Pamučar et al., 2018). These limitations may result in deserving candidates being overlooked or resources distributed inequitably.

The complexity of scholarship selection arises from the multi-criteria nature of the problem, where factors such as academic performance, socio-economic background, and extracurricular participation must be simultaneously considered. Rigid cut-off points—for instance, a specific CGPA threshold or strict income brackets—fail to capture the nuanced realities of students' circumstances. In some cases, students with slightly lower academic scores but significant financial need or strong leadership potential may be unfairly excluded (Chen & Hwang, 1992; Pérez et al., 2013).

To address these issues, this project proposes the development of a Fuzzy Inference System (FIS) for scholarship eligibility assessment. Fuzzy logic provides a powerful tool to model uncertainty and vagueness inherent in human decision-making (Mendel, 2017). By incorporating linguistic variables such as "active," "middle active," or "less active," and translating them into quantitative fuzzy sets, the system evaluates candidates more holistically.

The primary motivation behind this product is to enhance fairness, transparency, and inclusivity in scholarship selection. Objectives include: (1) analysing scholarship eligibility based on multiple academic and socio-economic criteria, (2) minimising subjective bias in evaluations, and (3) providing a scalable,

adaptable framework for diverse scholarship schemes. In doing so, this innovation aims not only to improve decision-making accuracy but also to promote educational equity.

METHODOLOGY

The development of the fuzzy inference system (FIS) for scholarship selection followed a structured process (see Figure 1), beginning with the identification of key eligibility criteria and ending with the implementation and testing of the system in MATLAB's Fuzzy Logic Toolbox. Four input variables were selected based on their relevance and frequent use in real scholarship assessments: CGPA, parents' income, co-curricular activeness, and number of siblings. These inputs were linguistically categorised into membership functions (e.g., CGPA: first-class, upper second-class, lower second-class; Parents' income: B40, M40, T20).

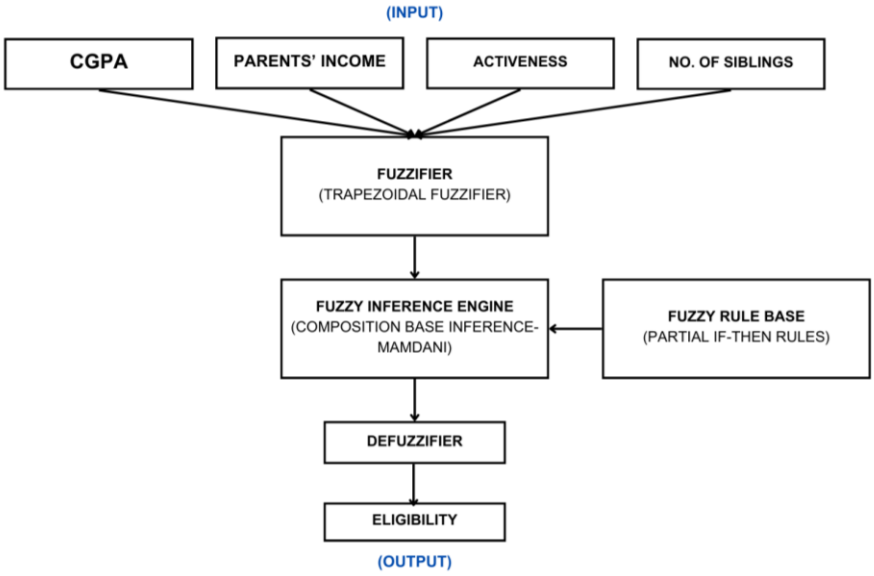

Figure 1: Framework of scholarship selection system

A trapezoidal fuzzifier was applied for each input variable due to its flexibility in modeling ranges with uncertain boundaries. The system output was defined as scholarship eligibility with two categories: accept or reject.

The rule base was constructed using expert knowledge and logical reasoning, resulting in 81 fuzzy IF–THEN rules. For instance: IF CGPA is first-class AND income is B40 AND activeness is active THEN eligibility is accepted. These rules were encoded in MATLAB to form the decision-making backbone of the system.

The fuzzy inference engine applied the Mamdani method, using the minimum operator for the "AND" condition to evaluate the truth values of input combinations. The aggregated results were then converted into crisp outputs through the centroid defuzzification method, yielding a membership value between 0 and 1.

Finally, the model was tested using real-world inspired input cases to validate its ability to handle diverse scenarios. Results demonstrated the system's robustness in capturing uncertainty, ensuring fairness, and producing transparent scholarship eligibility outcomes.

RESULTS AND DISCUSSION

The fuzzy inference system (FIS) developed for scholarship eligibility assessment was tested using various input scenarios to evaluate its effectiveness in handling diverse candidate profiles. The system produced outputs in the form of crisp eligibility values ranging between 0 (reject) and 1 (accept), with higher values indicating stronger eligibility.

Five representative cases were analysed as shown in Table 1. For instance, a student with CGPA 3.80, parents' income RM2,000, high co-curricular activity, and six siblings achieved a membership value of 0.605, resulting in acceptance. In contrast, a student with CGPA 3.00, parents' income RM1,000, moderate activeness, and three siblings obtained a membership degree of 0.227, leading to rejection. These results highlight how the system effectively balances academic, financial, and social dimensions in its decision-making.

Table 1: Scholarship Selection FIS Results

Case	CGPA	Parents' Income (RM)	Activeness (Certificates)	No. of Siblings	Eligibility Score	Decision
1	3	1000	8	3	0.227	Reject
2	3.8	2000	7	6	0.605	Accept
3	2.3	900	13	10	0.75	Accept
4	4	1000	14	8	0.786	Accept
5	3.5	1500	5	2	0.5	Borderline

Interestingly, borderline cases emerged, such as a student with CGPA 3.50, parents' income RM1,500, low activeness, and two siblings, who scored exactly 0.5. In such scenarios, the system demonstrates flexibility, allowing final decisions to be guided by scholarship quotas or policy considerations. This reflects the practical adaptability of fuzzy logic in addressing real-world ambiguities.

The discussion of results indicates three key findings. First, the system enhances fairness by prioritising candidates from disadvantaged socio-economic backgrounds without ignoring academic merit. Second, it improves transparency through explainable rules, reducing reliance on subjective judgment. Third, the model accommodates uncertainty, particularly in cases where candidates exhibit mixed profiles.

Overall, the fuzzy inference approach proves to be a promising solution to the limitations of traditional scholarship selection processes. By integrating multiple criteria into a holistic framework, the system ensures that opportunities are distributed more equitably, providing a robust foundation for policy implementation and potential expansion to larger-scale educational funding programs.

CONCLUSION

This project demonstrates the potential of fuzzy inference systems (FIS) to transform scholarship selection into a fairer, more transparent, and inclusive process. By integrating multiple factors such as academic performance, socio-economic background, co-curricular activeness, and family responsibilities—the system captures the complex realities of candidate profiles that traditional rigid criteria often overlook.

The results validate the system's ability to handle diverse scenarios, including strong candidates from disadvantaged backgrounds and borderline cases requiring flexible decision-making. Unlike conventional methods prone to bias or oversimplification, the fuzzy logic approach accommodates uncertainty and ensures that selection outcomes reflect both merit and equity.

The novelty of this work lies in its holistic evaluation framework, supported by rule-based transparency and adaptability. Beyond its immediate application in scholarship selection, the methodology can be scaled and extended to other decision-making contexts, such as grant allocations, admission processes, and social welfare distribution.

In essence, the fuzzy inference approach not only enhances the credibility of scholarship distribution but also contributes to broader educational equity by ensuring opportunities are allocated more justly and effectively. This innovation highlights the value of computational intelligence in addressing complex human-centered decision-making challenges.

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The authors would like to express their sincere gratitude to Universiti Teknologi MARA (UiTM) for providing the necessary support, facilities, and academic resources that enabled the successful completion of this project. Special thanks are extended to the Faculty of Computer and Mathematical Sciences for offering access to computational tools, laboratory space, and guidance throughout the development process.

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EVALUATING THE SATISFACTION OF LIBRARY WEBSITE USAGE USING FUZZY ANALYTIC NETWORK PROCESS (FANP)

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ABSTRACT

The quality of a library website strongly influences undergraduate students' satisfaction, yet limited studies have applied advanced methods such as FANP to evaluate this experience. This study objectives are to identify factors influencing satisfaction, to apply FANP to assess satisfaction levels, and to rank the influencing factors toward website quality. Three main criteria which are information quality, system quality, and service quality, and twelve sub-criteria were examined. Results show that information quality ranks first, followed by system quality and service quality. Among sub-criteria, usability ranks highest, followed by responsiveness, privacy, and soundness. These findings provide clearer insights to improve library website design and performance, while also supporting the Sustainable Development Goals (SDGs) by enhancing Quality Education (SDG 4), driving Innovation and Infrastructure (SDG 9), and promoting Reduced Inequalities (SDG 10) through inclusive and equitable access to digital knowledge.

Keywords: FANP, Library Website, User Satisfaction

INTRODUCTION

The rapid growth of digital technologies has transformed how academic libraries deliver information and services to their users. Library websites are now central gateways that provide access to digital collections, research tools, and learning resources (Kumar, 2023). The quality of these websites strongly influences user satisfaction, particularly among undergraduate students who rely heavily on online platforms for academic purposes. Despite their importance, limited studies have applied advanced decision-making approaches such as the Fuzzy Analytic Network Process (FANP) to systematically evaluate the factors that shape user satisfaction with library websites. The method, i.e., the FANP enables comprehensive analysis by assigning appropriate weights to all relevant criteria, ensuring that every aspect is considered when evaluating alternatives (Lakhouit et al., 2025).

This study addresses this gap by focusing on the MyKM portal, an online library platform provided by Perpustakaan Tun Abdul Razak (PTAR) of Universiti Teknologi MARA (UiTM). MyKM is an accessible library website of e-learning resource and library's innovative new layout to revolutionize user experience with a personalised system. The main objectives are to identify the key factors influencing satisfaction, apply FANP to assess the relative importance of these factors, and rank them in relation to website quality. There are four steps involved in evaluating the satisfaction criteria which are shown in Figure 1.

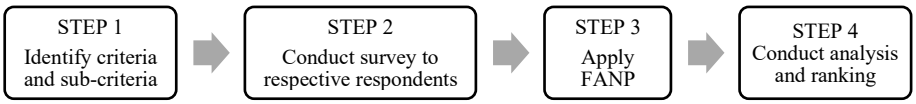

Figure 1: Four steps of applying FANP to measure satisfaction level to library website

The first step is to identify criteria and sub-criteria. There are three main criteria: quality, system quality, and service quality along with twelve sub-criteria were selected as shown in Figure 2. These criteria were extracted from past studies on Web 2.0 applications satisfaction study by Chua and Goh (2010). The second

step involved conducting a survey among the targeted respondents. The study focused on undergraduate students from UiTM Cawangan Negeri Sembilan, Kampus Seremban to obtain authentic user perspectives. Data collection was carried out using a Google Form questionnaire, which enabled efficient and accessible responses from the participants. The next step involved the application of the Fuzzy Analytic Network Process (FANP), with the calculation procedure adapted from Tarmudi et al. (2021). The final phase of the study focused on analysis and ranking, where the satisfaction factors were prioritised based on their output values where the highest value indicating the most significant factor, and the lowest value representing the least influential factor.

Figure 2: The criteria and sub-criteria of the MyKM satisfaction level among undergraduates.

RESULTS AND DISCUSSION

The results show that Information Quality (C2) ranks first, followed by System Quality (C1) and Service Quality (C3), indicating that MyKM is highly dependent on the quality of its information. For the sub-criteria, Usability (F1) is ranked highest, reflecting ease and speed of use, followed by Responsiveness (F2), which relates to obtaining and downloading information. Privacy (F4) comes next, highlighting user trust in data protection, while Soundness (F5) ensures accuracy and consistency of resources.

These findings demonstrate that MyKM's greatest strength lies in the quality and usability of its information, which positions it as a reliable and effective digital library platform for UiTM students. MyKM shows strong performance in information quality and usability, yet there are still opportunities for enhancement across other sub-criteria. By strengthening these areas, MyKM can evolve into a more interactive, user-friendly, and engaging digital library platform.

CONCLUSION

This study evaluated user satisfaction with the MyKM library website provided by PTAR UiTM, focusing on undergraduate students from UiTM Cawangan Negeri Sembilan, Kampus Seremban. The FANP was applied and as results, the Information Quality is the most influential criterion, followed by System Quality and Service Quality. At the sub-criteria level, Usability ranked highest, followed by Responsiveness, Privacy, and Soundness, demonstrating that MyKM's main strength lies in delivering high-quality and usable information. By strengthening digital learning access, it advances Quality Education (SDG 4); through smarter and more innovative portal design, it supports Industry, Innovation, and Infrastructure (SDG 9); and by ensuring equitable access to knowledge, it promotes Reduced Inequalities (SDG 10). Future research can expand the scope of respondents to include students from other UiTM campuses to obtain a broader and more representative perspective of user satisfaction. Such an expansion will provide deeper insights for continuous improvement, ensuring MyKM evolves into a more user-friendly, interactive, and engaging digital library platform.

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AN INTEGER LINEAR PROGRAMMING APPROACH TO TEACHING LOAD ALLOCATION

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ABSTRACT

Teaching Load Allocation (TLA) problem is a common operational challenge in higher education institutions, where aligning lecturer expertise with course demands while balancing workloads remains complex. Traditionally, TLA at Mathematics Department in Faculty of Computer and Mathematical Sciences, UiTM Seremban, has been conducted manually by the timetabling committee, often leading to issues such as workload imbalance, mismatched subject expertise, and inefficient resource allocation. This study aims to address these challenges by proposing a mathematical optimisation model using Integer Linear Programming (ILP) to systematically assign lecturers to student groups based on courses and lecture hours. The model was applied to consider the maximum teaching hours, and the need to consolidate small student groups. A real dataset comprising 19 courses, 92 student groups, and 25 lecturers was used. The results demonstrate that the ILP model effectively maximises the utilisation of lecturer teaching hours while adhering to all defined constraints. This approach provides a practical and systematic alternative to manual scheduling, enhancing resource allocation and contributing to better academic planning.

Keywords: Teaching Load Allocation (TLA), Integer Linear Programming (ILP), Microsoft Excel Solver

INTRODUCTION

In Faculty of Computer and Mathematical Sciences (FSKM) at UiTM Kampus Seremban, TLA is solved manually by timetable committee which is assigned by the head of department in a month before the student starts to register their courses. Even though TLA is solved manually, the decision makers must consider several parameters before proceeding with the scheduling. First, lecturers have different fields of specialty, and it is important to match the requirements for a subject to be taught effectively (Caselli et al., 2022). Second, lecturers should be assigned based on their maximum number of teaching hours to prevent burning out and ensure they have sufficient time to prepare and deliver content effectively to students. Third, a small number of students in a group should be combined to prevent excessive teaching hours. In general, scheduling TLA needs to be balanced with all aspects to create a better teaching and learning environment. However, TLA will usually change due to the dynamic environment, like the number of educators may change unexpectedly, the number of students in a group may increase which need additional lecturers (Caselli et al., 2022).

This study points out the inefficiencies in manual TLA by proposing an Integer Linear Programming (ILP) model. The ILP model is designed to optimize the TLA by incorporating a set of constraints. The production of an effective TLA, scheduling decisions can be made more systematically and effectively, ensuring compliance with academic standards and easing the workload for the lecturer in charge. ILP is an extension of LP by limiting the choice variables to integers. This approach is useful for assignment problems when there are only two possible outcomes: either a lecturer is assigned to a course, or they are not. Algethami and Laesanklang (2021) used ILP to schedule courses, considering the lecturer's credentials and time restrictions.

The data of 25 Mathematics lecturers in Faculty of Computer and Mathematical Sciences in UiTM Kampus Seremban were taken from the timetable committee contain of number of lecturers, lecture hour, list of

courses and student groups per course. Table 1 shows the list of courses with lecture hour and student groups while Table 2 presents the list of lecturers with limit of student groups and lecture hour.

Table 1: List of courses with lecture hour and student groups

Course code	**Lecture hour**	**Student group**
K1	4	G1 – G4
K2	4	G5 – G9
K3	4	G10 – G11
K4	4	G12 – G15
K5	5	G16 – G17
K6	5	G18 – G26
K7	4	G27 – G30
K8	4	G31 – G36
K9	4	G37 – G43
K10	4	G44 – G50
K11	4	G51 – G54
K12	4	G55 – G56
K13	4	G57 – G59
K14	4	G60 – G61
K15	4	G62 – G64
K16	4	G65 – G67
K17	4	G67 – G72
K18	4	G73 – G84
K19	4	G85 – G92

Table 2: List of lecturers with limit of student groups and lecture hour

Lecturer	**Limit student group**	**Limit lecture hour**
L1	4	16
L2	4	16
L3	4	16
L4	4	18
L5	4	18
L6	4	16
L7	4	16
L8	4	16

L9	4	18
L10	4	16
L11	4	16
L12	4	18
L13	4	16
L14	1	4
L15	4	16
L16	2	8
L17	4	18
L18	4	16
L19	4	16
L20	4	16
L21	4	16
L22	4	16
L23	4	18
L24	4	18
L25	4	16

ILP FORMULATION

This study utilizes an ILP model to maximize the total number of lecture hours assigned to lecturers while considering a set of constraints to balance the workloads.

Notation

Set of student groups (Gi) : $\{G1, G2, \dots, G92\}$
Set of lecturers (Lj) : $\{L1, L2, \dots, L25\}$
Lecture hour for each student group (K_{Gi}) : $\{K_{G1} = 4, K_{G2} = 4, \dots, K_{G92} = 4\}$
Limit student group for each lecturer (N_{Lj}) : $\{N_{L1} = 4, N_{L2} = 4, \dots, N_{L25} = 4\}$
Limit lecture hour for each lecturer (M_{Lj}) : $\{M_{L1} = 16, M_{L2} = 16, \dots, M_{L25} = 16\}$

Decision variable, $X_{Gi,Lj} = \begin{cases} 1, & if\ a\ student\ group\ Gi\ is\ aasigned\ to\ a\ lecturer\ Lj \\ 0, & otherwise \end{cases}$

Objective function

$$\text{Max } Z = \sum K_{Gi}\, X_{Gi,Lj} \tag{1}$$

Subject to

Constraint 1: Each student group must be assigned to a lecturer

$$\sum X_{Gi,Lj} = 1 \qquad \forall Gi \tag{2}$$

Constraint 2 : Limit student group for each lecturer

$$\sum X_{Gi,Lj} \leq N \qquad \forall Lj \qquad (3)$$

Constraint 3 : Limit lecture hour for each lecturer

$$\sum K_{Gi} X_{Gi,Lj} \leq M \qquad \forall Lj \qquad (4)$$

RESULTS AND DISCUSSION

Table 3 the output of ILP solution using Microsoft Excel Solver that assigns lecturers to specific student groups for various courses. Most lecturers have 16 to 18 lecture hours, which satisfy Constraint 2 which is the limit of lecture hour. L16 which involves in administration post in faculty only assigned to 2 student groups with a total of 8 lecture hours. The same goes to L14 with 1 student group (4 hours) assigned. The course allocation results indicate that some lecturers are assigned to multiple student groups within the same course, which promotes continuity in content delivery and efficient scheduling. Additionally, most lecturers are responsible for teaching more than one course, reflecting a balanced distribution of workload and optimal use of teaching resources across the curriculum.

CONCLUSION

Overall, the findings clearly demonstrated that the model could maximise the total teaching hours, while the constraints were respected. The assignments of lecturers were appropriate for their expertise level, and the workloads were fairly distributed. Microsoft Excel Solver was a very interesting example of a tool that can be used in institutional settings to tackle optimisation issues, especially where institutions may not have invested in additional money to purchase advanced software to solve optimization issues.

In conclusion, this study illustrated how utilizing an ILP model can revolutionise academic administration. The ILP model provided not only a systematic, transparent, and effective alternative to traditional scheduling approaches, but it was also much less time consuming. The quality of TLA assignments produced was also significantly improved over previous methods mentioned in the literature review.

Table 3: Output teaching load for each lecturer

Lecturer	Course-student group	Lecture hour	Lecturer	Course-student group	Lecture hour
L1	K7: G29 K10: G48-G50	16	L14	K18: G71	4
L2	K12: G55 K16: G65 – G67	16	L15	K7: G30 K8: G31 – G33	16
L3	K12: G56 K13: G57 – G59	16	L16	K8: G34 – G35	8
L4	K19: G76 K20: G86 – G88	16	L17	K4: G13 – G14 K9: G16 – G17	18
L5	K1: G1 K4: G15 K6: G22 – G23	18	L18	K8: G36 K9: G37 – G39	16
L6	K14: G60 – G61 K15: G62 – G63	16	L19	K15: G64 K18: G72 K19: G74 – G75	16

L7	K19: G77 – G80	16	L20	K9: G40 – G43	16
L8	K1: G2 – G4 K2: G5	16	L21	K10: G44 – G47	16
L9	K2: G6 – G8 K6: G20	17	L22	K11: G51 – G54	16
L10	K19: G81 – G84	16	L23	K2: G9 K3: G10 K6: G18 – G19	18
L11	K18: G68 – G70 K19: G73	16	L24	K6:G25 – G26 K7: G27 – G28	18
L12	K3: G11 K4: G12 K6: G21, G24	18	L25	K20: G89 – G92	16
L13	K20: G85	4			

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NUMERICAL SOLUTION OF UNSTEADY MICROPOLAR NANOFLUID MODEL OVER EXPONENTIALLY CURVED SURFACE WITH CHEMICAL REACTION USING BVP4C

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ABSTRACT

This study examines the time-dependent behavior of micropolar nanofluids over exponentially curved surfaces in the presence of chemical reaction. Micropolar nanofluids are fluid systems that combine the beneficial microstructure effects of micropolar fluids and the improved thermal properties of nanofluids due to presence of nanoparticles in suspension. Micropolar nanofluids have several applications for heat transfer in industry. The partial differential equations (PDEs) for the governing equations of motion, micropolar motion, energy, and concentration are developed and reduced into a system of nonlinear ordinary differential equations (ODEs) using a form of similarity transformations. The nonlinear ODE system of equations is solved numerically using the bvp4c solver, a collocation method, from MATLAB. The solutions obtained from the bvp4c solver are compared to existing studies using the shooting method, and the results verify the accuracy of the bvp4c method of numerical solution. The study considers the effect of several important parameters including curvature k, unsteadiness β, micropolar K, Prandtl Pr, and Schmidt Sc numbers, on physical profiles of velocity, micropolar motion, temperature, and concentration. The study finds that velocity of the micropolar fluid increases as the k and K numbers increase, and that the micropolar profiles increase with increasing β and decrease as K increases. The temperature and concentration profiles are found to increase with curvature while decreasing with Pr and Sc numbers respectively.

Keywords: Micropolar Nanofluid, Exponentially Curved Surface, Chemical Reaction, Bvp4c, Numerical Solution

INTRODUCTION

Fluid dynamics is foundational to engineering, medicine, and environmental uses, especially for the estimation of boundary boundary layer flow properties. Nanofluids are nano-particle suspensions with a minimum particle size of 100 nm or below, which show enhanced thermal conductivity and heat transfer, and therefore, can be advantageous in applications involving cooling and heating systems. Micropolar fluids (Eringen, 1966) are an extension of non-Newtonian fluids, which incorporate effects caused by micro-rotation, and are relevant for things like suspension flows, liquid crystals, and biological fluids.

This work provides a model for unsteady micropolar nanofluids over exponentially curved surfaces taking into consideration chemical reactions. Curved geometries have a significant impact to velocity distribution, pressure gradients, and heat transfer quality, and exponentially curved surfaces show distinctive flow characteristics as was examined during uniform curvature surfaces. Chemical reactions which are endothermic and exothermic can continue to alter the boundary layer behaviour in opposing ways.

The problem statement indicates the need for better heat transfer fluids in applications on cooling systems, electronics, and energy systems. Currently available research lacks extensive studies related to micropolar nanofluids over exponentially curved surfaces with chemical reactions, particularly using robust solvers like bvp4c.

The objectives are:

i. To reduce nonlinear PDEs governing micropolar nanofluid flow into ODEs using similarity transformations.
ii. To solve the reduced equations using MATLAB's bvp4c solver.
iii. To validate results against the shooting method and analyze the impact of physical parameters.

METHODOLOGY

Based on the conservation laws, continuity, momentum, micropolar, energy, and concentration governing equations are presented and derived according to Fuzhang et al. (2022). Using similarity transformations enables the conversion of the PDEs into the following system of ODEs:

$$\begin{aligned}&(1+K)\left(f^{iv}+\frac{2}{\eta+k}f'''-\frac{1}{(\eta+k)^2}f''+\frac{1}{(\eta+k)^3}f'\right)\\&+\frac{k}{\eta+k}\left(ff'''-3f'f''+ff''+f'^2\right)-\frac{4k}{(\eta+k)^2}f'^2\\&-K\left(h''+\frac{1}{\eta+k}h'\right)-\beta\left(\eta f'''+\frac{\eta}{\eta+k}f''+\frac{2}{\eta+k}f'+3f''\right)=0,\end{aligned}\tag{1}$$

$$\begin{aligned}&\left(1+\frac{K}{2}\right)\left(h''+\frac{1}{\eta+k}h'\right)-K\left(2h+f''+\frac{1}{\eta+k}f'\right)\\&+\frac{k}{\eta+k}\left(f'h-fh'\right)-\beta\left(3h+\eta h'\right)=0,\end{aligned}\tag{2}$$

$$\begin{aligned}&\frac{1}{Pr}\left(\theta''+\frac{1}{\eta+k}\theta'\right)+\frac{k}{\eta+k}\left(f\theta'-Af'\theta\right)+Nb\theta'\varphi'\\&+Nt\left(\theta'\right)^2+\delta\theta-\beta\left(2\theta+\eta\theta'\right)=0,\end{aligned}\tag{3}$$

$$\begin{aligned}&\frac{1}{Sc}\left(\phi''(\eta)+\frac{1}{\eta+k}\phi'(\eta)\right)+\frac{k}{\eta+k}\left(f(\eta)\phi'(\eta)-Bf'(\eta)\phi(\eta)\right)\\&+\frac{Nt}{Nb}\frac{1}{Sc}\left(\theta''(\eta)+\frac{1}{\eta+k}\theta'(\eta)\right)-\beta\left(4\phi(\eta)+\eta\phi'(\eta)\right)=0,\end{aligned}\tag{4}$$

with boundary conditions as follows:

$$\begin{aligned}&f(\eta)=0,\ \ h(\eta)=-\eta f''(\eta),\ \ f'(\eta)=1,\\&\beta t\theta'(\eta)+1=\theta(\eta),\ \ \beta c\phi'(\eta)+1=\phi(\eta),\ \ at\ \ \eta=0,\ \ f'(\eta)\to 0,\ \ f''(\eta)\to 0,\\&h(\eta)\to 0,\ \ \theta(\eta)\to 0,\ \ \phi(\eta)\to 0\ \ \ at\ \ \ \eta\to\infty\end{aligned}\tag{5}$$

To solve the equations using bvp4c in MATLAB software, the ODEs will be reduced to a system of first-order equations.

RESULTS AND DISCUSSION

The results achieved using bvp4c are validated with shooting method in previous studies; Sajid et al. (2010) and Sajid et al. (2011) which shows close agreement and affirming the solver's accuracy. The key findings include the velocity profile $f'(\eta)$ increased with higher curvature parameter k and micropolar parameter K, indicating better momentum transfer near the boundary layer. The micropolar profile $h(\eta)$ showed the trade-off between microrotation and micropolar resistance, with larger values of K decreasing microrotation and the unsteadiness parameter β encouraging it. In terms of temperature distribution $\theta(\eta)$, both curvature k and the Prandtl number Pr enhanced heat transport; in particular, Pr reduced the thickness of the thermal boundary layer. On the other hand, the concentration profile $\phi(\eta)$ increased with increasing curvature but declined with increasing Schmidt number Sc because higher Sc values inhibit mass diffusivity and provide thinner concentration boundary layers. Overall, the research demonstrates that curvature and micropolar effects are critical in fluid flow behaviour, while diffusivity and chemical reaction parameters significantly affect heat and mass transfer performance. In addition, graphical plots are employed to depict the flow behaviour and heat transfer performance, providing a complete visualisation of the system response for changing conditions. The results in Figure 1 and Figure 2 present some of the main trends and physical observations from the numerical simulations, paving the way for further discussion and interpretation.

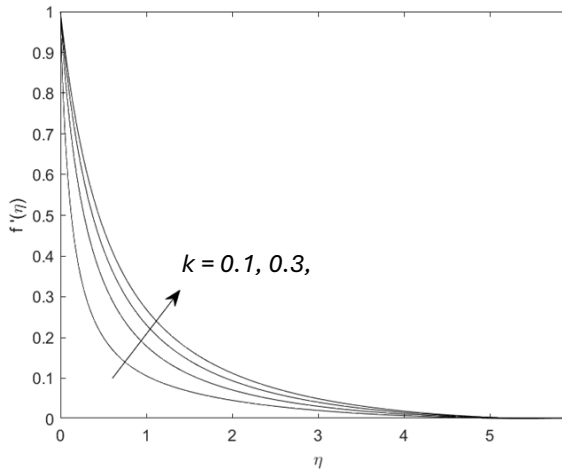

Figure 1: Velocity profile $f'(\eta)$ for different values of k

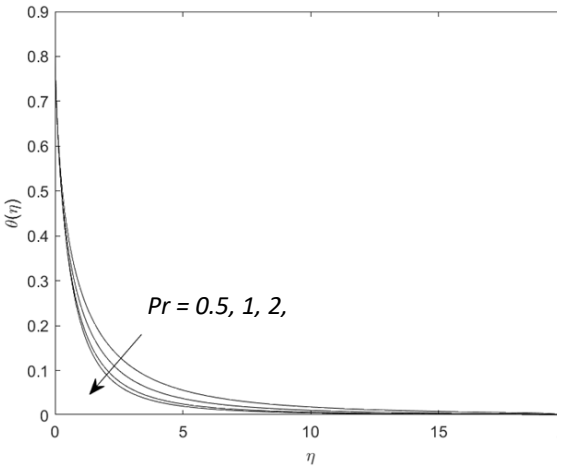

Figure 2: Temperature profile $\theta(\eta)$ for different values of Pr

Table 1: Skin friction and coupling stress numbers when all other parameters are set as: $\beta t = \beta c = 0.1$, $Sc = 1$, $n = Nb = 0.5$, $A = B = 0.3$, $Nt = \delta = 0.4$, $Pr = 4$

k	K	β	$C_f Re_s^{1/2}$	$C_m Re_s$
0.5	0.1	0.1	-0.48391	1.072053
1.0	-	-	-0.63957	0.329143
0.5	0.1	0.2	-0.55508	0.830222
-	0.2	-	-0.69022	0.587362
0.5	0.2	0.0	-0.54072	1.019638
-	-	0.1	-0.61705	0.783008

Table 2: Nusselt and Sherwood numbers were determined by establishing the parameters $\beta t = 0.1$, $\beta c = 0.2$, $Nb = 0.2$, $Nt = 0.2$, $\delta = 0.1$, $A = 0.1$ and $B = 0.1$

k	K	β	Sc	Pr	$-\theta'(0)$	$-\phi'(0)$
0.1	0.1	0.1	1	0.4	1.74618	1.97429
0.3	-	-	-	-	1.03409	1.25814
1	0.1	0.1	1	0.4	0.64459	0.84836
-	0.3	-	-	-	0.64737	0.85137
0.1	0.1	0	1	0.1	1.59993	1.71370
-	-	0.2	-	-	1.72954	2.12720
0.7	0.1	0.1	0.5	0.1	0.61230	0.81874
-	-	-	1.5	-	0.61181	1.13100

The numerical results in Table 1 and Table 2 indicate that the increase in curvature (high k) increases skin friction (more drag on the fluid) but results in lower couple stress (diminishes the microrotational effects). For heat and mass transfer, higher curvature will reduce both Nusselt and Sherwood numbers, impeding thermal and concentration performance slightly. In addition, higher unsteady flow (higher β) increases both Nusselt and Sherwood numbers which improves the heat and mass transfer rates. The effect of microrolar parameter K increases skin friction noticeably, however this has low significance in heat and mass transfer. Finally, higher Schmidt number Sc increases the Sherwood number significantly improving the mass transfer.

NOVELTY

The present research offers fresh knowledge about the unsteady flow of the micropolar nanofluids over exponentially curved surfaces with chemical reactions, the numerical solutions of which have been conducted using the bvp4c solver. The impact of curvature, unsteadiness and chemical reactions on heat and mass transfer are discussed in finer details and are original contribution to the topic.

CONCLUSION

The problem of unstable micropolar nanofluid flow over exponentially curved surfaces with chemical reactions was successfully solved numerically in this paper using MATLAB's bvp4c solver. The solver showed accuracy and reliability in comparison to the shooting approach. Crucial physical characteristics such as curvature, unsteadiness, micropolar effects, Prandtl, and Schmidt numbers have a significant impact on the profiles of temperature, concentration, velocity, and microrotation. Future work could explore additional physical effects including magnetic fields or variable viscosity to enhance the model's applicability further. Applying the knowledge gained to the construction of sophisticated cooling systems, microreactors, and thermal management technologies can demonstrate the usefulness of micropolar nanofluids in engineering and industrial applications.

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INNOVATIVE DIGITAL EMPOWERMENT: A CROSS-BORDER HEALTH PROMOTION ON DEMENTIA AWARENESS LED BY MEDICAL UNDERGRADUATES

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ABSTRACT

This project showcases an innovative, student-led approach to community empowerment through digital health promotion, bridging Malaysia and Indonesia in a shared mission to raise dementia awareness. Organised by the medical undergraduates from Universiti Teknologi MARA (UiTM), Malaysia, in collaboration with Yayasan Rumpun Nurani, Indonesia, the initiative leveraged digital platforms to reach 150 elderly individuals and caregivers via an interactive Zoom-based webinar. The program featured expert talks, personal caregiver stories, a student-created e-book, and a live chairobic demonstration—delivering accessible, culturally relevant health education. Post-event data revealed a significant increase in dementia knowledge (mean score from 33.63 to 45.08), underscoring the impact of digital tools in enhancing community health literacy. Uniquely, this initiative moved beyond traditional bedside learning, empowering students to become proactive health educators while developing leadership, communication, and digital competencies. By combining innovation, cross-cultural collaboration, and technology, the project exemplifies a scalable model for empowering underserved communities and redefining undergraduate medical education through real-world public health engagement.

Keywords: Empowerment, Digital, Dementia, Medical, Undergraduates

INTRODUCTION

Dementia is a growing global public health concern, with significant social, psychological, and economic implications for individuals, families, and healthcare systems. In Southeast Asia, where populations are ageing rapidly, the burden of dementia is intensifying. Despite this, public awareness and understanding of dementia remain limited, particularly in rural and underserved communities. This knowledge gap often contributes to stigma, delayed diagnosis, and inadequate care for individuals living with dementia.

Traditional medical education largely emphasises bedside clinical skills and disease management, often overlooking the broader socio-behavioural dimensions of health and the importance of preventive strategies. In the digital age, however, health professionals must be equipped not only with clinical competencies but also with skills in communication, leadership, and digital technology to effectively engage and empower communities.

Recognising the urgent need to foster a new generation of socially responsive, tech-savvy medical professionals, the Department of Public Health Medicine at Universiti Teknologi MARA (UiTM), Malaysia, spearheaded an innovative, student-led digital health promotion initiative. This cross-border collaboration with Yayasan Rumpun Nurani in Indonesia aimed to raise awareness about dementia while simultaneously nurturing essential non-clinical competencies among undergraduate medical students.

OBJECTIVES

The overarching aim of the initiative was twofold:

i. Community Impact: To improve dementia awareness and knowledge among elderly individuals and caregivers in Indonesia and Malaysia using an accessible, technology-driven platform.
ii. Educational Innovation: To provide undergraduate medical students with experiential learning opportunities in leadership, health promotion, and digital engagement—skills crucial for 21st-century medical practice.

Specific objectives included:

- Designing a culturally appropriate, engaging digital health promotion campaign on dementia.
- Evaluating knowledge improvement in participants post-intervention.
- Assessing student growth in soft skills through structured self-evaluation metrics.

The initiative aimed to:

- Empower students to design and deliver an impactful digital health campaign.
- Strengthen students' digital literacy, leadership, teamwork, and communication skills.
- Create sustainable educational materials and experiences for communities and caregivers.
- Evaluate both community impact (in terms of knowledge improvement) and student development (in terms of self-evaluated competencies).

DESCRIPTION – CONCEPT, DESIGN, AND IMPLEMENTATION

Held on 12 October 2024 via the Zoom platform, the initiative was led by medical undergraduates under faculty guidance and supported by partners at Yayasan Rumpun Nurani, a non-governmental Indonesian organisation dedicated to elderly care. A total of 150 elderly individuals and caregivers attended the webinar.

The session included:

- Chairobic Demonstration: A fun, low impact seated aerobic exercise session designed to promote physical and cognitive health among the elderly.
- Expert's Talk: A simplified, engaging overview of dementia by a public health expert, tailored to a lay audience.
- Caregiver's Sharing Session: Personal reflections and lessons learned from family caregivers, humanising the dementia journey.
- E-Book Launch: A downloadable, student-created e-book offering practical information and self-care tips for dementia caregivers. This book, entitled "Demensia KITA © Buku Saku (Versi Bahasa Indonesia)" was published with International Standard Book Number (ISBN) 9786299885887 and copyrighted (CRLY2024W09030).

Digital tools, including Canva, Google Forms, and video conferencing platforms, were utilised to design, promote, and deliver the event. The interactive structure encouraged participation through real-time quizzes, polls, and Q&A, ensuring two-way communication rather than passive learning.

RESULTS

Community Outcomes:
Among the 150 participants, 97 completed pre- and post-webinar knowledge assessments. Results indicated a statistically significant increase in dementia knowledge, with mean scores rising from 33.63 to 45.08 out of 60. This demonstrates that the digital health promotion event effectively enhanced participants' understanding of dementia, its symptoms, and caregiving principles.

Student Outcomes:
Students involved in the program also demonstrated significant personal and professional growth. Using a structured self-assessment tool focused on leadership, teamwork, communication, and digital competencies, students reported increased scores from a pre-intervention mean of 16.72 to 21.42 out of 25.

These findings reflect improved confidence and skill acquisition through their engagement in real-world, community-focused digital health promotion.

DISCUSSION

This initiative presents a novel educational approach that combines community service, digital health promotion, and interprofessional collaboration, providing mutual benefits for both community members and student facilitators.

The uniqueness of the project lies in its departure from traditional bedside medical training. Students were entrusted to lead a real-time public health intervention, transitioning from passive learners to active agents of change. This shift from classroom to community empowered them to understand the social determinants of health and the importance of health literacy at the grassroots level.

Furthermore, the cross-border collaboration between Malaysia and Indonesia added a rich intercultural dimension. Students had to adapt communication styles, content, and delivery to suit a multicultural audience. This experience fostered cultural competence and digital skills, enabling them to achieve the course learning outcome and possess an increasingly vital skill in global health practice. The use of technology as a delivery and engagement tool further distinguishes the program. Students gained hands-on experience using digital platforms for not only logistics and communication but also for creating educational content. By producing e-books, interactive media, and social media campaigns, students learned how to translate scientific knowledge into accessible, actionable health messages.

From the perspective of health promotion theory, the initiative was grounded in several principles:

- Empowerment: The session helped caregivers and elderly participants gain knowledge, tools, and confidence in understanding/managing dementia.
- Participation: Both students and community members played active roles, ensuring mutual learning.
- Multisectoral collaboration: The partnership with a community NGO (Yayasan Rumpun Nurani) exemplified how academia and civil society can collaborate for greater impact.
- Equity: The digital nature of the initiative ensured wider reach, especially to rural and remote participants who may not have access to in-person events.

Importantly, this initiative also contributed to capacity-building among future health professionals. In line with the WHO's recommendations on transforming and scaling up health professional education, this project serves as a model for integrating competency-based education with community needs and global health priorities.

In summary, the program's novelty is reflected in:

- Its student-led, digital-first design.
- Its cross-national, culturally contextualised implementation.
- It has a bidirectional benefit for both learners and the public.
- Its grounding in public health and health promotion principles, offering a real-world application of theory into practice.

CONCLUSION

This technology-driven, student-led dementia awareness initiative successfully achieved its dual mission: to empower communities through accessible health education and to cultivate future-ready, socially responsible medical professionals. By stepping beyond the hospital walls and embracing digital platforms, students learned how to lead, communicate, and innovate in ways that traditional clinical rotations may not afford.

The project's success also underscores the potential for scalable, replicable models of digital health promotion that can be embedded into undergraduate medical curricula. By embracing digital tools and emphasising community engagement, academic institutions can train a new generation of doctors who are not only clinically competent but also digitally fluent, culturally aware, and committed to health equity.

The initiative stands as a compelling example of what can be achieved when students are given ownership, mentorship, and a meaningful cause. As the global burden of dementia continues to grow, especially in ageing societies like Malaysia and Indonesia, empowering both caregivers and future health professionals through such innovative educational models will be crucial to shaping resilient and compassionate health systems.

ACKNOWLEDGEMENT

The authors would like to express their gratitude to Universiti Teknologi MARA, Rumpun Nurani Foundation, and the developers of Demensia KITA for their support in making this event a success.

ONE APP, EVERY NEED: CAMPUS LIFE WITH SeTigo

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ABSTRACT

SeTigo is a mobile application designed for Universiti Teknologi MARA (UiTM) Seremban students. It provides a centralised platform for campus announcements, events, and student-driven entrepreneurial activities. The project addresses the absence of a unified communication channel and the lack of visibility for student sellers. Thus, it enhances convenience, safety, and decision-making on campus. The project has a user-centric interface with integrated features such as real-time news feeds, a student marketplace, secure payment systems, and intelligent search capabilities. Advanced technologies, including Artificial Intelligence (AI), Big Data Analytics, and Sentiment Analysis, are embedded to personalize user experiences, automate notifications, and deliver data-driven insights to student entrepreneurs. The system is built on cloud computing, which means users can access it easily from anywhere, while data is stored and managed securely in the cloud. SeTigo can significantly enhance student engagement, support small-scale entrepreneurship, and improve communication across the university. It introduces a novel, intelligent decision-support ecosystem that enriches student life by combining a marketplace with a campus information hub to build a smart, connected, and collaborative community.

Keywords: Student Marketplace, Decision Support System, Sentiment Analysis, Artificial Intelligence, Big Data Analytics

INTRODUCTION

SeTigo is a mobile application developed to enhance campus communication and entrepreneurship among students of UiTM Seremban. The platform is a centralized hub for announcements, events, and a student marketplace. It aims to improve accessibility to campus information while supporting entrepreneurial initiatives. Its creation was motivated by the need to integrate digital solutions into campus life. This will promote a connected and informed student community. Designed to assist UiTM Seremban students, SeTigo addresses the lack of a dedicated system for real-time updates on campus events and student activities. Announcements are often limited to on-campus boards or social media platforms, which are unreliable or inaccessible to all students. It gets worse when they are posted on channels accessible only to those residing in university accommodation. Furthermore, student entrepreneurs face difficulties promoting their products or services as social media post threads often get lost among other posts. As a result, students are required to repost frequently throughout the day to maintain the visibility of their products.

OBJECTIVE

The objectives of this project are: (1) to provide students with centralized access to announcements, events, and updates, (2) to create a safe and structured space for student businesses to grow, and (3) to design a user-friendly app for students to enhance income opportunities.

DESCRIPTION

SeTigo begins with a simple login or sign-up for students. The home page displays a centralized feed of announcements, programs, and events, which can be searched and filtered. A built-in AI algorithm learns from students' interests and activity, recommending events, products, or services they will most likely explore. Students receive personalised notifications and find what they need more quickly. In the marketplace, sellers can upload listings with images, prices, and details, while buyers browse, add items to cart, and pay via e-wallets or online banking. Once a transaction is complete, buyers are encouraged to leave feedback through ratings and reviews. This input is processed using Sentiment Analysis through Natural Language Processing (NLP), which helps sellers improve the quality of their products and services. On the seller side, entrepreneurs can monitor their performance through a profile dashboard, which displays sales statistics, order histories, and customer insights. At the system's back end, Big Data Analytics tracks and analyses user activity such as popular products, event trends, and sales performance, which helps student entrepreneurs make informed decisions about what to sell or promote. Cloud Computing provides secure storage and ensures the app is accessible anytime and on any device. SeTigo offers all students reliable, innovative, and user-friendly experience with these technologies.

Figure 1: Image of SeTigo logo

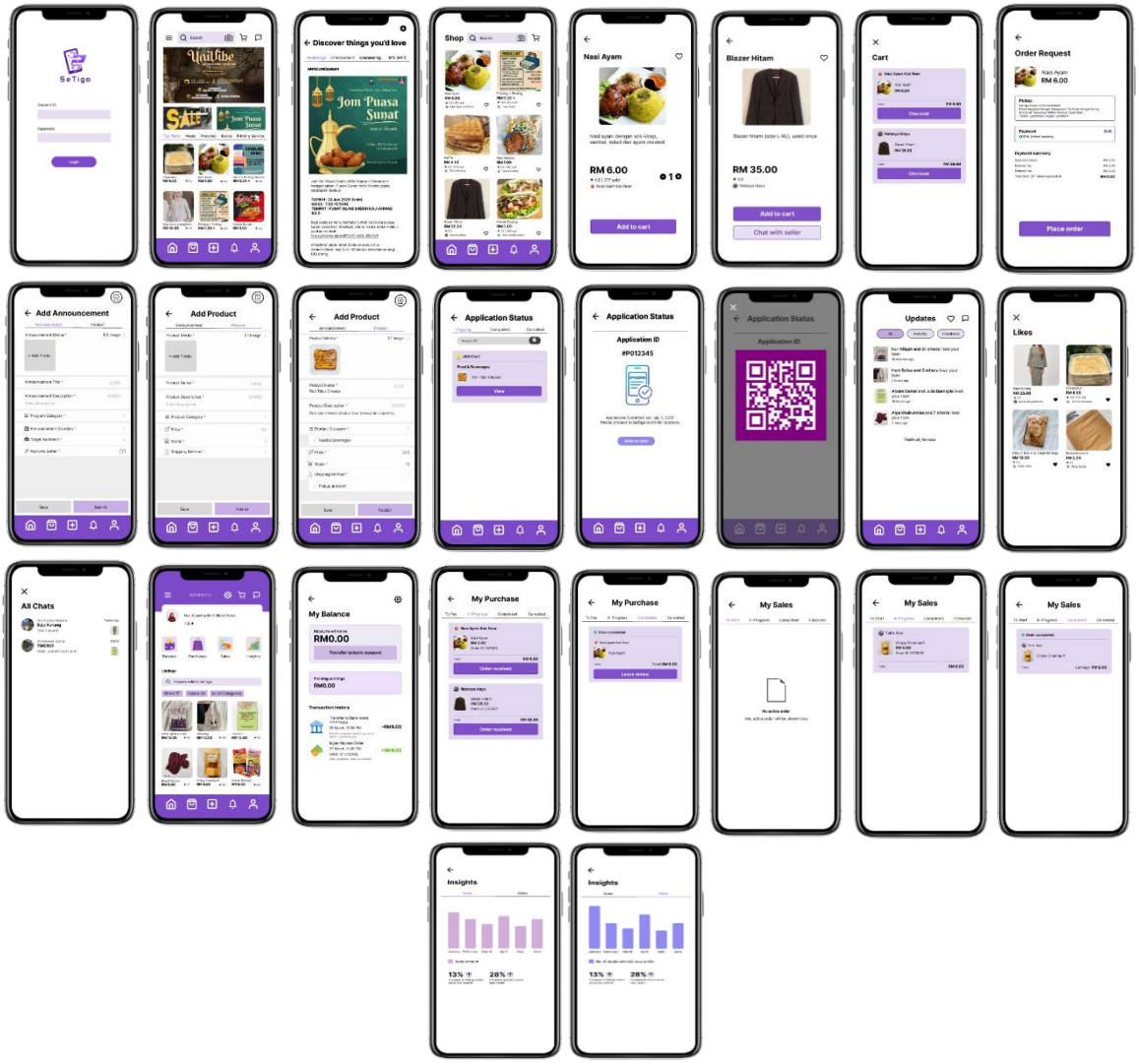

Figure 2: Prototypes of SeTigo User Interface Design

NOVELTY

The main feature is a centralised announcement feed that provides real-time updates on campus events, programs, and official news. It helps students stay informed without relying on scattered or unreliable communication channels. The app also includes a student marketplace where users can sell products or services such as food, pre-loved items, or personal services. Listings are simple to create, with options to upload photos, descriptions, and prices. A search and filter function allows students to quickly find events, announcements, or products, saving time and effort. SeTigo integrates secure payment methods, including e-wallets and online banking, to ensure safe transactions. Sellers can create and manage their profiles, showcasing products professionally to build trust with buyers. With these features, SeTigo improves communication and supports students in becoming entrepreneurs.

The uniqueness of the products can be summarized as: (1) the usage of AI plays a significant role in the personalisation experience of the users, which also provides intelligent decision-making and guarantees the platform stays dynamic, engaging, and centered around the users. Next, (2) Big Data Analytics, which assist in processing, analyzing extensive amounts of user-generated data, and further provide real-time insights into sales performance, product demand, and trends in student engagement. Moreover, (3) Sentiment Analysis Natural Language Processing (NLP) to derive valuable insights from product reviews and

comments. Finally, (4) the technological backbone for SeTigo's reliability and accessibility to real-time data is the application of cloud computing.

CONCLUSION

SeTigo is an innovative and practical solution that improves communication and entrepreneurship among UiTM Seremban students. By combining a centralised announcement system with a student marketplace, the platform makes it easier for students to stay informed and run their businesses safely and efficiently. Using technologies such as AI, Big Data, Sentiment Analysis, and cloud computing, SeTigo provides a personalised and reliable user experience. The platform helps students save time and access real-time information, supports income-generating opportunities, and builds a stronger campus community. SeTigo is a valuable tool that brings convenience, safety, and innovation to student life.

ACKNOWLEDGEMENT

The authors would like to thank the course lecturer, evaluation panel, and project advisor for their guidance, support, and valuable feedback throughout the development of this project. The authors also extend their appreciation to the Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA for providing the support and resources necessary for the completion of ISP688: Intelligent Decision-Making Support System course.

PREDICTIVE MODELING OF PROPERTY PRICE IN MALAYSIA USING TREE-BASED MODELS IN MACHINE LEARNING

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ABSTRACT

This study aims to conduct predictive modelling on property price prediction in Malaysia's property market. The market, influenced by economic conditions, supply and demand, and government regulations, is dynamic and multifaceted; hence advanced forecasting methods are essential. Traditional regression models often fail to handle nonlinear and complex relationships. This study applies tree-based machine learning models, namely Decision Tree and Random Forest, for higher accuracy in property price prediction and to provide insight into the main determinants affecting pricing. Data was obtained from the National Property Information Centre, covering transactions across various property sectors from 2001 to 2022. Data cleaning, feature engineering, and data visualization in Tableau were performed to ensure integrity and engagement. Predictive modelling focuses on a comparison between Decision Tree and Random Forest. The objectives are to create an interactive dashboard, develop predictive models, and determine the best tree-based approach for predicting Malaysian property prices. Results indicate that Random Forest outperformed Decision Tree in accuracy, precision, recall, and F1-score. The visualisation dashboard and predictive models will assist stakeholders in policymaking, investment, and housing decisions. This contributes to a more transparent, data-driven, and equitable Malaysian property market, supporting future urban planning and economic strategies.

Keywords: Property price prediction, machine learning, Malaysian property market, data visualization, tree-based models

INTRODUCTION

The Malaysian property market is an important component of the national economy with interaction of economic, social and policy-driven forces. Accurate price prediction is important for homebuyers, sellers, investors and policymakers as it supports decision making within the property market which is often marked by fluctuations and complexity (Shahirah et al., 2021). In recent years, new opportunities have been created with rapid technological advances to address the challenges in facing property valuation and forecasting. Machine learning is able to predict property prices accurately based on amenities, size, location, accessibility and market conditions by leveraging large volumes of data and discovering complex patterns. This study utilises tree-based models and machine learning principles to develop the most accurate and reliable methods of predicting property prices in Malaysia.

The Malaysian property market is becoming more complicated and dynamic without much data-driven insights to guide stakeholders in their decision-making process. Some of the past research mainly highlights the application of machine learning models for property price prediction but lack of focus on real-time analysis to address the evolving market dynamics effectively. Insufficient analysis on property price trends is restraining buyers, investors and policymakers from predicting the market behaviour and hence making proper decisions on property investments. Regression models are generally utilised because of their simplicity for analyzing relationships between variables, but the inability to capture nonlinear and interactive effects seriously impairs their usefulness in property market studies. This emphasises the need to adopt tree-based models to improve property price prediction.

The main objective of this study is to address the challenges of property price prediction in Malaysia through data visualisation and machine learning. The study aims to create an interactive visualisation dashboard that allows users to explore and analyse property price trends and regional differences in Malaysia, to develop predictive models for Malaysian property prices using the Decision Tree and Random Forest models in machine learning, and to determine which tree-based machine learning model provides the highest accuracy in predicting property prices in Malaysia while optimising it for better results.

METHODOLOGY

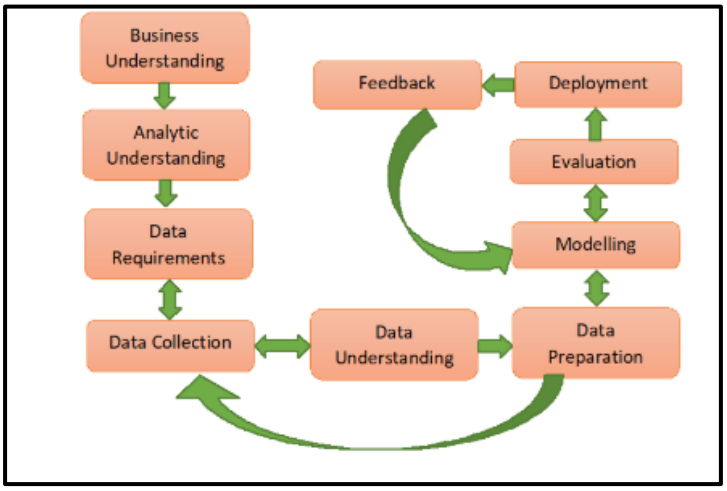

Figure 1: Research Flowchart

The research methodology for this study involves a systematic approach to predict property prices in Malaysia, as outlined in the research flowchart in Figure 3. The process begins with the Business Understanding phase, which identifies the core problem of predicting property prices, analysing influencing factors, and segmenting the property market. This is followed by the Analytic Understanding phase, where business goals are converted into analytical tasks, and the Data Requirements phase, which defines the necessary data sourced from the National Property Information Centre (NAPIC). The next stages include Data Collection, Data Understanding to identify data types and issues, and Data Preparation, which involves cleaning and transforming the dataset. The data cleaning process included restructuring the dataset headers, removing columns with null values, renaming fields for clarity, and handling missing or duplicate entries to ensure data integrity before further analysis.

Once the dataset was cleaned and prepared, predictive modelling was performed using Decision Tree and Random Forest algorithms to capture non-linear relationships and identify significant factors influencing property prices. The models were evaluated using accuracy, precision, recall, and F1-score to ensure robust performance, while hyperparameter tuning was applied to enhance predictive accuracy. Following this, an interactive visualisation dashboard was deployed through Tableau Public to analyse property price trends, regional disparities, and market opportunities. Finally, a Feedback phase collected inputs from stakeholders such as investors, policymakers, and developers to refine the models and dashboards for improved usability and decision-making support.

RESULTS AND DISCUSSION

An interactive dashboard was developed to analyze property price variations across sectors, fulfilling Objective 1 of this study. It allows users to explore sectoral differences, identify price patterns, and drill down into property values by section and year. The dashboard presents data through user-friendly charts and graphs, making fluctuations easier to interpret and supporting stakeholders in property market decision-making. The dashboard can be accessed via the following Tableau Public link:
https://public.tableau.com/app/profile/tanushalani.muniandy5320/viz/MalaysianPropertyMarketOverview/Introduction

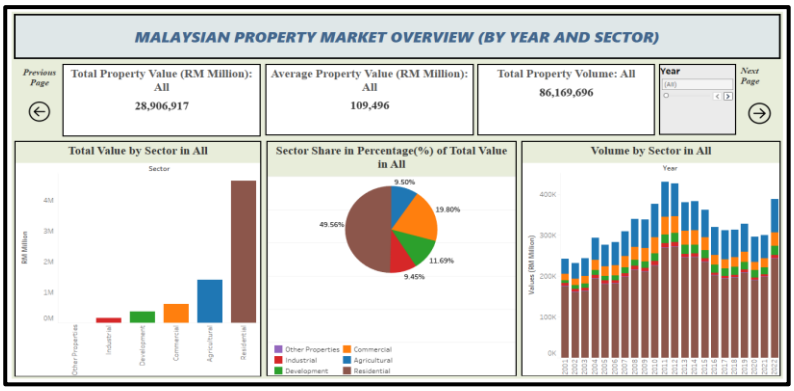

Figure 2: Malaysian Property Market Overview Dashboard

Figure 2 presents a comprehensive dashboard of the Malaysian property market from 2001 to 2022, highlighting key metrics such as total property value, average value, and transaction volume. Over this period, the total property value amounted to RM 28,906,917 million, reflecting the overall scale of transactions, while the average property value of RM 109,496 million serves as a benchmark for market growth. The total of 86,169,696 transactions underscores strong market activity and liquidity. Sector analysis shows that residential properties consistently dominate in both value and share at 49.56%, followed by the commercial sector at 19.8%, with industrial and agricultural sectors making smaller contributions.

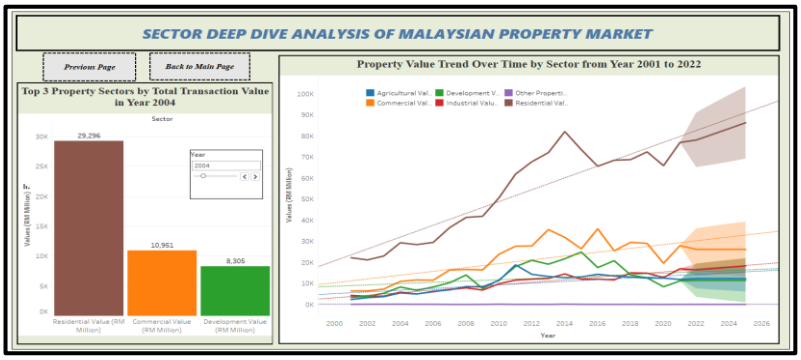

Figure 3: Sector Deep Dive Analysis of Malaysian Property Market Dashboard

The second dashboard in Figure 3 provides a comprehensive analysis of the Malaysian property market, focusing on premier property sectors and their trends over time. It highlights the Top 3 Property Sectors by Total Transaction Value for 2004 and the Property Value Trend Over Time from 2001 to 2022. In 2004, the residential sector led with RM 29,296 Million, followed by the commercial sector at RM 10,951 Million and the development sector at RM 8,305 Million. The trend line from 2001 to 2022 shows residential properties with the highest and most consistent growth, while other sectors such as commercial, industrial, agricultural, and development also display upward trends. Overall, the analysis reflects a general rise in property values across Malaysia over the years.

Table 1: Evaluation metrics of model before and after hyperparameter tuning

Model	**Accuracy**	**Precision**	**Recall**	**F1-score**
Before Tuning				
Decision Tree	0.40	0.60	0.40	0.48
Random Forest	0.80	1.00	0.80	0.88
After Tuning				
Decision Tree	0.60	1.00	0.60	0.75
Random Forest	0.80	1.00	0.80	0.88

The second objective of this study is to develop predictive models for property prices in Malaysia using the Decision Tree and Random Forest algorithms in machine learning. Both models are developed in a number of steps which involve data preparation, model training, evaluation, and optimization. The Decision Tree model intended to predict Malaysian property price categories based on volume and year of each sector. The model building process involves training the classifier, evaluating predictive performance, and hyperparameter tuning to optimise its accuracy. After tuning the hyperparameters, Decision Tree achieved accuracy at 0.60 with improved precision, recall, and F1 score compared to the initial model, as shown in Table 1.

Meanwhile, the Random Forest model performed well both before and after hyperparameter tuning in predicting Malaysian property price categories based on year and transaction volumes across sectors. It achieved an accuracy of 0.80 with precision of 1.00, recall of 0.80, and F1-score of 0.88, where 80% of predictions were correct. After tuning, the optimised model retained the same performance, confirming its robustness. Compared to the Decision Tree, the Random Forest consistently demonstrated superior accuracy, precision, recall, and F1-score, making it the best-performing model.

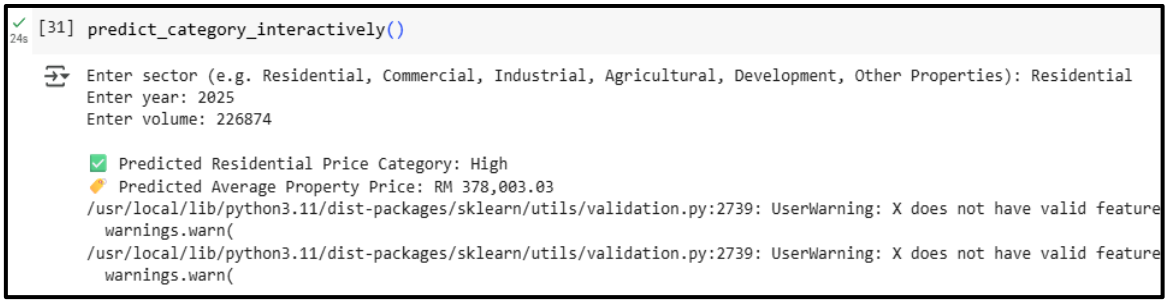

Figure 4: Prediction Output using Random Forest model

To satisfy Objective 3, which is to predict property prices using the best model chosen from Objective 2, the Random Forest model was used to predict property prices based on sector, year, and transaction volume. For the Residential sector with a transaction volume of 226,874 in the year 2025, the model classified the price category as High with a predicted average property price of RM378,003.03, as shown in Figure 4. This result reflects a continued upward trend in residential prices and demonstrates the model's ability to handle future data accurately with an accuracy rate of 0.80.

CONCLUSION

This study successfully applied machine learning and data visualisation to predict property prices in Malaysia. The first objective was achieved through an interactive Tableau dashboard that visualised transaction volumes and values across sectors and years, highlighting the residential sector's dominance. For the second objective, Decision Tree and Random Forest models were developed, with Random Forest demonstrating superior performance in accuracy, precision, recall, and F1-score. The third objective was fulfilled by using Random Forest, the best-performing model, to predict property price categories with higher accuracy, confirming its reliability for stakeholders. By integrating predictive modelling with interactive visualization and proposing enhancements such as richer datasets and user engagement, the study provides valuable insights into market trends and supports the development of a smart property platform that empowers data-driven decision-making in Malaysia's property market.

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I would like to extend my sincere appreciation to my supervisor, Dr. Siti Zanariah Satari for her invaluable guidance, encouragement, and constructive feedback. My gratitude also goes to Universiti Malaysia Pahang Al-Sultan Abdullah and Centre for Mathematical Sciences for providing the facilities and supportive environment that enabled the completion of this work. Finally, I am profoundly grateful to all individuals who have directly and indirectly contributed to this endeavour.

BRIDGING THE GAP: REGIONAL POVERTY PREDICTION AND POLICY INSIGHTS USING MACHINE LEARNING

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ABSTRACT

Poverty remains a significant socio-economic challenge in Malaysia, with regional disparities affecting the effectiveness of centralized aid programs. Many interventions lack precision, often due to the limited use of predictive tools and insufficient data-driven targeting. This project introduces a machine learning-based system for classifying poverty levels (low, moderate, high) using multi-domain socio-economic indicators, including income, employment, education, and inflation. Publicly available data from the Department of Statistics Malaysia (DOSM) from 2019 to 2022 was used to train and evaluate five classification models. Among them, the XGBoost model demonstrated the highest performance, achieving an accuracy of 77.2% and an AUC score of 0.93. Key features influencing poverty were selected based on the model that performed best. The solution is deployed as an interactive web application using Streamlit. The dashboard provides district-level insights into poverty, visualisations of poverty distribution, and a feature importance analysis. It also presents tailored policy recommendations based on dominant poverty factors in each region. This tool empowers decision-makers to implement more informed and evidence-based poverty interventions. By bridging artificial intelligence with social policy, the project contributes to more effective resource allocation and equitable development strategies across Malaysian states.

Keywords: Poverty, Machine Learning, Socioeconomic Indicators, Policy Recommendation, Streamlit Application

INTRODUCTION

Poverty relief encompasses both short-term support, including food, shelter, and emergency aid, and long-term strategies, such as education, job training, and inclusive development programs. In Malaysia, poverty is not just a personal hardship, but a systemic issue that hinders national progress, exacerbates inequality, and leads to broader social challenges. In alignment with the United Nations Sustainable Development Goals (SDGs), particularly SDG 1: No Poverty, Malaysia has committed to eradicating poverty in all its forms by 2030, as outlined in the 2030 Agenda for Sustainable Development. However, despite these commitments and numerous policy efforts, significant disparities persist across regions, particularly in underdeveloped states such as Sabah and Kelantan, where access to education, infrastructure, and economic opportunities remains limited (Md Shah et al., 2023). Programs like 1AZAM have highlighted inefficiencies in resource allocation and gaps in addressing the root causes of poverty. Additionally, demographic shifts and the rising cost of living continue to worsen socioeconomic vulnerabilities across the country (Rahman et al., 2021).

This project adopts a data-driven approach to understanding and addressing poverty in Malaysia, with a specific focus on the roles of education, household income, and employment. Publicly accessible datasets from the Department of Statistics Malaysia (DOSM) and data.gov.my are analysed across the years 2019 to 2022. Machine learning techniques, utilizing Python and SQL, are applied to model poverty levels, identify key contributing factors, and visualize patterns of regional disparity. The resulting model is integrated into an interactive Streamlit dashboard that enables users to explore poverty classification, feature importance, and tailored policy recommendations for targeted intervention.

The main objective of this study is to develop a machine learning-based model that accurately classifies poverty levels across Malaysian districts and identifies the underlying socio-economic factors contributing to poverty. By training and evaluating multiple machine learning models, such as decision trees, XGBoost, artificial neural networks (ANNs), k-nearest neighbors (k-NN), and Naive Bayes, the best model is selected based on its performance metrics. In addition to developing and deploying the most effective model for predicting poverty, the study also aims to propose actionable, data-driven solutions by mapping model-derived insights to practical policy recommendations.

METHODOLOGY

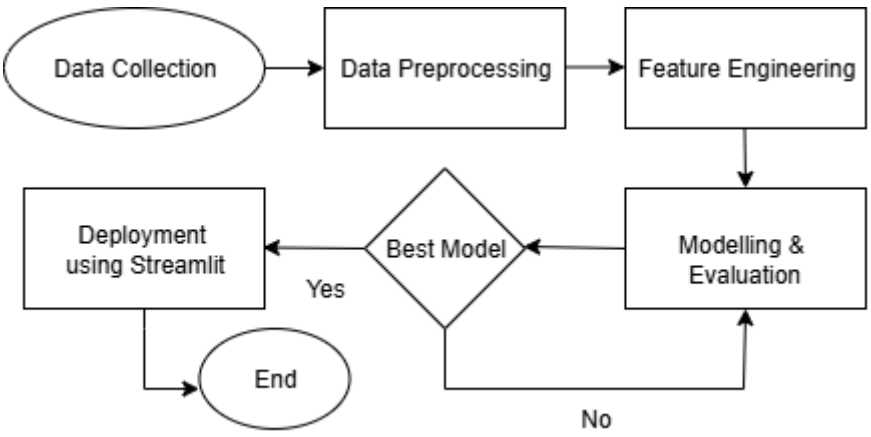

Figure 1: Flowchart of Methodology

The methodology involved a structured pipeline comprising data collection, preprocessing, feature engineering, modelling, and evaluation, followed by deployment using Streamlit, as shown in Figure 1. Data from six distinct sources covering poverty metrics, household income, labor force statistics, educational enrolment, completion rates, and inflation were cleaned, integrated using SQL, and preprocessed to handle missing values, outliers, and categorical encoding. The dataset was then split into training (70%) and testing (30%) sets, scaled using StandardScaler, and dimensionality was reduced via Principal Component Analysis (PCA) to improve model efficiency.

Five machine learning algorithms were implemented, such as decision tree, Naive Bayes, k-NN, XGBoost, and ANNs. Each model was evaluated based on accuracy, precision, recall, F1-score, confusion matrices, and ROC-AUC curves.

RESULTS AND DISCUSSION

XGBoost emerged as the top-performing model with the highest macro-average AUC score (0.93), as shown in Figure 2, demonstrating strong ability in classifying poverty categories and identifying influential factor features. Key factors affecting poverty included mean and median income, labor force participation rate, and regional disparities, underscoring the importance of economic stability and employment opportunities. The analysis of error metrics further reinforced the model's performance, with KNN recording the lowest Mean Absolute Error (MAE) at 0.3113 and Root Mean Squared Error (RMSE) at 0.6951, indicating high predictive accuracy. XGBoost achieves comparable MAE (0.3174) and RMSE (0.7046). However, XGBoost was selected for its superior interpretability and feature importance analysis, which is crucial for deriving actionable policy insights.

Model	Macro-Average AUC	AUC for Class 0	AUC for Class 1	AUC for Class 2
XGBoost	0.932858	0.962344	0.936109	0.900094
KNN	0.931568	0.962698	0.931874	0.900132
ANN	0.906288	0.949940	0.906541	0.862321
Decision Tree	0.883276	0.917135	0.887277	0.845405
Naive Bayes	0.718115	0.777946	0.742854	0.633466

Figure 2: Macro-Average Area Under the ROC Curve (AUC) of Each Model

The XGBoost predictive model was utilized to identify the key factors that influence poverty. By analyzing the feature importance scores derived from the model, we were able to determine the most significant variables contributing to the poverty levels. Figure 3 illustrates the top features, providing valuable insights into the main factors of poverty and laying the foundation for proposing actionable solutions. The top features influencing poverty are primarily centered around income levels, labor force dynamics, and regional disparities. Notably, the mean and median income emerged as the most critical features, with feature scores of 0.3137 and 0.3129, respectively, reflecting the central role of financial stability in poverty alleviation. Higher income levels directly correlate with reduced poverty, highlighting the need for targeted interventions aimed at increasing household income. The results clearly indicate that interventions should prioritise boosting household income, creating stable employment opportunities, and addressing regional inequities, particularly in states like Sabah and Kelantan. Furthermore, while education metrics were less dominant in the short-term predictive model, they remain vital for long-term poverty reduction strategies, highlighting the need for sustained investment in educational infrastructure and digital access.

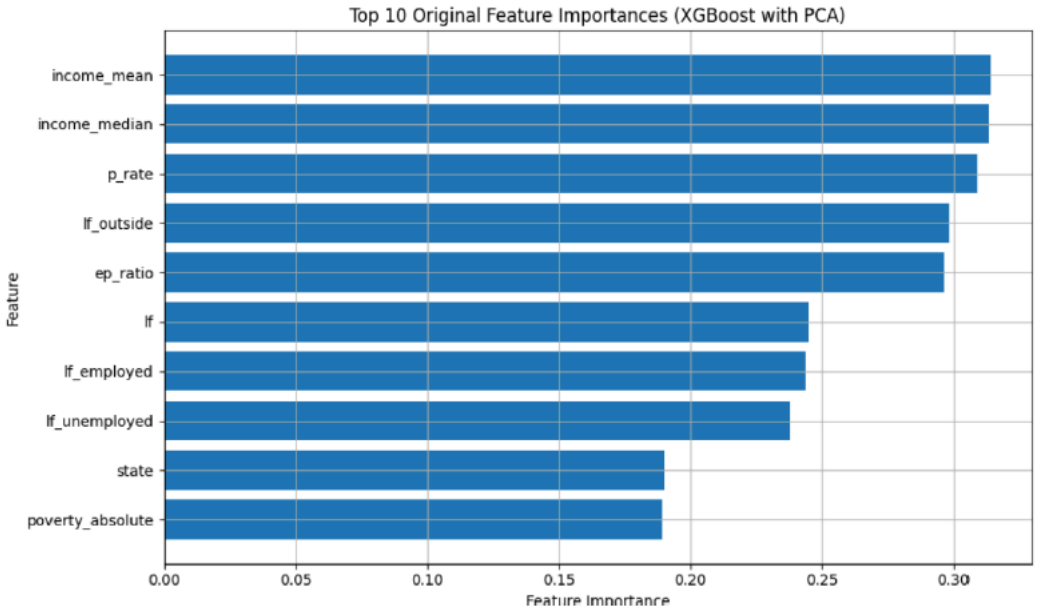

Figure 3: Top 10 Feature Importances from XGBoost with PCA

This comprehensive, data-driven approach successfully translates complex machine learning outputs into practical, targeted solutions, embodying the principles of evidence-based policymaking that are increasingly central to modern governance (Amazing Hope Ekeh et al., 2025). It provides a replicable and scalable framework for leveraging advanced analytics in social policy, ensuring that public and NGO resources are allocated efficiently and equitably to the regions and demographics where they are most

needed (Maidin et al., 2024). By moving beyond one-size-fits-all solutions to offer targeted, region-specific interventions such as tailored employment programs in Sabah and Kelantan or digital education infrastructure projects in rural areas, this methodology directly addresses the critical issue of regional disparities. The integration of diverse socioeconomic data sources creates a holistic view of poverty's multifaceted nature, a strategy that aligns with other data-centric policy frameworks developed in Malaysia (Abas et al., 2025). Ultimately, by enabling precise and proactive interventions, this research makes a significant contribution to fostering more sustainable and inclusive socioeconomic development across Malaysia, demonstrating the transformative power of machine learning in addressing entrenched societal challenges.

CONCLUSION

This study successfully demonstrated the application of machine learning in classifying poverty levels across Malaysian states and districts by integrating diverse socio-economic indicators. The XGBoost model, identified as the best-performing algorithm with an AUC of 0.93, enabled the extraction of key features such as household income, labour force participation, and education, which are central to understanding regional poverty disparities. The findings underscore the importance of data-driven approaches in supporting policymakers in designing targeted interventions, particularly in underdeveloped regions such as Sabah and Kelantan, where structural inequities persist.

The novelty of this work lies in the deployment of the model within an interactive Streamlit web application that not only visualises poverty insights but also provides state-specific recommendations on how to address the dominant factors of poverty. By linking feature importance analysis directly to actionable policy suggestions, the system moves beyond static predictions to offer practical guidance for filling poverty gaps in each state. This integration of explainable AI with policy-focused recommendations represents a unique and value-added contribution, as it transforms complex machine learning outputs into user-friendly, decision-support tools. Such an approach ensures that predictive analytics are not only accurate but also impactful in shaping equitable poverty alleviation strategies aligned with Malaysia's development goals.

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A NURSE SCHEDULING SYSTEM USING 0-1 GOAL PROGRAMMING TECHNIQUE

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ABSTRACT

Scheduling plays a crucial role in optimising workforce management, particularly in healthcare sectors where efficiency and fairness directly impact service quality. This study focuses on developing an optimised nurse scheduling system for Hospital Alor Gajah (HAG) using the 0-1 Goal Programming technique. Primary data were collected from the male adult ward at HAG, and a mathematical model was formulated to integrate hospital rules as hard constraints and nurse preferences as soft constraints. LINGO software was utilised to generate feasible shift patterns, which were further refined to produce a proposed two-week schedule. The results showed significant improvements in workload distribution, compliance with minimum staffing requirements, and accommodation of nurse preferences. This scheduling approach demonstrates its potential as a practical decision-support tool to replace traditional manual scheduling, thereby enhancing operational efficiency and nurse satisfaction.

Keywords: Nurse Scheduling, Goal Programming, Workforce Optimisation, LINGO Software, Hospital Management

INTRODUCTION

Nurse scheduling is essential for ensuring effective hospital operations while maintaining nurse well-being. Manual scheduling practices at Hospital Alor Gajah (HAG) often led to issues such as biased shift allocation, unfair workload distribution, and insufficient off days, resulting in potential burnout and decreased job satisfaction. To address these problems, this study aims to formulate a nurse scheduling system using 0-1 Goal Programming that integrates hospital regulations and nurses' preferences. The objectives of the study are to evaluate the current scheduling system at HAG by interviewing the head nurse in male adult ward, develop a Goal Programming model, and produce an optimised two-week nurse schedule that balances operational requirements and staff satisfaction.

RESULTS AND DISCUSSION

The proposed nurse scheduling model incorporated hard constraints such as minimum staffing requirements (six nurses for morning and evening shifts, four for night shifts), ensuring each nurse works only one shift per day, and guaranteeing two off days within a two-week cycle. Soft constraints included scheduling each nurse for approximately 10 days while minimising rapid shift transitions that could cause fatigue. The implementation of LINGO software facilitated the generation of shift patterns satisfying these constraints stated in Figure 1 and Figure 2.

```
Feasible solution found.
Infeasibilities:                                0.000000
Total solver iterations:                             347
Elapsed runtime seconds:                            0.19

Model Class:                                          LP

Total variables:                    1344
Nonlinear variables:                   0
Integer variables:                     0

Total constraints:                   392
Nonlinear constraints:                 0

Total nonzeros:                     2688
Nonlinear nonzeros:                    0
```

Figure 1: LINGO result after input constraints

Number of Nurse, k	Days													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	O	E	E	E	E	O	N	N	NE	M	M	M	M	O
2	N	N	NE	M	M	M	M	M	O	O	E	O	N	N
3	N	N	NE	E	E	E	O	O	M	M	M	O	N	N
4	O	M	M	M	O	E	E	O	N	N	NE	M	M	M
5	M	M	M	O	N	N	NE	O	E	E	O	E	E	E
6	M	O	N	N	NE	E	E	E	E	E	O	M	M	O
7	E	E	O	E	E	O	N	N	NE	O	M	M	M	M
8	O	M	M	M	M	O	E	O	N	N	NE	M	M	M
9	E	E	E	O	M	M	M	O	N	N	NE	O	M	M
10	E	E	E	O	N	N	NE	E	E	E	O	M	M	O
11	M	M	M	O	N	N	NE	M	M	O	E	E	E	E
12	M	M	M	O	E	E	E	E	E	O	N	N	NE	E
13	M	M	O	E	O	E	E	E	E	O	N	N	NE	M
14	E	E	O	M	M	O	E	E	E	O	N	N	NE	M
15	M	M	M	O	E	O	N	N	NE	E	E	O	E	E
16	M	O	N	N	NE	M	M	M	M	O	E	E	O	M
17	E	O	N	N	NE	M	M	O	M	M	M	O	E	E
18	N	N	NE	M	M	M	O	O	E	E	E	O	N	N
19	E	E	E	O	M	O	N	N	NE	E	E	E	O	M
20	N	N	NE	E	E	E	O	M	O	M	M	O	N	N
21	E	O	E	O	N	N	NE	M	M	M	M	O	E	E
22	M	O	E	E	O	M	M	O	N	N	NE	E	E	E
23	M	M	M	M	O	E	E	E	O	O	N	N	NE	E
24	O	O	N	N	NE	M	M	M	M	M	O	E	E	E

Figure 2: Proposed schedule with the helps from LINGO

Comparative analysis revealed that the proposed schedule improved workload equity among nurses, eliminated undesirable consecutive shifts, and enhanced adherence to hospital policies compared to the existing manual schedule. This approach demonstrates the effectiveness of Goal Programming in addressing multi-objective scheduling problems within the healthcare sector.

CONCLUSION

This study successfully developed a nurse scheduling system using 0-1 Goal Programming for Hospital Alor Gajah. The proposed model ensured fair shift distribution, compliance with hospital regulations, and consideration of nurse preferences. The novelty of this study lies in integrating both operational constraints and human preferences into a single mathematical framework, moving away from manual trial-and-error methods towards a structured, data-driven solution. Implementing such optimisation techniques in scheduling can enhance operational efficiency and workforce satisfaction, thus supporting better healthcare service delivery. Future studies are recommended to extend the model with real-time adjustments to accommodate unforeseen staffing changes.

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ECOLUBE-S: SUSTAINABLE BIOLUBRICANT BASE STOCK DERIVED FROM SOYBEAN OIL

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ABSTRACT

The increasing need for lubricants in both the automotive and industrial fields emphasizes the importance of developing effective, high-performance solutions with low environmental impact. Conventional lubricants, mostly made from petroleum-based mineral oils, are non-renewable, pose ecological hazards, and are major contributors to pollution and greenhouse gas emissions. These challenges underscore the urgent need for environmentally sustainable alternatives. This innovation presents Ecolube-S**,** an advanced biolubricant base stock derived from soybean oil, an abundant and eco-conscious resource. Ecolube-S is synthesized via a two-step process: the hydrolysis of soybean oil yields soybean oil fatty acids, which are then esterified with trimethylolpropane (TMP). This modification enhances the thermal and oxidative stability of the lubricant, increasing its durability and efficiency in demanding operational environments. Ecolube-S is biodegradable, non-toxic, and helps lower ecological harm by reducing soil and water contamination. Its development aligns with green chemistry practices and supports the circular economy by adding value to agricultural by-products. Additionally, it offers superior lubrication performance, reducing friction and wear in engines and machinery, resulting in enhanced reliability and energy savings. By transitioning from petroleum-based lubricants to this renewable option, industries can maintain high efficiency while advancing environmental protection and long-term economic sustainability.

Keywords: Biolubricant, biodegradable, renewable, soybean oil

INTRODUCTION

The widespread use of petroleum-based lubricants in industrial and automotive sectors has raised significant environmental and sustainability concerns, owing to their non-biodegradability, toxicity, and reliance on limited fossil fuel resources. In response, there is a growing global interest in developing biolubricants derived from renewable plant oils as a greener and more sustainable alternative. Plant oils such as soybean, canola, and palm are abundant, biodegradable, and non-toxic, making them ideal candidates for lubricant base stock production. This innovation aligns with several United Nations Sustainable Development Goals (SDGs), specifically SDG 7 (Affordable and Clean Energy)**,** SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action)**.** By shifting toward biobased lubricants, this innovation contributes to reducing greenhouse gas emissions, minimising environmental pollution, and promoting the use of renewable resources in industrial processes. However, the direct application of plant oils in lubrication systems is often limited by issues such as low oxidative stability and poor performance under extreme temperatures due to the presence of β-hydrogen in the glycerol backbone in triacylglycerol structure (Nor et al. (2019), Nor et al. (2022), Khairuddin et al. (2024)). To overcome these limitations, chemical modifications such as esterification with polyols such as trimethylolpropane (TMP) are employed to enhance the physicochemical properties of the oil, resulting in high-performance biolubricants suitable for a wide range of industrial applications. The objectives of this innovation are to formulate Ecolube-S, a sustainable biolubricant base stock that is biodegradable, non-toxic, and eco-

friendly, serving as an alternative to conventional mineral oil-based lubricants and to support the progress of green technology by developing a high-performance biolubricant that aligns with environmental standards and encourages sustainable applications in both industrial and automotive sectors.

RESULTS AND DISCUSSION

Ecolube-S is a sustainable, high-performance biolubricant base stock derived from chemically modified soybean oil. A high-quality biolubricant must possess excellent physicochemical properties to perform effectively in industrial applications. To evaluate the performance of the Ecolube-S, its properties were compared with a commercial synthetic lubricant, SAE 20 (Perodua Genuine Oil). The flash point of the Ecolube-S was recorded at 272°C, compared to 230°C for SAE 20. The higher flash point of the Ecolube-S indicates greater thermal stability, which is essential for high-temperature operations. According to Nor et al. (2022), another key parameter in assessing biolubricant potential is the pour point, the lowest temperature at which a lubricant remains flowable. A low pour point is crucial for engines operating in cold environments. The Ecolube-S exhibited a pour point of -19 °C, which is comparable to that of SAE 20 (-20 °C). These results demonstrate that the synthesised Ecolube-S has desirable lubrication characteristics, which are a high flash point and a low pour point, making it a viable biolubricant base stock for use in both petrol and diesel engines, particularly in environments where temperatures do not fall below -19°C. These features enhance cold-start performance and bolster thermal stability, making Ecolube-S well-suited for rigorous industrial and automotive applications.

In terms of novelty, this project introduces a biolubricant base stock with enhanced molecular architecture, achieved through the esterification of soybean oil with trimethylolpropane. This results in a branched structure that significantly improves oxidative stability, thermal resistance and lubrication efficiency. What sets this innovation apart is its dual focus on advanced molecular design and sustainable resource utilisation. By converting agricultural by-products into high-value green technology, the project directly supports the circular bioeconomy and encourages rural economic growth, while decreasing reliance on fossil resources. This aligns with multiple Sustainable Development Goals (SDGs): SDG 12, promoting responsible consumption and production; SDG 13, supporting climate action through reduced carbon emissions; SDG 7, enhancing energy efficiency and access to clean energy; and SDG 9, driving industry innovation and infrastructure development through eco-friendly technological advancements.

CONCLUSION

This innovation presents the successful synthesis of a high-performance biolubricant base stock (Ecolube-S) derived from soybean oil through chemical modification with trimethylolpropane. Ecolube-S exhibits a high flash point and excellent low-temperature flow behavior, making it suitable for a wide range of industrial and automotive applications. As a biodegradable, renewable, and non-toxic alternative, it addresses environmental, and sustainability concerns associated with conventional petroleum-based lubricants. The findings demonstrate that plant-based oils can be effectively engineered to meet modern performance standards, supporting the advancement of green technology. Overall, this biolubricant offers a viable, eco-friendly solution that integrates performance, safety and sustainability in lubrication systems.

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APPLICATION OF DIJKSTRA'S ALGORITHM TO FIND THE SHORTEST PATH AND MINIMUM TIME TRAVEL FOR COURIER DELIVERY ROUTES

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ABSTRACT

This project seeks to optimise the routes used in courier delivery and travel time by using Dijkstra's Algorithm in Lukut, Port Dickson. Efficient route planning has become more relevant because of the rising demand for fast delivery services due to the growth of e-commerce. This research aims to enhance delivery performance by identifying the shortest path between multiple delivery locations using graph theory. The records of the distance and travel time to nine delivery points were obtained using Google Maps. Nodes are the assumed location of these places, and the edges between locations are the roads with weight in the form of time and distance. Dijkstra's Algorithm was applied in Microsoft Excel to determine the fastest route between Parcelhub, Lukut and the Tasik Villa International Resort Port Dickson. It was found out that the application of this algorithm would assist in reducing delivery time and making the route efficient. The technique cuts down on the amount of fuel used, delays in delivery and the cost of operation. Its outcomes indicate that although only a small area is studied and a set of static data is used, it shows strong potential for practical use in real-life courier services. This project proves that mathematical tools like Dijkstra's Algorithm can help solve real-world logistics problems by providing faster and more reliable delivery routes, improving service quality and customer satisfaction.

Keywords: Dijkstra's Algorithm, Shortest Path, Courier Delivery, Route Optimisations, Graph Theory

INTRODUCTION

In recent years, the courier delivery industry has experienced a significant transformation by adopting modern technology to enhance service efficiency. The surge in e-commerce has driven the need for faster, more reliable delivery systems. Companies such as Pos Laju, GD Express, Ninja Van, and J&T Express have responded by optimising their logistics strategies, particularly through route optimisation. Efficient delivery route planning minimises operational costs and improves customer satisfaction. This study focuses on implementing Dijkstra's Algorithm to optimise courier delivery routes in Lukut, Port Dickson, a key area affected by delivery congestion. Dijkstra's Algorithm is a reliable shortest path method in graph theory, offering accurate route decisions by analysing nodes, edges, and associated weights such as time and distance. The use of this algorithm in courier delivery services helps address delivery delays, fuel consumption, and overall logistics cost, thus demonstrating its value in real-world applications.

Route optimisation has been approached using a variety of algorithms. Genetic Algorithms (GAs) are commonly used for their ability to explore complex search spaces efficiently, particularly when hybridised with other metaheuristics (Katoch et al., 2021). Ant Colony Optimisation (ACO), inspired by the foraging behaviour of ants, has effectively solved vehicle routing problems and search and rescue scenarios (Morin et al., 2023). The A* Algorithm, combining Dijkstra's method with heuristic functions, provides efficient pathfinding in dynamic environments (Suryadibrata et al., 2019). Bellman-Ford Algorithm supports negative weights and fuzzy logic in decision-making for uncertain networks (Parimala et al., 2021). However, among all of them, Dijkstra's Algorithm stands out for its accuracy and performance in static and non-negative weighted graphs, making it ideal for fixed delivery networks (AlShaikh et al., 2019). Several studies confirm its superiority in route planning, with improvements focusing on multi-objective optimisation, energy efficiency, and dynamic rerouting.

The objectives of this study are:

i. To identify travel network of the courier delivery using Dijkstra's Algorithm.
ii. To determine the minimum travel time and distance of the courier delivery using Dijkstra's Algorithm.

This study used a three-phase methodology to evaluate and determine the shortest route with minimal travel time in Lukut, Port Dickson. Figure 1 presents the structured process used in this research.

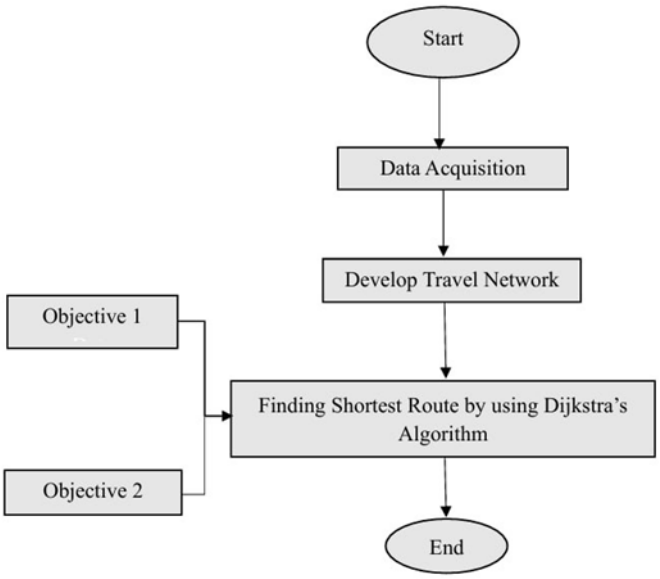

Figure 1: The structured process used in this study

The first phase involved data acquisition from Google Maps, which provided real-time data including distance and time between delivery locations. In Phase Two, a travel network was developed using nodes (delivery points) and edges (routes), with each edge assigned a weight representing time or distance. Phase Three involved applying Dijkstra's Algorithm through Manual Calculation and Microsoft Excel, which allowed visualisation of travel networks and shortest path computation. The algorithm was manually applied in a preliminary study and later validated using Excel Solver for practical implementation. Time penalties were included for traffic lights, junctions, and road conditions to improve the realism of travel time estimation.

The equation to find the shortest time is:

$$(s, j) = min(L'_j, L_j + L_{kj}) \quad (1)$$

where,

s = Initial node
L'_j = The value of time travel from the initial node to node j
L_j = Total current minimum time travel
L_{kj} = The time travel from node k to node j

RESULTS AND DISCUSSION

Table 1 presents the summarised results of the whole study. The "Places" column shows the sequence of delivery points, such as starting from Parcelhub Lukut and ending at Tasik Villa International Resort Port Dickson. The "Route" column shows the specific sequence of nodes, which are identified as the shortest path by the Dijkstra Algorithm. The "Minimum Distance" and "Minimum Time" columns represent the

total length and travel duration for each path, respectively. For example, the route from Parcelhub Lukut to Pejabat Pendidikan Daerah Port Dickson has a minimum distance of 2.881 km and requires 17.5 minutes of travel time by using the shortest path, which is the node sequence 35-20-19-21-23-37-27-33-38. This process is consistently applied to each delivery point, ensuring a continuous and optimised route across all delivery locations.

The cumulative result, as presented in the final row of the table, indicates that the total optimised distance for the complete delivery operation is 14.048 km, while the total estimated travel time is 109 minutes. These results show the effectiveness of Dijkstra's Algorithm in significantly reducing delivery route length and time, thus fulfilling the objectives of this study, which are to find the travel network, minimum time and minimum distance across all delivery locations to optimise courier delivery operations.

Table 1: The summarised results of the whole study

Places	**Route**	**Minimum distance (km)**	**Minimum time (min)**
Parcelhub Lukut to Pejabat Pendidikan Daerah Port Dickson.	35-20-19-21-23-37-27-33-38	2.881	17.5
Pejabat Pendidikan Daerah Port Dickson to Atlas Edible Ice Sdn Bhd.	38-33-27-28-29-31-39	2.298	11.5
Atlas Edible Ice Sdn Bhd to Taman Wawasan.	39-31-29-28-34	1.198	9.5
Taman Wawasan to Lukut Police Station.	34-28-27-37	2.35	12.5
Lukut Police Station to AJL Trading.	37-23-24-26-36	1.4	11
AJL Trading to CIMB Bank Lukut	36-26-24-25-16-15-14	1.82	17
CIMB Bank Lukut to SJK(C) Chung Hua.	14-13-12-11-10-08	0.968	13.5
SJK(C) Chng Hua to Tasik Villa International Resort Port Dickson.	08-10-07-06-05-04-02-09	1.133	16.5
TOTAL		14.048	109

CONCLUSION

This study concludes that Dijkstra's Algorithm is an effective solution for optimising courier delivery routes and minimising travel time. The implementation in Lukut, Port Dickson, demonstrates how mathematical algorithms can provide actionable insights into logistics operations. Future research should consider real-time traffic integration and dynamic route adjustments to enhance the system's adaptability. Additionally, expanding the study to cover larger geographic areas and using real-time delivery data can further validate the algorithm's scalability and effectiveness.

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NUMERICAL SOLUTION OF TIME-DEPENDENT MICROPOLAR NANOFLUID FLOW OVER A LINEAR CURVED STRETCHING SURFACE USING BVP4C

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ABSTRACT

This study focused on unsteady micropolar nanofluid flow over a linear curved stretching surface, aiming to improve the numerical approach for solving heat transfer problems. Similarity transformations were applied to reduce the Partial Differential Equations (PDEs) into Ordinary Differential Equations (ODEs). The momentum and energy profile along with numerical results were obtained by using BVP4C solver in MATLAB. This study explores the effects of the curvature parameters on momentum profile and the stretching parameters on energy profile. The results indicate that momentum profile increased as curvature parameters increased. For energy profile, it shows that the energy profile decreased as stretching parameters increased. In addition, this study also explored the effects of curvature on wall shear stress, microrotation, heat transfer and mass transfer as reflected in the variation of skin friction, couple stress coefficient, Nusselt number and Sherwood number. These findings highlight the effectiveness of BVP4C in solving nonlinear systems in heat transfer problems and provide valuable insight into how different physical parameters influence the flow and temperature behavior. Overall, this study offers insight applicable to cooling system, biomedical field and material coating processes where curved and stretching surface interact with complex fluid like micropolar nanofluid.

Keywords: Micropolar, Nanofluid, Linear Curved Stretching Surface, BVP4C, Heat Transfer

INTRODUCTION

Heat transfer has caught much attention over the past few years and has widely been used in industry and engineering. Terms of micropolar were introduced by Eringen (1966). Choi and Eastman (1995) started to use the term nanofluid by adding nanoparticles in base fluid to an advanced heat transfer fluid. Combining nanoparticles with micropolar fluid enhances thermal properties and influences microrotation (Ahmad et al., 2021). In this study, micropolar nanofluid considered to be time-dependent and flow over a linear curved stretching surface which is more complex and widely applicable in real life problems.

Sakiadis (1961) was one of the earliest researchers who examine the boundary layer flow problem on continuously moving surfaces. Saleh et al. (2017) discovered that the boundary layer thickness increases for a curved sheet when compared to a flat sheet. In this study, BVP4C were used to solve micropolar nanofluid flow over a linear curved stretching surface.

BVP4C solver is a MATLAB function that is designed to solve ODEs. Ramzan et al. (2021) stated that a highly nonlinear system of equations such as fluid velocity and concentration in nanofluid can be solved by a BVP4C solver. In thermal engineering applications, this solver helps to provide an initial prediction for optimal parameter control (Wahid et al., 2021). To use BVP4C in MATLAB, PDEs need to be transformed into ODEs first. Hence, this study aims to transform PDEs into ODEs and solve the micropolar nanofluid flow over a linear curved stretching surface by using BVP4C solver.

METHODOLOGY

This study considered several PDEs which consist of the continuity, momentum, micropolar, energy and concentration equation (Abbas & Shatanawi, 2022). All these equations will be transformed into ODEs by using similarity variables. The ODEs were obtained as follows:

$$\begin{aligned}&\left(1+K_1\right)\left(F'''' + \frac{2}{\zeta+K_0}F''' - \frac{1}{\left(\zeta+K_0\right)^2}F'' + \frac{1}{\left(\zeta+K_0\right)^3}F'\right)\\ &-\frac{K_0}{\zeta+K_0}\left(F''F' - FF'''\right) - \frac{K_0}{\left(\zeta+K_0\right)^2}\left(F'^2 - FF''\right) - \frac{K_0}{\left(\zeta+K_0\right)^3}FF'\\ &-K\left(G'' + \frac{G'}{\zeta+K_0}\right) - \frac{\beta_0}{\zeta+K_0}\left(F' + \frac{\zeta}{2}F''\right) - \frac{\beta_0}{2}\left(3F'' + \zeta F'''\right) = 0,\end{aligned} \tag{1}$$

$$\begin{aligned}&\left(1+\frac{K_1}{2}\right)\left(G'' + \frac{G'}{\zeta+K_0}\right) + \frac{K_0}{\zeta+K_0}F'G - \frac{K_0}{\zeta+K_0}FG'\\ &-K_1\left(2G + F'' + \frac{1}{\zeta+K_0}F'\right) + \frac{\beta_0}{2}\left(\zeta G' + G\right),\end{aligned} \tag{2}$$

$$\frac{1}{Pr}\left(\theta'' + \frac{1}{K_0+\zeta}\theta'\right) + \frac{K_0}{K_0+\zeta}F\theta' - \frac{K_0}{K_0+\zeta}\theta + \left(N_B\phi'\theta' + N_T\theta'\theta'\right) - \frac{\beta_0}{2}\zeta\theta = 0, \tag{3}$$

$$\left(\phi'' + \frac{1}{\zeta+K_0}\phi'\right) + \frac{K_0}{\zeta+K_0}F\phi' - \frac{K_0}{\zeta+K_0}\phi + \frac{N_T}{N_B}\left(\theta'' + \frac{1}{\zeta+K_0}\theta'\right) - \frac{\beta_0}{2}\left(\zeta\theta'\right) = 0, \tag{4}$$

with boundary conditions of

$$\begin{aligned}&F'(0) = \lambda + \Pi\left(F''(0) - \frac{F'(0)}{K_0}\right),\ F(0) = \omega, \delta\theta'(0) + 1 = \theta(0),\ N_B\phi'(0) + N_T\theta'(0) = 0,\\ &G(0) = -nF''(0),\ F'(\infty) = 1,\ F''(\infty) = 0,\ G(\infty) = 0,\ \theta(\infty) = 0,\ \phi(\infty).\end{aligned} \tag{5}$$

Next, this ODEs will be transformed into the first order form to obtain numerical results by using BVP4C solver in MATLAB software.

RESULTS AND DISCUSSION

Figure 1 shows effects of curvature (K_0) on momentum profile, $f(\zeta)$. The curvature parameter represents the effect of a curved surface on fluid flow. In real-world systems, many surfaces are not flat such as pipes or tubing in industrial application. To study the effects of curvature parameter, K_0 on momentum profile, $f(\zeta)$, K_0 were examined at values 0.3, 0.5, and 0.7. In contrast, the other parameters are considered fixed where β_0 = 0.1, $N_B = N_T = T_0 = K_1$ = 0.5, $\omega = \lambda = \Pi = \delta$ = 0.4, k = 10, Pr = 6.2 and n = 0. It indicates that as the value of curvature increases, momentum profile also increases. This means that the flow momentum at the surface becomes stronger with higher curvature. This result has not been reported in previous studies, highlighting its significance for future research in this topic.

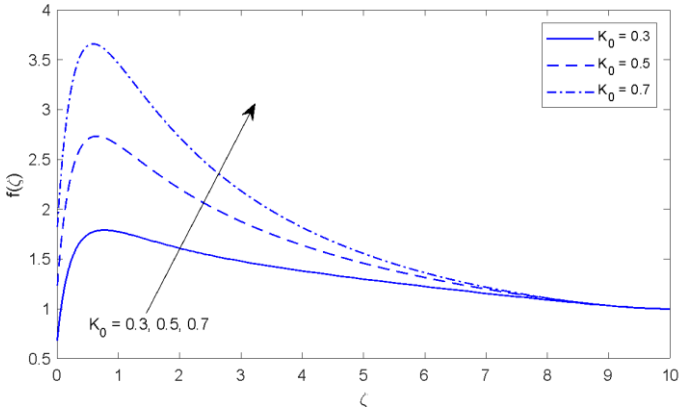

Figure 1: Momentum profile $f(\zeta)$ on different values of curvature parameter K_0

Figure 2 shows the effects of stretching parameter (ω) on energy profile, $\theta(\zeta)$. Stretching parameter plays a significant role in influencing fluids behavior and heat transfer rate. It represents how fast a surface is being stretched when interacting with a fluid such as micropolar nanofluid. By considering $\beta_0 = N_B = N_T = T_0 = K_1 = K_0 = 0.5$, $\delta = \lambda = \Pi = 0.4$, $k = 10$,$Pr\ Pr = 6.2$ and $n = 0$, the effects of stretching on energy profile were examined. The stretching parameter ω were analyzed at values 0.3, 0.5 and 0.7. It indicates that, as ω increased energy profile was reduced which means that the temperature of the fluids will drop since it absorbs less heat due to higher stretching. This result fills a gap in past studies and may be useful for future work.

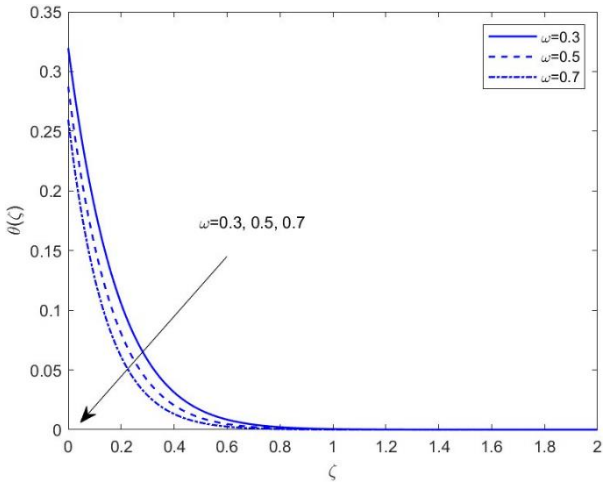

Figure 2: Energy profile $\theta(\zeta)$ on different values of stretching parameter ω

Table 1: Results of $C_f Re_s^{-1/2}$, $C_m Re_s$, $N_{u_s} Re_s^{-1/2}$ and $Sh_s Re_s^{-1/2}$ for different values of K_0 when $n = 0.0$.

K_0	$C_f Re_s^{-1/2}$	$C_m Re_s$	$N_{u_s} Re_s^{-1/2}$	$Sh_s Re_s^{-1/2}$
0.1	-858.9418461	-16.15112207	1.763189854	-1.763189854
0.3	-473.7042335	-10.14335702	1.696857490	-1.696857490
0.5	-498.9568583	-9.471270552	1.712402242	-1.712402242
0.7	-549.4206213	-9.019570392	1.736404595	-1.736404595

The numerical result was shown in Table 1 obtained by using BVP4C solver in MATLAB. The skin friction decreases sharply from K_0= 0.1 to 0.3, then slightly increases again at higher values. This means the wall shear stress is reduced at first but starts to rise as curvature gets stronger. The couple stress coefficient also decreases as K_0 increases, showing that higher curvature lowers the microrotation effect near the wall. For heat transfer, the Nusselt number slightly drops at first but then increases, suggesting that curvature helps

improve temperature transfer after a certain point. For the Sherwood number, a small increase is seen from 0.1 to 0.3, followed by a decrease from 0.3 to 0.7, meaning mass transfer first weakens slightly and then becomes stronger again as curvature increases.

NOVELTY

This study provides new insights into unsteady flow of micropolar nanofluid over a linear curved stretching surface focusing on the effects of stretching and curvature, which are relevant for improving cooling systems and industrial processes involving micropolar nanofluid. Numerical results of skin friction, couple stress coefficient, Nusselt number and Sherwood number under the influence of curvature are also analyzed. Unlike previous studies, this work used BVP4C method to obtain the solution. To the best of our knowledge, these findings have not been previously reported, making this work original and contributing new understanding to the study of micropolar nanofluid flow.

CONCLUSION

This study solved the unsteady flow of micropolar nanofluid over linear curved stretching surfaces by using BVP4C. All the governing equations of the flow problems (PDEs) were reduced into ODEs by using similarity variables. Then, BVP4C was used to explore the numerical results, the effects of curvature parameters on momentum profile and the stretching parameters on energy profile. This study also helps improve the understanding of heat transfer in micropolar nanofluid, providing insight that can be applied to fields such as chemical processing, mechanical engineering and electronics cooling.

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THE IMPACT OF SOCIAL MEDIA USAGE ON ACADEMIC PERFORMANCE AMONG UITM SEREMBAN STUDENTS

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ABSTRACT

Social media plays an important role in the daily lives of students in today's digitally connected world, impacting not only their social interactions but also their academic performance. This article is based on data gathered from students at the UiTM Negeri Sembilan Branch, Seremban Campus. A total of 375 UiTM Seremban students, selected through purposive sampling, responded to the questionnaire. Employing multiple linear regression analysis, it explores the impact of various aspects of social media usage on students' academic performance. The results revealed that excessive time spent on social media and multitasking behavior significantly affect students' academic performance. The use of WhatsApp for entertainment purposes also showed significant negative associations, whereas the use of Telegram had a significant positive impact. The results suggest the need to manage social media habits wisely. Meanwhile, educators are encouraged to develop guidelines and awareness programs to mitigate negative effects and promote academic success. Moreover, a practical application derived from the regression equation, called 'GPA Prediction Tool Based on Social Media,' was developed to enable UiTM Seremban students to estimate their academic performance in conjunction with their use of social media.

Keywords: Regression Model, Social Media, Grade Point Average, University Students, Practical Tool

INTRODUCTION

Social media has revolutionized the way students communicate, collaborate, and access information. Kemp (2025) reported that individuals aged 16 to 24 are the most active users, placing students at risk of negative academic effects. Excessive use during this critical stage of development may lead to poor academic performance. Platforms such as WhatsApp, TikTok, Telegram, and YouTube are widely used by students for both academic and non-academic purposes. While these tools offer opportunities for knowledge sharing and group coordination, they may also contribute to distraction, procrastination, and cognitive overload. According to Junco (2012), students who use social media primarily for socializing or entertainment purposes tend to perform worse academically, while those who use it for academic purposes may experience improvements in their learning outcomes. The increasing dependency on social media calls for a deeper understanding of how its usage affects academic performance.

There is no doubt that social media has many benefits, but there is also evidence showing that social media harms academic performance as well (Henderson, 2024). Many students spend hours daily on social media, often multitasking while studying or attending classes. This behaviour reduces focus and productivity, affecting academic outcomes. This study was conducted to investigate the impact of usage duration, platform preference, usage purpose, and multitasking behavior on academic outcomes. The findings aim to guide students, educators, and institutions in fostering responsible digital habits that enhance academic achievement.

OBJECTIVES

i. to develop a regression model that examines the impact of social media on academic performance among UiTM Seremban students.
ii. to investigate the impact of social media usage on academic performance among UiTM Seremban students.
iii. to develop a practical tool that enables students at UiTM Seremban to estimate academic performance based on patterns of social media usage.

DESCRIPTION OF THE PRODUCT

Population, Sample, Data Collection Method, and Sampling Method

This study targets undergraduate students at Universiti Teknologi MARA (UiTM) Seremban Campus as the target population. Based on Slovin's formula, at least 375 samples should be included in this study (Ellen, 2022). Through the use of a purposive sampling method, 375 students from UiTM Seremban responded to the questionnaire. To ensure the clarity, relevance, and reliability of the research instrument, a pilot study was conducted with a small group of students before the actual administration of the questionnaire. The questionnaire, adapted from Swathi & Kumar (2023) and Alghamdi et al. (2020), was then finalized and distributed via Google Forms, with the link shared on WhatsApp. There are five questions related to the study, including Level of Multitasking Behavior, consisting of six items ranging from (1) never to (5) always.

Multiple Linear Regression Model

This study employed a multiple linear regression model to identify the factors of social media usage that impact academic performance, which is Grade Point Average (GPA). This method examines how student grades respond to their social media usage time, considering platform types, usage objectives, and multitasking capabilities. The model of multiple linear regression was derived after all assumptions had been met. It was developed using significant unstandardized beta coefficients for each predictor. The significance level of α at 0.05 was used to examine the statistical significance of the predictors.

Practical Excel-Based Tool

The regression equation obtained from the analysis was also applied to the development of an Excel spreadsheet that will be used by students and stakeholders at UiTM Seremban in the future. This tool, 'GPA Prediction Tool Based on Social Media', is designed to provide students and stakeholders at UiTM Seremban with an estimation of academic performance based on their social media usage behaviors, thereby facilitating self-assessment and awareness of the potential impact of digital habits on academic performance.

NOVELTY

This study contributes several new insights to the growing body of literature on social media and academic performance. It provides campus-specific evidence by focusing on students at the UiTM Negeri Sembilan, Seremban Campus, which may differ from national or international trends in social media usage. Next, the study examines the impact of social media platforms in different ways, exposing contrasting effects such as WhatsApp's negative impact on entertainment and Telegram's positive influence, rather than treating social media as a single entity. In addition, the integration of regression findings into a practical Excel-based tool represents a novel application that will enable students and stakeholders to predict academic performance outcomes based on their individual social media usage patterns. Through this practical tool, the study expands its applicability beyond theoretical insights to meet the needs of students and institutions in the real world.

RESULTS

A final multiple linear regression model yielded significant results with a p-value less than 0.05, with an R^2 value of 0.159, indicating that approximately 15.9% of the variation in GPA can be explained by social

media usage variables. The table below presents the parameter estimates for each predictor included in the regression model:

Table 1: Parameter Estimation Table

Model	Parameter Estimate	Standard Error	t-statistic	p-value
Constant	3.849	0.015	68.682	<0.001
Time spent on Social media	-0.026	0.005	-5.443	<0.001
Multitasking Behaviour	-0.053	0.016	-3.385	<0.001
Purpose Entertainment	-0.070	0.034	-2.040	0.042
Platform Telegram	0.249	0.104	2.399	0.017
Platform WhatsApp	-0.090	0.040	-2.245	0.025

The final regression model includes only the variables that were found to have a significant influence on GPA. The analysis revealed that WhatsApp usage, social media usage for entertainment, time spent on social media, and multitasking behavior were all negatively associated with GPA, whereas Telegram usage was positively associated. Specifically, the findings indicate that students who spend more time on WhatsApp or use social media primarily for entertainment purposes tend to have lower academic performance. Likewise, students who spend more time overall on social media and those who frequently multitask while using these platforms also tend to achieve lower GPA scores. In contrast, Telegram usage was positively associated with GPA, suggesting that students who use Telegram more often may benefit academically, possibly due to its use for educational communication or academic group discussions. Overall, the model suggests that while certain forms of social media use can be detrimental to academic achievement, others, such as Telegram, may offer academic benefits. Below is the regression equation for this study.

$$\hat{Y} = 3.849 - 0.026X_1 - 0.053X_2 - 0.070X_3 + 0.249X_4 - 0.090X_5 \quad (1)$$

where:
$\hat{Y}$ = academic performance (GPA)
X_1 = time spent on social media
X_2 = multitasking behaviour
X_3 = purposes of social media (Entertainment)
X_4 = social media platforms (Telegram)
X_5 = social media platforms (WhatsApp)

The following figure illustrates a practical tool that UiTM Seremban students can use to estimate their GPA based on social media usage, presented in the form of an Excel spreadsheet.

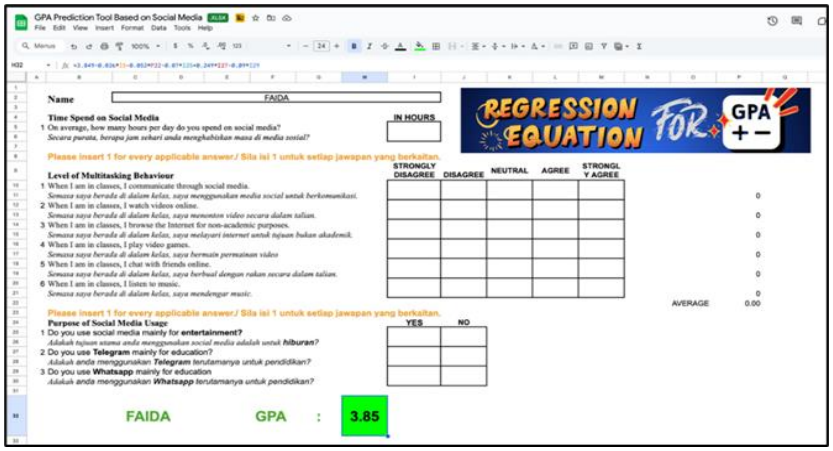

Figure 1: GPA Prediction Tool Based on Social Media

CONCLUSION

The study concludes that social media usage has a measurable impact on academic performance among students at UiTM Seremban. Time spent on social media and multitasking behaviour were associated with lower GPAs, while the use of Telegram positively influenced academic results. WhatsApp and entertainment-related usage had a detrimental effect on academic performance. These insights emphasise the importance of promoting digital literacy and responsible usage habits among students. Educational institutions should consider implementing awareness campaigns, digital detox initiatives, and incorporating digital well-being into academic counselling. Further research may explore longitudinal patterns of social media behaviour and its long-term effects on learning outcomes.

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AR GAME FOR LEARNING WASTE RECYCLING

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ABSTRACT

Recycling education is crucial for promoting environmental awareness from a young age, which is why the Malaysian Ministry of Education introduced it in schools. However, current methods are not engaging enough to capture students' attention. A preliminary study at Sekolah Kebangsaan Merlimau 1 showed limited student participation due to unengaging programs and limited time. To address this, an Augmented Reality Game-Based Learning application was developed, allowing students to learn about recycling anytime and anywhere. Using the ADDIE methodology and marker-based via Vuforia in Unity, the game included incentives, personalised agents, and navigation tools to enhance motivation and knowledge retention. An evaluation with 30 students aged 7 to 12 using the Game Engagement Questionnaire resulted in an overall mean score of (2.14), indicating moderate engagement. Results show improved immersion and presence, with room to enhance absorption and flow. Future plans include multilingual support, progress tracking, and markerless Augmented Reality.

Keywords: Augmented Reality, Game-Based Learning, Waste Recycling, ADDIE model, GEQ.

INTRODUCTION

Recycling is one of the most effective methods for preserving the environment and addressing the increasing problem of municipal solid waste, with Malaysia disposing of more than 39,000 tons daily (Zhou, 2022; ITA, 2024). Despite government efforts, the country's recycling rate still lags behind neighboring nations, emphasising the urgent need for strategic waste management and stronger public awareness. Research has shown that early environmental education plays a vital role in shaping children's knowledge, attitudes, and long-term behavior toward sustainability (Iwasaki, 2022). In line with this, the Malaysian Ministry of Education has incorporated recycling awareness into primary schools, including Sekolah Kebangsaan (SK) Merlimau 1 in Melaka. However, according to teacher Zuriyati Binti Bakar (personal communication, 10 July, 2025), student engagement in the school's recycling activities is often limited, with only 10 to 30 students actively participating, and programs are conducted just three to five times annually. Existing initiatives such as waste collection, awareness campaigns, competitions, and recycled art projects are entirely school-driven but face challenges in maintaining students' interest and consistency. Therefore, an alternative and more engaging platform is necessary to strengthen recycling education. Augmented Reality (AR) has been identified as a promising tool in education because it offers engaging learning experiences (Syafiq Yusof et al., 2022). When combined with Game-Based Learning (GBL), AR can further enhance motivation, focus, and retention through rewards, challenges, and hands-on interaction (Ying et al., 2021). This study proposes developing an AR-based game to teach recycling concepts such as waste collection, sorting, and pollution awareness through interactive levels and AR markers, creating both engagement and lasting knowledge retention.

PROBLEM STATMENTS

Current recycling educational initiatives demonstrate low levels of engagement

According to Sihvonen et al., (2024) the challenge in educating children about environmental issues, such as recycling, lies in the limitations of traditional methods, which often struggle to engage young learners effectively. This is supported by a preliminary analysis, which highlights that students' sources of information about recycling primarily rely on text-based materials. According to the data, 11 students cited teachers as their main source, followed by social media (10 students), posters (5 students), and books (4

students). These sources are generally unappealing to students and often result in a lack of sustained interest, as learners tend to lose attention quickly when exposed to static and passive content.

Limited exposure to do recycling education at school

According to Teacher Zuriyati (personal communication, 10 July, 2025), recycling programs at school are conducted only three to five times per year, with each session lasting approximately two hours. As a result, students receive very limited exposure to recycling education. This is also supported by a preliminary analysis conducted on students at SK Merlimau 1, which shows that the main obstacles they face in practicing recycling are insufficient time and a lack of information. Based on the data, 21 students cited insufficient time, while 8 students identified a lack of information as the key challenge. Iwasaki (2022) emphasizes that environmental education at an early age is critical in shaping children's awareness and attitudes toward environmental responsibility. Students who receive limited exposure at a young age are more likely to have lower knowledge and a weaker understanding of important concepts like recycling.

OBJECTIVES

i. To design an engaging interface for an AR game-based learning application for primary students about waste recycling.
ii. To develop an AR game-based learning application for primary students that teaches about waste recycling.
iii. To evaluate students' engagement with the AR game-based learning application designed for waste recycling education.

METHODOLOGY

This study adopts the ADDIE model which consists of several phases (analyze, design, development, implementation, and evaluation), as the guiding methodology for developing the AR game-based learning application. The ADDIE model is a widely recognised instructional design framework used across various disciplines to systematically create effective and learner-centered educational solutions (Anggala et al., 2022). Each phase of the model is applied in sequence to ensure the structured development and implementation of the AR educational game.

Figure 1: ADDIE Model phases.

In the analysis phase, a preliminary study was conducted to identify gaps in recycling education among primary school students. An online interview was carried out with teachers from SK Merlimau 1, and an online survey was distributed to 30 students to gather insights on current recycling practices and student engagement. The findings of this preliminary work highlighted limited exposure and a lack of interactive elements in existing programs. Additionally, a literature review was conducted to support the study's direction, guiding the selection of relevant content, target users, AR techniques, game genre, and GBL features. The literature revealed that a puzzle genre integrated with marker-based AR and GBL elements would be most effective in promoting engagement and environmental awareness.

During the design phase, the learning objectives and game structure were carefully planned to ensure an engaging educational experience. A flowchart was created to illustrate the gameplay sequence, user interactions, and system responses, serving as a visual guide to streamline development and identify logical inconsistencies. A low-fidelity storyboard was also developed to visualise the game's narrative, layout, and interactive components. This provided a clear framework for how educational content would be embedded within the game environment, ensuring alignment between learning goals and gameplay elements.

The development phase focused on producing all necessary materials and assets for the AR game based on the design specifications. Hardware and software requirements were identified, with development carried out on a laptop meeting the minimum technical specifications. The game was built using Unity as the primary engine, with the Vuforia SDK enabling marker-based AR functionality. Blender was used to create 3D models, while Adobe Illustrator 2025 was used for graphic assets. Once tools and resources were in place, a working prototype of the AR game was developed, integrating interactive recycling lessons and GBL features such as rewards, avatars, and navigation tools.

In the implementation phase, the AR game was deployed in APK format and tested with real users. Feedback from the users was crucial for improving the prototype before developing the final version, ensuring the application would be ready for end users.

The evaluation phase measured student engagement with the AR game using the Game Engagement Questionnaire (GEQ), which assesses four key elements: Immersion, Presence, Flow, and Absorption. A total of 30 students from SK Merlimau 1 participated in the evaluation. After playing the game, the students completed the questionnaire in hard-copy questionnaire. The questionnaire employed a 3-point Likert scale, and the collected responses were analysed to evaluate the effectiveness of the AR game in enhancing engagement as well as to identify potential areas for improvement.

RESULTS AND DISCUSSION

The evaluation results of the AR game-based learning application revealed varying levels of student engagement across four dimensions which is immersion, presence, flow, and absorption. Immersion achieved the highest mean score (2.53), indicating that students were highly mentally involved and engaged in the game environment, likely due to the use of AR features, interactive visuals, and real-time feedback. Presence also showed strong engagement (2.38), suggesting students felt a realistic sense of being in the virtual environment. In contrast, flow recorded a moderate mean score (1.97), showing that students experienced focused engagement at times but were unable to maintain it consistently. This was mainly due to language barriers, which made some instructions difficult to follow, and the technical requirement of scanning markers at specific distances, which occasionally disrupted gameplay. Similarly, absorption scored moderately (1.69), reflecting that while students were attentive, they struggled to achieve deep concentration. This was influenced by scanning difficulties related to distance and lighting conditions, which interrupted their overall focus.

Overall, the average engagement score across all 19 questionnaire items was (2.14), reflecting a moderate level of engagement. These findings demonstrate that the AR game was effective in capturing students' attention, especially through immersion and presence, but also highlight the need for improvement in maintaining flow and deep absorption through more dynamic and challenging gameplay.

Table 1: Mean Engagement Scores For Each Element

Elements	Mean Score	Engagement Level
Absorption	1.69	Moderate
Presence	2.38	High
Flow	1.97	Moderate
Immersion	2.53	High
Overall	2.14	Moderate

CONCLUSION

The AR educational game developed in this study successfully enhances recycling awareness among primary school students by providing an engaging learning experience. Using marker-based AR combined with game-based learning features, the application increases students' interest and understanding of recycling concepts while promoting active involvement in the learning process. For teachers, it offers an alternative classroom tool that creates a dynamic, student-centered environment, while for parents it serves as a additional tool to support recycling education at home. All project objectives were achieved, including user interface design, AR game development, and evaluation of student engagement. The evaluation, conducted with the GEQ, revealed a moderate overall engagement level, with higher engagement in presence and immersion. However, moderate scores in flow and absorption indicate that sustained focus and deep involvement were hindered by language barriers and the requirement to scan markers at specific distances. Addressing these issues by introducing a Malay language option and adopting markerless AR technology could improve accessibility, reduce distractions, and create a smoother, more engaging learning experience for students in the future.

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FEEDNOVA

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ABSTRACT

This FeedNova project investigates the valorisation of organic waste through the production of nutrient-dense chicken bran as a sustainable and cost-effective alternative. This project tackles two critical issues in chicken farming: escalating commercial feed costs and the environmental effect of uncontrolled organic waste. High feed prices diminish farmers' profitability, while enormous amounts of agricultural residue and food scraps contribute to landfill overflow, greenhouse gas emissions, and pollution. To address these challenges, FeedNova develops organic chicken bran by recycling biodegradable waste such as eggshells, banana stems, anchovy heads, and coconut dregs. The production process consists of systematic collection, sorting, fermentation, drying, grinding, and formulation. Fermentation is the vital phase that considerably increases protein, fiber, and mineral content, resulting in a nutrient-rich and balanced chicken feed. The finished product of this project potentially enhances chicken growth, immunity, and productivity while minimising dependency on expensive commercial feeds. At the same time, the initiative implements a successful waste-to-wealth approach that diverts organic waste from landfills, reduces environmental pollution, and promotes circular economy principles. Finally, FeedNova presents a scalable, long-term innovation that balances economic feasibility and environmental responsibility. The initiative promotes agricultural resilience and global food security by transforming organic waste into high-quality chicken feed.

Keywords: Waste to wealth, Circular Economy Principles, Organic Chicken Bran, Poultry Feed

INTRODUCTION

FeedNova was created in response to a rising need to solve the interrelated concerns of agricultural sustainability, economic pressure in poultry farming, and the ongoing problem of organic waste mismanagement. The persistent reliance on commercial feed continues to put farmers, particularly small and medium-sized businesses, under increasing financial strain. According to Wongnaa et al. (2023), poultry feed alone accounts for roughly 70% of the total expense of the production. This difficulty diminishes production, limits growth options, and weakens the resilience of chicken farming in general.

At the same time, organic waste mismanagement has become a major environmental concern. Vast amounts of agricultural residue and food scraps are discarded on a daily basis, with the majority ending up in landfills. Food waste contributes to around 24% of municipal solid waste disposed of in landfills, thus generates more methane than any other material because of its rapid decomposition (Quantifying Methane Emissions From Landfilled Food Waste | US EPA, 2025). Methane, a greenhouse gas that is more destructive than carbon dioxide. Untreated organic residue also pollutes water supplies and deteriorates soil quality. What is commonly seen as waste is in fact a valuable resource that may be recycled back into farming via circular economy principles.

The FeedNova process comprises collecting, sorting, fermenting, drying, grinding, and formulating raw materials such as eggshells, banana stems, anchovy heads, coconut dregs, and other leftovers. Fermentation is a vital stage because it increases protein, fiber, and mineral content. Throughout the fermentation process,numerous essential nutrients are generated (Zhang et al., 2022). Therefore, it potentially results in

a nutrient-dense and balanced feed that promotes poultry growth, health, and productivity while decreasing reliance on pricey commercial feed.

The concept is driven by a clear problem: increasing feed costs make it challenging for farmers to remain profitable, while valued organic materials are wasted, polluting the environment. By addressing both issues simultaneously, FeedNova proposes a practical and sustainable solution that transforms waste as a valuable resource for food production. Therefore, the main objectives of FeedNova are to present farmers a low-cost alternative to industrial feed, boost poultry nutrition, and encourage sustainable farming practices. By using locally accessible resources opposed to imported feed, the initiative promotes agricultural independence, environmental conservation, and long-term food security.

Ultimately, by turning waste into valuable products, the project illustrates how farming can be both economically viable and environmentally responsible. Although this project does not rely fully on organic waste, it provides a practical and scalable waste-to-resource innovation approach that benefits farmers, communities, and ecosystems while simultaneously contributing to establishing a more sustainable and resilient food system.

RESULTS AND DISCUSSION

Potential Nutritional Value of FeedNova

The FeedNova project demonstrated that transforming agricultural residue and food scraps into organic chicken bran could significantly boost the nutritional value of poultry feed. The fermentation process, which was acknowledged as the most significant step, increased the protein, fiber, and mineral content of the bran, resulting in a balanced diet capable of maintaining healthy development and immunity in chicken. Compared to conventional feed, organic bran supplied a more natural nutritional profile that was supposed to be devoid of excessive synthetic additives.

Figure 1: Images of fermentation process as the core phase in the FeedNova production of nutrient-dense organic chicken bran.

The raw materials used in this project—corn, coconut dregs, soy dregs, banana stems, grinded rice, grinded anchovy head, grinded egg shells and chopped dried pineapples. Corn, a primary carbohydrate source in poultry diets, is critical in supplying easily digestible energy required for development and metabolic processes. According to Admin (2023), corn has high carbohydrate content which offers chickens the energy to grow and regulate their body temperature, thus a good source of protein that comprises important amino acids for muscle development and maintenance. Besides, the incorporation of coconut and soy dregs used increases the protein composition of the diet. Not only that, banana stems and grinded rice serve as additional sources of nutritional fiber and complex carbs (Ma, J. (2015). Fiber improves gastrointestinal motility and digestive efficiency, whereas rice contains starch, which increases energy density without the use of synthetic feed additives.

Figure 2: Image of materials utilized in the formulation of organic chicken bran.

Furthermore, grinded anchovy heads are a great natural source of animal protein and omega-rich oils. Beyond that, grinded eggshells give highly bioavailable calcium, which is required for good bone growth and eggshell quality in laying hens. Moreover, a chicken's body is unable to produce calcium on its own, thus they must rely only on their diet and forage to obtain calcium and therefore egg shells are also a great supplier of calcium for them (Kurczodyna, 2025). Lastly, chopped dried pineapples provide natural sugars, fiber, and trace vitamins for the poultry.

Projected Economic Implications for Poultry Farmers

The Feednova project has significantly supplied an adequate quantity of nutrients to poultry, particularly chickens. Like regular chicken bran, the Feednova is able to sustain the chicken growth. Additionally, the farmer has also benefited because it decreases reliance on costly commercial feed and is remarkably cost-effective. According to industry analysts, between 65% to 75% of the overall cost of chicken farming is spent on feed (M & M, 2025). Commercial chicken feed is frequently found to be costly due to the utilization of imported raw materials, processing expenses, and market price variations. Although Feednova does not utilize organic waste fully, this idea enables to reduce production costs by using organic waste materials as the primary input and maintain the nutritional value necessary for the healthy growth of chickens. Farmers' financial burden is supposed to be directly lessened by this affordability, particularly small-scale poultry producers that bear the burden of growing feed costs.

Anticipated Environmental Contributions through Waste Utilization

Beyond its nutritional and economic attributes, FeedNova is a significant ecological innovation. Organic waste mismanagement has grown into a major issue, with neglected agricultural residue and food scraps resulting in landfill overflow, greenhouse gas emissions, and environmental contamination. By repurposing such biodegradable materials, the initiative exemplifies circular economy concepts in practice. According to Jim (2024), converting food waste into chicken feed does not only offer a rich economic benefit but also offers a more ecologically benign alternative to the detrimental practice of burning agricultural waste. Reducing organic waste entering landfills reduces methane emissions, while reusing nutrient-rich byproducts helps to prevent soil and water pollution. Furthermore, by reducing dependency on commercial feed ingredients like maize and soybean, the initiative indirectly alleviates constraints on land usage and biodiversity. This illustrates how agricultural practices could shift from major causes to environmental deterioration towards solutions for ecological restoration.

CONCLUSION

The FeedNova project demonstrates how creative waste-to-resource solutions may alter the poultry business by balancing economic viability and environmental responsibility. The findings show that fermentation-based valorisation of agricultural and food waste produces nutrient-dense chicken bran, which may improve poultry development, immunity, and productivity while decreasing farmers' reliance on costly industrial feeds. Economically, the invention enables farmers to reduce expenses and increase profitability, particularly for small- and medium-sized businesses dealing with rising feed prices. Environmentally, it provides a scalable approach

for diverting organic waste from landfills, reducing greenhouse gas emissions, and promoting sustainable resource cycles. Ultimately, by converting waste into wealth, the effort increases farming resilience,

promotes environmental responsibility, and aligns with global demands for regenerative farming methods. This combined impact—increasing poultry output while decreasing environmental burdens—highlights FeedNova's potential to inspire broad acceptance and replication, paving the path for a more sustainable and integrated agricultural future.

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INVADOPODIA: THE FORMATION THROUGH THE LENS OF LIGAND DECAY

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ABSTRACT

Cancer is a major global health challenge, with metastasis identified as the leading cause of cancer-related deaths. A critical step in this process is the formation of invadopodia, actin-based membrane protrusions that enable cancer cells to degrade the extracellular matrix (ECM) and invade surrounding tissues. This research designs a two-dimensional mathematical model to examine the role of ligand decay in invadopodia formation. The model incorporated ligand-signal interactions with decay terms, while actin polymerisation is represented as plasma membrane velocity. Numerical algorithms were implemented using the level set method, second-order finite difference schemes, and the ghost fluid method to capture the movement of the free boundary membrane. Simulation results show that ligand concentration highest at the membrane interface due to receptor-ligand binding, with decay rates strongly influencing the extent and behavior of protrusion formation. These findings demonstrate that mathematical modeling provides an effective framework to capture the dynamics of invadopodia formation and offer new insights into the role of ligand decay in cancer cell invasion.

Keywords: Decay rate, Invadopodia formation, Level set method, Ligand, Mathematical modeling

INTRODUCTION

Cancer remains one of the most formidable and devastating causes of mortality worldwide. According to data from the World Health Organization (WHO), there were 19,976,499 total cancer cases and 9,743,832 cancer-related deaths (WHO, 2022). The deadly aspect of cancer lies in metastasis, which represents the key phenomenon observed in patients approaching death. Evidence from Norway supports this, showing that for solid tumors, 66.7% of cancer deaths were registered with metastasis as a contributing cause (Dillekås *et al.*, 2019). Metastasis is facilitated by the formation of invadopodia, actin-rich protrusions that degrade the ECM and enable cancer cells to invade surrounding tissues and disseminate to distant organs (Yaacob *et al.*, 2022).

The study of invadopodia formation was initially introduced by (Saito *et al.*, 2012), who described the process in terms of detailed actin reorganisation, ECM degradation, receptor signaling, and matrix metalloproteinase (MMP) transmission, though the model was limited by insufficient consideration of actin connectivity. Subsequent research sought to address this limitation. For example, there is a study that proposed a one-dimensional signal transduction model that treated the plasma membrane as a free boundary to represent continuous actin connections (Admon & Suzuki, 2017), while another explored actin polymerisation and boundary conditions through the application of Laplace's equation (Gallinato *et al.*, 2017). In addition, an extended model incorporated ligand dynamic, signaling pathways, actin, MMPs, and ECM interactions into a more comprehensive framework (Yaacob *et al.*, 2021, Yaacob *et al.*, 2022, Yaacob *et al.*, 2024). The present research builds on these efforts by introducing a decay constant, while focusing specifically on the role of ligands and signal transduction in invadopodia formation.

This research aims to investigate two-dimensional mathematical model describing the formation of invadopodia during cancer cell invasion. It focuses on formulating simplified representations of ligand interactions and signaling processes with the inclusion of decay terms, while also developing numerical algorithms that employ the level set method and finite difference techniques to solve the proposed

equations. Furthermore, this research analyses the resulting ligand and signal distributions at the membrane interface, with particular attention to their relationship to the protrusive behavior of the plasma membrane. The significance of this research lies in its potential to advance understanding of the mechanistic role of invadopodia in cancer cell invasion, thereby contributing to the development of therapeutic strategies aimed at curtailing metastatic dissemination.

In addition, this research also connects with SDG 3: Good Health and Well-being, as understanding invadopodia dynamics is essential in the broader fight against cancer metastasis. By modeling the ligand decay influences protrusion growth, this work provides insights that can help medical researches explore new ways to interrupt or slow down metastasis. In the long term, such mathematical models can contribute to strategies that improve treatment outcomes and support healthier lives.

THE FORMULATION OF MATHEMATICAL MODEL

This research develops a mathematical model to describe the formation on invadopodia in invasive cancer cells. The model considers the extracellular, intracellular and membrane interface regions where MMPs degrade the ECM and release ligands. These ligands bind to epidermal growth factor receptors (EGFR) on the cell surface, triggering signal transduction that reorganizes the actin cytoskeleton and promotes actin polymerization. The resulting changes push the plasma membrane outward, giving rise to invadopodia.

In this research, the new mathematical model approach has been introduced by considering a ligand decay term into the formulation. This additional term captures the natural degradation of ligands over time, which has not been explicity highlighted in earlier models. In reality, ligands do not stay constant, they gradually fade as they spread out, attach to receptors, or break down in the surrounding environment. By including this decay effect, our model captures the biological process more realistically. This approach highlights the novelty of our research, as it allows us to directly explore how different rates of ligand decay shape the growth and persistence of invadopodia.

Rather than replicating the entire complexity of the biological system, the model focuses on the essential mechanisms that diretly influence invadopodia growth: ligand density, $c^*(x,t)$, signal transduction, $\sigma(x,t)$, ECM degradation, and membrane movement, $v(x,t)$. By highlighting these key factors, the model provides insight into how small-scale molecular interactions translate into large-scale structural changes at the cell surface.

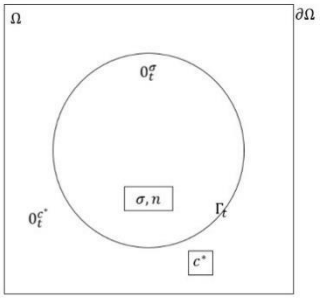

Figure 1: Illustaration of the domain structure applied in the two-dimensional model of invadopodia formation

The formation of invadopodia is explained using the following mathematical model:

a) For Ligand, (c^*):

$$\begin{aligned} c_t^* &= d_{c^*}\Delta c^* - \lambda c^*, && x \in 0_t^{c^*}, && t \in (0,T], \\ c^* &= 0, && x \in 0_t^{\sigma}, && t \in (0,T], \\ c^*(x,0) &= c_0^*(x), && x \in 0_t^{c^*} \end{aligned} \qquad (1)$$

$$\begin{aligned} c^*(x,t) &= 0, && x \in \partial\Omega, && t \in (0,T], \\ c^*(x,t) &= g(x), && x \in \Gamma_t, && t \in (0,T], \end{aligned}$$

where the first line introduces the decay term, λc^*. This term is the novelty of this research, representing the natural loss of ligand concentration due to degradation and receptor binding.

b) Signal Transduction, (σ):

$$\begin{aligned} \sigma_t &= d_\sigma \Delta\sigma, && x \in 0_t^\sigma, && t \in (0,T], \\ \sigma &= 0, && x \in 0_t^{c^*}, && t \in (0,T], \\ \sigma(x,0) &= \sigma_0(x), && x \in 0_t^\sigma, \\ \sigma(x,t) &= c^*(x,t), && x \in \Gamma_t, && t \in (0,T], \end{aligned} \tag{2}$$

c) On the Interface, (Γ_t):

$$\begin{aligned} \Gamma_t &= \{\psi(x,t) = 0\}, && t \in (0,T), \\ \psi_t + v.\nabla\psi &= 0, && x \in \Gamma_t, && t \in (0,T), \\ v &= \nabla\sigma - \nabla c^*, && x \in \Gamma_t, && t \in (0,T), \end{aligned} \tag{3}$$

d) Velocity Extension, (w):

$$(\nabla\psi.\nabla)w = 0, \quad x \in \Omega, \quad t \in (0,T), \tag{4}$$

RESULTS AND DISCUSSION

The simulations reveal that ligand decay is a critical factor in invadopodia formation. Slow decay preserves ligand availability at the plasma membrane, sustaining receptor binding and signal transduction, which drives the growth of larger and more stable protrusions. In contrast, fast decay reduces ligand concentration, limits signaling, and produces smaller, short-lived protrusions. Over time, protrusions expand only in regions where ligands persist, confirming that ligand decay directly governs both the scale and persistence of invadopodia.

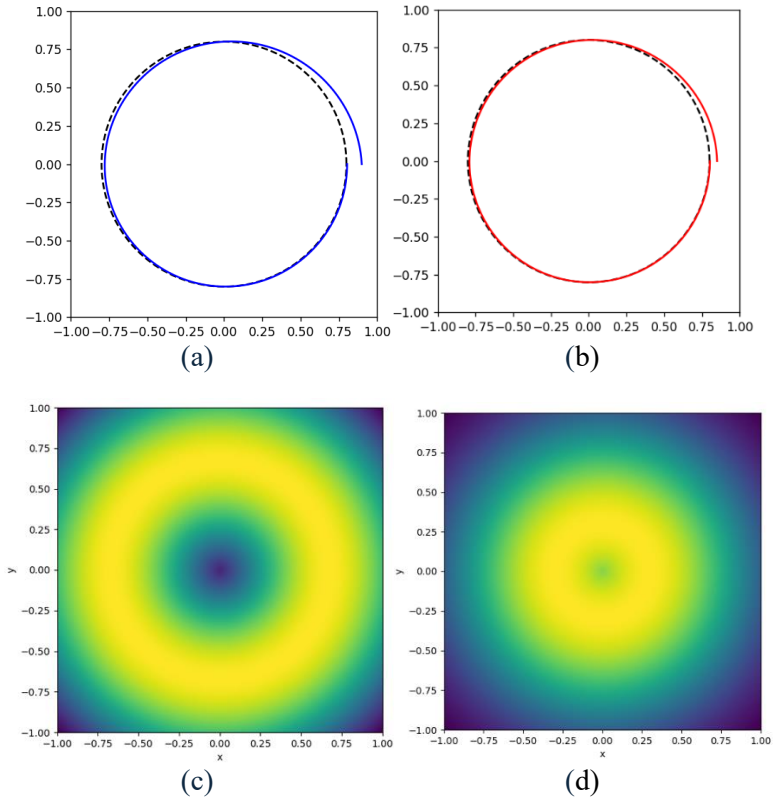

Figure 2: Effect of ligand decay on invadopodia formation. (a) Interface position with slow ligand decay, (b) Interface position with fast ligand decay, (c) Ligand density distribution for slow decay and (d) Ligand density distribution for fast decay.

As indicated in Figures (a) and (b), it can be seen that at the slow decay case, the interface extends further outward, indicating that ligand availability supports sustained protrusion growth. In contrast, at the fast decay case, the interface remains closer to the initial position, reflecting limited protrusion development. Meanwhile, Figures (c) and (d) compare the ligand density distributions, where slow decay maintains higher concentrations near the plasma membrane, while fast decay shows a reduction in ligand levels.

CONCLUSION

This research highlight the role of ligand decay in invadopodia formation through mathematical modeling and simulation. The results show that slow ligand decay sustains higher ligand concentration at the plasma membrane, supporting continuous receptor binding and stronger signal transduction, which promote the development of larger and more stable protrusions. In contrast, fast ligand decay limits ligand availability, weakens signaling, and results in smaller, short-lived protrusions. These findings demonstrate that the rate of ligand decay is a key factor governing both the persistence and scale of invadopodia. By showing how molecular turnover shapes membrane dynamics, these findings provide new insight into the mechanisms of metastasis and underscore the importance of ligand decay in controlling invasive behavior.

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HYBRID MACHINE LEARNING MODELS FOR ASPECT-BASED SENTIMENT ANALYSIS ON MOOC QUORA REVIEWS FOR E-LEARNING PERSONALIZATION

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ABSTRACT

The growing popularity of Massive Open Online Courses (MOOCs) makes it hard for new learners to choose the right platform. To help with this, a web-based application was developed to analyse reviews from Quora using Aspect-Based Sentiment Analysis (ABSA). The system uses a special hybrid machine learning model that combines a Decision Tree (DT) and a Support Vector Machine (SVM) to sort user comments by sentiment and five key topics, including content, structure, assessment, interaction, and instructor. This combination of models makes the system more accurate and reliable. The application shows these results for Coursera, edX, and Udemy using easy-to-understand charts and gives recommendations. The hybrid model was effective, achieving an overall accuracy of 92% on the development data. This project offers a useful tool that helps students make smarter choices when picking a MOOC.

Keywords: Hybrid Machine Learning, Aspect-Based Sentiment Analysis, MOOC, Quora Reviews, E-Learning

INTRODUCTION

MOOCs have changed education by making learning flexible, affordable, and accessible in many fields. Platforms like Coursera, Udemy, and edX are popular worldwide, attracting millions of learners (Gomez et al., 2022; Zulkifli et al., 2020). This shows how MOOCs help make education more equal and available to people everywhere. Despite their benefits, learners struggle to choose the right platform. Star ratings and reviews are often biased, inconsistent, or unorganised, and the large amount of feedback makes it harder to find useful insights (Ahamed & Ahangama, 2023). As a result, students face uncertainty and difficulty in deciding which platform best matches their learning needs.

Traditional sentiment analysis often classifies reviews only as positive, neutral or negative, without looking at the specific aspects that affect learners' experiences. This makes reviews less useful, as students need details about how features like course content, structure, assessments, interaction, and instructor quality are viewed. A simple positive or negative label cannot capture these differences. Researchers highlight that aspect-level sentiment analysis provides more reliable and practical insights that better reflect user experiences (Geet et al., 2023).

This study aims to give learners clearer insights to support better decisions in online learning. It applies ABSA to Quora reviews of Coursera, Udemy, and edX. The method has two parts, which are aspect classification and sentiment classification, where a hybrid machine learning model is used to improve accuracy and reliability. The results are shown in an interactive dashboard with charts and word clouds, helping learners compare platforms more effectively and choose the one that fits their needs with confidence.

RESULTS AND DISCUSSION

The project successfully met its objectives by developing and validating a web application for ABSA on MOOC reviews. Functionality testing, which included eight test cases and 23 inputs, was completed successfully, showing that all system components worked as intended. The core of the system, a hybrid model combining DT and SVM, achieved 92% accuracy as shown in Figure 1, demonstrating strong performance. Overall, the system proved effective and reliable in carrying out the intended analysis.

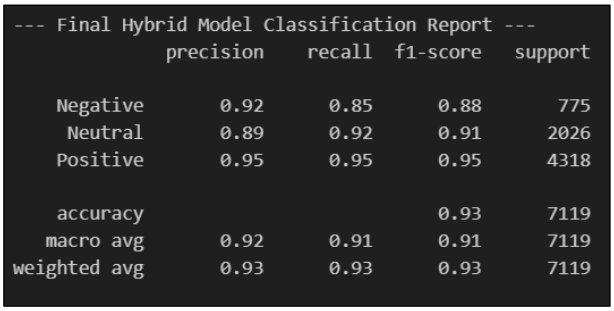

Figure 1: Most Mentioned Positive Words from Coursera

The performance of the hybrid model was evaluated in detail across the five predefined topics. The model demonstrated consistently strong results, achieving aspect-specific accuracies of 82.5% for 'Content,' 81.8% for 'Instructor,' 80.5% for 'Interaction,' 76.6% for 'Structure,' and 76.2% for 'Assessment.' These results show that the model is not only accurate overall but also effective at classifying sentiment within each specific category, confirming its reliability for the fine-grained analysis required by this project.

As detailed in a comparative result in Table 1, an overview of the analysis for each platform revealed that all three platforms received a higher number of positive reviews compared to neutral and negative ones. This finding indicates a favourable sentiment from Quora users towards Coursera, edX, and Udemy based on the collected reviews. A more granular, aspect-level analysis further highlighted key themes in the reviews, with the "Content" aspect receiving the highest overall engagement and mentions. As visually demonstrated by the system's dashboard, the combination of bar charts, pie charts, and word clouds provides a comprehensive summary of MOOC strengths and weaknesses, empowering learners to make better-informed decisions.

Table 2: Comparison Results for Coursera, edX and Udemy

MOOC Platforms	Grand Total Reviews	Total Positive Reviews	Total Neutral Reviews	Total Negative Reviews
Coursera	3557	2425	834	298
edX	1766	1125	452	189
Udemy	2587	1374	942	271

The system's interactive visualisations effectively translate raw review data into clear, actionable insights. A key visualisation is the word cloud, as shown in Figure 2, which provides a high-level overview of the most prominent topics discussed by users. This tool highlights the key terms driving user feedback. For instance, words like "machine" and "academy" were found to be dominant in positive reviews, indicating the subjects that resonate most with learners. This allows prospective students to quickly grasp the main themes and priorities within the user community.

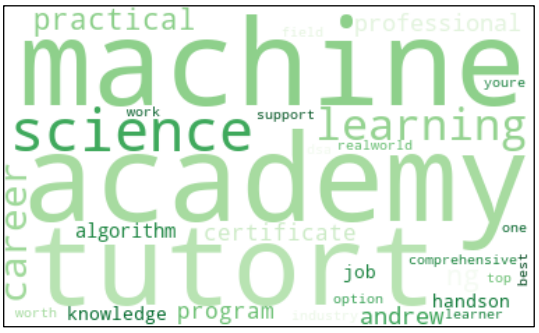

Figure 2: Most Mentioned Positive Words from Coursera

Beyond a general overview, the system empowers users to conduct a deeper, granular analysis by directly comparing different aspects of the learning experience. The "Aspect Comparison" tool generates a side-by-side grouped bar chart, as illustrated in Figure 3, allowing users to visually assess the sentiment distribution for two topics at once. For example, when comparing 'Content' and 'Assessment' for Coursera, the chart clearly shows that the 'Content' aspect received a significantly higher volume of positive reviews. This feature provides specific, data-driven evidence that helps learners make a more informed decision based on the platform attributes that matter most to them.

Figure 3: Comparison of 'Content' vs. 'Assessment' for Coursera

CONCLUSION

In conclusion, this project successfully developed a web application that performs ABSA on MOOC reviews from Quora. The system helps learners choose an e-learning platform by analysing reviews for Coursera, edX, and Udemy using a hybrid model that combines a DT and a SVM model. This method classified user opinions across five key aspects, including content, structure, assessment, interaction, and instructor. The system proved to be effective and reliable, achieving a high predictive accuracy of 92%. While successful, the study was limited by using a single data source, fixed aspect categories, and performance variations due to data imbalance. Future work should focus on expanding data sources, adding advanced features like sarcasm detection, and creating a dynamic retraining pipeline to keep the model's insights current.

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The authors would like to express their deepest gratitude to their supervisor, Prof. Madya Ts. Dr. Khyrina Airin Fariza Binti Hj. Abu Samah, for her invaluable guidance and unwavering support throughout this project. Appreciation is also extended to Universiti Teknologi MARA for providing the resources and academic environment necessary for this research.

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MULTIVARIATE ANALYSIS OF AIR POLLUTION IN SOUTHERN PENINSULAR MALAYSIA : PRINCIPAL COMPONENT ANALYSIS AND FACTOR ANALYSIS APPROACH

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ABSTRACT

Air pollution in Southern Peninsular Malaysia has become a critical environmental issue, exacerbated by rapid urbanization and industrial activities. This study aims to identify the main contributors of air pollution and construct underlying factors of air pollution in Southern Peninsular Malaysia using Principal Component Analysis (PCA) and Factor Analysis (FA), respectively. The data used in this study were a daily dataset that covered the period from 1 January 2023 to 31 December 2023. Eleven air monitoring stations from three region (Negeri Sembilan, Melaka and Johor) were used to record concentrations of six air pollutants which were CO, O_3, SO_2, NO_2, PM_{10}, and $PM_{2.5}$ for this study. Two principal components were obtained after performing PCA, with the cumulative percentage of variance for both principal components being 64.274%. The first principal components consisted of PM_{10}, $PM_{2.5}$, NO_2, and CO, while the second principal component consisted of SO_2 and O_3. All the assumptions related to FA were conducted and found to be complied. Two factors were extracted using PCA, and after varimax rotation, the variances of factor 1 and 2 accounted for 43.422% and 20.852% respectively, with the cumulative 64.274%. Factor 1 consisted of PM_{10}, $PM_{2.5}$, NO_2, and CO, whereas factor 2 consisted of SO_2 and O_3. It can be concluded that factor 1 loaded together since the pollutants in factor 1 shared the same source which is vehicle emissions. Since they are linked and involved in the photochemical process, SO_2 and O_3 are loaded together in factor 2. In conclusion, the main contributors to PC1 are PM_{10}, $PM_{2.5}$, NO_2, and CO, while PC2 is SO_2 and O_3. The grouping of the pollutants was the same in FA, where factor 1, the air pollutants shared by the same sources which was vehicle emissions. While factor 2, the pollutants were linked in the photochemical process.

Keywords: Principal Component Analysis (PCA), Factor Analysis (FA), air pollution, principal component, factor

INTRODUCTION

Air pollution can be described as the contamination of either indoor or outdoor air with various gases and particles that include sulfur dioxide (SO2), nitrogen dioxide (NO2), carbon monoxide (CO), ozone (O3), and particulate matter (PM2.5 and PM10) change the natural makeup of the air (WHO, 2019). Sulfur dioxide (SO_2) is a colourless air pollutant with a sharp, irritating odour, primarily emitted from industrial sources such as paper manufacture, petroleum and metal refining (DCCEEW, 2022). Nitrogen dioxide (NO2) is a significant air pollutant generated during high-temperature combustion in the air reacts with oxygen. Particulate matter is a combination of solid particles and liquid droplets in the air. According to the California Air Resources Board (2015), PM10 and PM2.5 from different emissions sources for PM2.5 omitted from the combustion of gasoline, oil, diesel fuel or wood. Meanwhile, PM10 is omitted

from construction sites, agriculture, landfills, and waste burning. Carbon monoxide (CO) is a highly toxic, colourless, odourless, and flammable gas that results primarily from the incomplete combustion of carbon-containing fuels. Ozone (O3) is an air pollutant that not directly emitted into the air. It is formed through chemical reactions in atmosphere. The southern region of Peninsular Malaysia, which includes states such as Johor, Melaka, and Negeri Sembilan, plays a vital role in the nation′s economic growth, hosting numerous industrial zones, urban centers, and busy transportation hubs. However, these developments have also contributed to significant air pollution challenges. The primary aim of this study is to identify the main contributors to air pollution and construct underlying pollution factors in Southern Peninsular Malaysia using Principal Component Analysis (PCA) and Factor Analysis (FA).

RESULTS AND DISCUSSION

The following results were based on daily air quality data that have been retrieved from Department of Environment between 1 January 2023 and 31 December 2023 from 11 monitoring stations across Johor, Melaka, and Negeri Sembilan. The dataset included concentrations of six pollutants: SO_2, NO_2, CO, O_3, PM_{10}, and $PM_{2.5}$. This study introduces a dual analytical approach, integrating PCA and FA to simultaneously identify dominant air pollutants in a high-growth industrial and urban region. In additional, this study provide a statistical basis for developing real-time monitoring dashboards and mobile applications that can predict and communicate pollution risks in future. By combining advanced multivariate analysis with practical application potential, the study bridges the gap between academic research and real-world environmental management tools, a perspective not commonly applied in previous regional studies. Table 1 shows the list of eigenvalues associated with each linear component before and after extraction. Principal components 1 and 2 should be retained since the eigenvalues of PC1 are 2.631 and PC2 are 1.225, with both eigenvalues greater than one. The results of cumulative variance showed that two principals components should be retained since the cumulative variance of PC2 is 64.274%, which is more than 60%.

Table 1: Total Varianced for Principal Component Analysis

Component	Initial Eigenvalues			Extraction Sum of Squared Loadings		
	Total	Variance (%)	Cumulative (%)	Total	Variance (%)	Cumulative (%)
1	2.631	43.857	43.857	2.631	43.857	43.857
2	1.225	20.417	64.274	1.225	20.417	64.274
3	0.937	15.619	79.893			
4	0.724	12.066	91.959			
5	0.436	7.272	99.232			
6	0.046	0.768	100.00			

Table 2 represents the factor loadings and correlation that consisted of 2 components. The first component consisted of PM_{10}, $PM_{2.5}$, NO_2 and CO. PM_{10} had the highest contribution to the first component with strong negative loading with -0.940, followed by $PM_{2.5}$ with -0.923. PM_{10} and $PM_{2.5}$ were known as pollutants with similar sources from vehicle emissions, and various industrial processes and construction sites. Among these, vehicle emissions were the most contributor for PM_{10} and $PM_{2.5}$ (Azliyana, 2020). The increased trend in new vehicle numbers across three regions (Negeri Sembilan, Melaka and Johor) showed the fact that PM_{10} and $PM_{2.5}$ were the main contributor of air pollution in southern peninsular Malaysia due to vehicle emissions. The second principal component consisted of only 2 pollutants, SO_2 and O_3. SO_2, with a moderate value of -0.416, separates the pollutant from the first principal component. This could be because SO_2 was lower or less dominant in its sources, such as in the combustion of fossil fuels and industrial processes, compared to other pollutants. O_3 was separated from other pollutants because O_3 was a secondary pollutant unlike other pollutants that directly emitted from their sources.

Table 2: Factor Loading and Factor Analysis

Variables	Factor Loading Before Rotation		Factor Loading After Rotation	
	Component		Component	
	1	2	1	2
PM_{10}	0.940	0.126	**0.948**	0.003
$PM_{2.5}$	0.923	0.214	**0.944**	-0.086
SO_2	0.209	-0.416	0.150	**0.440**
NO_2	0.666	-0.493	**0.593**	0.579
O_3	0.170	0.861	0.285	**-0.830**
CO	0.617	-0.77	**0.600**	0.160

For factor analysis (FA) the results of the KMO test and Barlett′s test. The value of KMO was 0.628, which is in the mediocre category since the value was between 0.60 to 0.69 and was considered acceptable. The p-value of Barlett′s test was 0.000. Hence, adequate to conduct FA. Principal component analysis (PCA) was used as an extraction method in this analysis. After rotation, factor 1 accounted for 43.422% and for factor 2 it was 20.852%. Hence, the cumulative variance of the 2 factors was 64.274%.

Table 3: Factor Loading Before Rotation and After Rotation

	Factor Loading		Correlation	
	1	2	1	2
PM_{10}	-0.579	0.114	**-0.940**	0.126
$PM_{2.5}$	-0.569	0.193	**-0.923**	0.214
SO_2	-0.129	-0.376	-0.209	**-0.416**
NO_2	-0.411	-0.445	**-0.666**	-0.493
O_3	-0.105	0.778	-0.170	**0.861**
CO	-0.380	-0.070	**-0.617**	-0.077

Table 3 shows the factor loading after extraction in first factor contained PM_{10}, $PM_{2.5}$, NO_2 and CO since the loadings of variables exceed 0.4. The first components had a strong correlation of air pollutants (PM_{10}, $PM_{2.5}$, NO_2 and CO) due to a similar source which was vehicle emission. The second component was made up of O_3 and SO_2. SO_2 and O_3 loading together in second factor indicated there was significant correlation between them that most probably shared atmospheric processes that influence their concentration (Xiofan et al., 2024).

CONCLUSION

In conclusion, principal component analysis (PCA) and factor analysis (FA) were applied in this study to achieve their objectives. Two principal components were obtained from those methods, with 64.274% of the cumulative percentage of variance. The first component comprised PM10, PM2.5, NO2 and CO, while the second comprised SO2 and O3. The main contributors were PM10, PM2.5, NO2 and CO for the first principal component and SO2 and O3 for the second principal component. FA also conducted this study to construct underlying air pollution factors in Southern Peninsular Malaysia. The value of KMO was 0.628, which was acceptable, and the p-value of Barlett′s test was 0.000, which was significant, hence adequate to conduct FA. The first factor consisted of PM10, PM2.5, NO2 and CO, they loaded together because they were from the same sources, which were vehicle emissions. The second factor, SO2 and O3, are both pollutants in the photochemical process. The outcomes of this study are highly relevant to policymakers, public health agencies, and local communities. This study also brings benefits to both users and society by

identifying the dominant pollutants, which helps authorities in making decisions for preventive health measures. These findings raise community awareness of the health risk associated with exposure to high level of pollutants. The study also supports Malaysia′s efforts to meet United Nations Sustainable Development Goals (SDGs), particularly Goal 3: Good Health and Well-Being and Goal 11: Sustainable Cities and Communities. The results of this study may also guide the Department of Environment (DOE) and government in enforcing stricter emission control on industries and vehicles. In terms of commercialization, the PCA and FA models developed in this study can be transformed into practical tools by integrating into real time air quality monitoring dashboards or mobile applications that alert the public about pollution risks in specific areas. This study not only contributes to academic knowledge but also provides benefits to society and shows potential for commercialization.

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A PROTOTYPE OF FAKE JOB POSTING PREDICTION SYSTEM USING LOGISTIC REGRESSION

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ABSTRACT

Online job platforms make job searching efficient by offering broader opportunities. However, scammers use these platforms to deceive job seekers by creating fake job postings. Fraudsters use complex tactics that make it hard to differentiate between legitimate and fraudulent posts. It can be harmful for job seekers as it risks their privacy and also financial. The objectives of this system is to develop a prototype of fake job posting prediction using logistic regression and to evaluate the performance of the logistic regression algorithm. This Fake Job Posting Prediction System uses a Logistic Regression trained on a Employment Scam Aegean Dataset(EMSCAD) of job postings. Key preprocessing steps include handling missing values, combining important text fields, encoding categorical variables, and applying TF-IDF vectorization. SMOTE was used to balance the dataset, and GridSearchCV was applied for hyperparameter tuning. The model achieved an accuracy of 97.83%, recall of 79.49%, precision of 76.54% and an F1-score of 77.99% using a 90/10 train-test split with SMOTE and tuning applied. It successfully predicts fake job postings and provides keyword-based explanations to support user understanding. The proposed system successfully predicts fake job postings using a transparent and user-friendly interface.

Keywords: Fake Job Posting, Logistic Regression, TF-IDF Vectorization, SMOTE, GridSearchCV

INTRODUCTION

Nowadays, everything is done online, from schooling to buying. Technology has advanced significantly (Reddy, 2023). In order to reach a wider audience, businesses are now using web technologies such as employment portals (Wang et al., 2024). Online job platforms like LinkedIn and JobStreet allow employers to post open positions and connect with candidates efficiently. The amount of job information available on the internet is rapidly increasing. Employers and job seekers now primarily rely on online job portals and websites to find suitable employment possibilities. (Wang et al., 2024). Job seekers have numerous options available to them. Applying for jobs online is convenient and saves time. People received the benefits, however there are a few people out there that post fraudulent job openings and attempt to swindle job searchers (Reddy, 2023).

The increasing number of scam online has become serious issues and impacting the trust and safety in the job market. Job seekers face significant challenges in distinguishing between genuine and fraudulent job postings, which can expose them to being victim to scams, resulting in the loss of their personal information, financial resources, or in some cases, even their existing employment. Employment scams are one of the main issues with online recruitment fraud (ORF) that have received a lot of attention lately. These days, a lot of businesses have decided to post job positions online so that candidates can find them easily. However, this can be one of the scammers' goals since they offer positions to applicants in return for their money. It is possible to harm a reputable company's reputation by publishing false job openings (Boka, 2024). Scammers frequently use false company websites, clone bank websites, and clone official-looking papers to attract job seekers. Job scammers typically use email instead of direct contact (Habiba et al., 2021). Not all people are fully aware of what is correct and what is not. Some people fall victim to fraudulent legitimate businesses that provide employment opportunities (Reddy, 2023).

People are unaware that the jobs that are posted may be genuine or fraudulent (Srivedi, 2024). These scammers usually target platforms like Linkedln to prove themselves as recruitment agencies. One can quickly find a job that fits their qualifications and desired field by searching the internet (Srivedi, 2024). Usually fraudster will try to represent their company profile or websites to the job seekers as realistic as possible (Habiba et al., 2021). The fraudsters also use complex tactics to lure people into the scam, making it impossible for them to tell the difference between real and false employment adverts (Akram et al., 2024) .The consequences of this is individuals may not be interested in new job advertisements due to concerns about personal, academic, and professional information security (Habiba et al., 2021). It becomes increasingly difficult to keep data and privacy safe online. The number of people who have been victims of fake job postings is constantly increasing. Companies and recruiters attract job seekers in a variety of ways, most of which come from digital job-providing websites (Ranparia et al., 2020).

Job seekers can face serious risks, such as losing their privacy, money, or even their current jobs, due to online recruitment fraud and employment scams. While online recruitment systems have brought convenience and benefits to both job seekers and recruiters, they can also cause harm if not implemented carefully. This issue has been highlighted in studies, showing how vulnerable job seekers are in today′s digital job market (Akram et al., 2024). Furthermore, fraudsters undermine the integrity of well-known organizations by damaging their reputation in the employment market (Akram et al., 2024). By rethinking the approaches to overcome this issue, the proposed solution can helps them to prevent financial losses, pay an application fee to register, or pay for the hiring process (Swathi et al., 2023).

The product developed from this project is the prototype of fake job posting prediction system using logistic regression that serves as the practical solution for the problems mentioned. The system allows user to input job posting details such as employment type, required experience, required education, job function and other job details which are then analyzed through logistic regression model trained on real dataset, Employment Scam Aegean Dataset(EMSCAD). Important features such as job title, description, requirements and categorical information are combined and processed using TF-IDF and encoding techniques. The system not only provide the prediction results such as fake job posting or real job posting, but also highlights the influential keywords that contributed to the result of the prediction. By having these features, it offers transparency and increases user trust in the output. This system is designed to assist job seekers by acting as a decision support tool, helping them to differentiate between genuine job opportunities and potentially harmful job scams.

This project will identify fraudulent job postings using selected prediction model. Prediction model is designed to analyze and classify job listings based on various features that distinguish legitimate opportunities from scams. One of the example of prediction model is Logistic Regression, also known as the logistic model or logit model. It is to evaluates the relationship between several independent factors to categorize dependent variable (Khandagale et al., 2022). Based on this approach the objectives is defined as follow. The first objective is to develop a prototype of fake job posting prediction using logistic regression and the second objective is to evaluate the performance of the logistic regression algorithm.

RESULTS AND DISCUSSION

Table 1 shows the comprasion table results for each splitting set under three comparisons which are vefore smote & tuning, after smote and after smote & tuning.

Table 1: Comparison Table Results for each Splitting Set with 3 Comparisons

Splitting Set	Comparison	Accuracy	Precision	Recall	F1-Score
90/10	Before SMOTE & Tuning	96.65	100	30.77	47.06
90/10	After SMOTE	96.35	58.56	83.33	68.78
90/10	After SMOTE & Tuning	97.83	76.54	79.49	77.99
80/20	Before SMOTE & Tuning	96.68	98.04	32.05	48.31
80/20	After SMOTE	96.43	59.62	81.41	68.83
80/20	After SMOTE & Tuning	97.67	73.97	80.13	76.92
70/10	Before SMOTE & Tuning	96.44	98.53	28.15	43.79
70/10	After SMOTE	96.59	61.66	81.09	70.05
70/10	After SMOTE & Tuning	97.50	73.88	76.05	74.95

This resulted in a total of nine distinct experiments, each evaluated using four standard metrics which are Accuracy, Precision, Recall, and F1 Score. Starting with the 90/10 split, the model achieved an accuracy of 96.65% before any form of balancing or tuning was applied. Interestingly, the precision in this case was perfect 100.00%, indicating that all predictions labeled as fake were indeed correct. However, this came at the cost of very poor recall 30.77%, which means that many actual fake job postings were missed. The overall F1 score was only 47.06%, highlighting that the model, though highly precise, failed to generalize well to the minority class due to severe class imbalance. When SMOTE was applied, the model′s recall significantly improved to 83.33%, but precision dropped to 58.56%, yielding a more balanced F1 score of 68.78%. After tuning the hyperparameters, the model achieved its best performance under the 90/10 setting, with an improved accuracy of 97.83%, precision of 76.54%, recall of 79.49%, and an F1 score of 77.99%, a considerable improvement in both detection quality and consistency.

Under the 80/20 split, a similar trend was observed. Initially, the model showed a high accuracy of 96.68% and precision of 98.04%, but recall was only 32.05%, resulting in a low F1 score of 48.31%. This confirmed once again that while the model was very cautious in predicting fake postings, hence the high precision, it failed to predict a significant portion of them. After SMOTE was applied, recall dramatically increased to 81.41%, and although precision dropped to 59.62%, the F1 score improved to 68.83%, offering better balance. With additional hyperparameter tuning, the model reached its best condition with accuracy of 97.67%, precision of 73.97%, recall of 80.13%, and F1 score of 76.92%, showing slightly better recall and stability than the 90/10 version.

The 70/30 split, having the largest proportion of test data, posed a greater challenge. Initially, the model scored accuracy of 96.44% and an extremely high precision of 98.53%, but with a very poor recall of 28.15%, the F1 score was limited to 43.79%. This imbalance is typical in imbalanced datasets without proper resampling. When SMOTE was introduced, recall surged to 81.09%, precision balanced at 61.66%, and F1 score reached 70.05%, suggesting a more practical model for real use. Finally, after tuning, the model achieved accuracy of 97.50%, precision of 73.88%, recall of 76.05%, and F1 score of 74.95%, showing robust and consistent results comparable to those of the 80/20 configuration.

Finally, the comparison revealed that using SMOTE significantly improved the model's recall, allowing it to spot more fake job posts that were previously overlooked. The most effective results were achieved when SMOTE was combined with hyperparameter tuning, providing a good balance between precision and recall. Among all examined train-test splits, the 90/10 configuration with SMOTE and tuning performed the best, with an F1 score of 77.99% and an overall accuracy of 97.83%.

CONCLUSION

This project successfully achieved all the objectives outlined at the beginning of the study. The first objective, to develop a prototype of fake job posting prediction using logistic regression, was fulfilled by building prediction model implemented in Python. The model is capable of predicting whether a job posting is real or fake and displays explainable output by highlighting influential keywords in the prediction. The second objective, to to evaluate the performance of the logistic regression algorithm, was successfully addressed through a series of experiments using three different train-test splits: 90/10, 80/20, and 70/30. Evaluation metrics such as accuracy, precision, recall, and F1-score were applied. The best result was achieved using the 90/10 split with SMOTE and hyperparameter tuning, reaching 97.83% accuracy and an

F1-score of 77.99%. This confirmed that the model performs well, especially in predicting fake job postings while minimizing misclassification of real ones. This project has successfully designed, implemented, and evaluated a fake job posting prediction system using logistic regression. It provides a strong foundation to protect job seekers from scams.

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SOLAR STICKY INSECT TRAP

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ABSTRACT

The Solar Sticky Insect Trap is an eco-friendly, solar-powered pest control device designed to attract and trap flying insects, such as fruit flies and moths, without the use of harmful chemicals. It operates by utilising solar energy to power an ultraviolet light that attracts insects, while a sticky surface ensures they are captured. The trap was invented to provide a cost-effective and sustainable alternative to chemical pesticides, reducing environmental impact and improving farming practices. Its key features include low maintenance, chemical-free operation, affordability, and ease of use, making it ideal for smallholder farmers, organic farms, and residential gardeners. The device helps improve agricultural productivity by controlling pest populations, leading to healthier crops and increased yields. Environmentally, it supports biodiversity by minimising pesticide use and reducing pollution. Socio-economically, it offers an affordable solution for farmers, particularly in developing regions, reducing their dependency on expensive pesticides and labour. The Solar Sticky Insect Trap has strong commercialisation potential in both local and international markets, especially as demand for sustainable pest management solutions rises. Its application across the agricultural, residential, and commercial sectors positions it as a viable product for a wide range of consumers seeking environmentally friendly and efficient pest control methods.

Keywords: Solar Sticky Insect Trap, Solar Panel, Chemical Free, Pest Management, Eco-friendly

INTRODUCTION

Global crop productivity is significantly impacted by pest problems affecting fruit crops. Traditional pest management is based on chemical pesticides, and although they can be effective in the short term, they have significant health, environmental and sustainability implications. Overuse and misuse of pesticides are the causes of soil and water contamination, loss of biodiversity, pests' resistance to these chemicals, as well as risks to the health of farmers and consumers. In Malaysia, which depends on fruit (crop) farming as an important sector of the agricultural economy, farmers, especially smallholders, are still facing difficulties in managing pest control adequately as well as in line with both pest management and sustainable production.

Consistent with international requests for sustainable farming, there is an urgent need for alternative pest control strategies. Environmentally friendly appliances that reduce reliance on chemicals without being prohibitive in cost and availability for farmers are required to guarantee food safety, protect the environment, and conform to international market requests for safe food. It was in this context that the Solar Sticky Insect Trap emerged as a novel, low-cost, and eco-friendly pest control measure specifically for agricultural and residential purposes.

OBJECTIVES

The main objective of this project is to design and develop a solar-powered sticky insect trap that:

i. Reduces dependence on chemical pesticides through an eco-friendly, chemical-free pest control method.
ii. Provides farmers, especially smallholders and organic producers, with a cost-effective, low-maintenance device for managing pest populations.

iii. Enhances agricultural productivity and crop quality by effectively controlling flying insect pests such as fruit flies and moths.
iv. Contributes to long-term sustainability by aligning with key United Nations Sustainable Development Goals (SDGs), particularly in food security, health, and environmental conservation.

PRODUCT DESCRIPTION

The Solar Sticky Insect Trap is an eco-friendly solution to pest control- It's a quality product that incorporates cutting-edge technology. The device consists of:

- A solar panel that harvests energy all day, then uses it to power the unit at night.
- There's an ultraviolet (UV) LED light that kicks in after dark, catching any flying insects such as fruit flies and moths.
- A sticky surface under the light that captures & immobilises insects.
- Tripod stand and tray design, convenient installation and stable in orchard, plantation or garden.

This is an easy-care system that doesn't take much space or time to use – all one must do is clean the surface now and then and put on new sticky traps. Being compact, the implement can be used across a wide variety of farmlands and since it is chemical-free, all the useful organisms and the health of the soil are maintained. Powered by solar energy, the trap requires no electrical network and can be used even in farming regions distant from built-up areas. It is affordable and easy to use, and is suitable for a variety of end users, from smallholders to organic farms and home gardeners.

The Solar Sticky Insect Trap consists of a tripod stand, a tray, an LED light, a solar panel, and a sticky insect trap. The solar panel charges during the day and powers an ultraviolet light at night, attracting harmful insects that are most active during this time. It can be placed in fruit farms, particularly during the fruit season, to attract and trap insects. Figure 1 shows the prototype of the Solar Sticky Insect Trap.

Figure 1: The prototype of the Solar Sticky Insect Trap

NOVELTY AND UNIQUENESS

The Solar Sticky Insect Trap is unique and novel due to several key features:

1. Solar-Powered Operation: It uses renewable solar energy to power the device, eliminating the need for electricity and reducing environmental impact.
2. Chemical-Free Pest Control: Unlike traditional pest control methods, it does not rely on harmful pesticides, promoting a healthier environment for both farmers and consumers.

3. Sticky Trap Technology: The combination of ultraviolet light and a sticky surface effectively attracts and traps insects, ensuring a non-toxic, efficient solution for pest management.
4. Low Maintenance: Designed for minimal upkeep, requiring only occasional cleaning and trap replacement, making it easy for farmers to use without frequent intervention.
5. Cost-Effective: The product is affordable, making it accessible for small-scale farmers, while reducing reliance on expensive chemical treatments and labour.
6. Ease of Use: Simple to install and operate, it allows farmers to independently manage pest control without the need for external assistance.
7. Eco-Friendly and Sustainable: By reducing pesticide usage, it supports sustainable farming practices and contributes to environmental conservation.

BENEFIT TO MANKIND AND SUSTAINABILITY

The Solar Sticky Insect Trap offers significant benefits to mankind by improving health and safety, reducing harmful chemical exposure, and enhancing agricultural productivity through cost-effective pest control. Its solar-powered, chemical-free operation not only provides an affordable solution for small-scale farmers but also supports environmental protection by reducing pesticide use, preserving biodiversity, and promoting sustainable farming practices. The trap helps increase crop yields, contributing to food security and supporting farmers' livelihoods. In terms of sustainability, it aligns with several United Nations Sustainable Development Goals (SDGs), including SDG 2 (Zero Hunger) by improving food supply, SDG 3 (Good Health and Well-being) by reducing pesticide-related health risks, SDG 12 (Responsible Consumption and Production) through sustainable practices, SDG 13 (Climate Action) by reducing fossil fuel reliance, and SDG 15 (Life on Land) by protecting ecosystems and reducing environmental impact. Overall, the product supports environmental, economic, and social well-being, while promoting long-term sustainability in agriculture.

POTENTIAL COMMERCIALISATION

The Solar Sticky Insect Trap offers significant commercialisation potential across multiple markets, including the agricultural sector, residential market, and commercial pest control. It provides an eco-friendly, chemical-free solution for farmers, particularly in fruit farming, helping reduce the reliance on harmful pesticides while improving crop health and yields. Its solar-powered operation makes it affordable and low-maintenance, appealing to smallholder farmers, organic farms, and home gardeners. The trap can also be marketed to commercial pest control companies managing large spaces like hotels and restaurants, supporting sustainable pest management. With the growing global demand for organic farming and sustainable agriculture, the product holds strong export potential.

CONCLUSION

The Solar Sticky Insect Trap demonstrates how renewable energy and simple design can be combined to create an effective, affordable, and eco-friendly pest management tool. By reducing reliance on chemical pesticides, it not only enhances crop productivity and food safety but also supports biodiversity and sustainable farming practices. With its low cost, ease of use, and alignment with global sustainability goals, the device holds strong potential for widespread adoption in both local and international agricultural sectors.

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ENHANCING *TETRASPORA* SP. CULTIVATION: A GOMPERTZ-OPTIMISED GROWTH FRAMEWORK FOR BIOFUEL APPLICATIONS

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ABSTRACT

Microalgae especially *Tetraspora* sp. are sustainable alternatives to fossil fuels that require accurate growth models to improve production efficiency. Therefore, this study utilized Logistic Sigmoidal and Gompertz models to determine the growth rate and population of Tetraspora sp. and evaluated both performances using root mean square (RMSE), coefficient of determination (R^2) and percentage error. The analysis indicates that the Gompertz model as the optimal predictive tool due to its conservative and accurate growth rate (0.025 day^{-1}). It also had a lower RMSE (0.1537), higher R^2 (0.9859), and a decreased error of 12.28%. This study confirms the Gompertz model as the most reliable predictor of *Tetraspora* sp. growth, which makes it a crucial resource for maximising sustainable biofuel production and contributing to SDG 7 (affordable and clean energy).

Keywords: Microalgae, Tetraspora sp., Logistic Sigmoidal, Gompertz, Growth Rate

INTRODUCTION

Nowadays, fossil fuels are being used too much, which pollutes the air and causes global warming. To address this issue, green algae generation of H_2 has recently gained attention as a sustainable alternative energy source. Currently, microalgae biotechnology is contributing to the global bioeconomy by providing valuable biomass for applications like medications, cosmetics, and food (Fernández *et al.*, 2021). Furthermore, hydrogen gas is regarded as the best fuel for reducing air pollution and halting global warming (Melis & Happe, 2001), and improvements in growth, culture techniques, and genetic engineering could further increase algae's potential as a source of bio-products (Ramlee *et al.*, 2021). Therefore, adopting mathematical models like sigmoidal growth curve has been studied and employed for modelling biological growth.

The predominant classical sigmoidal growth models used in scientific studies are the Logistic, Gompertz, and Richards models. These models are extremely useful because can accurately represent natural events with a sigmoidal growth pattern, especially in biology, chemistry and medicine field. Their practical utility is demonstrated by Abd Al-Rahman *et al.* (2023), who showed that sigmoidal growth curves can accurately model experimental growth data following this pattern over time. This situation is also supported by Hanief *et al.* (2020), who studied the growth kinetics of the microalga *Botryococcus braunii* for biofuel production using the Logistic and Gompertz growth models. Therefore, this study focuses on *Tetraspora* sp. which ideal for biofuel research due to it grows quickly, thrives in diverse conditions (Chowdury *et al.*, 2020), and even helps clean wastewater and capture carbon (Mahmood *et al.*, 2023).

The objectives of this study: (1) to determine the growth rate and population of *Tetraspora* sp. using Logistic Sigmoidal and Gompertz growth model, and (2) to evaluate the performance of the Logistic Sigmoidal and Gompertz models by comparing their fit to *Tetraspora* sp. population growth data, using error measures such as Root Mean Square Error (RMSE), R^2 and mean percentage error. This study utilised two sigmoidal growth models: Logistic Sigmoidal in Eq. 1 and Gompertz in Eq. 2.

$$P(t) = \frac{K}{1 + \left(\frac{K - P_0}{P_0}\right) e^{-kt}} \tag{1}$$

$$P(t) = Ke^{-lnln\left(\frac{K}{P_0}\right)} e^{-kt} \tag{2}$$

From the general model in Eq. 1 and Eq. 2, the growth rate, k of microalgae *Tetraspora sp.* for Logistic Sigmoidal growth model and Gompertz model can be computed as Eq. 3 and Eq. 4, respectively.

$$k_{LS} = \frac{-\ ln\ ln\ \left(\frac{P_0(K - P_t)}{P_t(K - P_0)}\right)}{t} \tag{3}$$

$$k_G = -\frac{ln\ ln\left(\frac{-\ ln\ ln\ \left(\frac{P_t}{K}\right)}{ln\ ln\ \left(\frac{K}{P_0}\right)}\right)}{t} \tag{4}$$

where k_{LS} = growth rate of Logistic Sigmoidal model, k_G = growth rate of Gompertz model, P_0 = the initial population, P_t = the number of populations at time, t and K = carrying capacity. The calculation for population, P_t of microalgae *Tetraspora sp.* can be computed using Logistic Sigmoidal; seen Eq. 5 and Gompertz; seen Eq. 6.

$$P_t = \frac{K}{1 + \left(\frac{(K - P_t)}{P_t}\right) e^{-kt}} \tag{5}$$

$$P_t = Ke^{-lnln\left(\frac{K}{P_0}\right)e^{-kt}} \tag{6}$$

where P_t = the number of populations at time, t, K = carrying capacity, k = growth rate and P_0 = the initial population. The performance of the Logistic Sigmoidal and Gompertz models were compared using three error measures: Root Mean Square Error (RMSE) (Akin *et al.*, 2020), coefficient of determination (R^2) (Sariyel *et al.*, 2017) and percentage error. The lowest RMSE, highest R^2 and lowest percentage error was selected as the better model when comparing among models.

RESULTS AND DISCUSSION

The microalgae *Tetraspora* sp. data was collected in triplicate over a period of 20 days by Mustaffa et al. (2019). Figure 1 presents the growth curve of *Tetraspora* sp. displays the typical three different sigmoidal growth patterns: lag, exponential, and stationary. As shown in Figure 1, a lag phase (Days 1-5) with a concentration range of 0.80 to 3.3 mg/ml, followed by an exponential growth phase (Days 6-17) with a concentration range of 3.3 to 29.4 mg/ml, and a stationary phase with 35 mg/ml.

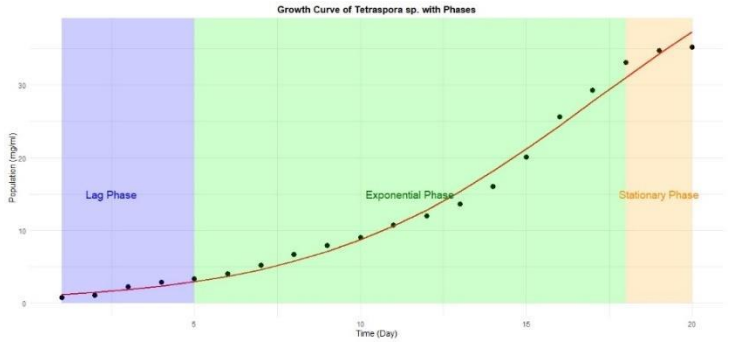

Figure 1: Growth curve of Tetraspora sp. data

(Source: Author's visualization using R statistical software)

Growth rate

The 20 days of the *Tetraspora* sp. were analysed to determine the growth rate, k and population growth using Logistic Sigmoidal and Gompertz growth model by assuming a carrying capacity, K of 36. Table 1 illustrates the comparison of the daily growth rates (k) of *Tetraspora* sp. between Logistic Sigmoidal model (k_{LS}) and Gompertz model (k_G). Both models' growth rate patterns reveal low initial rates from days 1 to 5. As seen in Table 1, the growth rate on day 4 for Gompertz model $(k_G = 0.023)$, which yielded a more conservative value of 0.023, reflecting its sensitivity to initial growth constraints. From Table 1, the result showed that both the Logistic and Gompertz models have an inflection point within day 18, where growth rate reaches maximum. After day 18, the population is approaching its carrying capacity. The Logistic Sigmoidal model produced an average growth rate of 0.051 day^{-1}, whereas the Gompertz model resulted in a lower average of 0.025 day^{-1}. This clarify that the Gompertz model yields a more conservative estimate.

Table 1: A Comparison of the growth rate from the Logistic Sigmoidal model and Gompertz model for Tetraspora sp.

t	P_t	k_{LS}	k_G	t	P_t	k_{LS}	k_G
1	0.80328	0	0	11	10.73403	0.02182	0.01223
2	1.12666	0.17377	0.04659	12	11.98435	0.01341	0.00796
3	2.26643	0.24406	0.07512	13	13.61269	0.01520	0.00947
4	2.88778	0.06522	0.02292	14	16.03581	0.01988	0.01318
5	3.32171	0.03064	0.01142	15	20.10697	0.03029	0.02189
6	4.02056	0.03543	0.01392	16	25.64382	0.04197	0.03379
7	5.23530	0.04325	0.01833	17	29.35538	0.03406	0.02990
8	6.68575	0.03661	0.01695	18	33.12094	0.05317	0.04974
9	7.94051	0.02397	0.01197	19	34.76580	0.04713	0.04584
10	9.01739	0.01663	0.00879	20	35.23086	0.02431	0.02398

Note: t=day, k_{LS}= growth rate for Logistic Sigmoidal model, k_G= growth rate for Gompertz model

Population Growth

Figure 2 (left) shows that the Logistic Sigmoidal model provided a good fit to the actual *Tetraspora* sp. data during the exponential growth phase but slightly underestimated the population in the stationary phase. In contrast, the Gompertz model in Figure 2 (middle) demonstrated a remarkably precise fit across all growth phases. The comparative analysis of all three curves in Figure 2 (right) confirms that the Gompertz model is the superior model of *Tetraspora* sp. population growth over the 20-days period.

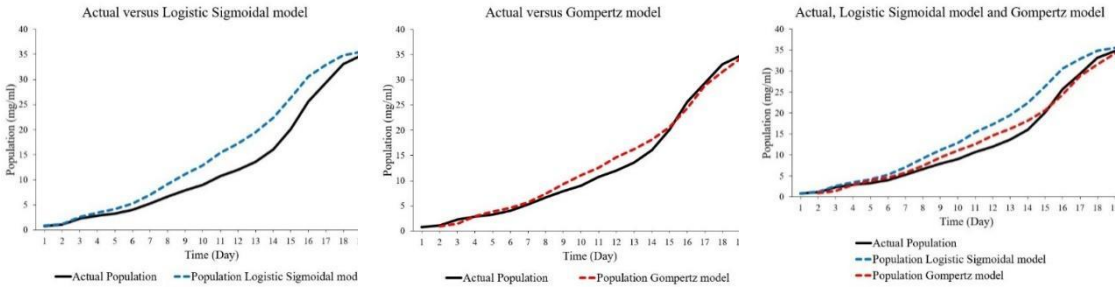

Figure 2: Growth curve of actual population versus Logistic Sigmoidal model (left), actual population versus Gompertz model (middle) and actual population versus Logistic Sigmoidal model and Gompertz model (right)

Model Performance

Table 2 presents the model performance for *Tetraspora* sp. population growth between Logistic Sigmoidal and Gompertz model. The Gompertz model produced a significantly reduced RMSE value of 0.1537, outperforming the Logistic model (RMSE=0.2933). The R^2 values for the Logistic Sigmoidal and Gompertz models shows 0.9102 and 0.9859, respectively. This indicates that the Gompertz model explains almost 98% of the variation in the data, which is much higher than the Logistic model's 91%. The Gompertz model has a percentage error of 12.28%, which is less than the Logistic Sigmoidal model's percentage error of 25.19%. Table 2 indicates that the Gompertz growth model is the best accurate model for predicting the population of the microalgae *Tetraspora* sp.

Table 2: Comparison of model performance for *Tetraspora* sp. population growth: Logistic Sigmoidal vs. Gompertz model

Models	RMSE	R^2	Percentage error (%)
Logistic Sigmoidal	0.2933	0.9102	25.19
Gompertz	0.1537	0.9859	12.28

Note: Author's calculation using R statistical software

CONCLUSION

This study aimed to determine the growth rate and population of *Tetraspora* sp. using Logistic Sigmoidal and Gompertz growth model, and to evaluate the performance of both models by comparing their fit to *Tetraspora* sp. population growth data, using error measures. The following conclusions were obtained. 1) The Gompertz model provided a more accurate average growth rate estimate (0.025 day^{-1}) compared to the Logistic Sigmoidal model (0.051 day^{-1}). 2) The Gompertz model demonstrated superiority with lower Root Mean Square Error (RMSE: 0.1537), higher coefficient of determination (R^2: 0.9859), and reduced percentage error (12.28%). As a consequence, the Gompertz model is proposed for future biotechnology and aquaculture study, whereas other sigmoidal models, such as Richards and Baranyi require further exploration.

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THE RATE OF CONVERGENCE OF b-BISTOCHASTIC QUADRATIC STOCHASTIC OPERATOR ON 1-DIMENSIONAL SIMPLEX

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ABSTRACT

This research studies the dynamics of a quadratic stochastic operator (QSO) called the *b*-bistochastic QSO defined on a 1-dimensional simplex. The QSO was first constructed on a 1-dimensional simplex before fixed-point analysis was conducted on the QSO. Under some conditions, the QSO is defined to be the *b*-bistochastic QSO. It is found that such *b*-bistochastic QSO converges to a unique fixed point at a constant rate.

Keywords: Quadratic Stochastic Operator, b-order Majorization, Hyperbolicity, Rate of Convergence

INTRODUCTION

The concept of the quadratic stochastic operator (QSO) was first introduced in 1924 through Bernstein's pioneering work on the theory of heredity and it is commonly used to describe the species time evolution in a biological system (Mukhamedov & Ganikhodjaev, 2015). In a biological system with n species or traits, the state space is represented by the simplex $S^{n-1} = \{x_1, x_2, x_3, \dots, x_n\}$. We denote $x^{(0)} = \left(x_1^{(0)}, \dots, x_n^{(0)}\right)$ as the probability distribution of the species where $x_i^{(0)}$ is the probability of species i. Let $p_{ij,k}$ be the probability that individual in the i^{th} and the j^{th} species interbreed to produce an individual of the species k. The probability distribution of the first generation, $x^{(1)} = \left(x_1^{(1)}, \dots, x_n^{(1)}\right)$ can be found by using a total probability,

$$x_k^{(1)} = \sum_{i,j=1}^{n} p_{ij,k} x_i^{(0)} x_j^{(0)}, \quad k = 1, \dots, n. \tag{1}$$

The QSO, commonly denoted as V, describes the population evolution and dynamics across successive generations. Starting from the initial arbitrary state of probability distribution, $x^{(0)}$ evolves to the probability distribution of the first generation, $x^{(1)} = V\left(x^{(0)}\right)$ and continues to evolve to the second generation, $x^{(2)} = V\left(x^{(1)}\right) = V\left(V\left(x^{(0)}\right)\right) = V^2\left(x^{(0)}\right)$ and so on. Thus, each QSO describes the dynamics of probability distributions based on the parameters of $p_{ij,k}$ and the distribution of the current generation or state.

Formally, a QSO is defined on the $(n-1)$-dimensional simplex,

$$S^{n-1} = \{x = (x_1, \dots, x_2) \in R^n | x_i \geq 0, \sum_{i=1}^{0} x_i = 1, \forall i\}. \tag{2}$$

A general QSO $V: S^{n-1} \to S^{n-1}$ can now be defined as the following form:

$$V(x)_k = \sum_{i,j=1}^{n} p_{ij,k} x_i x_j, \quad k = 1, \dots, n. \tag{3}$$

The probability coeffiecient $p_{ij,k}$ has the following properties:

(1) $p_{ij,k} \leq 0$,
(2) $p_{ij,k} = p_{ji,k}$,
(3) $\sum_{i,j=1}^{n} p_{ij,k} = 1,\ k = 1, \dots, n.$

A general QSO can be characterized by equation (3) and the properties of its probability coefficient. Additional conditions and properties define each of the QSO class uniquely. For each $k \in \{1, \dots, n-1\}$, we define functional $U_k: R^n \to R$ by

$$U_k(x_1, \dots, x_n) = \sum_{i=1}^{k} x_i. \tag{4}$$

Based on equation (4), a new majorization is introduced called the *b*-order majorisation. Specifically, for any $x, y \in S^{n-1}$, we say x is said to be b-ordered by y if and only if $U_k(x) \leq U_k(y)$ for all $k \in \{1, \dots, n-1\}$, and is denoted as $x \leq^b y$. For any $x, y, z \in S^{n-1}$, the b-order majorization satisfies the following conditions:

1. $x \leq^b x$,
2. $x \leq^b y, y \leq^b \Leftrightarrow x = y$,
3. $x \leq^b y, y \leq^b z \Leftrightarrow x \leq^b z.$

Additionally, it also has the following properties:
1. $x \leq^b y \Leftrightarrow \alpha x \leq^b \alpha y, \forall \alpha > 0$,
2. $x \leq^b y, \alpha < \beta \Rightarrow \alpha x \leq^b \beta y.$

We provide important notions and information regarding the *b*-bistochastic QSO, canonical form and hyperbolicity as follows:

Theorem 1: Let V be a QSO. Then, if V satisfies $V(x) \leq^b x$ for all $x \in S^{n-1}$, then V is called a *b*-bistochastic QSO.

The following theorem by Mukhamedov and Embong (2015) describes the general properties of the *b*-bistochastic QSO.

Theorem 2: Let V be a *b*-bistochastic QSO defined on S^{n-1}, then the following statements hold:

1. $\sum_{m=1}^{k} \sum_{i,j=1}^{n} p_{ij,m} \leq kn,\ k \in \{1, \dots, n-1\}$,
2. $p_{ij,k} = 0$ for all $i, j \in \{k+1, \dots, n\}$ where $k \in \{1, \dots, n-1\}$,
3. $p_{nn,n} = 1$,
4. for every $x \in S^{n-1}$, one has:
   (i) $V(x)_k = \sum_{l=1}^{k} p_{ll,k} x_l^2 + 2 \sum_{l=1}^{k} \sum_{j=l+1}^{n} p_{lj,k} x_l x_j$ where $k = \underline{1, n-1}$,
   (ii) $V(x)_n = x_n^2 + \sum_{l=1}^{n-1} p_{ll,n} x_l^2 + 2 \sum_{l=1}^{n-1} \sum_{j=l+1}^{n} p_{lj,n} x_l x_j$,
5. $p_{lj,l} \leq \frac{1}{2}$, for all $j \geq l+1,\ l \in \{1, \dots, n-1\}$

The behaviour of the *b*-bistochastic QSO was studied on a 1-dimensional simplex. Throughout this paper, only the 1-dimensional simplex will be considered, which is defined as follows.

Definition 1 [Mukhamedov & Ganikhodjaev, 2015]. For a population distribution with 2 species, from equation (2), the 1-dimensional simplex is defined as

$$S^1 = \{x = (x_1, x_2) \in R^2 | x_1, x_2 \geq 0, x_1 + x_2 = 1\}. \tag{5}$$

Definition 2 [Alligood et al., 2000]. Let $x \in R^n$ be a point of a function $f: R^n \to R^n$. Then, x is called a fixed point of the function f if $f(x) = x$.

If a point ξ exists for a QSO V such that $V(\xi) = \xi$, then x is said to be the fixed point of V. If an operator V has multiple fixed points, then the set of its fixed points is denoted as (V) as mentioned by Zada and Shah (2017). A fixed point ξ of a QSO can be further identified as hyperbolic or non-hyperbolic. From (3), we obtain the canonical form of the QSO as follows,

$$V(x)_1 = p_{11,1}x_1^2 + 2p_{12,1}x_1x_2 + p_{22,1}x_2^2. \quad (6)$$

By letting $p_{11,1} = a$, $p_{12,1} = b$ and $p_{22,1} = c$ be arbitrary coefficients such that $a, b, c \in [0,1]$ and expressing $x_2 = 1 - x_1$, we rewrite equation (6) as follows:

$$V(x)_1 = (a - 2b + c)x_1^2 + 2(b - c)x_1 + c. \quad (7)$$

Thus, let $a = 1, c = 0$ and from (7), we obtain the following

$$V(x)_1 = 2bx - 2bx^2. \quad (8)$$

For our case, we consider the case where $a \neq 1$, that is $a \in [0,1)$ and $b \neq \frac{1}{2}$. Let $\lambda = V'(\xi)$ where ξ is the fixed point. The hyperbolicity coefficient can be determined by the following,

$$\lambda = 2\,(a - 2b + c)\xi + 2(b - c). \quad (9)$$

According to Mukhamedov and Ganikhodjaev (2015), a fixed point ξ is called hyperbolic fixed point if $|\lambda| \neq 1$ and non-hyperbolic otherwise. In the hyperbolic case, ξ can be further identified as either an attracting fixed point or a repelling fixed point. The dynamical behaviour of the hyperbolic fixed point ξ of the operator V is determined by the hyperbolicity λ.

Theorem 3: If $|\lambda| < 1$, then ξ is said to be an attracting fixed point. If $|\lambda| > 1$, then ξ is said to be a repelling fixed point.

The behavior of the hyperbolic fixed point ξ can also be determined by using the discriminant, Δ of equation (9).

Lemma 1: If $0 < \Delta < 4$, then ξ is an attracting fixed point and if $4 < \Delta < 5$, then ξ is a repelling fixed point.

The interval $(0,5)$ contains all possible values of Δ, as proven by Mukhamedov and Ganikhodjaev (2015). From Shahidi (2013), we have the following,

Definition 3. A QSO V is said to be a regular QSO if for any arbitrary point of the QSO, $V^m(x)$ exists. If otherwise, then V is said to be a non-regular QSO.

Next, from Mukhamedov and Embong (2015), we have the following,

Proposition 1. Let V be a b-bistochastic QSO on S^1 defined on (5). Then, $\xi = (0,1)$ is one of the fixed points.

RESULTS AND DISCUSSION

We obtain that $a = 1, c = 0$ and from **Proposition 1**, the attracting fixed point is $\xi = (0,1)$. Thus, from equation (9), we have that

$$\lambda = 2(1 - 2b)(0) + 2b = 2b. \quad (10)$$

The rate of convergence of an operator describes the rate at which the operator converges to its attracting fixed point (Ahlberg et al., 2021) as its iteration goes unbound. The rate is determined by λ defined in (9). Specifically, for a QSO defined on S^1, the rate of convergence of the QSO is described in the following theorem (Mukhamedov and Ganikhodjaev, 2015).

Theorem 4: Let $V(x) = (a - 2b)x^2 + 2bx$ be a b-bistochastic QSO defined on S^1 in (8) and let $a \in [0,1]$ and $b \in [0, \frac{1}{2})$. Then, for any given initial point x_0, the operator converges to the fixed point $\xi = (0,1)$ at the rate $C(x_0)(2b)^m$.

In this case, $C(x_0)$ is any constant that depends on the initial condition x_0. Note that this rate of convergence of the b-bistochastic QSO on S^1 is specific for when $b < \frac{1}{2}$ only.

CONCLUSION

The rate of convergence of the b-bistochastic QSO on 1-dimensional simplex S^1, was obtained, showing that the QSO converges to the attracting fixed point $\xi = (0,1)$ at a rate of $C(x_0)(2b)^m$. The result is verified for the case of $b < \frac{1}{2}$. This work presents preliminary findings on the convergence rate. A more detailed analysis including the stochastic matrix approach and ergodicity properties has been submitted for publication in the Malaysian Journal of Fundamental and Applied Sciences (MJFAS).

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MIXED CONVECTIVE FLOW OF NEWTONIAN FLUID IN CORRUGATED CHANNEL WITH MAGNETIC FIELD EFFECTS

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ABSTRACT

This paper investigates the effects of magnetic fields and undulation number on the velocity and temperature profiles of a viscous fluid in a sinusoidal-corrugated channel. The continuity equation, momentum equation, and energy equation will be transformed into their weak formulation and will be solved numerically with the help of the automated solution technique FEniCS. The velocity and temperature profiles will be plotted and discussed. It is observed that increasing the undulation number leads to a boost in the velocity and the temperature profiles. Additionally, it is found out that there is a decrease in the velocity profile with the amplification of the magnetic field. However, the amplification of the magnetic field shows no significant impact to the temperature profile.

Keywords: MHD, Wavy Channel, Undulation Number, Finite Element Method, FEniCS

INTRODUCTION

Fluid dynamics is a branch of fluid mechanics that specialised in the fluids motion. The fluids movement can be represented with the Navier-Stokes equations. Additionally, magnetohydrodynamics (MHD) has been extensively studied in fluid dynamics. MHD is a study on the electrically conducting fluid with the presence of magnetic field (Jalili et al., 2024). FEniCS is an open-source computing platform for solving partial differential equations using the finite element method. Hence, this study aims to investigate the influence of the magnetic field as well as the undulation number with the presence of a magnetic field on the velocity and the temperature profiles of a viscous fluid within a sinusoidal-corrugated channel with the help of automated solution technique FeniCS.

Alharbi et al. (2025) mentioned that amplifying the Hartmann number decreases the flow velocity due to the Lorentz force retarding the flow. Moreover, A study by Alsabery et al. (2022) reported that the increment of the undulation number of the wavy surfaces led to the formation of the recirculation zone within the channel crests. They discovered that the presence of the waviness allows the fluid to excalate and it is supported by Madlool et al. (2023). In this research, the governing equations proposed by Iwatsu et al. (1993) alongside the boundary conditions modified from Madlool et al. (2023) will be employed and will be solved numerically with the help of the automated solution technique FEniCS.

METHODOLOGY

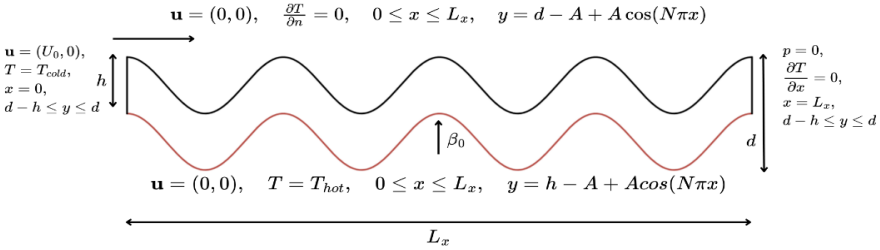

Figure 1: Configuration with Boundary Conditions

The dimensionless governing equations consisting of continuity equation (1), momentum equation (2), and energy equation (3) are:

$$\nabla \cdot u = 0 \tag{1}$$

$$(u \cdot \nabla)u = -\nabla p + \frac{1}{Re}\nabla^2 u + Ri \cdot Te - Mu \tag{2}$$

$$u \cdot \nabla T = \frac{1}{Pr\ Pr\ Re}\nabla^2 T \tag{3}$$

With boundary conditions modified from Madlool et al. (2023):

At the lower wavy surface:

$$u = (0,0), \qquad T = T_{hot}, \qquad 0 \le x \le L_x, \qquad y = h - A(1 - cos\ cos\ (N\pi x))$$

At the cold inlet left surface:

$$u = (U_0, 0), \qquad T = T_{cold}, \qquad x = 0, \qquad d - h \le y \le d$$

At the adiabatic upper wavy surface:

$$u = (0,0), \qquad \frac{\partial T}{\partial n} = 0, \qquad 0 \le x \le L_x, \qquad y = d - A(1 - cos\ cos\ (N\pi x))$$

At the adiabatic outlet right surface:

$$p = 0, \qquad \frac{\partial T}{\partial x} = 0, \qquad x = L_x, \qquad d - h \le y \le d$$

(4)

where $u = (u_x, u_y)$ is the velocity, T is the temperature, p is the pressure, Re is the Reynolds number, Ri is the Richardson number, Pr is the Prandtl number, M is the magnetic parameter, $e = (0,1)$ is a unit vector in the direction of the buoyancy force, β_0 is the magnetic field, A is the wavy wall amplitude, and N is the undulation number or wavy surfaces.

In the pre-processing part, we import all the necessary FEniCS libraries, then we generate a mesh based on the wavy channel geometry. After that, we create a finite element space with three elements. Afterwards, we define the test functions and trial functions and identify the boundary conditions in Fig. 1. In the processing step, we will transform the equations (1), (2), and (3) into their weak formulation using the standard Galerkin method by multiplying the equations with their respective test functions and integrating over the domain, Ω (Larson & Bengzon, 2013), as follows:

$$\int_{\Omega} (\nabla \cdot u) q \, dx = 0 \tag{5}$$

$$\int_{\Omega} (u \cdot \nabla) u \cdot v \, dx - \int_{\Omega} p(\nabla \cdot v) \, dx + \int_{\Omega} \frac{1}{Re} (\nabla u \cdot \nabla v) \, dx - \int_{\Omega} Ri \cdot T(e \cdot v) \, dx + \int_{\Omega} M(u \cdot v) \, dx = 0 \tag{6}$$

$$\int_{\Omega} (u \cdot \nabla T) s \, dx + \int_{\Omega} \frac{1}{PrPr \, Re} (\nabla T \cdot \nabla s) \, dx = 0 \tag{7}$$

Equations (4), (5), and (6) will be coupled together and will be solved based on the Newton-Raphson method (Logg et al., 2012). In the post-processing part, the velocity and the temperature profiles will be plotted and discussed. The computation will be executed, and the Richardson number, Prandtl number, inlet velocity, Reynolds number, T_{cold}, and T_{hot} are set to 1, 7, (0.5,0), 100, 0.01, and 1 respectively.

RESULTS AND DISCUSSION

In Figure 2, displays the velocity (left) and the temperature (right) profiles for different magnetic parameters with constant undulation number, $N = 4$, and wavy wall amplitude, $A = 0.1$. From Figure 2(a), it can be seen that the maximum magnitude for velocity decreases as the magnetic field becomes stronger due to the Lorentz force delaying the flow. However, Figure 2(b) shows that the temperature profiles exhibit the same behavior as we increase the magnetic parameter, indicating that there is no significant impact to the flow.

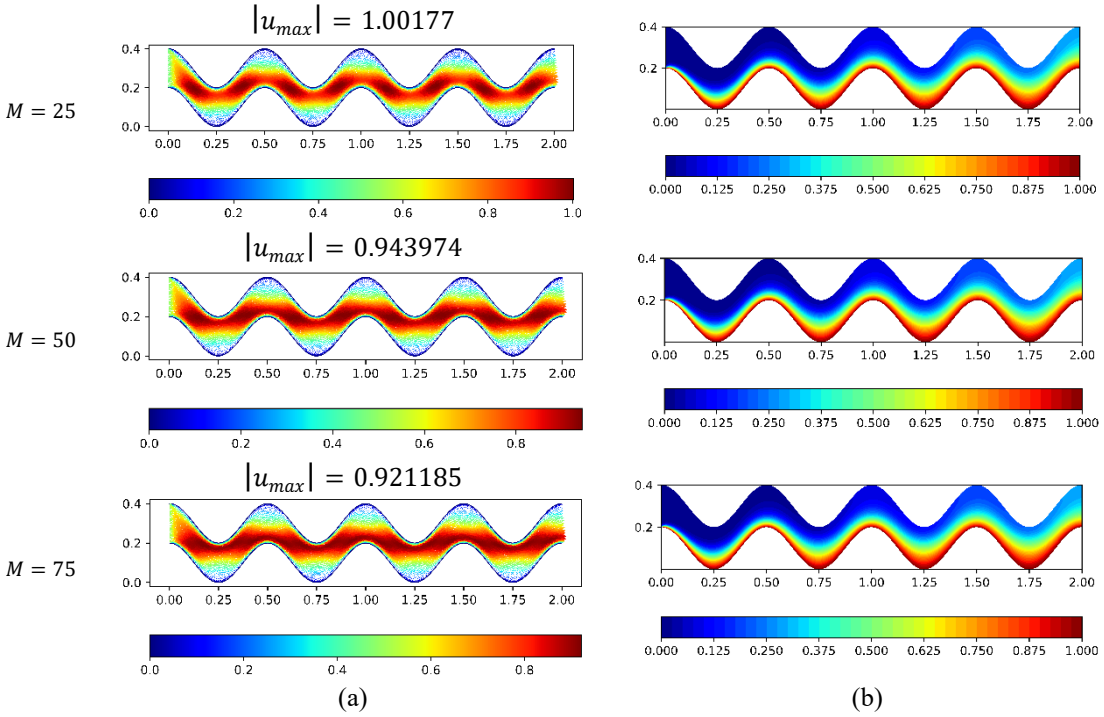

Figure 2: Velocity (a) and Temperature (b) Profiles with Different Magnetic Parameter

Figure 3 presents the velocity (left) and temperature (right) profiles with variation of undulation number with constant magnetic parameter, $M = 80$ and wavy wall amplitude, $A = 0.1$. Based on Figure 3(a), it is unveiled that the recirculation zone appeared at the wavy walls' crests, and it became larger as the undulation number increased. Moreover, the maximum value of the velocity magnitude rises as the undulation number increases. Based on Figure 3(b), it is revealed that the fluid is starting to get warmer at the right side of the channel for all N. However, at $N = 6$, the fluid starts to become warmer at around $x = 1.5$, in contrast to the flow at $N = 8$, where the fluid becomes warmer starting at around $x = 1.25$. This

shows that there is a growth in the fluid-walls interaction, thus enhancing the friction between the walls and the fluid.

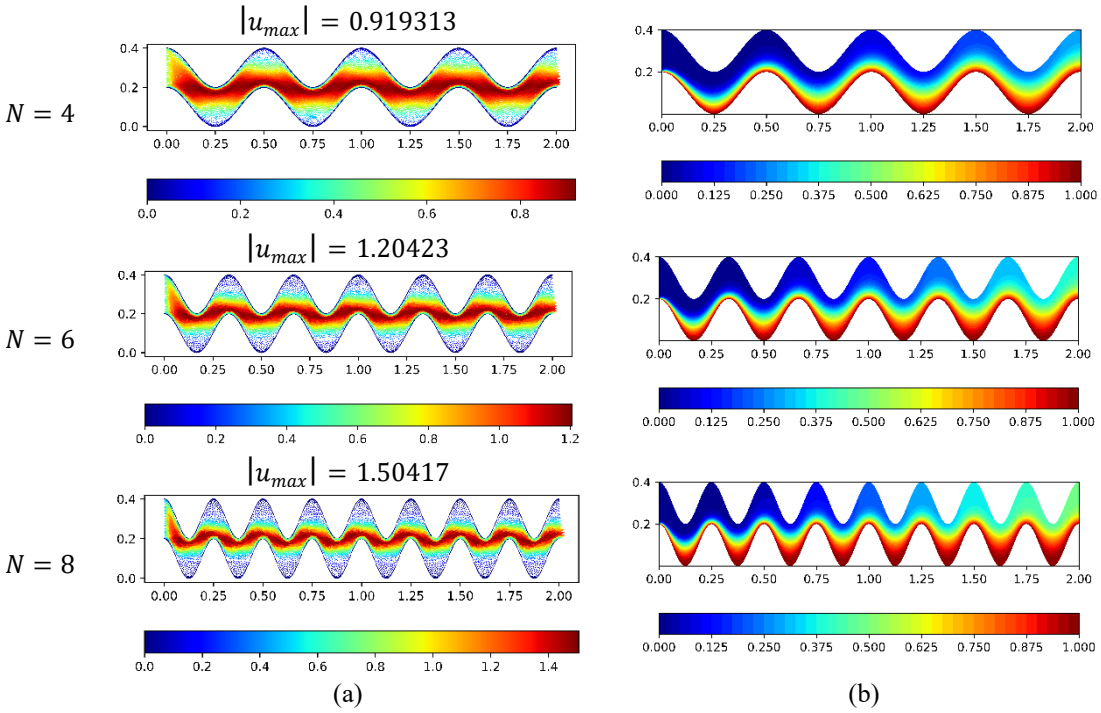

Figure 3: Velocity (a) and Temperature (b) Profiles with Different Undulation Number of Wavy Surfaces

CONCLUSION

Numerical investigation of MHD mixed convective flow of viscous fluid in a sinusoidal-corrugated channel was performed using the finite element method with the help of the automated solution technique FEniCS. This study discovered that amplifying the magnetic field results in the reduction of the velocity profile due to the Lorentz force. However, the increment of the magnetic field shows no significant impact to the temperature profile. Moreover, the increment of the undulation number of wavy surfaces led to the enlargement of the recirculation zone at the crests of the channel and causes a boost in the velocity and the temperature profiles. A more detailed analysis including the effects of different Richardson number and wavy amplitude has been submitted for publication in Revelation and Science.

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OXIDATIVE STABILITY OF MOIST CAKE FORMULATED WITH GREEN TEA EXTRACT AS AN ACTIVE INGREDIENT, MOISTEA CAKE

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ABSTRACT

The demand of the natural food preservatives by the consumers has increased in recent years, as there are some questions raised in the safety of synthetic additives like butylated hydroxyanisole (BHA), which are widely being used in bakery products to inhibit lipid oxidation process. This study was done to investigate the possibility of tea extracts as a natural antioxidant in enhancing the oxidative stability of moist cakes. It aimed at comparing and evaluating the antioxidant activity of the green tea extract and to determine how effective the green tea extract would be in retention of the quality of the moist cakes during storing. The antioxidant properties of the samples were determined using total phenolic content (TPC) and ferric reducing antioxidant power (FRAP) analysis whereas the cake samples were analysed regarding oxidative stability considering peroxide value (PV) and thiobarbituric acid (TBA) levels. Antioxidant tests showed that green tea extract had slightly lower TPC and FRAP values than BHA, but the difference was minimal. Cakes made with green tea extract had lower PV and TBA values than that of the control, indicating their delayed oxidation. Nonetheless, cakes with BHA showed the highest stability in general. The findings indicated that the green tea extract could impart as high an antioxidant effect at 246 ppm as compared to 200 ppm of BHA, which means that it could be used as an additional natural preservative. To sum up, this study points out that green tea extract has a potential to be a functional ingredient in the bakery formulations to increase its shelf life and cut dependence on synthetic antioxidants.

Keywords: Green Tea Extract, Antioxidant Activity, Oxidative Stability, Moist Cakes, Natural Preservatives

INTRODUCTION

Antioxidants, oxidative stability, and the use of green tea are closely related concepts that enhance the nutritional and sensory quality of cakes. Antioxidants are molecules that inhibit oxidation caused by free radicals, which can damage cells and lead to illnesses such as cancer, heart disease, and neurological disorders (Constantinescu & Mihis, 2023). In foods, lipid oxidation causes rancidity, off-flavours, and reduced shelf life, making antioxidants essential for maintaining freshness. Alongside natural antioxidants, synthetic ones like butylated hydroxyanisole (BHA) are widely used to delay lipid oxidation, preserve flavour, and extend shelf life, though their use is debated due to consumer preference for natural additives. Oxidative stability refers to a product's resistance to oxidation, which is critical in cakes where lipids are highly susceptible to rancidity, colour changes, and off-flavour formation (Domínguez et al., 2019).

Green tea provides natural antioxidants, particularly catechins such as epigallocatechin gallate (EGCG), which reduce oxidative stress in the body and improve food stability (Musial et al., 2020). These compounds help maintain cake quality by slowing fat oxidation, while also contributing to colour, shelf life, and health benefits. Incorporating green tea into bakery products not only improves oxidative stability but also adds functional value, enriching nutritional quality and supporting chronic disease prevention. With strong antioxidant properties, green tea offers a natural means to extend shelf life, preserve flavour and texture, and reduce dependence on synthetic preservatives (Halim et al., 2024).

RESULTS AND DISCUSSION

Total Phenolic Content

The results obtained in Table 1 through this study demonstrated that the Total Phenolic Content (TPC) present in green tea extract (4.58 ± 0.28 mg GAE/g).

Table 1: Total Phenolic Content of green tea extract.

Samples	TPC (mg GAE/g)
Green Tea Extract	4.58 ± 0.28^{a}

All values are shown as mean ± standard deviation of three replicates analysis. The values with different alphabet were significantly different ($p < 0.05$) between samples.

This finding indicated that green tea extract contained a considerable amount of phenolic compounds (4.58 ± 0.28 mg GAE/g), which are known as the main source of antioxidant potential. The presence of these compounds suggests that green tea has strong antioxidant capacity, making it valuable for functional use in food and health-related products. However, TPC values may vary depending on factors such as extraction method, solvent polarity, and the source of tea leaves. Similar results were also reported by Luo et al. (2023), reinforcing that processing degree and leaf maturity play crucial roles in determining the final phytochemical profile of green tea.

Ferric Reducing Antioxidant Power

Table 2: FRAP of BHA and green tea extract.

Samples			Concentration (ppm)		
	200	400	600	800	1000
Green Tea	0.41 ± 0.00^{hi}	0.80 ± 0.04^{e}	1.05 ± 0.04^{d}	1.23 ± 0.04^{b}	1.30 ± 0.06^{a}
BHA	0.60 ± 0.02^{g}	0.73 ± 0.01^{f}	1.03 ± 0.02^{d}	1.16 ± 0.06^{c}	1.28 ± 0.06^{ab}

*All values are shown as mean ± standard deviation.
*There is a significant difference between the two samples at $P < 0.05$.

Based on Table 2, the Ferric Reducing Antioxidant Power (FRAP) of BHA and green tea extract showed a significant increase across all tested concentrations (200–1000 ppm) with $p < 0.05$. Green tea extract consistently exhibited slightly higher antioxidant activity than BHA, indicating comparable reducing capacities. The FRAP absorbance of 246 ppm green tea was nearly equal to 200 ppm BHA, hence 246 ppm was selected for moist cake development. FRAP assay measures the ability of antioxidants to reduce Fe^{3+} to Fe^{2+}, producing a blue complex with $FeCl_3$, where intensity reflects antioxidant power (Langley-Evans, 2000). These results confirm that green tea has reducing capacity similar to BHA, likely due to its high catechin content, especially EGCG, as also supported by Nain et al. (2022).

Peroxide Value Test

Table 3: Peroxide value of control, BHA and green tea extract.

Samples	PV (meq/kg)
Control	2.10 ± 0.03a
BHA	0.97 ± 0.04c
Green Tea Extract	1.40 ± 0.03b

All values are shown as mean ± standard deviation of three replicates analysis. The values with different alphabet were significantly different ($p < 0.05$) between samples.

F1: Control; F2: added BHA; F3: added green tea.

Table 3 shows the Peroxide Value (PV) of three moist cake formulations: control (F1), cake with BHA (F2), and cake with green tea extract (F3). Significant differences ($p < 0.05$) were observed, with the control having the highest PV (2.10 ± 0.03 meq/kg), indicating greater lipid oxidation. Cakes with green tea extract (1.40 ± 0.03 meq/kg) and BHA (0.97 ± 0.04 meq/kg) showed much lower PV, confirming that both antioxidants effectively delayed primary lipid oxidation. The PV test measures hydroperoxides formed from oxygen reacting with unsaturated fats, where fewer titrations with sodium thiosulfate indicate higher peroxide levels (Kontogianni & Gerothanassis, 2022). These results suggest green tea extract is a promising natural antioxidant, though less effective than BHA, in protecting moist cakes. Similar findings by Mokra et al. (2022) attributed this effect to green tea catechins, especially EGCG, which stabilize lipids via hydrogen donation and metal binding. The lower PV values demonstrate that antioxidants maintained cake quality during storage. Since rancidity occurs above 20 meq/kg (Ahmadi et al., 2024), all values reported here were far below this threshold, confirming product acceptability and antioxidant efficacy.

Thiobarbituric Acid Value

Table 4: TBA value of control, BHA and green tea extract.

Samples	TBA (mg MDA/kg)
Control	0.34 ± 0.03^{a}
BHA	0.27 ± 0.03^{c}
Green Tea Extract	0.30 ± 0.02^{b}

All values are shown as mean ± standard deviation of three replicates analysis. The values with different alphabet were significantly different ($p < 0.05$) between samples.
F1: Control; F2: added BHA; F3: added green tea.

Table 1.4 presents the TBA values (mg MDA/kg) of moist cakes with BHA, green tea extract, and the control. All samples differed significantly ($p < 0.05$), with the control showing the highest secondary lipid oxidation (0.34 ± 0.03 mg MDA/kg), indicating more malondialdehyde (MDA) formation as a rancidity marker. Cakes with BHA (0.27 ± 0.03 mg MDA/kg) and green tea extract (0.30 ± 0.02 mg MDA/kg) had lower TBA values, confirming effective suppression of secondary oxidation. In the TBA test, MDA reacts with thiobarbituric acid to form a pink complex measured at 532 nm; higher values indicate greater oxidation and lower quality. According to Ma et al. (2021), TBA values above 1.5 mg MDA/kg render products rancid, but all values here were well below this threshold, confirming stability and acceptability. The antioxidant effect of green tea extract is attributed to polyphenols, especially catechins like EGCG, which scavenge free radicals and stop lipid oxidation (Nain et al., 2022). Both treatments extended cake stability during storage, proving their effectiveness in preventing quality loss.

CONCLUSION

In conclusion, the Moistea Cake is an innovative bakery product that successfully integrates the health-promoting properties of green tea extract into a moist cake formulation. It demonstrates that natural ingredients can effectively replace synthetic additives, offering both functional benefits and consumer appeal. By providing a product that is indulgent, health-oriented, and eco-friendly, the Moistea Cake addresses key industry challenges related to food quality, shelf life, and consumer trust. This innovation highlights the potential for tea extracts to transform the bakery sector and aligns with global trends toward sustainable, clean-label, and functional foods.

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ASPECT-BASED SENTIMENT ANALYSIS OF EMPLOYEE SATISFACTION AND COMPANY RECOMMENDATION IN MALAYSIA'S IT INDUSTRY BASED ON GLASSDOOR REVIEWS

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ABSTRACT

The Malaysian information technology (IT) sector has seen significant transformation, with job seekers increasingly relying on employee-generated content to assess company culture and workplace satisfaction. However, many existing platforms do not break down reviews into specific aspects, making it difficult for users to make employment decisions based on their preferences of aspects of employee satisfaction. This study addresses the need for structured insights by implementing aspect-based sentiment analysis (ABSA) on employee reviews sourced from Glassdoor. The system employs Support Vector Machine (SVM) classifiers to categorise reviews into sentiments, as well as into one of five aspects of employee satisfaction which are career growth, management, benefits, salary, and work-life balance. The classification models achieved 81.47% accuracy for sentiment classification and 75.64% for aspect classification. Moreover, a content-based filtering (CBF) approach, supported by cosine similarity, was used to generate personalised company recommendations based on user priority of each aspect of employee satisfaction. The system's features include interactive data visualisations using charts and word clouds which provide users with an intuitive understanding of sentiment trends. Usability testing showed that the system reduced decision-making time by 84.18%, with an average user satisfaction score of 4.93 out of 5. The findings demonstrate that applying ABSA and CBF to Glassdoor reviews can significantly improve career decision-making by offering structured, aspect-level insights and personalised recommendations.

Keywords: Aspect-Based Sentiment Analysis, Employee Satisfaction, Support Vector Machine, Content-Based Filtering, Glassdoor

INTRODUCTION

The use of job search platforms like Glassdoor has made employee-generated reviews a primary resource for job seekers assessing company culture and workplace satisfaction within Malaysia's rapidly expanding information technology (IT) sector (Feng, 2023). However, a significant challenge persists where these reviews are often unstructured and overwhelming, making it difficult for job seekers in Malaysia's IT industry to extract meaningful insights on the factors that matter most to them (Ren et al., 2022). This lack of structured data directly contributes to the difficulties job seekers face when comparing companies on specific aspects of employee satisfaction (Sainju et al., 2021). As a result, a common outcome is a mismatch between a job seeker's expectations and the actual work environment, which can lead to higher turnover rates and professional dissatisfaction (Wang, 2024).

To address this challenge, this research introduces a web-based system designed to provide structured, data-driven insights into employee satisfaction within Malaysia's IT industry. The core of this system is its implementation of Aspect-Based Sentiment Analysis (ABSA) on employee reviews from Glassdoor. It employs Support Vector Machine (SVM) classifiers to not only determine the overall sentiment of a review but also to categorize it into one of the five aspects of employee satisfaction including career growth and

development, management, benefits, salary, and work-life balance. Furthermore, the system incorporates a Content-Based Filtering (CBF) approach, leveraging cosine similarity to generate personalised company recommendations based on a user's chosen priorities for each of the aspects of employee satisfaction. This project's primary objectives were to design a classification and recommendation system, develop it into a functional web application, and validate its effectiveness and usability.

RESULTS AND DISCUSSION

The project successfully achieved its objectives by developing a web application that performs ABSA on employee reviews from Glassdoor and provides personalised company recommendations. Functionality testing, which included 18 test cases, confirmed that all system features were working as intended, from navigation and data visualisation to the core sentiment and aspect classification. This demonstrates the system's robustness and reliability in providing a fully functional platform for job seekers.

The core of the system's effectiveness lies in its SVM models. The sentiment classification model achieved a test accuracy of 81.47%, while the aspect classification model reached 75.64% accuracy. This proves the system is highly effective in assisting users to analyse and comprehend employee reviews with a high degree of precision. The sentiment confusion matrix shows that the model was highly effective at correctly identifying positive and negative reviews, while it had a slightly higher rate of misclassifying neutral reviews. Similarly, the aspect confusion matrix demonstrates the model's strength in accurately classifying reviews related to specific aspects like 'Work-Life Balance' and 'Career Growth and Development', while occasionally misclassifying other aspects. The model's predictive performance is further detailed in the confusion matrices for both sentiment and aspect models, as illustrated in Figure 1 and Figure 2.

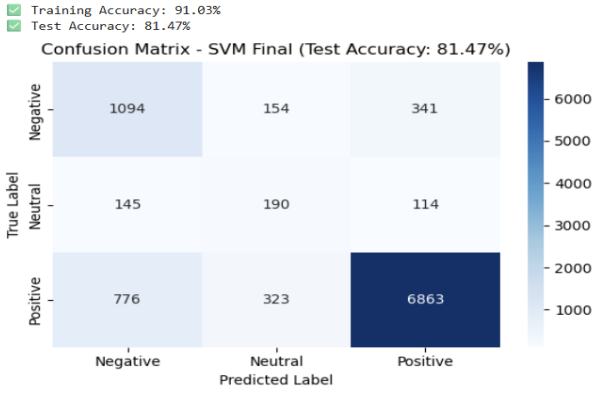

Figure 1: Confusion Matrix of Sentiment Classification Model

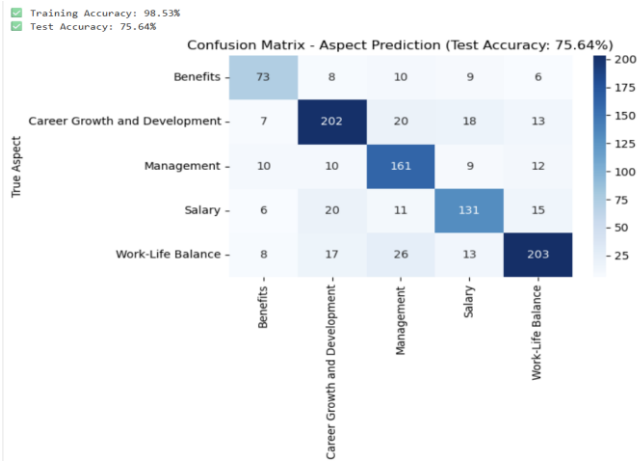

Figure 2: Confusion Matrix of Aspect Classification Model

The system's output, derived from an analysis of real employee review data from five leading Malaysian IT companies, is presented through interactive data visualisations. These include bar charts that show sentiment polarity distribution, pie charts that detail aspect distribution, line charts that track sentiment trends over time, and word clouds that highlight the most frequent terms associated with positive, neutral, and negative reviews. This visual approach transforms complex, unstructured text into intuitive and digestible insights. For example, a user can instantly see that while one company may have a high overall positive rating, its reviews specifically related to "work-life balance" might be predominantly negative, as shown in Figure 3. This demonstrates the system's robust capability in providing a fully functional platform for job seekers to gain structured, aspect-level insights of employee satisfaction in each company.

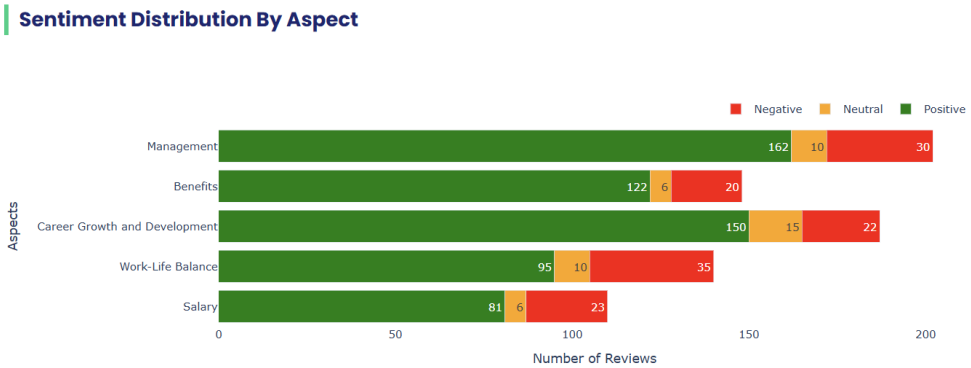

Figure 3: Sentiment Distribution by Aspect for Maxis Communications

Finally, the system's real-world efficacy was quantitatively assessed through a structured usability test involving 15 participants. This experiment was designed to compare the time required for manual versus system-assisted decision-making. A notable reduction in processing time when choosing a company was observed when participants utilised the system's features. Specifically, the system facilitated a significant average time reduction of 84.18% in the decision-making task, as shown in Table 1. This result, coupled with an average user satisfaction score of 4.93 out of 5, provides compelling evidence of the system's functional utility and user-centric design.

Table 1: Results of Usability Testing

Participant	**Time Taken (Manual) (mins)**	**Selected Company (Manual)**	**Time Taken (System) (mins)**	**Selected Company (System)**	**Satisfaction Rating (1-5)**
Participant 1	12.36	TM	0.35	TM	5
Participant 2	5.22	WT	1.04	TM	5
Participant 3	6.22	TM	1.29	TM	5
Participant 4	7.42	TM	0.44	TM	5
Participant 5	5.31	IBM	0.58	MC	5
Participant 6	2.45	TM	0.47	TM	5
Participant 7	10.07	TCS	5.26	TCS	4
Participant 8	4.31	TM	1.06	TM	5
Participant 9	6.01	TM	0.56	TM	5
Participant 10	9.54	MC	1.20	MC	5
Participant 11	7.23	MC	1.16	MC	5
Participant 12	3.40	MC	0.42	MC	5
Participant 13	5.18	TM	0.52	TM	5
Participant 14	3.57	MC	0.45	TM	5
Participant 15	6.16	IBM	0.49	IBM	5
Average	**6.27**	-	**0.95**	-	**4.93**

CONCLUSION

In conclusion, this project successfully developed and evaluated a web application that provides a structured, data-driven approach to analyzing employee satisfaction in Malaysia's IT sector. The system uses a Support Vector Machine (SVM) model to classify reviews and a Content-Based Filtering (CBF) approach to generate personalised company recommendations, addressing the problem of information overload for job seekers. The models achieved a strong predictive accuracy, with 81.47% for sentiment classification and 75.64% for aspect classification. More importantly, usability testing with 15 participants showed a significant practical benefit, with the system reducing decision-making time by 84.18%. While successful, the study was limited by its reliance on a static dataset from a single source and a single-label prediction methodology. Future work should focus on integrating with live data to ensure real-time relevance, expanding the model to handle multi-label aspect classification, and incorporating a hybrid recommendation model to further improve personalisation.

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CONFIDENTLY WRONG: AUDITING CLASSIFIERS USING REVERSIBLE GENERATOR MLP (RevGEN-MLP)

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ABSTRACT

Machine learning classifiers are known to be overconfident when facing unseen or anomalous inputs. These present a dangerous vulnerability that reduces the trust in the systems that rely on artificial intelligence as it becomes increasingly widespread. We present a novel method of auditing these machine learning models by generating confidently classified anomalies using Reversible Generator Multilayer Perceptron (RevGEN-MLP). These generated anomalies act as a tool for testing the robustness of different models, identifying which models are more vulnerable to overconfidence on a specific dataset. Our method can be adapted to datasets with continuous numerical features and can be tailored for domain-specific robustness testing. We demonstrate the application of this technique on two different datasets and show that the generated anomalies not only deceive the original model but can also transfer to other classifiers. Results reveal that a classifier's vulnerability to such anomalies can vary by dataset, with Random Forest observed to be more robust towards these generated inputs compared to other neural networks and K-Nearest Neighbour classifiers.

Keywords: Artificial Intelligence (AI), Model Robustness, Overconfidence, Reversible Neural Networks

INTRODUCTION

Artificial intelligence (AI) has become a fundamental part of modern systems and has led to significant improvements in predictive analytics and decision-making. As we continue integrating AI systems into our everyday lives, it is critical to ensure the trustworthiness of these systems. Ideally, these models would only be confident when working with data that is similar to that on which it was trained. In practice, many systems, especially those designed for classifications, are overconfident on anomalous and unrealistic data. These issues reflect poor model calibration and are common in real-world systems. This work defines any anomalous or unrealistic input that is confidently classified as a sample that deceives or tricks the model.

For neural networks that are built for classification, softmax probabilities are often used as a confidence score to indicate how confident a model is in its classification. However, softmax probabilities are widely recognised as an unreliable confidence score, as it is prone to being overconfident on inputs it has never seen (Lee et al., 2018). Neural network classifiers are normally not bijective, hence there are multiple distinct inputs that can produce outputs with similar softmax probabilities. This leads to overconfidence as the neural network can assign high confidence to anomalies whose features overlap with those of the training data. Overconfidence can also be caused by limitations of the dataset, as there are many regions in feature space where models extrapolate with high confidence (Pearce et al., 2021). By exploiting these weaknesses, we can produce new inputs to evaluate and audit the robustness of other classification models as well. Thus, we present a new model called Reversible Generator MLP (RevGEN-MLP) that generates confidently classified anomalies.

We focus our analysis on the Iris and White Wine Quality datasets, which are well-known tabular benchmark datasets for classification. The Iris dataset consists of 150 samples with four features each and is assigned to three balanced classes of Iris species (Fisher, 1936). The White Wine Quality dataset consists of 4898 samples, each with 11 features that represent wine characteristics, and comes with 7 quality ratings from 3 to 9, where 3 is bad and 9 is excellent. To simplify training, we combine the ratings into two classes,

high-quality (7-9) and low-quality (3-6) wine. However, the resulting classes are imbalanced with a low-to-high quality ratio of 3838:1060 (Cortez et al., 2009).

OBJECTIVES

i. To construct a reversible neural network that acts as a generator for confidently classified anomalies.
ii. To generate new inputs that trick other commonly used classifiers and find shared vulnerabilities.
iii. To analyse robustness of different models against overconfidence on anomalous inputs.

ARCHITECTURE

A neural network can be thought of as a composite function where each layer, denoted L_i is a component function. Each layer has the following form,

$$L_i(x) = \phi\,(Wx + b), \tag{1}$$

where ϕ is the activation function, $W \in R^{Out \times In}$ is the matrix containing all the weights of the layer, $x \in R^{In}$ is the input, $b \in R^{Out}$ is the bias, Out and In are the output and input dimensions. The design of RevGEN-MLP for classification and generating new samples requires the following constraints:

1. Dimension Consistency: The dimensions of each layer must be the same as the input
2. Invertible Weight Matrix: The weight matrix, $\boldsymbol{W}$ for each layer must be invertible
3. Invertible Activation Function: The activation functions for each layer, ϕ must be invertible

The activation function of the hidden layers in the model is Leaky ReLU as it is invertible and for classification, we use the softmax function. Although the softmax function is not invertible, we can obtain a pseudo-inverse by storing the denominator during the forward pass and using it to find the original input. This limits the model to being invertible only for outputs with stored softmax denominators. It has the following form,

$$x_i = ln\ ln\ p_i + ln\ ln\ C\,, \tag{2}$$

where p_i is the softmax probability of class i and C is the stored denominator from the forward pass. The inverse of a layer will then have the following form,

$$L_i^{-1}(x) = W^{-1}\,(\,\phi^{-1}(x) - b). \tag{3}$$

The network outputs class probabilities through a softmax layer with k neurons corresponding to the number of classes ($k = 3$ for Iris and $k = 2$ for White Wine Quality). Since the network is invertible, the dimensions of the output must match the input (n features). Therefore, the remaining $n - k$ outputs are latent variables copied from the previous hidden layer, as shown in Figure 1. Training will only be done with the output values containing the k softmax class probabilities using the cross-entropy loss function. The design also lets us keep the class probabilities constant and modify the latent variables before inverting, guaranteeing any generated sample has the exact same probabilities as the original, which is different from other generative models without this guarantee.

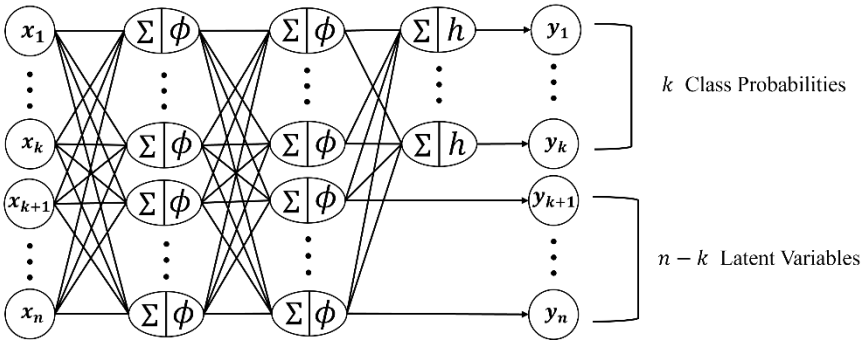

Figure 1: General Architecture Diagram for RevGEN-MLP (ϕ: Leaky ReLU, h: Softmax)

GENERATING NEW SAMPLES

The training and testing set for all models is the same and follows the 80:20 train-test split. As shown in Figure 2, we generate new samples by perturbing the latent variables in the outputs of confidently and correctly classified test data with varying shift parameters ϵ, until flagged as anomalies by an Isolation Forest at a chosen anomaly threshold, λ. The generated samples will remain confidently classified by RevGEN-MLP and may be more likely to fool other well-trained models. This is because RevGEN-MLP can potentially share similar high-confidence regions with other well-trained models, and the generated samples could transfer, although this is not guaranteed.

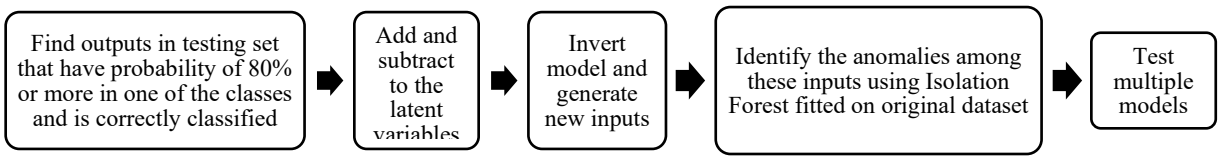

Figure 2: Flowchart of Method used for Generating Confidently Classified Anomalies

RESULTS AND DISCUSSION

We trained the RevGEN-MLP model on the Iris and White Wine Quality datasets and used the generated anomalies to test a non-invertible neural network, a Random Forest, and a K-Nearest Neighbor (K-NN) classifier (Wan & Gobithaasan, 2025). Anomalies were identified using an Isolation Forest, with more negative anomaly scores indicating it as more anomalous. The number of epochs was chosen after experimentation to find the best set of hyperparameters that leads to good performance and avoids overfitting. For Iris, RevGEN-MLP had one hidden layer and achieved a test accuracy of 91.1%, precision of 91.6%, and a recall of 91.1% after 160 epochs. The neural network used for comparison had one hidden layer with 20 neurons using Leaky ReLU, trained for 250 epochs. For White Wine Quality, RevGEN-MLP had 3 hidden layers and achieved a test accuracy of 83.37%, precision of 75.82%, and a recall of 72.14% after 101 epochs. The neural network used for comparison had 4 hidden layers with ReLU activation (number of neurons: 64,32,16,8) trained for 440 epochs. The Random Forest models used an unscaled version of the data for both datasets, had 200 estimators, whereas the K-NN classifier had K = 5 and used the scaled versions of the data.

Anomaly scores from Isolation Forests denoted as λ are relative to the dataset, hence to evaluate robustness fairly, we generate new inputs using two thresholds. The first threshold, λ_1 is chosen to be the 5th percentile of anomaly scores among the original dataset, this represents moderately anomalous samples and is directly comparable between the two datasets (Iris: $\lambda_1 = -0.09136$, Wine Quality: $\lambda_1 = -0.00921$). On the other hand, the second threshold, $\lambda_2 = -0.15$ is a fixed threshold for both datasets and it is due to a higher negative value than the minimum anomaly score observed in the samples of both dataset (Iris: -0.1457, Wine Quality: -0.1425). This ensures that samples generated with λ_2 are likely to be extreme anomalies or unseen data.

Table 1: Experimental Results

Model	Test Metrics		Anomalies Confidently Classified (Fooling Rate)	
	Iris	Wine Quality	Iris	Wine Quality
Neural Network	Accuracy : 93.3% Precision : 93.5% Recall : 93.3%	Accuracy: 85.4% Precision: 78.7% Recall : 77.2%	λ_1: 56/66 (84.85%) λ_2: 54/68 (79.41%)	λ_1: 558/580 (96.21%) λ_2: 1050/1063 (98.78%)
Random Forest	Accuracy : 91.1% Precision : 91.6% Recall : 91.1%	Accuracy : 89.1% Precision : 86.6% Recall : 79.4%	λ_1: 55/66 (83.33%) λ_2: 30/68 (44.12%)	λ_1: 181/580 (31.2%) λ_2: 100/1063 (9.4%)
K-NN	Accuracy : 91.1% Precision : 93.0% Recall : 91.1%	Accuracy : 84.2% Precision : 77.1% Recall : 73.9%	λ_1: 57/66 (86.36%) λ_2: 42/68 (61.76%)	λ_1: 504/580 (86.9%) λ_2: 898/1063 (84.48%)

Table 1 shows that even models with good test performance can still be tricked by samples generated by RevGEN-MLP. As the anomaly score decreases (more anomalous), the Random Forest model is tricked by fewer samples than the other models. This indicates it is more robust than neural networks and the K-NN classifier for these two examples. However, it should be noted that we are still able to find anomalies that trick the Random Forest, and thus, it is still not foolproof. On the other hand, we have been able to generate anomalies that consistently trick neural networks of different architectures in both datasets. This confirms the well-known vulnerabilities of softmax confidence and neural networks on unseen data.

For the Iris dataset, 62.12% (41/66) of generated anomalies under λ_1 were confidently classified by all tested models and decreased to 8.82% (6/68) under λ_2. For the White Wine Quality dataset, this was observed as 30.17% (175/580) under λ_1 and 8.37% (89/1063) under λ_2. These anomalies represent a shared weakness, which we believe is likely the result of the dataset-driven vulnerabilities and is not model specific. Thus, these generated samples can be used to test other models in deployment. Notably, this approach is not just a result of exploiting known weaknesses in softmax confidence, rather it has also deceived tree-based ensemble models like Random Forest and distance-based ones such as K-NN, indicating transferability and general vulnerability. This makes the method suitable for auditing different models, as it reveals regions of shared overconfidence that are likely learned by multiple classifiers trained on the same dataset. Table 2 details generated data with shown values rounded.

Table 2: Example of a Generated Anomalous White Wine Quality Sample (values rounded for readability only)

Fixed Acidity (g/dm^3)	Volatile Acidity (g/dm^3)	Citric Acid (g/dm^3)	Residual Sugar (g/dm^3)	Chlorides (g/dm^3)	Free Sulfur Dioxide (mg/dm^3)	Total Sulfur Dioxide (mg/dm^3)	Density (g/cm^3)	pH	Sulphates (g/dm^3)	Alcohol (%)
6.2906	0.42731	**- 0.26**	**- 6.053**	0.021421	**- 10.484**	61.0321	**0.9869**	3.356	0.4454	8.996

The sample in Table 2 is confidently classified (with a probability of at least 80%) as a low-quality wine by all models. However, its feature values are unrealistic as the residual sugar, citric acid, and free sulfur dioxide are negative, while the density is lower than the minimum (minimum density = 0.9871). This example highlights a confidently classified input that is unrealistic but has consistently fooled several classifiers.

COMMERCIAL POTENTIAL AND IMPACT

Our proposed method has been submitted for copyright, and it has a significant potential impact on the reliability and robustness of AI-based systems. It has high commercial value as an auditing tool used by auditing or consulting firms such as EY, Deloitte, KPMG, PwC, and Accenture in their technology divisions. It addresses the critical issues of overconfident machine learning models on unseen anomalous

inputs and provides a novel way to audit model robustness across different domains such as finance, healthcare, and autonomous systems. This approach works for testing different models, making it suitable to be implemented in existing toolboxes such as the IBM Adversarial Robustness Toolbox (ART), which includes other types of robustness testing distinct from ours. Safety will be increasingly important as AI is gradually integrated into various industries. As we contribute to robust AI systems, this aligns with the sustainable practices as outlined by the UN Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation and Infrastructure). This tool aids in the development of resilient AI infrastructure, which results in safer and more trustworthy AI. Other related work in robustness testing includes Fast Gradient Sign Method (FGSM) and AdvGAN. Both methods focus on finding perturbations that alter input data to cause misclassification rather than focusing on overconfidence. In contrast, Expected Calibration Error (ECE) is a metric that measures how closely the confidence scores reflect reality, but it requires true labels and is usually applied to original data instead of using generated high-confidence anomalies for testing.

CONCLUSION

We have introduced a new model called RevGEN-MLP that is capable of auditing classification models by generating confidently classified anomalies to test the robustness of models on specific datasets. This approach exposes a hidden weakness shared by multiple models trained on the same dataset. These vulnerabilities are not captured by traditional metrics such as accuracy, as it deals with unseen anomalies without labels. By testing these generated samples on models with different confidence scores, we are able to analyse anomalies that are dangerous to real-life systems. We have also shown that Random Forest is more robust against the confidently classified anomalies we generated when compared to neural networks and K-NN classifiers. These generated anomalies can be integrated into real-world auditing frameworks and guide model selection beyond just classification performance. This approach lays the foundation for safer and more reliable AI systems, contributing to AI governance and sustainable innovation. In the future, this work can be extended to a family of models called RevGEN-Net with advanced invertible architectures, such as using normalizing flows to construct RevGEN-Flow.

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ACTIN-RICH PROTRUSIONS: LEADING TO CANCER CELL INVASION THROUGH MATHEMATICAL FORMULATION

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ABSTRACT

Metastasis accounts for most cancer-related deaths, with invadopodia formation playing a central role in tumor cell invasion. Invadopodia are actin-rich protrusions that degrade the extracellular matrix (ECM), enabling cancer cells to penetrate and spread. This research presents a simplified mathematical model to investigate the effect of signal decay on invadopodia dynamics using the level set method. The model incorporates ligand diffusion and intracellular signaling with a decay term to capture essential biological behavior while remaining computationally efficient. The plasma membrane is represented as a moving interface driven by jump velocity, defined by the gradients of ligand and signal variables. Numerical discretisation techniques are applied to simulate signal distribution, ligand interaction, and interface deformation. The findings suggest that signal decay significantly influences membrane protrusion behavior, where reduced signaling activity leads to shrinking of the interface while stronger gradients sustain invadopodia growth. This approach provides both visual and quantitative insights into cancer cell invasion mechanisms, demonstrating the potential of mathematical modeling as a tool to support future therapeutic strategies targeting metastasis.

Keywords: Cancer Cell Invasion, Invadopodia, Level Set Method, Metastasis, Signal Decay

INTRODUCTION

It is reported that 90% of cancer-related fatalities are caused by cancer metastasis, which continues to be one of the most significant challenges in medical science (Neophytou *et al*., 2021). A crucial component of this process is the formation of invadopodia that enable cancer cells to degrade the ECM and infiltrate surrounding tissues (Augoff *et al*., 2020). While it is important to comprehend the dynamics of invadopodia to develop methods for preventing or forecasting metastasis, the complexity of biological interactions make the experimental methods alone are costly and time-consuming. For instance, invadopodia formation is tightly regulated by various signaling pathways, including kinases and actin remodeling proteins, which connect extracellular cues with the dynamics of intracellular protrusion (Masi *et al*., 2020).

Building on this, recent studies emphasize that molecular regulators like NADPH oxidase and reactive oxygen species further amplify these processes, significantly enhancing invadopodia-mediated invasion (Quilaqueo-Millaqueo *et al*., 2024). Taken together, these findings highlight the complex regulation of invadopodia and raise questions about the specific ways in which signal strength and decay influence their formation and progression (Admon & Suzuki, 2017; Saitou *et al*., 2012).

The issue addressed by this research is the absence of a simplified but biologically relevant framework for simulating the formation and progression of invadopodia in response to decaying signals. Driven by this issue, this study aims to build a mathematical model and numerical simulation of invadopodia formation including ligand variables and signal degradation. Utilising advanced numerical techniques, the model presents a systematic approach in a two-dimensional system to replicate membrane deformation, ligand diffusion, and signal transduction by employing sophisticated numerical methods, notably the level set

method, in conjunction with finite difference methods (Yaacob *et al*., 2021; Yaacob *et al*., 2022, Yaacob *et al*., 2024).

The novelty of this research lies in highlighting signal decay within invadopodia modeling, providing new perspectives compared to existing approaches. In addition, the use of the level set method to capture the progression of the plasma membrane provides a more accurate representation of dynamic protrusion behavior compared to conventional models. Together, these innovations make the framework both computationally efficient and biologically meaningful. The outcomes of this research are expected to provide deeper insight into cancer invasion mechanisms and contribute to future strategies in preventing metastasis.

In line with SDG 3 Good Health and Well-being, this research emphasises the importance of mathematical modelling of invadopodia formation. Since invadopodia are key structures in cancer invasion during metastasis, developing a comprehensive model can help medical researchers gain deeper insights into strategies for preventing metastasis. Ultimately, such insights contribute to advancing human health and well-being.

MATHEMATICAL FORMULATION

Chemoattractants such as epidermal growth factor (EGF) bind to epidermal growth factor receptor (EGFR), initiating intracellular signaling that regulates the reorganization of the actin cytoskeleton and promotes the development of a polarized cell morphology through localised actin polymerization. At the invasive front of cancer cells, matrix metalloproteinases are secreted to degrade the ECM, producing fragments that act as ligands and further stimulate signaling. The movement of the plasma membrane is directed by velocity acting perpendicular to its surface, a process commonly illustrated in schematic diagrams of invadopodia formation, such as in Figure 1.

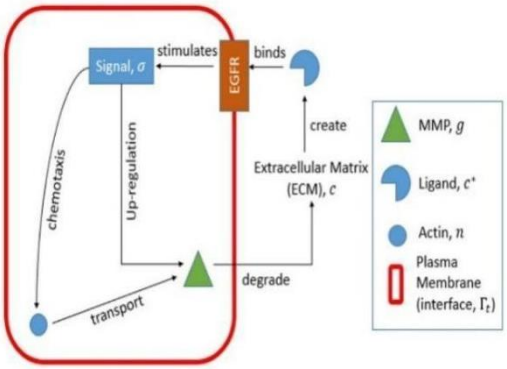


Figure 1: A schematic representation of invadopodia formation within an invasive cancer cell.

In biological systems, invadopodia form through several processes such as the interaction of actin, the ECM, ligands, signaling pathways, and matrix metalloproteinases (MMPs). Since it is difficult to represent all these mechanisms at once, this research focuses on the key elements only. A two-dimensional model of cancer cell invasion related to invadopodia formation is developed, which includes ligand concentration, signal transduction with decay, plasma membrane movement, and velocity extension in the extracellular region.

a) Ligand density, $c^*(x,t)$

$$\begin{aligned} c_t^* &= d_{c^*}\Delta c^*, && x \in 0_t^{c^*}, && t \in (0,T], \\ c^*(x,0) &= c_0^*(x), && x \in 0_0^{c^*}, && \\ c^*(x,t) &= 0, && x \in \partial\Omega\,, && t \in [0,T], \\ c^*(x,t) &= g(x), && x \in \Gamma_t\,, && t \in [0,T], \end{aligned} \tag{1}$$

b) Signal transduction, $\sigma(x,t)$

The novelty of our model lies in Equation. (2), where the decay term into the signal transduction dynamics has been employed. This extension distinguishes our work from existing models and allows us to analyse how variations in signal decay can influence cancer cell invasion.

$$\begin{aligned} \sigma_t &= d_\sigma \Delta\sigma - \lambda\sigma, && x \in 0_t^\sigma, && t \in (0,T], \\ \sigma(x,0) &= \sigma_0(x), && x \in 0_0^\sigma, \\ \sigma(x,t) &= c^*(x,t), && x \in \Gamma_t, && t \in [0,T]. \end{aligned} \tag{2}$$

c) On the interface, Γ_t

$$\begin{aligned} \Gamma_t &= \{x \in \Omega \mid \psi(x,t) = 0\}, && t \in (0,T), \\ \psi_t + v.\nabla\psi &= 0, && x \in \Gamma_t, && t \in (0,T], \\ v &= \nabla\sigma - \nabla c^*, && x \in \Gamma_t, && t \in (0,T]. \end{aligned} \tag{3}$$

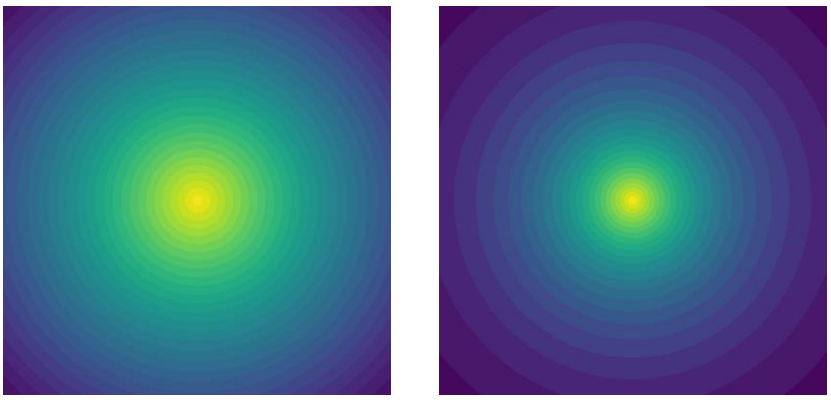
d) Velocity extension, $w(x,t)$

$$(\nabla\psi.\nabla)w = 0, \qquad x \in \Omega, \qquad t \in (0,T). \tag{4}$$

RESULTS AND DISCUSSION

Simulation outcomes indicate that ligand concentration diffuses into the extracellular region, while signal activity is localised within the intracellular space. These interactions drive deformation of the plasma membrane, where the interface may either expand or contract depending on the boundary velocity. The rate of signal decay plays a key role in this process, as it directly influences the persistence of protrusive structures.

As shown in Figure 2, two scenarios were compared to illustrate the effect of signal decay on invadopodia formation. In Figure 2(a**)**, representing low signal decay, the protrusion extends outward and remains stable over time, reflecting stronger and more sustained signalling activity that promotes invadopodia persistence. In contrast, Figure 2(b), representing high signal decay, shows the protrusion shrinking and becoming less stable, indicating weaker signals that limit membrane extension.



(a) (b)

Figure 2: Membrane deformation patterns for different signal decay rates: (a) low signal decay and (b) high signal decay.

These results highlight how signal decay serves as a regulatory mechanism in invadopodia dynamics. Lower decay supports cancer cell invasive behaviour by maintaining protrusions, while higher decay restricts protrusion growth, reducing the invasive potential. This demonstrates how mathematical modelling

can provide valuable insights into the relationship between intracellular signalling and cancer cell invasion, offering a framework that aligns with biological observations.

CONCLUSION

This research explores how signal decay influences the formation of invadopodia, which are important for cancer cell invasion. A simplified two-dimensional mathematical model was developed, combining ligand diffusion, signal transduction with decay, and membrane deformation using the level set method. The outcomes suggest that high signal decay reduces invadopodia persistence, while lower decay allows protrusions to grow and remain stable. Overall, the research shows that mathematical modelling can provide valuable insight into cancer cell behaviour and support future work in developing strategies against metastasis.

ACKNOWLEDGEMENT

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BOOSTING SOLAR OUTPUT WITH INNOVATIVE ANTI-REFLECTIVE LAYER DESIGN

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ABSTRACT

This research aims to improve the performance of silicon solar cells by using double-layer anti-reflective coatings (DLARCs). The goal of this research is to investigate how DLARCs minimize the reflection of light and maximize energy output. The DLARCs are simulated, using software known as PC1D, by creating three DLARC configurations: MgF_2/TiO_2, SiO_2/TiO_2, and Al_2O_3/TiO_2. The performance of all the configurations was found to be higher than that of the reference cell. The MgF_2/TiO_2 coating had the best efficiency of 23.10%, while the reference cell had an efficiency of 15.70%. The comparable performance of MgF_2/TiO_2 and SiO_2/TiO_2 can be attributed to their proximity in refractive indices, as well as to the limitations of the used material database in the simulation.

Keywords: Anti-reflective coatings, silicon, solar cell, PC1D, photovoltaic

INTRODUCTION

With the global shift toward cleaner and renewable sources of energy, solar has emerged as one of the best solutions. Particularly, silicon-based PV cells are still the most common and popular technology because of their availability, stability, and price (Andreani et al., 2018). However, high surface reflectivity of silicon is one of the limitations that can impair its performance as it reflects over 30% of the incoming sunlight (Sharma, 2019). This reflected loss decreases the quantity of the incident photons being absorbed by the active layer and suppresses the generation of charge carriers, thus leading to reduced power conversion efficiency (PCE) of the solar cell. To overcome this issue, anti-reflective coatings (ARCs) are applied to the front surface of solar cells. These coatings present greater light absorption that reaches the active region of the cell and lead to increased efficiency (Adwan et al., 2023). One potential resolution is a double-layer anti-reflective coating (DLARCs) for this issue. Through the different refractive indices of two materials, DLARCs can efficiently form a smoother transition area for the incident light from air to the silicon substrate. Such structures assist in achieving lower reflectance across a wider wavelength range than single-layer coatings, while maintaining reasonable fabrication complexity (Ji et al., 2022; Salleh, 2023).

In this study, the electrical performance of silicon solar cells with different DLARC configurations was simulated using PC1D. This step was done in the form of a one-dimensional device simulation, which is common practice in photovoltaic research. The simulation also included setting key parameters such as layer thicknesses, material properties, doping concentrations, and operating conditions under standard illumination (AM 1.5G) to examine the effects of the DLARCs on cell efficiency. The simulation results showed that every configuration of DLARC provided marked improvement when compared to an uncoated reference cell. More specifically, improvements were observed in the short-circuit current and open-circuit voltage alongside other metrics measured across all power conversion efficiency (PCE). With regards to these changes, the most effective DLARC design's PCE reached 23.10%, considerably exceeding bare silicon cells' 15.70%. This signifies more than 47.13% of the relative gain in efficiency post-implementation of DLARCs on silicon solar cells. Therefore, confirming that DLARCs can effectively increase energy output from silicon solar cells, thus justifying the continued development to advance the utilisation of solar power technology systems within renewable energy frameworks (Law et al., 2023).

METHODOLOGY

This study focuses on evaluating the effect of double-layer anti-reflective coatings (DLARCs) on the electrical performance of silicon solar cells through simulation. The research explores how the addition of two anti-reflective layers can reduce reflection losses and improve power conversion efficiency (PCE), which is relevant for optimising photovoltaic design and improving the output of commercial solar modules. PC1D allows researchers to model a solar cell and observe its electrical behavior by setting key devices and environmental parameters. It is suitable for this study because it provides detailed insight into how changes in front-layer coatings impact important electrical characteristics, such as short-circuit current (I_{sc}), open-circuit voltage (V_{oc}), and maximum power (P_{max}). In this simulation, DLARCs were represented as two thin film layers on top of a crystalline silicon (c-Si) substrate, as illustrated in Figure 1. The materials listed in Table 1 were selected due to their compatibility with silicon and because their refractive indices can help in forming destructive interference that leads to lower reflectance.

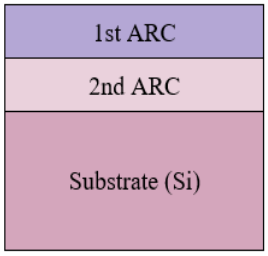

Figure 1: Schematic diagram of DLARCs configuration.

Table 1 Refractive index and thickness of ARC materials.

Materials	Refractive Index (n)	Thickness (nm)
MgF_2	1.36	110.3
SiO_2	1.46	102.7
Al_2O_3	1.62	92.6
TiO_2	2.30	65.2
c-Si (Substrate)	3.94	1×10^5

RESULTS AND DISCUSSION

The simulation using PC1D showed that applying double-layer anti-reflective coatings (DLARCs) to silicon solar cells significantly improved their electrical performance compared to an uncoated reference cell. The results obtained from the simulation mentioned in Table 3, with the baseline uncoated silicon cell to serve as a reference for comparison and followed by three different configurations. All three configurations recorded higher I_{sc}, V_{oc}, P_{max}, and PCE than the uncoated silicon cell. Among them, the MgF_2/TiO_2 configuration achieved the best performance, with an I_{sc} of 3.684 A, a V_{oc} of 0.7394 V, and a P_{max} of 2.310 W, resulting in a PCE of 23.10%. Meanwhile, SiO_2/TiO_2 and Al_2O_3/TiO_2 show slightly lower efficiencies of 23.01% and 22.55%, with respective readings of I_{sc} = 3.670 A, P_{max} = 2.301 W, V_{oc} = 0.7394 V, and I_{sc} = 3.594 A, P_{max} = 2.255 W, V_{oc} = 0.7388 V. In comparison, the uncoated reference cell recorded an efficiency of 15.70%, highlighting a relative efficiency improvement of over 47.13% for the best-performing DLARC.

Table 2 PC1D simulation results of the Reference and DLARCs scheme.

Scheme	Material	I_{sc} (A)	P_{max} (W)	V_{oc} (V)	Efficiency, μ (%)	Efficiency Enhancement (%)
Substrate (reference)	Silicon	2.542	1.570	0.7302	15.70	-
DLARC	MgF_2 / TiO_2	3.684	2.310	0.7394	23.10	47.13
	SiO_2 / TiO_2	3.670	2.301	0.7394	23.01	46.56
	Al_2O_3 / TiO_2	3.594	2.255	0.7388	22.55	43.63

The improvement observed is closely related to the optical behavior of the coating materials. Materials with appropriate refractive indices were selected to create a gradient between air and the silicon surface, which reduced reflection through destructive interference (Ji et al., 2022). The combination of a low-index top layer and a high-index bottom layer allowed better light transmission and minimised losses due to reflection (Salleh, 2023; Mousa et al., 2020). However, the differences in individual parameters for MgF_2/TiO_2 and SiO_2/TiO_2 remain below 1%, which indicates similar performance trends. This similarity aligns with previous studies that both MgF_2/TiO_2 and SiO_2/TiO_2 DLARCs exhibit low reflectance and efficient light trapping across the visible spectrum, resulting in comparable optical performance despite material differences (Ali et al., 2014; Mercy et al., 2020). These similarities can also be observed in the shape and slope of their I-V curves, as in Figure 2.

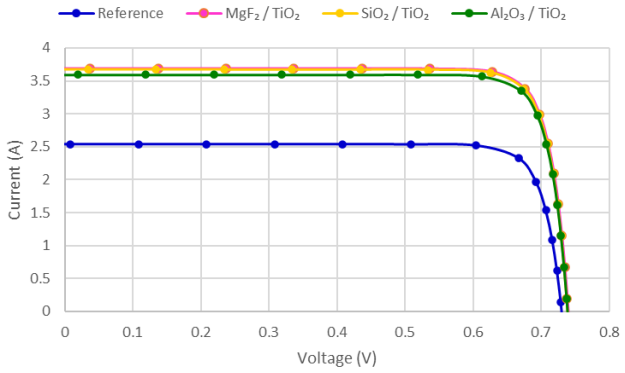

Figure 2: I-V curve for DLARC configuration.

CONCLUSION

This research demonstrates that the use of double-layer anti-reflective coatings (DLARCs) enhances the electrical characteristics of silicon solar cells while reducing reflection losses and enhancing absorption. All three DLARC configurations performed better than the uncoated cell, with MgF_2/TiO_2 being the most efficient. The similar performances of MgF_2/TiO_2 and SiO_2/TiO_2 may be owed to the similar refractive indices and the limitation of the material library used in the simulation. Overall, DLARCs improve solar cell energy output efficiently and need further validation in real-world settings as an area for future work, predicting performance under various conditions, while using different material combinations would be especially relevant.

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SMART SURFACE DESIGN: IMPACT OF TEXTURING ON SILICON SOLAR CELL OUTPUT

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ABSTRACT

This research studies the influence of surface texturing on the electrical properties of silicon solar cells to enhance solar cells' efficiency. The objectives of this study are to analyse the electrical properties of textured surfaces and identify optimal angle texture for highest efficiency. The methodology involves using PC1D software to simulate electrical behaviour. The key parameters used in this study are 200 μm thickness of silicon substrate, a 3μm pyramid height, and varied angles (0°-80°), surface area of 100 cm^2, a respective doping concentration with 1×10^{18} cm^{-3} for the n-type, and $1 \times 10^{17}cm^{-}$ for the p-type. Along this study, the textured surfaces are expected to increase light absorption, as well as reduce reflection losses and enhance crucial parameters such as short-circuit current and open–circuit voltage. Among all angles, solar cell surface with the angle 53° is the most optimal angle that balance both properties with the photogeneration density, J_{max} = 37.13 mA/cm^2 and reached a 45.04% enhancement as well as the short current circuit, I_{sc} = 3.907A, open circuit voltage, V_{oc} = 0.7342V. The final design's efficiency is 24.49%. These findings demonstrate higher angle pyramid textures enhance light absorption and current generation but must take consideration about surface recombination which may affect value of V_{oc}.

Keywords: Silicon, Solar Cells, Surface Angle, Surface Texturing, PC1D

INTRODUCTION

The sustainable and renewable energy sources have never been pressing for the worldwide but somehow the renewable energy technologies became one of need and more well-known as competitive replacements for traditional fossil fuels due to concern towards the growth of climate changes. In addition, Solar energy became a concern that brought one unique renewable energy source because of its benefits and functionality for the environment. For decades, silicon (Si) solar cells have ruled the photovoltaic industry which converts the sunlight into electrical energy (Xiao & Xu, 2013). However, there are issues with solar energy slowly increasing and limiting the Solar's availability to users (PV Case Team, 2024). According to Andreani et al. (2018), The most promising renewable energy source is solar energy which can be converted into usable power by photovoltaic (PV) conversion in solar cells. For instance, in the European Union, solar power accounts for roughly 4% of the average grid electricity, but in nations like Germany and Italy, it accounts for over 7%. The most widely used material in solar is the best solar modules of crystalline silicon which currently transform more than 22% of sunlight to electric power and can be low-cost and long-lasting (New World Record for CIGS Solar Cells, 2024). However, enhancing the efficiency of silicon solar cells is a key of research.

The photovoltaic (PV) market remains dominated by crystalline silicon solar cells due to their stability, abundant material supply, and reasonable efficiency. In 2020, the c-Si modules have been installed over 125 GW, in 95% of the total photovoltaic (PV) market, and the cumulatively installed is over 700 GW. There is strong evidence that predicts in 2040-2050, the crystalline silicon (c-Si) photovoltaic would become the most significant world electricity source (Ballif et al., 2022). However, one of the obstacles faced is the inherent reflection of sunlight on flat surfaces, which limits the amount of light absorbed and decreasing conversion efficiency. One of effective technique is by adding surface texturing. Surface texturing has come out as a important technique to electrical properties by decreasing reflection and

increasing light trapping within the cell. By optimising the surface texture such as adding upright structures, the interaction incident light and efficiency can increase. This study aims to investigate the effects of surface texturing on the electrical and optical properties of silicon solar cells, eventually determining the most effective texture arrangement for performance enhancement.

RESULTS AND DISCUSSION

Table 1 shows the value of parameter that becomes basic parameter to be use in this study. This fundamental parameter has been obtained from (Belarbi et al., 2014). Only a few parameters, such as surface texturing, angle, and thickness on the n- and p-regions will be manipulated in this study.

Table 1: The value of basic parameter for simulation of silicon solar cell.

Parameter	Value
Device area	100 cm^2
Surface texturing	Upright pyramidal
Varied angle	0°-80°
Dielectric constant	11.9
Band gap	1.124 eV
n-layer thickness	10 µm
n-doping concentration	1 x 10^{18} cm^{-3}
p-layer thickness	190 µm
p-doping concentration	1 x 10^{17} cm^{-3}
Excitation	One-sun

Figure 1 below shows the schematic diagram of pyramidal surface Si solar cell schemes and a p-n layer. The angle of upright pyramidal will be varied between 0-80, in increments that include small (10°-39°), medium (40°-59°), and large (60°-80°) angles, The same procedure was applied for 10µm thickness of n-type and 190µm thickness of p-type respectively. The results for short-circuit current density (Isc), open circuit voltage (V_{oc}) and maximum power output, and efficiency were tabulated.

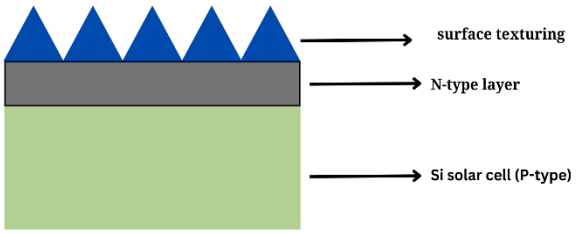

Figure 1: Schematic diagram of pyramidal surface Si solar cell.

The maximum current produced by the solar cell when the external load is shorted is known as the short circuit current (I_{sc}). It is directly influenced by the amount of light that is absorbed and converted into electron-hole pairs, and it indicates the photogeneration rate of charge carriers in the device. Short current circuit (I_{sc}) rises steadily with angle in Figure 2, from 3.867 A at planar surface to 3.938 A at 70°. This is because the influence of increasing photon absorption from multiple internal reflections in higher angle pyramidal textures which lead to greater photogeneration of charge carriers. The most notable enhancement in current occurred in the medium angle (50° and 53°) and large angle (65°-70°) categories.

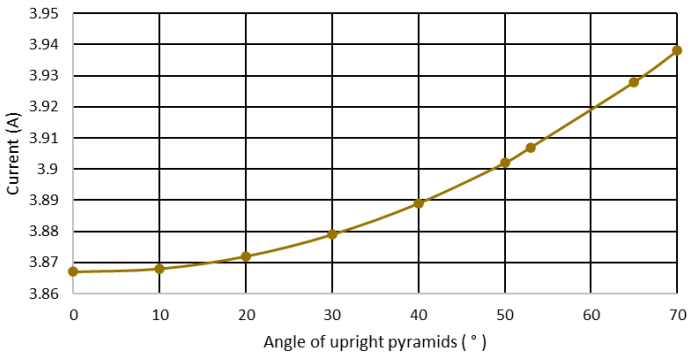

Figure 2: Current characteristic for the upright angle pyramids.

Open circuit voltage (V_{oc}) is a crucial parameter in determining solar cell performance, as it shows the maximum potential difference that a cell can produce when there is no current flow. In contrast to short circuit current, which is influenced by the amount of light absorbed, V_{oc} is strongly impacted by surface recombination and the carrier lifetime. As in Figure 3 shows the voltage characteristic for the upright angle pyramids. V_{oc} showed a slight decrease with increasing pyramid angle from 0.7345 V at planar surface to 0.7333 V at 70°. At 50° and 53°, V_{oc} decreases slightly to 0.7342 V and continues to reduce to 0.7337 V at 65° and 0.7333 V at 70°. A larger textured surface area leads to increased surface recombination, which is an important explaining physical effect that is caused in this drop. According to Ju et al. (2016), greater surface recombination velocity is caused by steeper pyramid textures on crystalline silicon, which decreases carrier lifetime and open-circuit voltage

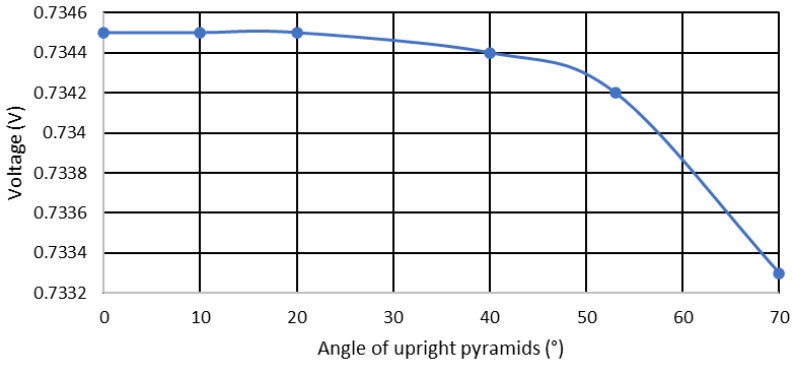

Figure 3: Voltage characteristic for the upright angle pyramids.

CONCLUSION

The electrical properties of silicon solar cells can be significantly improved by optimising surface texture angle. The highest overall efficiency of 24.62% was obtained at angle of 70°. However, the 53° pyramid angle is found to be the suitable configuration, and was identified as optimal angle, achieving a short circuit current of 3.907 A, an open circuit voltage of 0.7342 V, and a correspond power conversion efficiency of 24.49%. This angle offering a well-balanced trade-off between enhancing current generation and stable voltage performance.

ACKNOWLEDGEMENT

The authors would like to express their gratitude and thanks to Universiti Teknologi MARA for supporting this study.

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THICKER OR THINNER? UNVEILING THE BEST SILICON FOR SOLAR EFFICIENCY

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ABSTRACT

This thesis uses simulation methods to study how substrate thickness affects silicon (Si) solar cells' electrical and optical performance. The study simulates optical behavior using PV Lighthouse and analyses electrical factors using PC1D software. Substrate thicknesses ranging from 30µm to 190µm were examined, as well as surface texturing (upright pyramids) to improve light trapping. The PC1D results indicated that increasing thickness typically enhanced overall efficiency, power output (Pmax), and short-circuit current (Isc). The highest efficiency was recorded at 190µm (24.50%). However, open-circuit voltage (Voc) remained reasonably consistent, suggesting that voltage is less sensitive to thickness than current generation. Improved light absorption and decreased reflection with increased thickness were shown by optical simulation using PV Lighthouse, especially in the visible range (300–600nm). In comparison to a flat reference cell, the simulated photocurrent density (Jg) was further increased by using textured surfaces, increasing by 50.62%. These results imply that adding useful surface texturing and optimising substrate thickness, particularly between 160 and 190µm, greatly increase solar cell efficiency while using less material. Through design optimisation, the study advances the creation of high-performance, reasonably priced silicon-based solar systems.

Keywords: Silicon, Solar Cell, Subtrate Thickness, PC1D, Efficiency

INTRODUCTION

The increase demand for renewable energy sources has fueled research into enhancing the efficiency of photovoltaic (PV) technologies, notably silicon (Si)-based solar panels. Silicon is the most commonly utilised material in photovoltaic applications due to its abundance, stability, and high efficiency. However, as the world's energy needs grow, more efficient silicon solar cells are required to make solar energy more economically viable and sustainable. In order to tackle problems like shortages of food, and worldwide climate change, renewable energy technologies have the potential to significantly contribute to global sustainable development by providing clean energy (Izam et al., 2022).The thickness of the silicon substrate is a crucial element in the performance of silicon solar cells. Substrate thickness influences both optical and electrical qualities, which together determine power conversion efficiency. This research aims to investigate the impacts of substrate thickness on the efficiency of silicon solar cells, with an emphasis on how thickness changes affect critical optical and electrical properties, eventually reducing power conversion efficiency.

Existing research emphasises the importance of substrate thickness in silicon solar cell design. Thinner silicon substrates have been demonstrated to lower material costs and improve light-trapping capabilities, resulting in increased photon absorption. By using a lot less material, increasing optical absorption also makes it possible to reduce the thickness of the active absorber layer, which lowers production costs (Amalathas & Alkaisi, 2019). However, the use of very thin substrates brings additional issues, such as increased surface recombination losses and probable mechanical instability, both of which can reduce total efficiency. These problems highlight the importance of carefully balancing substrate thickness to optimise performance without losing structural integrity. An in-depth study of these thickness properties could bring new insights into better silicon solar cell design.

This study is expected to make a significant addition to the area of solar energy by improving our understanding of substrate thickness, a critical parameter in silicon solar cell performance. This work will help to refine design recommendations for high-efficiency, low-cost silicon solar cells by investigating how altering thickness affects power conversion efficiency. According to the findings of recent techno-economic research on thin silicon, wafers that are 50µm thick have the potential to lower manufacturing capital expenditure (capex) by 48%, module costs by 28%, and the levelised cost of electricity (LCOE) by 24% (Augusto et al., 2020). The findings may have important consequences for industrial applications, as optimising substrate thickness might lower production costs while preserving or even increasing cell efficiency. Finally, our research intends to promote the widespread use and economic viability of silicon-based solar technology, in line with global sustainability goals and contributing to the development of dependable renewable energy sources.

METHODOLOGY

The impact of substrate thickness on the electrical and optical performance of silicon solar cells was examined in this study using a simulation-based methodology. PC1D was utilised to evaluate electrical parameters, and PV Lighthouse Wafer Ray Tracer was used to analyse optical behaviour. Two solar cell designs were developed for simulation purposes. The first was a reference crystalline silicon (c-Si) solar cell with a flat surface, as illustrated in Figure 1 (a). The second was a pyramid-textured structure with front surface features slanted at 54.74°, which was intended to improve light trapping and reduce reflection, as shown in Figure 1 (b). The substrate thickness varied from 30µm to 190µm, while the emitter thickness remained constant at 10µm. Table 1 shows the details of basic parameter for the simulation of silicon solar cell.

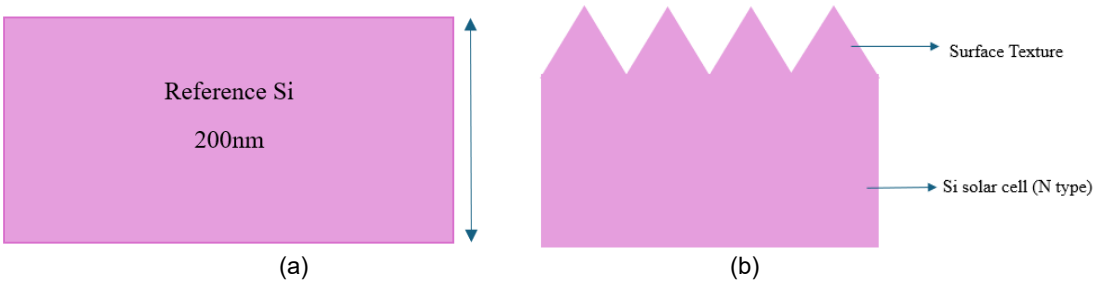

Figure 1: (a) Reference c-Si solar cell (b) Pyramid surface Si solar cell.

Table 1: The value of basic parameter for PC1D simulation of silicon solar cell.

Parameter	Value
Device area	100 cm^3
Front surface texture depth	3 µm
Dielectric constant	11.9
Band gap	1.124 eV
Intrinsic concentration at 300K	1 x 10^{10} cm^{-3}
Background doping	1 x 10^{19} cm^{-3}
Bulk recombination	1000 µs

RESULTS AND DISCUSSION

Simulation results using PC1D showed that raising the substrate thickness from 30µm to 190µm significantly improved the solar cell's electrical output. The short-circuit current (I_{sc}) rapidly grew as thicker substrates allowed more photons to absorb and convert into charge carriers. At the same time, the open-circuit voltage (V_{oc}) remained largely constant across all thicknesses, demonstrating that voltage is less affected by structural changes. Table 2 shows that the maximum power conversion efficiency (PCE) of 24.50% was obtained at 190µm. This confirms that thicker substrates enhance overall device performance,

although the benefits reduce after around 160µm. As highlighted by (Du et al., 2020) the performance of solar cells is greatly influenced by the device's thickness and light intensity. This is because bulk recombination becomes more likely when the produced carriers travel longer distances to reach the junction, increasing the likelihood of recombination before contributing to current. Furthermore, above a certain depth, light absorption is limited, so increasing thickness has no effect on the generation of further electron-hole pairs. The output power continues to increase with thickness, although at a slower rate, and efficiency eventually plateaus. The ideal range between 160µm and 190µm balances performance and material utilization.

Table 2: PC1D results for different subtrate thickness.

Surface texture	Thickness substrate (µm)	Isc (Amps)	Voc (Volts)	Power (Watts)	Efficiency (%)
None (reference)	200	3.867	0.7345	2.427	24.27
Upright pyramid	40	3.533	0.7440	2.239	22.39
	70	3.696	0.7421	2.326	23.26
	100	3.781	0.7401	2.393	23.93
	130	3.835	0.7382	2.422	24.22
	160	3.874	0.7363	2.438	23.38
	190	3.902	0.7347	2.448	24.48
	200	3.909	0.7341	2.450	24.50

The PV Lighthouse simulations concentrated on the optical characteristics of silicon solar cells with pyramidal surface patterns. Adding a textured front surface dramatically enhanced light absorption, particularly in the visible wavelength region (300-600nm). The photocurrent density (J_g) rose with thickness, settling at 38.71 mA/cm² for a 200µm thick textured substrate, representing a 50.62% enhancement over a flat reference cell. Figure 2 shows that the increase decreases beyond 160µm, indicating an appropriate range for maximum absorption while limiting material utilisation. This pattern suggests that although thicker substrates absorb more light overall, the majority of the J_g enhancement happens between 40 and 160µm, and additional thickness increases only yield slight improvements. Because of deeper light trapping within the textured structure, reflectance also reduced with increasing thickness, especially in the visible range of 300–600nm. (Kowalczewski & Andreani, 2015) claimed that reducing the thickness below about 40 µm is useless because it drastically lowers the maximum efficacy that may be achieved. However, due to silicon's increased transparency in the near-infrared spectrum, reflection patterns started to converge across all thicknesses at longer wavelengths above 1000nm. These results demonstrate how surface texturing and a moderate substrate thickness can be combined to greatly improve optical performance without using large amounts of material.

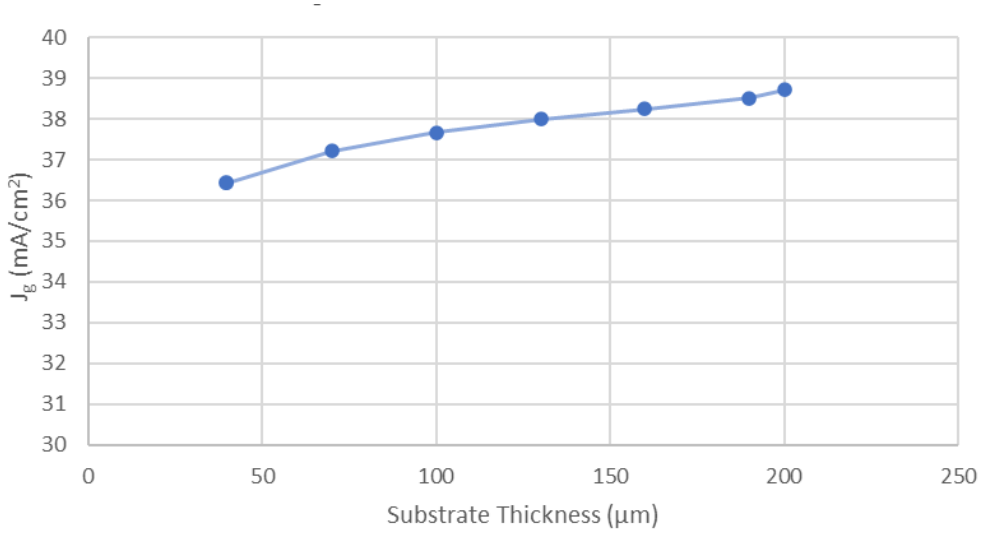

Figure 2: Photogenerations with substrate thickness for textured silicon solar cell.

CONCLUSION

This study investigated how a silicon solar cell's thickness impacts its ability to generate power and absorb light. According to the simulations, efficiency can be increased with thicker substrates, particularly between 160 and 190 μm. However, thickness increases only little beyond that point. Even for thinner cells, the use of pyramid textures on the surface significantly improved light trapping. Finding the ideal balance between thickness and surface design ultimately yields the highest performance, assisting in the development of solar cells that are both economical and efficient.

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The authors would like to express their gratitude and thanks to Universiti Teknologi MARA for supporting this study).

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SLEEP DISORDER DETECTION SYSTEM USING SUPPORT VECTOR MACHINE

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ABSTRACT

Sleep disorders are conditions that disrupt normal sleep patterns and can negatively affect physical, emotional, and mental well-being. These issues are becoming more widespread among adults, yet many individuals avoid diagnosis due to the high cost, discomfort, and time-consuming nature of clinical methods like polysomnography. Additionally, most machine learning systems rely on physiological data that are hard to obtain. This project focuses on developing a sleep disorder detection system using the Support Vector Machine (SVM) algorithm. The Sleep Health and Lifestyle Dataset was used, and the data underwent cleaning, encoding, normalisation, and feature selection through Recursive Feature Elimination (RFE). The dataset was then split into 60:40, 70:30, and 80:20 ratios to train and test the SVM model, which was implemented using both default and tuned versions with GridSearchCV. Performance was evaluated using accuracy, precision, recall, and F1-score, where the best results were achieved with the 60:40 split. The tuned SVM model reached an accuracy of 95.33%, precision of 95.35%, recall of 95.33%, and F1-score of 95.34%, showing strong and balanced classification between "None" and "Sleep Disorder" classes. In summary, the system acts as a useful tool for early screening using simple health inputs, although it is not a replacement for professional diagnosis and may require integration with external devices for more accurate results.

Keywords: Sleep Disorder, Diagnosis, Classification, Machine Learning, Support Vector Machine (SVM)

INTRODUCTION

Sleep is a physiological process in which the body and mind are resting by limiting some activity and interaction with the environment. The temporary withdrawal of sensory and voluntary muscles gives the body the time and opportunity to rest and gain energy. Although the processes which take place in the brain and body during sleep have not been fully explored, sleep is widely accepted as a vital organ for health (Dritsas et al., 2024). According to Alazaidah et al. (2023), sleep influences many aspects of daily life such as the way thinking, learning, working and reacting. A sleep disorder, a condition in which there is a lack of quality sleep, can disrupt these functions and activate hunger-regulating hormones, leading to increased consumption of sugary, salty, and fat-rich foods, thereby raising the risk of heart disease. Moreover, sleep disorders can lead to serious health problems such as cardiovascular diseases, obesity, and mental health issues like depression and anxiety (Dritsas et al., 2024). Thus, it is important to have a way to tell when sleep goes off track to prevent many health issues from happening later.

Machine Learning (ML) is a subset of Artificial Intelligence (AI) that allows computer systems to learn and optimise the information without programming. It is borrowing concepts of computer science, statistics and others. The ML approach is one of supervised learning, in which the training is done with labelled data for

making any prediction or decision. Classification, as one type of supervised learning, identifies boundaries that separate classes into distinct groups. Classification algorithms can make better decisions if they are allowed to lay out what decisions best fit certain boundaries (Cervantes et al., 2020). The technique that holds the opportunity to classify the presence of sleep disorder is Support Vector Machine (SVM), as it enables it to detect complex data like the duration of sleep and level of stress that are indicators to the quality of sleep. The algorithm is popularly implemented in classification because it analyses the case of the best line also referred to as the decision boundary. It begins with evaluating the training dataset, before testing it on a separate dataset to determine how well a classification algorithm can predict the outcomes. Hence, this study aims to use SVMs to develop a classification system for those who struggle with sleep disorder.

RESULTS AND DISCUSSION

This section detailed the development, evaluation, and implications of a sleep disorder classification system built using a Support Vector Machine (SVM) algorithm. The core objective was to create a robust and accurate binary classifier to distinguish individuals with a sleep disorder from those without. The system was developed in Python, utilising a structured pipeline from data preprocessing to classification. A critical design choice was the adoption of a binary classification framework, grouping all sleep disorders into a single category. This approach, endorsed by a medical expert, simplifies the model's task, mitigates class imbalance, and positions the system as a general screening tool rather than a specific diagnostic instrument, appropriately directing users to seek professional medical diagnosis for any detected condition.

Table 1: Performance Metrics Result

Split	Model Type	Accuracy (%)	Precision (None)	Precision (SD)	Recall (None)	Recall (SD)	F1-Score (None)	F1-Score (SD)
80/20	DefaultSVM	89.33	95.0	82.86	86.36	93.55	90.48	87.88
	GridSearchCV	92.00	95.24	87.88	90.91	93.02	93.02	90.62
70/30	DefaultSVM	92.04	95.24	88.00	90.91	93.62	93.62	90.72
	GridSearchCV	93.81	95.38	91.67	93.94	93.62	94.06	92.63
60/40	DefaultSVM	93.33	96.43	89.39	92.05	95.16	94.19	92.19
	GridSearchCV	95.33	96.55	93.65	95.45	95.16	96.00	94.40

To identify the optimal model configuration, rigorous testing was conducted using three different train-test data splits (60:40, 70:30, and 80:20) as shown in Table 1. For each split, two models were compared: a baseline SVM with default linear kernel settings and a tuned SVM optimised using GridSearchCV. This tuning process systematically explored combinations of kernels, regularization parameters (C), and gamma values to maximise performance. The results demonstrated conclusively that the GridSearchCV-tuned models consistently outperformed their default counterparts across all split ratios. The best results were achieved using a 60:40 data split with the tuned SVM model, which yielded an exceptional accuracy of 95.33%. The model also achieved high balanced scores in precision (95.35%), recall (95.33%), and F1-score (95.34%), indicating its proficiency in correctly identifying both classes—those with and without a sleep disorder.

This performance was benchmarked against a previous study by Alshammari et al. (2024), which used the same dataset but a more complex three-class classification and a differently tuned SVM. This project's result of 95.33% accuracy surpassed the benchmark's 92.04%, an improvement attributed to several factors: the effective binary classification strategy, the thorough hyperparameter optimisation via GridSearchCV, and a more comprehensive data preprocessing regimen that included advanced cleaning, feature encoding, scaling, and Recursive Feature Elimination (RFE). Furthermore, the selection of input features was validated through a correlation matrix, which identified strong relationships between the target variable and

factors like stress level, sleep quality, and BMI. This technical validation was aligned with a list of medically relevant features suggested by a domain expert, ensuring the model's foundation was both statistically sound and clinically pertinent.

In conclusion, the research successfully fulfilled its objectives by designing, implementing, and rigorously evaluating an SVM-based classification system. The final optimized model demonstrates high accuracy and reliability, validated through comparative analysis and expert insight. The resulting prototype serves as a potent proof-of-concept for an accessible public health tool, capable of enabling early screening for sleep disorders and encouraging individuals to seek timely professional medical advice.

CONCLUSION

The sleep disorder classification system built using SVM successfully met its goals. It identifies sleep disorders based on a person's lifestyle and health inputs. With proper data preparation and model tuning, the system reached an accuracy of 95.33%. This shows that SVM can be a helpful tool for early screening, offering a simple and straightforward solution. While there are still areas to improve, the system gives a strong starting point for future work and real-world use.

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CLASSIFYING PARSED LEGAL DOCUMENTS USING A VOTING-BASED ENSEMBLE OF NAÏVE BAYES AND SUPPORT VECTOR MACHINE WITH HIERARCHICAL KNOWLEDGE GRAPH VISUALIZATION

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ABSTRACT

Legal documents (LDs) are often too complex for non-experts, leading to the acceptance of unfavorable terms. This study addresses this by developing a web application to analyze and classify legal contracts. The methodology involves generating a synthetic dataset of financial clauses based on Product Disclosure Sheets from major Malaysian banks. A voting-based ensemble model combining Naïve Bayes (NB) and Support Vector Machine (SVM) is used to classify the extracted clauses, and the findings are presented in an interactive Hierarchical Knowledge Graph (HKG) to visualise the document's structure. The model categorises clauses into six key aspects and the final soft voting ensemble model achieved a classification accuracy of 80.36%. The system's effectiveness was further validated through reliability testing, which demonstrated a significant average time reduction of 71.08% for users analysing documents compared to manual methods ($p < 0.001$). The system's interface, supplemented by AI-generated summaries and a searchable jargon dictionary, proves to be a practical tool for enhancing user comprehension. This project offers a useful tool that empowers the public to make more informed financial decisions by deconstruct complex legal texts.

Keywords: Legal Documents, Naive Bayes, Support Vector Machine, Ensemble Model, Knowledge Graph

INTRODUCTION

Legal documents (LDs) exist in many forms, including contracts, loan agreements, policies, and wills. These documents play significant roles in ensuring conformity, upholding legal rights, and guiding decision-making in various sectors. LDs, such as loan agreements, are fundamental in formalising obligations but are often characterized by complex terminology and dense structures, making them difficult for individuals without a legal background to comprehend (Sancheti et al., 2023). Traditionally, reviewing these documents manually is time-consuming due to their length and specialized language (Begum & Goyal, 2021; Smith, 2022). Consequently, insufficient time for thorough reviews can lead to overlooked critical aspects, such as payment terms, termination rights, or hidden charges, resulting in the acceptance of unfavourable conditions (Chalkidis et al., 2020).

To address this problem, this research proposes the development of a web application designed to analyse and classify clauses from parsed legal documents. The core innovation of this system is a voting-based ensemble model that leverages the combined predictive power of two established machine learning algorithms: Naïve Bayes (NB) and Support Vector Machine (SVM). The system's output is not merely a classification result but also an interactive Hierarchical Knowledge Graph (HKG) that visually represents the document's structure and key clauses. The system also integrates on-demand explanations of legal jargon and AI-powered summaries, making LDs more accessible and comprehensible to the public. This project's primary objectives were to design a robust classification system, develop it into a functional web

application, and validate its functionality and reliability. The system's scope was defined by focusing on loan agreements from several major Malaysian banks, using a dataset from January 1, 2024, to December 31, 2024, to ensure its practical relevance.

RESULTS AND DISCUSSION

The project has successfully met its objectives with the development of a web application that classify clauses from parsed legal documents (LDs) using a voting-based ensemble of Naive Bayes (NB) and Support Vector Machine (SVM) models and visualise it in the form of Hierarchical Knowledge Graph (HKG). Functionality testing with 6 test cases was conducted successfully, showing that all of the system features are functioning exactly as intended. The voting-based ensemble of NB and SVM models demonstrated a high performance with 80.36% accuracy. This has proven the system to be effective and functional in assisting users to analyze legal documents more efficiently and with improved comprehension.

Upon the classification of the parsed clauses, the results are then visualized in the form of HKG which visually represents the document's structure and semantics as shown in Figure 1. This central network model is composed of a nested hierarchy of nodes, beginning with a Root Node representing the document. From this, Aspect Nodes (colored boxes) represent high-level categories, while Topic Nodes (hexagons) group semantically related clauses. The individual clauses are represented by color-coded Clause Summary Nodes, which, when expanded, reveal Phrase Nodes that highlight important terms.

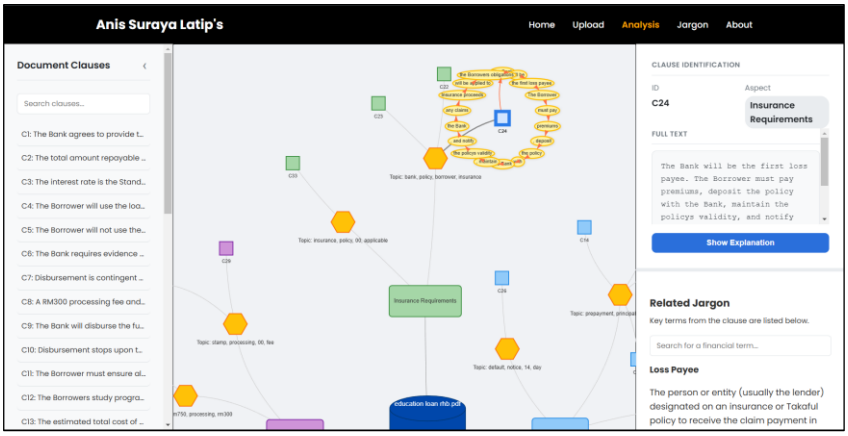

Figure 1: Interactivity of KG

To complement this visual model, the interface includes two interactive sidebars. The left-hand Clause List Sidebar offers a familiar, linear view of the document's content and is synchronised with the graph for seamless navigation. On the right, the Details Sidebar provides in-depth analysis. It features a "flipper card" interface where the front displays information about a selected clause and the back offers an "In Plain English" summary generated by the Gemini 1.5 Flash model displayed in Figure 4. A bottom panel, the "Jargon Explorer," automatically defines relevant terms, functioning as a comprehensive dictionary. Together, these components create an intuitive, multi-modal system that allows users to explore complex documents graphically, textually, and with detailed contextual information.

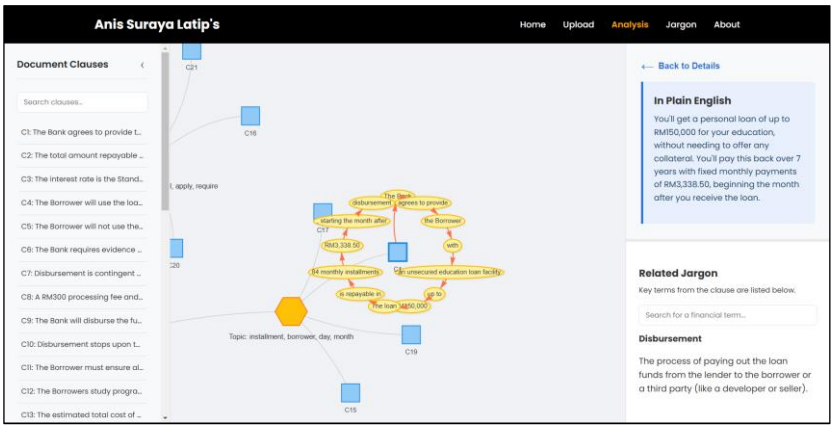

Figure 2: Flipper Card with Clause Summary

Reliability testing was conducted to determine if the system could produce consistent and reproducible results under similar conditions. The test analysed the system's ability to correctly classify clauses, generate meaningful KG structures, and provide jargon definitions. Ten participants, all of whom were members of the public without legal backgrounds, were randomly selected to perform a set of five tasks. Each participant first completed the tasks manually using a paper copy of a loan agreement. They then performed the same tasks using the project's web-based system, which automatically labeled the document, visualised it as a KG, and provided interactive jargon definitions. The time taken to complete each method was independently measured with a stopwatch. The findings showed an average time saving of 71.08% for participants using the system, which demonstrates its reliability and efficiency in reducing the time required to examine a LD.

The reliability test results were statistically analyzed using the Mann-Whitney U Test as illustrated in Table 1. This non-parametric test was chosen due to the small sample size of ten participants, which made it difficult to assume the data was normally distributed. The research question was whether the time taken for manual evaluation was significantly different from the time taken for the web-based system evaluation. The null hypothesis (H_0) stated there was no significant difference in the time taken between the two methods, while the alternative hypothesis (H_1) suggested there was a significant difference. The Mann-Whitney U Test yielded a p-value of <0.001, which is less than the conventional significance level of $p<0.05$. Since the p-value was lower than the significance level, the null hypothesis (H_0) was rejected. This led to the conclusion that a statistically significant difference exists between the time spent on manual evaluation and the time spent on the web-based system evaluation. The asterisk symbol (*) next to the p-value in the table indicates that the result is significant, emphasising that the reduction in time when using the system is a real performance improvement and not due to random chance.

Table 1: Mann-Whitney U Test for Manual and Web-based Evaluation

Mann-Whitney U Test of Two Samples		
	Manual	System
Minimum	9.36	2.58
Maximum	15.32	4.3
Median	12.3	3.31
Mean	12.25	3.52
p-value		< 0.001*

CONCLUSION

In conclusion, this project successfully developed a web application that classifies clauses from parsed legal documents (LDs) using a voting-based ensemble of Naive Bayes (NB) and Support Vector Machine (SVM) models and visualises the results as a Hierarchical Knowledge Graph (HKG). The system proved to be effective and reliable, achieving a high predictive accuracy of 80.36% and a statistically significant average time reduction of 71.08% compared to manual methods ($p<0.001$). While successful, the study was limited by its use of a synthetically generated dataset, fixed categories, and the inability to handle advanced functions like document comparison or tracking changes. Future work should focus on expanding the dataset with real-world documents, adding advanced features like document comparison, and creating a dynamic knowledge base to keep the model's insights current.

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EFFICIENCY ASSESSMENT OF ZAKAT INSTITUTION IN MALAYSIA: EVIDENCE FROM THE DEA-BCC MODEL

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ABSTRACT

Zakat institutions in Malaysia play a vital role in promoting economic and social well-being through the systematic collection and distribution of zakat. However, concerns regarding inefficiency, such as the inability to adequately meet recipients' needs and declining public trust, have raised questions regarding their operational effectiveness. This study aims to evaluate the efficiency levels of zakat institutions in Malaysia using Data Envelopment Analysis (DEA): the BCC model. The analysis involves a panel of fourteen State Islamic Religious Councils where each of them is treated as Decision-Making Units (DMU) to the BCC model. The model incorporates three input variables: number of staff, number of zakat payers, number of zakat recipients (*asnaf*) and two output variables: total zakat collected, and total zakat distributed. Result indicates that seven institutions achieved full efficiency scores ($\theta = 1$), indicating optimal performance relative to their peers. This outcome valuable for policymakers and zakat administrators aiming to enhance institutional performance, increase transparency, and restore public confidence. By strengthening redistribution mechanisms and ensuring a visible impact on beneficiaries, efficient zakat management can improve compliance, promote social justice, and contribute to sustainable socio-economic development in Malaysia.

Keywords: Zakat Institution, Data Envelopment Analysis, BCC Model, Efficiency

INTRODUCTION

Zakat institutions are formal entities that are responsible for the collection, management and distribution of zakat, particularly in Muslim-majority countries. Its core responsibility is to ensure zakat is distributed efficiently and effectively to the designated *asnaf* groups (Farah Aida, Rashidah & Normah, 2012). In Malaysia, the administration of zakat falls under the jurisdiction of respective State Islamic Religious Councils (SIRCs), in accordance with the Federal Constitution, which places Islamic affairs under state authority. As Malaysia comprises 13 states and one Federal Territory, there are 14 zakat institutions, where each of them manages zakat affairs within their respective regions. For example, Lembaga Zakat Selangor (LZS) administers zakat in Selangor, Pusat Pungutan Zakat – Majlis Agama Islam Wilayah Persekutuan (PPZ-MAIWP) serves the Federal Territories, and Lembaga Zakat Negeri Kedah is responsible for zakat matters in Kedah.

In recent years, public concern has grown regarding the operational inefficiency of the zakat institution. Several studies report issues such as failure to reach eligible recipients (Muhammad Aiman et al., 2021) inability to meet the needs of *asnaf* and lack of transparency and responsiveness (Punding et al., 202). The factors that led to the occurrence of this are due to the limited number of zakat payers, inefficient collection process (Nurulhazwani & Noraini, 2016), insufficient staff such as *amil* officers (Wahab & Rahman, 2022), and weak operational and technical infrastructure (Mukhtar et al., 2024).

Data Envelopment Analysis (DEA) is a non-parametric technique and has widely applied in various studies in order to evaluate the efficiency of zakat institutions. Muhammad Aiman et al. (2021) investigates the efficiency of the collection and distribution of zakat at the LZNK. Some studies focused on measuring the impact of privatisation on the performance of zakat institutions (Ahmad et.al., 2005). DEA technique

assesses the relative efficiency of comparable units, known as Decision-Making-Units (DMUs) by comparing their input-output ratio against a best-practice frontier formed by the most efficient units. In this study, each zakat institution in Malaysia is treated as DMU. The selected input variables include the number of staff, number of zakat payers and zakat expenses. Meanwhile, the output variables consist of the total zakat collected and total zakat distributed. Data for each input and output are collected from the website of each zakat institution.

The DEA-BCC model developed by Banker, Charnes, and Cooper (1984) introduces a convexity constraint into the original CCR model to account for variable returns to scale (VRS). This enhancement addresses a major limitation of the CCR model, which assumes constant returns to scale (CRS) and tends to overestimate efficiency, leading to too many DMUs being classified as efficient, thereby reducing the model's discriminatory power. The DEA-BCC model can be represented as follows:

$$\theta_0 = \sum_{r=1}^{s} u_r y_{\lambda_0} + u_0 \tag{1}$$

Subject to,

$$\sum_{i=1}^{m} v_1 x_{ij_0} = 1 \tag{2}$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_1 x_{ij} + u_0 \leq 0 \tag{3}$$

$$v_1 \geq 0, u_r \geq 0, u_0 \geq \varepsilon$$

An efficiency score of $\theta_0 = 1$ indicates that a DMU is efficient, whereas when the efficiency score is in the range of $0 \leq \theta o \leq 1$ indicates inefficiency.

Therefore, this study aims to measure the operational efficiency of zakat institutions in Malaysia using the input-oriented DEA-BCC model. The results will help identify performance gaps and provide insights for improving resource allocation, staffing, and service delivery. Besides, this improvement will also ultimately strengthen public trust and enhance the impact of zakat distribution in Malaysia.

RESULTS AND DISCUSSION

Table 1 shows the efficiency scores for each DMU calculated by the BCC model using LINGO software. The result reveals that there seven DMU with perfect efficiency score, $\theta = 1$. These include the zakat institution from Wilayah Persekutuan, Selangor, Johor, Melaka, Perak, Sabah, and Sarawak.

Table 1: Efficiency scores for each DMU

DMU	EFFICIENCY SCORE, θ
Wilayah Persekutuan	1.000000
Selangor	1.000000
Johor	1.000000
Kelantan	0.9217448
Terengganu	0.829876
Kedah	0.8931153
Perlis	0.5684028
Pahang	0.6529029
Pulau Pinang	0.9680396
Melaka	1.000000
Negeri Sembilan	0.9040041
Perak	1.000000
Sabah	1.000000
Sarawak	1.000000

An efficient zakat institution, as identified through the input-oriented DEA-BCC model, indicates that the organisation operates on the efficiency frontier, achieving maximum zakat collection and distribution outcomes with the optimal use of staff, expenses, and payer engagement compared to other inefficient institutions. This level of performance not only reflects effective operational strategy but also provides a benchmark for other institutions aiming to improve their efficiency.

CONCLUSION

Data Envelopment Analysis method was employed in this study in order to assess the efficiency levels of zakat institutions in Malaysia. The findings provide valuable insights for policymakers and zakat administrators seeking to enhance institutional performance, increase transparency, and restore public confidence. By strengthening redistribution mechanisms and ensuring a visible impact on beneficiaries, efficient zakat management can improve compliance, promote social justice, and contribute to sustainable socio-economic development in Malaysia.

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END-TO-END TALENT RECRUITMENT FRAMEWORK FOR TALENT CORPORATION MALAYSIA BERHAD

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ABSTRACT

This project explores the application of advanced data analytics, with a focus on deep learning model, to enhance the talent recruitment process. It proposes an end-to-end talent recruitment framework powered by Bidirectional Encoder Representations from Transformers (BERT), a deep learning model under Artificial Intelligence (AI) for natural language processing (NLP) to analyse and match candidate resumes with job descriptions. A system named Candidates Evaluation List for Employment Selection and Talent Acquisition Ranking (CELESTAR) was developed as the main product of this framework. Using datasets of job descriptions and candidate resumes, the BERT model was integrated into the framework to capture contextual insights and semantic meaning, enabling more accurate candidate-job matching and improving the identification of high-potential candidates. Data visualization dashboards were also used to present the results clearly and support Human Resource (HR) decision-making. The implementation of CELESTAR system has demonstrated its ability to streamline recruitment by reducing manual screening workload, shortening decision-making time, improving matching accuracy, and contributing to cost and resource efficiency. Most importantly, the integration of AI ensures a fairer and data-driven selection process, aligning with the New Industrial Master Plan (NIMP) 2030, which promotes the shift towards digitalisation in the workforce. This project benefits not only Talent Corporation Malaysia Berhad but also other organisations seeking to modernize and optimize their recruitment process.

Keywords: Talent Recruitment Framework, BERT Algorithm, Candidate-Job Matching, Resume Screening, Human Resource

INTRODUCTION

Recruitment today is no longer just about filling vacancies. Recruiting the right talent is not a sprint but a marathon, and in today's technology-driven world, the competition for top talent has become increasingly intense. Matching the right person to the right job is more critical than ever. Talent recruitment plays a vital role in helping organisations select the best candidates to achieve organisational goals while supporting individual career growth. In Malaysia, Talent Corporation Malaysia Berhad (TalentCorp) is responsible for managing and enhancing national talent development. To support this mission effectively, TalentCorp itself must first implement a strong and efficient recruitment system to ensure that its own workforce consist of qualified and well-matched employees. By recruiting the right talent, TalentCorp can successfully nurture and support the wider national talent ecosystem.

Traditional recruitment approaches consumes significant time when narrowing down resumes from large applicant pools (Tallapragada et al., 2023). Therefore, developing an accurate candidate-job matching model is critical as it influences the identification of high-potential candidates. However, many existing models face limitations in understanding the semantic relationships between job description and candidate resumes, leaving notable gaps in accurately identifying top talent (Deshmukh & Bajaj, 2024). Current platforms such as JobStreet are effective in attracting applicants and displaying matched skills, but they still require manual review and shortlisting, offering no ranking features to speed up decisions-making. As a result, HR department is left to manually filter large volumes of resumes, which is both time consuming

and prone to human error (Tallapragada et al., 2023). Traditional keyword matching and Boolean search techniques lack the ability to capture deeper contextual meaning (Mochol et al., 2007), making it difficult to identify high-potential candidates and often leading to mismatched hiring (Malherbe et al., 2014; Chen et al., 2018). Moreover, many existing studies focus only on job-matching models without addressing how they fit into a complete end-to-end recruitment framework.

Therefore, this project aims to proposed an integrated talent recruitment framework that combine two different workflow into a comprehensive end-to-end talent recruitment framework. The framework emphasises the candidate-job matching model, which utilises a deep learning model, Bidirectional Encoder Representations from Transformer (BERT) to calculate matching degree scores between candidate resumes and job descriptions. From this model, a system called CELESTAR was developed to automate and enhance the user experience. This system ensures that companies are able to hire the most suitable candidates for their specific job openings. Additionally, the framework integrates visualisation dashboard to provide actionable insights and a comprehensive solution for recruiters. By achieving these objectives, this project supports TalentCorp's mission to optimize the talent recruitment process, while also contributing to Malaysia's talent development, digitalisation agenda, and workforce sustainability.

RESULTS AND DISCUSSION

This section explains the results obtained and discussion, focusing on how each of the four objectives was successfully achieved. The first objective was to design and propose an end-to-end talent recruitment framework tailored for TalentCorp. The proposed framework is a combination of TalentCorp's existing hiring process and the integration of a BERT-based job matching model (Tallapragada et al., 2023) to enhance candidate screening and selection. The proposed framework encompasses the entire hiring process, divided into 16 distinct stages and categorised into four phases which are Preparation Phase, Execution Phase, Evaluation Phase, and Finalisation Phase. Figure 1 shows the proposed end-to-end talent recruitment framework designed for TalentCorp.

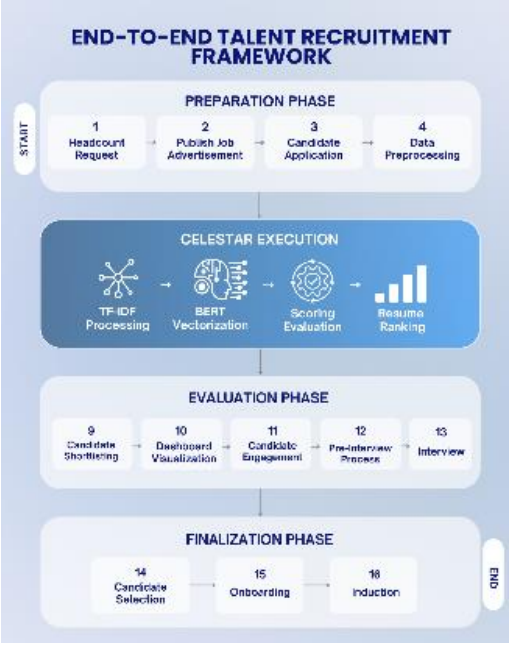

Figure 1: The Proposed End-To-End Talent Recruitment Framework for TalentCorp

To achieve the second objective, real recruitment data were collected from JobStreet between January and May 2025. During this period, a total of six job postings were published under TalentCorp's company profile, with four still available for application and the remaining two classified as expired. In total, 351 candidate resumes were collected from the JobStreet platform where 175 resumes from the expired postings and 176 resumes from the active ones. The job posting data was scraped directly from the JobStreet platform, while the candidate resumes were downloaded from the JobStreet employer portal. After cleaning

and preprocessing, these datasets were trained and used to develop a hybrid candidate-job matching model using the Term Frequency-Inverse Document Frequency (TF-IDF) and BERT. The TF-IDF highlights important keywords in resumes and job description. While BERT, understands the meaning and context of sentences. By combining keyword importance with deeper language understanding, the system produced more accurate matching results compared to traditional keyword searches. Figure 2 shows the CELESTAR system interface, which is available in both desktop and mobile view. Either they are used in the desktop or mobile, the interface for both remains clean, user-friendly and easy to use.

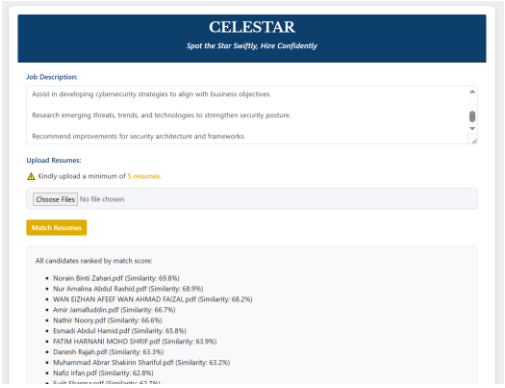

Figure 2: CELESTAR system interface displaying candidate ranking results

The third objective focused on identifying high-potential candidates. The trained model was integrated into a CELESTAR system. When the system tested on a closed job posting, the candidate ultimately hired by HR also appeared within CELESTAR's top 10 ranking, showing strong alignment with human judgment. While in an ongoing cybersecurity hiring, CELESTAR's top 20 shortlisted candidates significantly overlapped with HR's manual screening results. A similarity threshold of 60 percent was used, based on references from past studies that applied cosine similarity scores and identified 0.6 as an effective level for text classification and semantic matching tasks (Alsaket and El-Khatib, 2019). Candidates with scores above this level were considered strong matches. This threshold ensured that the shortlisting process was neither too strict nor too lenient. The list of high potential candidates and their scores was then downloaded into a CSV file and loaded into Tableau for dashboard visualisation. Figure 3 shows the dashboard visualisation of high potential candidates and job application insights.

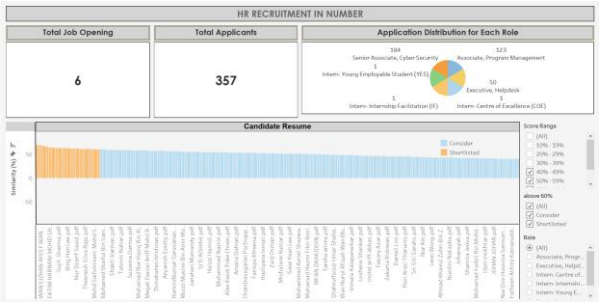

Figure 3: Dashboard visualization of high potential candidates and job application insights

The fourth objective was achieved by presenting CELESTAR's results through an interactive dashboard. The dashboard provided HR with a clear overview of candidate rankings, job application distributions, and filtering options that allowed deeper analysis. This transformed technical similarity scores into simple and actionable insights that recruiters could easily interpret, supporting both technical and non-technical decision-making. From Figure 3, candidates highlighted in orange represent shortlisted candidates and those in blue represent candidates who may be considered. Finally, feedback was gathered from three internal stakeholders, including the Head of Department and two Assistant Vice Presidents. The feedback questions focused on the proposed framework, the CELESTAR system, the identification of high-potential candidates, and the dashboard visualisation. All respondents answered positively to each question, confirming that the framework and system are effective and practical for real-world HR use. Figure 4 shows

the internal stakeholder feedback on the proposed framework, the effectiveness of the BERT model, the candidate identification in the CELESTAR system, and the visualisation dashboard.

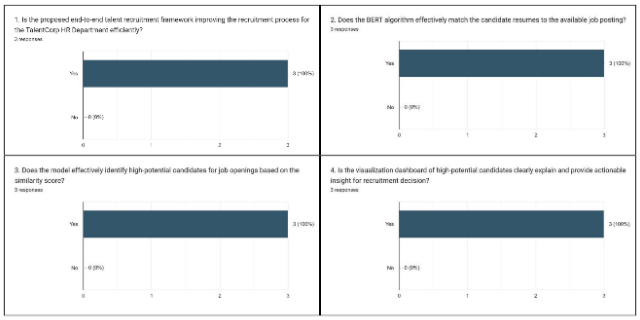

Figure 4: Internal Stakeholder Feedback Summary

Overall, the proposed end-to-end talent recruitment framework and CELESTAR system have shown that recruitment can be made more systematic, efficient and effective. By combining deep learning model with user friendly system interface and insighful dashboard, the solution reduces HR manual screening, speeds up decision-making, and ensures fairer shortlisting of candidates. This project uniqueness lies in combining the TF-IDF model and the BERT model within an end-to-end framework, supported by a user-friendly interface and insightful dashboards. Importantly, the outcomes align with Malaysia's digitalisation agenda under NIMP 2030 and contribute to the Sustainable Development Goals, namely SDG 8 on Decent Work by promoting fairer and more efficient hiring, SDG 9 on Industry Innovation by embedding AI into recruitment processes.

CONCLUSION

This project successfully achieved its objectives of proposing an end-to-end talent recruitment framework, developing the CELESTAR system, identifying high-potential candidates, and presenting the high-potential candidates through dashboard visualisation. The proposed framework provided a structured workflow from headcount request to induction session, while CELESTAR system, powered by BERT model, demonstrated reliable matching accuracy by aligning candidate resumes with job descriptions and supporting HR in making faster, fairer, and more data-driven hiring decisions. The dashboards further enhanced decision-making by transforming similarity scores into clear, actionable insights for both technical and non-technical stakeholders. Collectively, these outcomes reduce manual workload, improve recruitment efficiency, and lower costs, proving the effectiveness of integrating AI into recruitment. The novelty of this work lies in combining advanced deep learning with interactive dashboards in a real-world HR context, positioning CELESTAR as a practical solution beyond academia. Importantly, this project aligns with the New Industrial Master Plan (NIMP) 2030 and contributes to the Sustainable Development Goals (SDGs) by promoting digitalisation, fair employment practices, and inclusive workforce participation. The findings and system developed hold potential to benefit not only Talent Corporation Malaysia Berhad but also wider industries, SMEs, and educational institutions seeking to modernise recruitment and talent placement.

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OPTIMIZATION OF GOLD INVESTMENT RETURNS IN PEGADAIAN INDONESIA USING ARIMA MODEL AND INVESTOR RISK PROFILES

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ABSTRACT

This study classifies gold investors at Pegadaian based on their risk profiles: conservative, moderate, and aggressive. Conservative investors prioritise capital safety by choosing fully paid gold savings to avoid debt risks and price fluctuations. Moderate investors combine cash purchases with short-term installments (6–12 months) to potentially gain when gold price increases exceed installment costs. Aggressive investors use leverage to expand assets, thus increasing both profit and loss potential. In addition to these types, there are also Sharia-compliant investors who prefer instruments free from riba, gharar, and maysir, such as cash-based gold purchases. Gold price prediction for Antam and gold savings is conducted using the ARIMA model based on daily data from sahabat.pegadaian.co.id, analysed with Minitab and Python. Results indicate that the ARIMA model can predict price movements. After obtaining the predictions, margin comparisons are made by calculating the difference between buying and selling prices of Antam gold and gold savings. These margin differences assist in classifying investor characteristics by highlighting their risk levels and capital utilisation preferences.

Keywords: Investor Profile, Gold Savings, ARIMA Model, Gold Price Prediction, Investment Margin

INTRODUCTION

Pegadaian Indonesia is a government-owned non-bank financial institution established in 1901 during the Dutch colonial era as a provider of pawn-based credit. After independence, it became a state-owned enterprise and has held the status of PT Pegadaian (Persero) since 2012. In 2019, Pegadaian joined the ultra-micro holding ecosystem under the BRI Group to strengthen national financial service synergies (Karnawijaya & Rokhaniyah, 2021; Amelia, Apriani, & Finanto, 2024). Over time, Pegadaian expanded into micro-financing, Sharia services, and gold investment. Digital innovations have also enhanced customer satisfaction and loyalty through E-ServQual-based services emphasising efficiency, system reliability, service resolution, and privacy (Amelia, Apriani, & Finanto, 2024). Gold is a popular investment instrument in Indonesia due to its safe, stable, and liquid nature; during economic uncertainty, it serves as a safe haven and a hedge against inflation (Arianti & Nurfadillah, 2022; Hermawan & Wahyuni, 2021). Research indicates that gold can deliver competitive returns compared to stock indices in the long term (Gunawan & Setiawan, 2020) while maintaining stability during crises, including the COVID-19 pandemic (Yuliana & Robiyanto, 2021). The consistent rise in gold prices reinforces its perception as a stable long-term investment, particularly during periods of high inflation and rupiah depreciation (Siagian, 2025). Public interest is also influenced by financial literacy, especially through pawnshops and Islamic banks (Ramadhani & Lestari, 2023; Mardiya, Amani, & Vidiyastutik, 2025). Beyond security and accessibility, long-term motivation and adherence to Sharia principles encourage Muslim investors to choose Sharia Pawnshop products (Rosilawati, 2024). Thus, gold investment in Indonesia, particularly through pawnshops, plays a dual role as a safe and liquid financial instrument while also enabling broader community participation in long-term investment.

In this research, investors are classified into conservative, moderate, and aggressive groups based on their risk preferences in gold investment. Conservative investors prioritise capital security and avoid volatility.

Moderate investors balance safety and growth by combining cash purchases with short-term installments (6–12 months) to lock in prices, though profitability depends on price increases exceeding installment costs. Aggressive investors accept volatility for higher returns, often using leverage or credit (30–40% down payment) to magnify gains or losses, thus requiring strong market knowledge and financial resilience. Islamic investors reject riba, gharar, and maysir, preferring cash-based savings or physical gold aligned with Sharia (ICDX, 2025). Moreover, understanding gold price forecasts is crucial since gold is considered a safe instrument against inflation and global economic fluctuations; predictions guide timing, strategy, and portfolio adjustment (Jana Kane, 2025).

This study applies time series analysis to model daily Antam gold prices and gold savings at pawnshops using Autoregressive Integrated Moving Average (ARIMA), which captures short-term patterns and long-term trends. Since gold prices fluctuate due to factors such as inflation, exchange rates, and economic conditions, forecasting is essential to anticipate future movements and reduce uncertainty (Surahman et al., 2025). ARIMA is commonly referred to as the Box-Jenkins method, which is a forecasting method based on time series (Maharani, 2024). The data used consists of daily selling price data obtained from the website www.sahabat.pegadaian.co.id. The modeling was conducted with the assistance of Minitab and Python software to support statistical analysis and data visualisation. The forecasting process begins with data collection, stationarity testing, ARIMA model formation. Stationarity is tested through two approaches, namely Box-Cox transformation and differencing. Box-Cox was used to stabilise the variance of non-stationary data. Differencing is a method employed to stabilize the mean of non-stationary data (Nurman & Nusrang, 2022). The Box-Cox transformation and differencing method is formulated as:

$$Z_t^{(\lambda)} = \frac{Z_t^{(\lambda)} - 1}{\lambda} \tag{1}$$

$$\Delta Z_t = Z_t - Z_{t-1} \tag{2}$$

$$\Delta^2 Z_t = \Delta Z_t - Z_{t-1} = (Z_t - Z_{t-1}) - (Z_{t-1} - Z_{t-2}) \tag{3}$$

Z_t = value at time t
λ = Box-Cox transformation parameter

Model identification is carried out through the analysis of the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) to identify autocorrelation patterns and determine the appropriate orders in ARIMA modeling, namely the autoregressive order (p), differencing (d), and moving average (q). In general, the ARIMA model is expressed as:

$$(1 - B)^d Z_t = \varphi_1 Z_{t-1} + \ldots + \varphi_p Z_{t-p} + e_t + \theta_1 e_{t-1} + \ldots + \theta_p e_{t-p} \tag{4}$$

Z_t = value at time t; q = MA order; d = differencing order; θ = parameter in MA
B = backshift operator; e_t = error at time t; p = AR order; φ = coefficient in AR

Moreover, margin analysis between gold's buying and selling prices is conducted to estimate the time required for investors to resell their gold and generate profit using the following formula:

$$Margin = \frac{selling\ price - purchase\ price}{purchase\ price} x\ 100\% \tag{5}$$

RESULTS AND DISCUSSION

This research was conducted by collecting price data for two gold instruments, namely savings gold and Antam Pegadaian bullion, in the form of daily data taken from August 2024 to August 2025. This period

was chosen to represent price movements over a full year, allowing for data that reflects the dynamics of the gold market over a sufficiently long timeframe. This mapping provides an overview of the trends, fluctuation patterns, and price movement differences between the two gold instruments, serving as a foundation for further analysis. Subsequently, price forecasting is conducted using ARIMA method on four types of price data collected, with a forecasting horizon of five days following the conclusion of the data collection period. The forecasting results indicate the short-term price movement tendencies for each instrument, which then serve as a reference for profitability analysis.

Based on the margin analysis results, Antam Pegadaian gold bars have a larger margin compared to savings gold, with an average of 7.28 and a standard deviation of 2.57, while savings gold has an average of 3.83 and a standard deviation of 0.04. This larger margin leads to a longer duration required to reach the break-even point and necessitates a more substantial price increase to begin generating profits. Conversely, savings gold, with a lower margin, holds the potential to achieve the break-even point and profitability in a relatively shorter period. Nevertheless, if the trend of bullion gold price increases shows a more pronounced uptick, the break-even point and profit potential may be realised more swiftly than initially projected.Gold investment has become a preferred choice for many people due to its perceived safety and profitability. However, each investor possesses distinct characteristics and varying levels of risk tolerance.

Table 1: Predictions for Gold Selling and Buying Prices

Gold Savings Price (Buy)	Gold Savings Price (Sell)	Antam Gold Price (Buy)	Antam Gold Price (Sell)
1.800.050	1.867.535	1.987.506	2.002.414
1.801.880	1.869.685	1.986.986	2.008.853
1.803.180	1.870.853	1.986.929	2.014.210
1.804.550	1.872.390	1.986.923	2.018.952
1.805.910	1.873.788	1.986.922	2.023.255

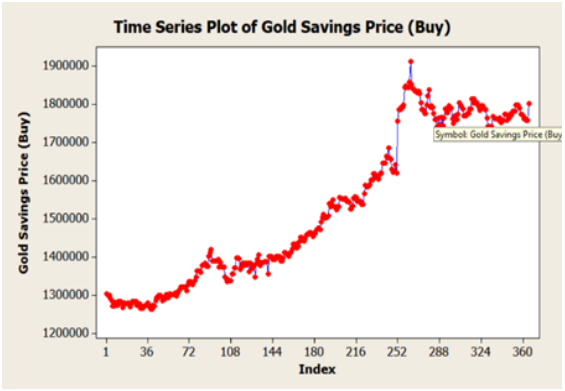

Figure 1: Time Series Plot of Gold Savings Price (Buy)

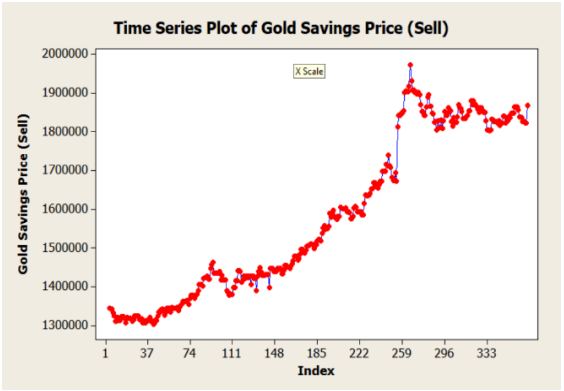

Figure 2: Time Series Plot of Gold Savings Price (Sell)

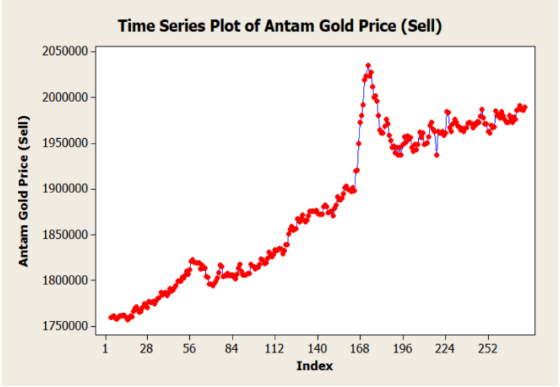

Figure 3: Time Series Plot of Antam Gold Price (Sell)

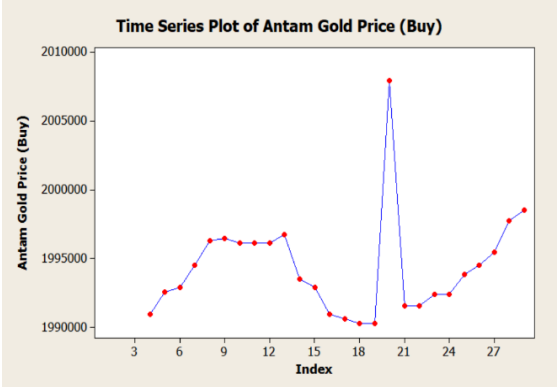

Figure 4: Time Series Plot of Antam Gold Price (Buy)

Table 2 compares options for gold savings and gold bullion based on conservative, moderate, aggressive, and sharia-compliant investor profiles.

Table 2: Investment Option Based on Characteristics of Investor

Gold Savings	Gold Bar
Conservative	
Cash gold savings are highly recommended for conservative investors as they prioritise safety. Without interest or installments, all gold price increases become net profit with very low risk.	Buying gold bullion in cash is advisable as it ensures full ownership, provides profit from long-term price appreciation, and involves no extra costs like interest or installments. Installments may benefit if interest is lower than gold's price increase, but they are still less recommended since conservative investors usually avoid debt risks.
Characteristic of investor: Moderate	
Gold savings are less recommended for moderate investors, as they usually seek higher returns, while savings offer only small gains without leverage.	Cash purchase of gold bullion is more suitable for moderate investors, as it offers higher profit potential from price increases and better resale margins than gold savings. Installments can benefit moderate investors if the 6–12 month gold price increase exceeds the interest cost, allowing them to lock in a lower initial price and gain from appreciation.
Characteristic of investor: Aggressive	
It is not highly recommended due to limited returns. Aggressive investors are better suited for instruments that offer high profit potential.	Cash gold can give profits from price increases, but it is less recommended for aggressive investors since returns are relatively stable and not optimal. Aggressive investors may benefit from installments or credit using low-interest external loans. If gold returns exceed loan interest, leveraging debt allows significant profit from large purchases.
Characteristic of investor: Sharia	
Cash, because it is advantageous in accordance with Islamic principles: without interest, without installments, and immediately benefiting from the increase in gold prices.	Cash because of pure profit from the increase in gold prices without any element of usury. Suitable for investors with a shariah-oriented focus.

CONCLUSION

Based on the research findings, it can be concluded that there are four types of gold investors in Pegadaian Indonesia, namely conservative, moderate, aggressive, and sharia. Each type of investor has different characteristics and levels of risk tolerance in managing their investments. On the other hand, the trend of gold prices, both in the form of gold bars and gold savings, shows an increasing tendency, thus reinforcing gold as an attractive investment instrument. Each investor needs to understand their risk profile accurately so that the chosen investment strategy aligns with their goals and level of comfort, thereby maximising the potential return on investment.

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StockXplore: BIG DATA-POWERED VIKOR SYSTEM FOR SMARTER STOCK SELECTION

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ABSTRACT

StockXplore: Big Data-Powered VIKOR System for Smarter Stock Selection addresses the challenge of identifying the best stocks when faced with multiple and often conflicting criteria. Stock decision-making is complex, as investors must consider various financial indicators such as profitability, risk, and return potential simultaneously. To overcome this, the study applies the VIKOR Multi-Criteria Decision-Making (MCDM) method, which enables a structured evaluation and fair ranking of stock alternatives. The system processes stock data through normalisation, determines the best and worst values, and calculates three key measures: group utility (S), individual regret (R), and the compromise index (Q). The final outcome is a ranked list of stocks, where the top-ranked option represents the most suitable choice. Findings demonstrate that integrating VIKOR with MCDM produces a transparent, reliable, and data-driven decision support tool that benefits investors, policymakers, and financial analysts in making smarter and more sustainable stock decisions.

Keywords: Stock Selection, Big Data, VIKOR, MCDM, Decision Support System

INTRODUCTION

Stock market presents complex choices for investors, who must weigh multiple factors like earnings, risk, and potential returns. Traditional ways of evaluating stocks often focus on just one factor, which can lead to decisions that are unclear or unfair. To improve this, researchers use Multi-Criteria Decision-Making (MCDM) methods, which offer organised, data-driven approaches to compare stocks using multiple criteria simultaneously.

One of the trusted MCDM methods is VIKOR, known for finding balanced solutions by weighing both overall benefit and the worst-case scenario. A recent study examined several MCDM methods including VIKOR for choosing the best design strategies in energy-efficient buildings and found that VIKOR performed reliably in ranking solutions under different conditions (Rachman et al., 2024). Another systematic review in healthcare highlighted that modern MCDM tools like VIKOR are widely used for making fair and structured recommendations in complex decision settings (Chakraborty et al., 2023), it provides strong validation for MCDM use in critical areas.

In line with this, StockXplore has been developed as a user-friendly web platform that applies the VIKOR technique to rank stocks. Users upload stock data, choose how important each criterion is, and the system computes scores **S** for group utility, R for individual regret, and Q for the final rank then displays results using interactive charts and tables.

The objectives of this project are twofold:

i. To develop a decision support system for stock selection using the VIKOR MCDM method
ii. To provide investors with a systematic and transparent approach for ranking and selecting the most suitable stocks.

By fulfilling these objectives, the project aims to deliver a practical tool that empowers investors to make smarter, data-driven, and sustainable decisions

RESULTS AND DISCUSSION

The StockXplore system provides an easy, step-by-step workflow to guide users in stock evaluation. First, users upload stock datasets as input. Next, they select and assign weights to evaluation criteria according to their preferences. The system then normalises the data to ensure fair comparisons. After this, the VIKOR method computes three important values: S (Group Utility), representing overall performance; R (Individual Regret), representing the worst-case scenario; and Q (Compromise Index), which provides the final ranking of stocks. Finally, the results are displayed in clear tables and interactive charts, where users can dynamically adjust the weights and immediately observe changes in stock rankings. Figure 1 shows the workflow of StockXplore, highlighting the step-by-step process from data input to stock ranking using the VIKOR method.

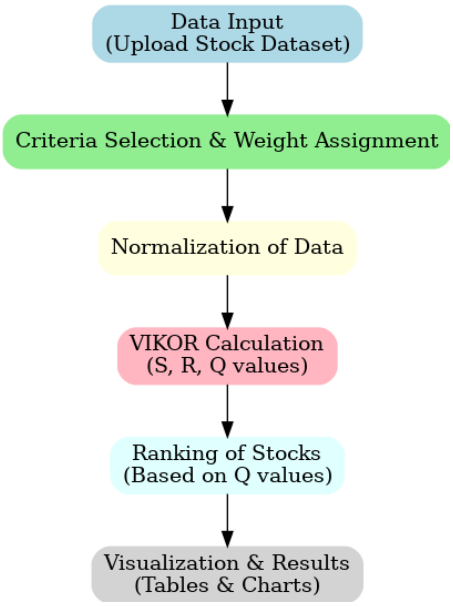

Figure 1: Flowchart of StockXplore

StockXplore evaluates multiple aspects of stock performance such as profitability, value, and risk. Each criterion is labeled as either a benefit (higher values are preferred) or a cost (lower values are preferred), enabling balanced and fair comparisons across indicators. By analysing all these factors together, the system provides a comprehensive view of stock strengths and trade-offs, supporting more accurate and transparent investment decisions. Figure 2 shows the StockXplore interface, which offers a simple and interactive platform for stock data input, analysis, and visualisation. While Fig. 3 shows the StockXplore output.

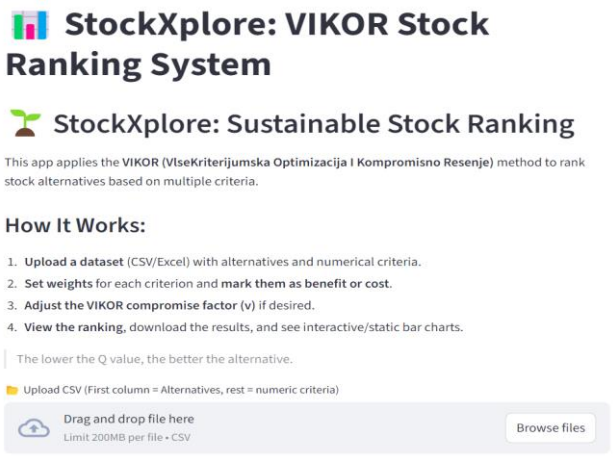

Figure 2: StockXplore inteference

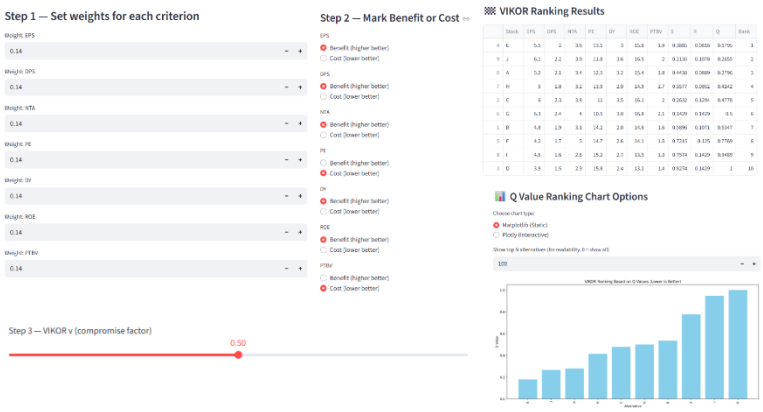

Figure 3: StockXplore output

The StockXplore platform is simple, interactive, and web-based, making it easily accessible to a wide range of users. The system can be accessed online via the following link: 👉 https://stockxplore-humairanajihah.streamlit.app/

The novelty of StockXplore lies in its ability to integrate the VIKOR method with a web-based, interactive platform, moving beyond traditional stock evaluation approaches that often rely on a single financial indicator. Instead, StockXplore simultaneously considers multiple performance criteria such as profitability, value, and risk, classifying each as either a benefit (where higher values are better) or a cost (where lower values are better). By balancing group utility with individual regret, the system ensures fairer and more reliable rankings. Furthermore, the inclusion of interactive features, such as dynamic weight adjustment and instant visualisation, makes StockXplore both practical and user-friendly. These features provide a comprehensive view of stock strengths and trade-offs, thereby bridging the gap between theoretical MCDM methods and real-world financial decision-making.

CONCLUSION

StockXplore is a web-based decision support system that helps investors choose the best stocks using the VIKOR Multi-Criteria Decision-Making (MCDM) method. Unlike traditional evaluation approaches that focus on a single financial indicator, StockXplore compares multiple criteria such as profit, risk, and value. By balancing both group benefit and individual regret, the system provides fairer and more reliable results.The process is simple yet powerful: users upload data, set the importance of each criterion, and the system automatically calculates and ranks stocks. Results are presented through clear tables, visual charts, and interactive features that allow investors to adjust weights and instantly observe changes.

This project demonstrates how VIKOR can be applied in a practical and accessible way for financial decision-making. By reducing bias, enhancing transparency, and minimising human error, StockXplore offers a data-driven, user-friendly, and sustainable approach to stock evaluation. Ultimately, it serves as an innovative tool to support researchers, policymakers, and investors in making evidence-based financial decisions.

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UiTMS-MHAE: AN ASSESSMENT TOOL FOR ESTIMATING MENTAL HEALTH AWARENESS AMONG UiTM SEREMBAN STUDENTS

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ABSTRACT

Mental health issues among undergraduate students in Malaysia have become increasingly common in recent years, and most of the students have experienced conditions such as anxiety, depression, and stress. It is due to the increase in academic burden, students' lifestyle, family institution, and media exposure. This article aims to develop a regression model for mental health awareness among students at the Universiti Teknologi MARA (UiTM) Seremban Campus. An online questionnaire was utilised to conduct a cross-sectional study, and respondents were selected through non-probability purposive sampling. Based on multiple linear regression analysis, all examined independent variables have a significant impact on mental health awareness. Thus, more programs and activities should be developed to help students understand and manage their mental health. Furthermore, an assessment tool was also created to estimate students' mental health awareness levels based on the regression model obtained. Students who have a greater understanding of stress can manage it more effectively and perform better in their studies and everyday lives.

Keywords: Assessment Tool, Academic Burden, Student's Lifestyle, Family Institution, Media Exposure.

INTRODUCTION

It has been recognised that mental health issues are widespread among university students globally, representing a major public health concern (Montagni et al., 2019). There are tons of stressors at university, including academic pressure, financial challenges, and social adjustments, which can increase the risk of stress, anxiety, and depression. In a previous study, university students in Malaysia reported suffering from significant depression, anxiety, and stress, with 46% reporting depression, 61% reporting anxiety, and 40% reporting stress. (Azlan et al., 2024). Furthermore, according to Mohamad et al. (2021), 29% of the university students were at risk of anxiety. Therefore, these statistics highlight the significance of mental health issues faced by students in Malaysia, with increasing levels of stress, anxiety, and depression. Besides, a recent study shows a rise in mental health problems among students at various educational levels, with anxiety, depression, and stress being common disorders (Asif et al., 2020). The rise in mental health complications in students has highlighted the critical necessity for measuring mental health awareness.

It is essential to use effective assessment tools to identify students at risk and to provide them with timely interventions. Digital technologies and innovative tools have proven useful in assessing and supporting the mental health of students (Stallman & King, 2016). However, existing assessment tools may not meet the needs of today's students, are not tailored to specific student populations, and lack sufficient accessibility for practical use. Consequently, it is essential to develop a tool that reflects recent data, especially following the COVID-19 pandemic, and is accessible and easy to use for accurately assessing students' mental health. Thus, this study bridges the research-practice gap in mental health management by developing a specialized assessment tool for UiTM Seremban students.

OBJECTIVES

This study aims to construct a regression model that examines mental health awareness among UiTM Seremban students. Its primary objective is to develop an assessment tool based on the regression model that can be used to estimate the level of mental health awareness among these students.

DESCRIPTION OF THE PRODUCT

Description of the Data Used

375 undergraduates from all faculties at UiTM Seremban were selected using a purposive sampling technique involved in this study. An online questionnaire created using Google Forms was utilised to gather the data. The questionnaire employed a 6-point Likert scale to measure all questions related to the dependent variable (mental health awareness) and the independent variables (academic burden, student lifestyle, family institution, and media exposure). All the questions in this study were adapted from previous studies (Lee et al., 2023 & Ghazali et al., 2024). An analysis of multiple linear regression was performed to model mental health awareness and identify the most significant contributing factors. Statistical significance of the variables was determined using the significance level of 0.05.

Assessment Tool (Product of the Study): UiTM Seremban Mental Health Awareness Estimator (UiTMS-MHAE)

The 'UiTM Seremban Mental Health Awareness Estimator (UiTMS-MHAE)' is an assessment tool using an Excel spreadsheet developed from a multiple linear regression model. It is designed to estimate and measure the level of mental health awareness among UiTM Seremban students based on identified significant factors. The cutoff points used to categorize the level of awareness were based on Pimentel (2019). It helps to connect academic research (the regression model) with real-world usability (the tool) to make it more effective.

NOVELTY

This study offers novelty in both methodological and practical aspects. Methodologically, it employs multiple linear regression to model mental health awareness among UiTM Seremban undergraduates by examining diverse predictors, including academic burden, student lifestyle, family institution, and media exposure. Unlike previous studies, this study provides localized evidence using purposive sampling from all faculties at UiTM Seremban, with data collected through a structured 6-point Likert scale.

Practically, the study advances beyond statistical findings by developing the UiTM Seremban Mental Health Awareness Estimator (UiTMS-MHAE), an Excel-based assessment tool derived from the regression model. This product enables students and stakeholders to estimate levels of mental health awareness based on significant contributing factors and classify them using cutoff points adapted from Pimentel (2019). By bridging research outcomes with real-world application, the tool provides a novel contribution that supports self-assessment, promotes awareness, and guides institutional strategies for student well-being.

RESULTS

Based on Table 1, the results of the regression analysis indicated that all four independent variables significantly and positively influenced students' mental health awareness at UiTM Seremban. Among these factors, the family institution played the most significant role in shaping students' mental health awareness, outweighing other factors.

Table 1: Statistical Significance Table.

	Unstandardized Coefficients Beta	Standardized Coefficients Beta	Standard Error	t-value	p-value
Constant	1.562		0.190	8.200	<0.001
Academic Burden	0.194	0.229	0.036	5.317	<0.001
Students' Lifestyle	0.113	0.124	0.045	2.494	0.013
Family Institution	0.265	0.341	0.038	6.993	<0.001
Media Exposure	0.194	0.243	0.038	5.054	<0.001

The regression equation developed from the significant factors in this study is shown below.

$$\hat{Y} = 1.562 + 0.194X_1 + 0.113X_2 + 0.265X_3 + 0.194X_4 \quad (1)$$

where:
$\hat{Y}$: Mental Health Awareness
X_1: Academic Burden
X_2: Students' Lifestyle
X_3: Family Institution
X_4: Media Exposure

The following is an assessment tool that can be used by students at UiTM Seremban Campus to determine how well they are aware of their mental health.

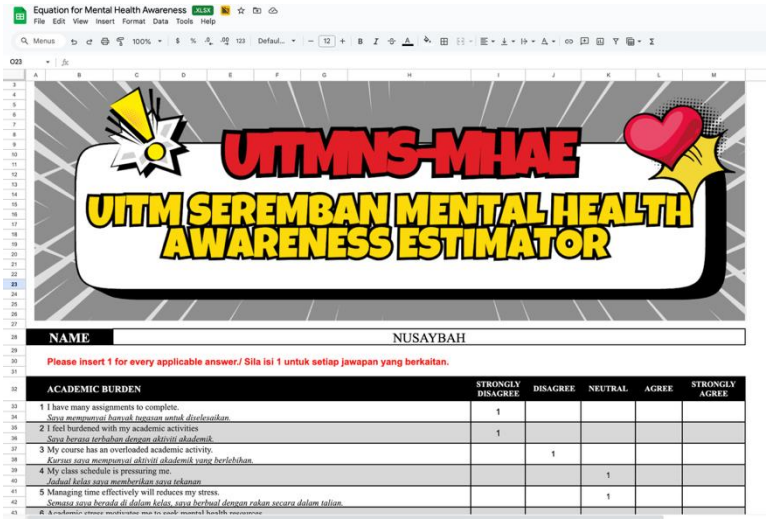

Figure 1: UiTM Seremban Mental Health Awareness Estimator (UiTMS-MHAE)

CONCLUSION

Multiple linear regression analysis confirmed that all selected variables, which are academic burden, student's lifestyle, family institution, and media exposure, were significant contributors to mental health awareness, with family institution being the most influential factor, followed by media exposure, academic burden, and student's lifestyle. The developed regression model was statistically significant, making it a valid tool for understanding the relationship between these factors and mental health awareness. For future research, it is recommended to adopt a longitudinal design, as a cross-sectional study only provides data at a single point in time.

The 'UiTMS-MHAE' tool offers many benefits to students and the institution. It helps identify early indicators of low awareness levels, encourages self-reflection, and enables students to make informed decisions about their mental health. Meanwhile, educators and stakeholders can use it to monitor awareness

levels, develop targeted support programs, and guide interventions. Ultimately, it helps foster a culture of openness, reduces stigma, and supports both student well-being and academic success. It would be beneficial to include participants from both private and public universities in future research, allowing the tool to be tested, refined, and implemented in different university settings.

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RENTAL HOUSE SELECTION USING FUZZY TOPSIS

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ABSTRACT

The increasing number of students living off-campus necessitates effective decision-making tools for selecting suitable rental housing. Students frequently encounter challenges in identifying the most crucial criteria and choosing among numerous available options, as their decisions are heavily influenced by a multitude of factors. While various methods exist for multi-criteria decision-making, no prior research has specifically applied the Fuzzy Technique for Order Preference by Similarity to Ideal Solution (Fuzzy TOPSIS) method to address the problem of optimal rental house selection for students. This study bridges this significant methodological gap by establishing a novel framework for determining the most preferred rental house among students. Key input criteria, including accessibility, facilities, cost, privacy, and environment, were identified as critical factors influencing student choices. The Fuzzy TOPSIS method was then systematically applied to rank various rental house alternatives, specifically Taman Seremban 3, Taman Rasah Jaya, Taman Iringan Bayu, and Taman Desa Rasah based on these weighted criteria. The findings of this study demonstrate that Taman Seremban 3 emerged as the most preferred rental house among students of UiTM Cawangan Negeri Sembilan Kampus Seremban 3. This result confirms the efficacy of Fuzzy TOPSIS in successfully assisting the complex selection process of student rental housing. This pioneering application of Fuzzy TOPSIS provides a robust and objective decision-making tool, with future potential for developing a dedicated system for diverse selection problems and for integration with other weighting methods to further enhance its applicability across various fields.

Keywords: Rental House, Fuzzy TOPSIS, MCDM, Fuzzy Logic, Alternative Ranking

INTRODUCTION

In many countries, students' expectations concerning the quality of the accommodation have been increasing and the number of students who are living outside campus has also risen (Źróbek-Rózańska, 2022). Therefore, rental houses hold significant importance for university students who are unable to secure a place in a campus hostel or those who may live far away from campus.

The process of selecting an ideal rental house involves many criteria that must be considered. As a result, determining the most important criteria to be prioritised often leads to decision paralysis and suboptimal choices. Therefore, decision making methods such as Multiple Criteria Decision-Making (MCDM) are required since this method is known for decision makers to solve highly complex problems (Azhar et al., 2021). However, MCDM alone is insufficient to decide the best rental house because the presence of various criteria often leads to decision paralysis and suboptimal choices resulting in uncertain criteria. Hence, fuzzy logic is needed as it provides the mathematical framework that accommodates both uncertainty and precision (Sahoo et al., 2024).

Fuzzy Multi-Criteria Decision-Making (FMCDM) is a powerful development of fuzzy logic and an approach to decision-making problems. This is agreed by Sahoo et al. (2024), who stated that FMCDM solves the problems in environments with multiple criteria by providing a systematic framework for ranking alternatives. Furthermore, Junior et al. (2014) demonstrated that the Fuzzy TOPSIS is an efficient method in solving the problems of alternative selection concerning the changes in the alternatives and criteria. This study aimed to analyse the most preferred rental housing area among students at UiTM Cawangan Negeri Sembilan Kampus Seremban 3 based on the important criteria using Fuzzy TOPSIS methodology.

METHODOLOGY

In a study of renter′s preferences, accessibility, facility, cost, privacy and environment were identified as the key criteria. The alternatives for this study were four specific locations for students housing in area Taman Seremban 3, Taman Rasah Jaya, Taman Iringan Bayu and Taman Desa Rasah. The methodology for this study follows the eight steps for Fuzzy TOPSIS (Tanveer et al. 2023; Kore et al. 2017). First step is the fuzzy average weight, W is determined by calculating the weight for each criterion, j, as Equation (1), where k is number of experts, l is number of criteria, w_j^k is the weight of the criteria and j is rated by the experts, k and $j = 1, 2, \cdots, l$.

$$W = \left[W_1, W_2, W_3, \cdots, W_l\right]$$

$$W_j = \frac{1}{k}\left[w_j^1 + w_j^2 + w_j^3 + \cdots + w_j^k\right] \tag{1}$$

After that the fuzzy rating alternative, X_{ij} is constructed for all alternatives, i by using Equation (2), and x_{ij}^k, written as $\left(a_{ij}, b_{ij}, c_{ij}\right)$ represents the raw data collected from questionnaires.

$$X_{ij} = \frac{1}{k}\left[x_{ij}^1 + x_{ij}^2 + \cdots + x_{ij}^k\right] \tag{2}$$

This fuzzy rating alternative is then organized into a matrix, D as follows:

$$D = \begin{bmatrix} x_{11} & \cdots & x_{1j} \\ \vdots & \ddots & \vdots \\ x_{i1} & \cdots & x_{ij} \end{bmatrix}$$

Then, the fuzzy rating for each alternative across all criteria, r_{ij}, was normalised by using Equation (3) and Equation (4) where, $c_j^* = \max c_{ij}$ if $j \in B, B$ is for the benefit criteria and $a_j^- = \min a_{ij}$ if $j \in C, C$ is for the cost criteria.

$$r_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right), j \in B \tag{3}$$

$$r_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right), j \in C \tag{4}$$

Calculating all normalized fuzzy rating alternative, r_{ij}, is calculated to form the normalized fuzzy rating alternative matrix, R where m is number of rows for alternatives, i and n defines number of columns for criteria, j,

$$R = \left[r_{ij}\right]_{m \times n}$$

Next, the weighted normalised fuzzy matrix, V, is constructed using Equation (5) where u_{ij} is weighted fuzzy rating for each alternative across all criteria, get from $u_{ij} = r_{ij} \cdot W$ and r_{ij} is fuzzy rating for each alternative across all criteria and w_j denotes weight for each criterion

$$V = \left[u_{ij} \right]_{m \times n} \tag{5}$$

The FPIS, A^* and FNIS, A^- for each criterion, j are calculated using the following Equation (6) and Equation (7), respectively.

$$\begin{aligned} \mathrm{A}^* &= \left[\mathrm{A}_1^*, \mathrm{A}_2^*, \cdots, \mathrm{A}_l^* \right] \\ \mathrm{A}_j^* &= \left(\max_i u_{ij}^a, \max_i u_{ij}^b, \max_i u_{ij}^c \right) \end{aligned} \tag{6}$$

$$\begin{aligned} \mathrm{A}^- &= \left[\mathrm{A}_1^-, \mathrm{A}_2^-, \cdots, \mathrm{A}_l^- \right] \\ \mathrm{A}_j^- &= \left(\min_i u_{ij}^a, \min_i u_{ij}^b, \min_i u_{ij}^c \right) \end{aligned} \tag{7}$$

For each alternative, i and each criterion, j the calculation between the fuzzy weighted normalised value, u_{ij} with FPIS, $\mathrm{A}^*\left(d\left(u_{ij}, \mathrm{A}_j^*\right)\right)$ and FNIS, $\mathrm{A}^-\left(d\left(u_{ij}, \mathrm{A}_j^-\right)\right)$ is by using Equation (8) and Equation (9), respectively as follows:

$$d\left(u_{ij}, \mathrm{A}_j^*\right) = \sqrt{\frac{1}{3}\left[\left(a_1 - a_2\right)^2 + \left(b_1 - b_2\right)^2 + \left(c_1 - c_2\right)^2 \right]} \tag{8}$$

$$d\left(u_{ij}, \mathrm{A}_j^-\right) = \sqrt{\frac{1}{3}\left[\left(a_1 - a_2\right)^2 + \left(b_1 - b_2\right)^2 + \left(c_1 - c_2\right)^2 \right]} \tag{9}$$

Then, the distance between the fuzzy weighted normalised value are calculated and form the matrix $d^* = \left[d\left(u_{ij}, \mathrm{A}_j^*\right) \right]_{m \times n}$ and $d^- = \left[d\left(u_{ij}, \mathrm{A}_j^-\right) \right]_{m \times n}$. By using Equations (10) and (11), the total distance between each alternative with FPIS $\left(D_i^*\right)$ and FNIS $\left(D_i^-\right)$ is calculated as,

$$D_i^* = \sum_{j=1}^{l} d\left(u_{ij}, \mathrm{A}_j^*\right) \tag{10}$$

$$D_i^- = \sum_{j=1}^{l} d\left(u_{ij}, \mathrm{A}_j^-\right) \tag{11}$$

Calculating all the total distance between alternative with FPIS $\left(D_i^*\right)$ and FNIS $\left(D_i^-\right)$ for each alternative, i form matrix, $D^* = \left[D_1^* \quad D_2^* \quad \cdots \quad D_i^* \right]$ and $D^- = \left[D_1^- \quad D_2^- \quad \cdots \quad D_i^- \right]$ respectively. Relative closeness to the ideal solution, CC_i for each alternative, i is calculated using Equation (12).

$$CC_i = \frac{D^-}{D^* + D^-} \quad (12)$$

RESULTS AND DISCUSSION

A questionnaire was distributed to five selected students from UiTM Seremban 3 campus. These individuals were chosen as experts because they are final year students with prior experience in selecting rental houses, making their insights valuable and reliable for this study's purpose. The findings from their responses form the basis of the analysis and ranking of the rental properties. The final ranking is shown in Table 1.

Table 1: The final ranking of alternatives from Fuzzy TOPSIS

Alternative	Relative Closeness to Ideal Solution	Rank
Taman Seremban 3	0.75	1
Taman Rasah Jaya	0.57	2
Taman Iringan Bayu	0.43	3
Taman Desa Rasah	0.41	4

Based on Table 1, it shows that Taman Seremban 3 is ranked first among all alternatives with the highest relative closeness to ideal solution, 0.75. followed by Taman Rasah Jaya, 0.57 and Taman Iringan Bayu, 0.43 respectively. Taman Desa Rasah is ranked as the last, 0.41 out of all which means Taman Desa Rasah is the least preferred house. Table 2 shows the comparison for the ranking of alternatives using both Fuzzy TOPSIS and TOPSIS methodology.

Table 2: The comparison in result between Fuzzy TOPSIS and TOPSIS

Alternative	Fuzzy TOPSIS		TOPSIS	
	Relative Closeness to Ideal Solution	Rank	Relative Closeness to Ideal Solution	Rank
Taman Seremban 3	0.75	1	0.9989	1
Taman Rasah Jaya	0.57	2	0.7272	2
Taman Iringan Bayu	0.43	3	0.0033	4
Taman Desa Rasah	0.41	4	0.0035	3

The result from Table 2 shows that the ranking of Taman Seremban 3 and Taman Rasah Jaya remained its first and second most preferred rental houses. However, Taman Iringan Bayu and Taman Desa Rasah ranking have changed the position of third and fourth. Other than that, the results also show a drastic change in the value of relative closeness to the ideal solution for all alternatives. The value changed because in the TOPSIS method, the value of the rating of the criteria and alternatives is different with Fuzzy TOPSIS. The TOPSIS method relies on precise input data. Small differences in criteria or alternatives rating result in precise differences in the relative closeness to the ideal solution. Fuzzy TOPSIS works with fuzzy values so the closeness to the ideal solution reflects on the uncertainties and range. Hence, when the fuzzy value was defuzzified, the values slightly change due to the range of fuzzy numbers (Tanveer et al., 2023).

CONCLUSION

This study successfully demonstrates ranking rental houses for students by applying Fuzzy TOPSIS to a real world problem that has not been addressed by this method before. The study identifies five key criteria for the decision making process which are accessibility, facility, cost, privacy and environment. The findings confirm that Fuzzy TOPSIS is a useful tool for evaluating and ranking rental options. The results showed that Taman Seremban 3 was the most preferred rental house, followed by Taman Rasah Jaya, Taman Iringan Bayu and Taman Desa Rasah. This study also highlighted the differences between Fuzzy TOPSIS and traditional TOPSIS. While the top two rankings remained the same, the positions of the third and fourth options swapped. This change occurred because Fuzzy TOPSIS considers the uncertainty and variability in the decision making process, whereas the traditional method relies on precise data. Overall,

this study concluded that the Fuzzy TOPSIS model is an effective tool for helping renters make complex decisions when choosing a rental house.

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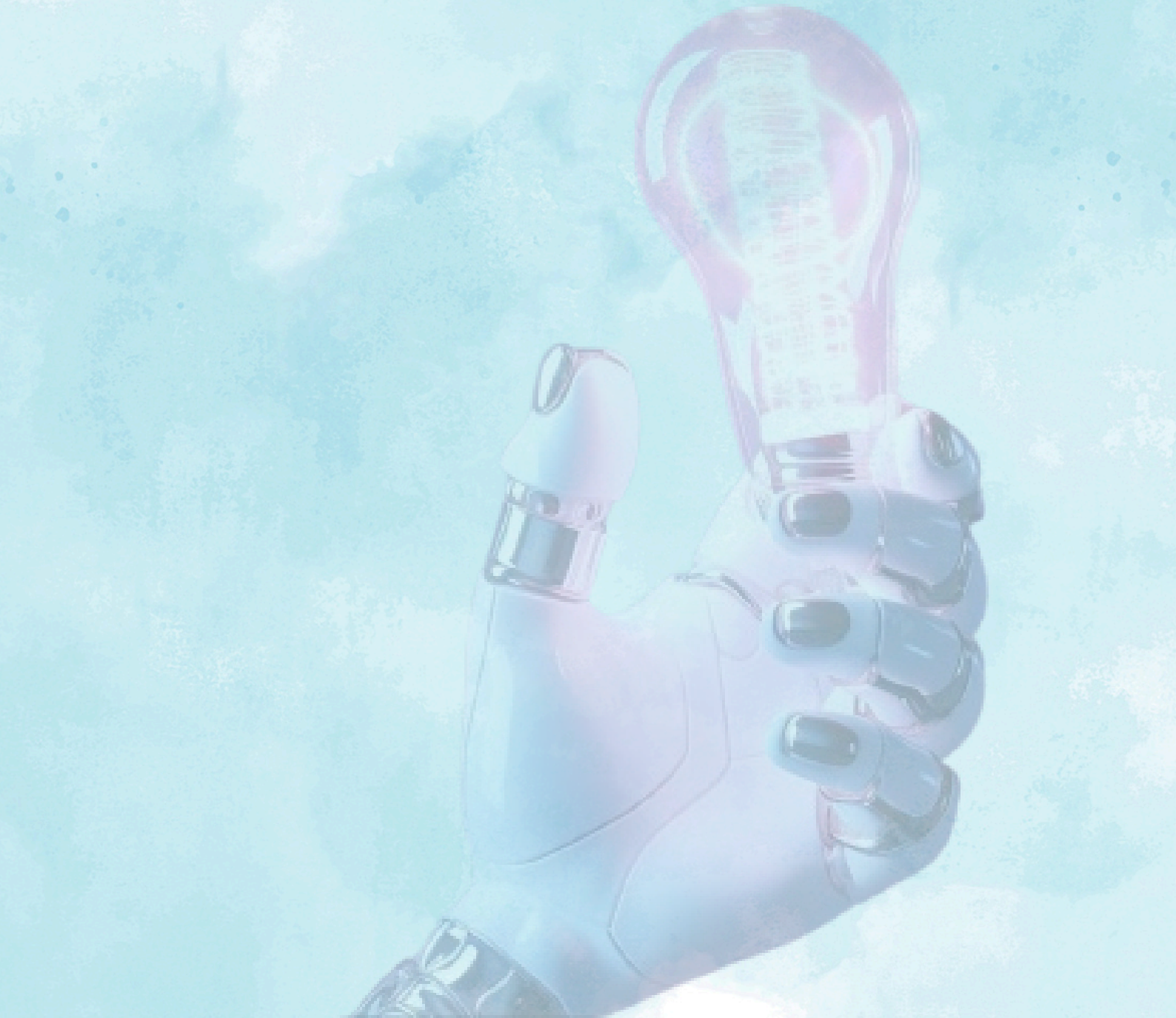

GREENLOOP (KITCHEN COMPOSTER)

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ABSTRACT

The GreenLoop kitchen composter is an innovation in the field of responsible consumption and production. This innovation helped reduce food waste from piling up in landfills. By combining advanced blades, a BioEnzyme carbon filter, a smart sensor, and a built-in digital screen, this product offers convenience to users. With GreenLoop's built-in digital screen and odor filter as the novelty, it stands out distinctly from its competitors. This paper provides a detailed description of the product, including a technology description that explains how the product works, and offers an in-depth explanation of the novelty.

Keywords: Kitchen Composter, Smart Sensor, Advanced Blade, Built-in Digital Screen, BioEnzyme Carbon Filter

INTRODUCTION

The originality of the GreenLoop kitchen composter lies in its ability to transform food waste management into a sustainable yet practical lifestyle solution. Conventional composting methods are often considered inconvenient due to their requirement for outdoor space, lengthy decomposition cycles, and frequent manual handling. For many urban households, especially those living in apartments or small homes, traditional compost bins are impractical due to limited space and the risk of attracting pests. In addition, the unpleasant odors and hygiene concerns associated with food waste often discourage users from composting altogether, resulting in increased food waste disposal in landfills. These challenges highlight the need for an innovative solution that can make composting easier, cleaner, and more adaptable to modern living conditions.

GreenLoop addresses these problems with a novel, user-centered design that combines efficiency, creativity, and sustainability. Its advanced motor with optimized blades accelerates the composting process, while the BioEnzyme carbon filter ensures an odor-free experience that eliminates one of the major barriers to indoor composting. The built-in digital screen with multiple modes provides users with the flexibility to choose composting cycles that match their specific needs, whether for gardening purposes, energy savings, or achieving same-day results. Beyond functionality, its sleek and minimalist design blends effortlessly into contemporary kitchens, reimagining composting as an attractive and convenient practice rather than a burdensome chore. By directly addressing the root causes of user dissatisfaction with traditional composting, GreenLoop demonstrates evident originality and uniqueness in its concept, design, and application.

PRODUCT DESCRIPTION

The uniqueness of this product is further emphasised through its built-in digital screen, which enhances usability and sets it apart from other home composters. Users can select between three creative modes tailored to their needs: Dry Mode, which produces soil-ready compost in 3.5 to 6 hours; Eco Mode, which uses 50% less energy than conventional systems; and Rapid Mode, which completes composting within 8 to 12 hours for same-day use. Additional features, such as a temperature display with safety alerts and a composting time tracker, provide real- time control and monitoring, ensuring both safety and convenience.

This integration of innovative technology demonstrates GreenLoop's creativity in merging practical functions with modern innovation.

In addition to smart controls, GreenLoop integrates an advanced motor with optimised blades that accelerate the breakdown of organic waste into fine, nutrient-rich compost. This innovation not only shortens the overall processing time but also ensures higher efficiency in handling various types of food waste, from vegetable scraps to more challenging organic materials. Complementing this is the BioEnzyme carbon filter, made from natural ingredients, which effectively eliminates odors while extending its lifespan to nearly 55 cycles, equivalent to approximately four months of use, compared to the standard 45 cycles of conventional filters. By reducing the frequency of filter replacements, GreenLoop lowers maintenance costs while minimising environmental waste. Through this combination of advanced technology, smart usability, and eco-friendly design, GreenLoop delivers a practical yet sustainable solution for modern households, redefining composting as both efficient and accessible.

PROJECT OBJECTIVES

The objectives of creating this home composter are to promote sustainable living through effective food waste management and to minimize the effort and time required to manage home food waste.

GreenLoop is a highly relevant innovation that addresses two significant challenges in Malaysia's urban landscape including the increasing volume of household food waste and the impracticality of traditional composting methods in high-rise living environments. As urban households face space limitations and growing environmental concerns, managing organic waste becomes difficult. GreenLoop offers a compact and intelligent solution designed specifically for Malaysian food waste types such as rice, spicy leftovers, and fibrous vegetables. Its innovative composting modes, BioEnzyme filtration system, and real-time monitoring features make it an efficient and hygienic alternative that supports national sustainability efforts.

The benefits of GreenLoop extend across multiple sectors and user levels. For individual households, it provides convenience, cost savings, and improved indoor air quality. Property developers can incorporate it into eco- housing packages to enhance market appeal. Urban farmers and gardening enthusiasts gain access to nutrient-rich compost, which reduces their dependence on chemical fertilisers. Educational institutions and community organisations can use GreenLoop as a tool for environmental education and outreach. Government agencies may also find it valuable for pilot programs and public campaigns focused on waste reduction and sustainable living. Its innovative features and modular design enable future scalability in broader applications, such as smart city initiatives.

NOVELTY AND COMMERCIAL POTENTIAL

The feasibility of implementing this eco-minded solution lies in its strong alignment with the growing awareness of sustainability in Malaysia, particularly in urban areas. Kuala Lumpur and Penang serve as strategic markets due to their distinct yet complementary characteristics. Penang's established leadership in waste management and recycling provides an informed consumer base that is receptive to eco-friendly innovations, making it an excellent ground for meaningful product feedback. Meanwhile, Kuala Lumpur, with its larger population density and diverse demographics, offers scalability potential and access to a wide range of eco-lifestyle partnerships. Together, these two regions provide the right mix of readiness, awareness and market diversity to test, refine and expand the kitchen composter bin.

This further strengthens this product's market potential with its innovative technology. The built-in digital screen not only enhances user convenience with multiple composting modes, including Eco mode that reduces energy use by 50%, Rapid mode for same-day composting, and Dry mode for gardening. However, at the same time, it promotes safe and efficient use through real-time temperature and hazard monitoring. Aside from that, GreenLoop produces the BioEnzyme carbon filter, which lasts longer than conventional alternatives, reducing both replacement frequency and maintenance costs. Therefore, making it more affordable and sustainable for households. Lastly, combined with advanced blade technology, the composter ensures faster and finer waste breakdown, reducing landfill dependency while encouraging communities to adopt a zero-waste lifestyle. On a broader scale, these innovations contribute to global

sustainability goals by minimizing household food waste, lowering carbon emissions and promoting greener consumption habits.

RECOGNITION AND INTELLECTUAL CONTRIBUTION

The GreenLoop kitchen composter has emerged as an effective solution to address the increasing domestic food waste problem. This approach has been well-received in academic pitching sessions due to its user-friendly design, affordable price, and potential to contribute to Malaysia's environmental innovation scene. This early recognition suggests its capacity to create substantial value within the regional sustainability and green technology sectors. From a conceptual standpoint, GreenLoop proposes a streamlined composting methodology designed for metropolitan living spaces. The proposed composting solution's user-friendliness and compact design set it apart from competitors. Furthermore, it establishes the foundation for future intellectual property development centered on product architecture and operational procedures through its environmentally conscious approach. These theoretical characteristics position it as a potentially viable environmental solution.

The proposed initiative demonstrates clear correspondence with multiple United Nations Sustainable Development Goals (SDG). GreenLoop promotes cleaner, healthier urban living by providing households with an effective way of handling food scraps, which helps achieve SDG 11 (Sustainable Cities and Communities). It supports SDG 12 (Responsible Consumption and Production) by encouraging waste reduction and turning kitchen waste into reusable compost. It aligns with SDG 13 (Climate Action) by helping to reduce methane emissions that would otherwise come from landfills. This clear connection to the SDGs strengthens their relevance not only as a business venture but also as an initiative that creates social and environmental value. Having established initial concept validation and positive reception, GreenLoop is well-positioned to pursue development opportunities, including innovation competitions, prototype funding, and partnerships with sustainability-oriented organisations. It is a potentially profitable endeavor that could also benefit the environment and nearby communities by fusing creative environmental engineering with realistic financial considerations.

FRAMEWORK AND METHODOLOGY

The development of the GreenLoop kitchen composter was guided by the New Product Development (NPD) framework, which provided a structured and systematic approach to product innovation. The process began with problem identification and research, where the increasing issue of household food waste and the shortcomings of existing composting solutions were examined. This initial stage ensured that the project was addressing a relevant and significant market need. Building on this, research and development (R&D) was carried out to explore sustainable technologies and integrate eco-friendly mechanisms into the design. These early steps established the foundation for a user-centred product that combines functionality with environmental responsibility.

The second stage involved product design and concept validation. Here, the GreenLoop was conceptualized with unique features, including an advanced motor with optimised blades, a BioEnzyme carbon filter, and a built-in digital display. To evaluate consumer perceptions, concept testing was conducted through a structured survey, which was electronically distributed via Google Forms across various platforms, including WhatsApp and Telegram. The survey explored household profiles, awareness, interest, purchase intention, and perceived value. The results offered data-driven insights and recommendations, ensuring that the design aligned with consumer expectations while highlighting areas for improvement before further investment in production.

The final stage of the methodology centered on prototype development, test marketing, and commercialization readiness. A working prototype was built to validate the technical feasibility and usability of the design. This prototype was subjected to test marketing, during which feedback from target users was gathered to assess its real-world acceptance and potential market performance. Iterative refinements were made based on this feedback, ensuring the product was not only functional but also appealing to consumers.

By employing the NPD framework, the project ensured that each stage of product creation was supported by empirical evidence, iterative refinement, and user feedback, thereby enhancing the clarity, soundness, and appropriateness of the methodology in addressing real-world challenges of food waste management.

IMPACT AND SUSTAINABILITY

The GreenLoop Kitchen Composter has strong potential to create a positive long-term impact by mitigating household food waste and providing a more sustainable waste management practice. It reduces the amount of organic waste generated by consumers daily and converts it into nutrient-rich compost. This will prevent a substantial amount of organic waste from ending up in landfills and thus reduce the methane emissions. This promotes a cleaner environment, leading to lower greenhouse gas emissions, improved hygiene in urban areas, and an overall healthier living environment over a prolonged period of usage, especially in high-density residential occupancy areas.

This project aligns with UN Sustainable Development Goal (SDG) 7: Responsible Consumption and Production, by promoting households to consume more sustainably through reducing food waste at the source. With the help of GreenLoop, users can transform unavoidable waste into a useful resource for gardening and urban agriculture, thereby bringing the circular economy to their communities. It encourages users to separate waste with greater mindfulness and utilize resources more sustainably, while promoting conscious household consumption with a reduced environmental impact.

CONCLUSION

In conclusion, the GreenLoop kitchen composter offers an efficient and practical approach to managing household food waste. The integration of an innovative sensor, a built-in digital display, a BioEnzyme carbon filter, and advanced blades offers comprehensive solutions to various waste management challenges. Ultimately, the product aims to support environmental preservation by promoting effective food waste management practices.

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Furresh: AN ECO-FRIENDLY CASSAVA AND COFFEE-BASED CAT LITTER INNOVATION FOR SUSTAINABLE PET CARE

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ABSTRACT

Pet ownership in Malaysia has been rising steadily, creating an increasing demand for safe, effective, and environmentally friendly pet care products. Conventional cat litter, especially clay or silica-based, poses significant problems as it is non-biodegradable, requires destructive mining, consumes high energy during production, and may release harmful dust that can cause respiratory issues in both pets and humans. This project was initiated to address these concerns by introducing an innovative eco-friendly cat litter named Furresh, developed from cassava pulp and recycled coffee grounds. The main objectives are to reduce dependency on non-biodegradable materials, promote sustainability through agricultural waste upcycling, and provide pet owners with a healthier, chemical-free alternative. Cassava pulp functions as the primary absorbent due to its natural fibrous texture that enhances clumping ability, while coffee grounds act as a natural deodoriser with strong odour-masking properties. Small amounts of corn flour and baking soda are also incorporated to improve texture and odour control. The novelty of Furresh lies in its unique combination of agricultural by-products rarely applied in cat litter formulation, producing a product that is not only biodegradable and compostable but also supports zero-waste initiatives. By utilizing locally available resources, Furresh promotes a circular economy, reduces environmental pollution, and raises awareness of sustainable pet care practices. With its affordability, effectiveness, and eco-friendly attributes, this project has strong potential for commercialisation in the growing pet care industry while contributing to the achievement of multiple Sustainable Development Goals (SDGs).

Keywords: Eco-friendly, Biodegradable Cat Litter, Waste Upcycling, Sustainability, Pet Care

INTRODUCTION

Pet ownership is on the rise globally, and with it, the demand for pet care products, particularly cat litter, has expanded significantly. Traditional cat litter, often made from clay or silica, has been criticised for its environmental impact, including non-biodegradability, landfill accumulation, and carbon-intensive production processes (Wang et al., 2021). Additionally, conventional litters may contribute to dust generation and chemical exposure, raising health concerns for both cats and owners.

In response, eco-friendly alternatives have gained increasing attention as consumers become more environmentally conscious (Yue et al., 2020). Agricultural by-products such as cassava pulp and coffee grounds present a promising opportunity for sustainable product innovation. Cassava pulp, rich in starch, is known for its natural absorbency and clumping properties (Onyango et al., 2019), while coffee grounds have been demonstrated to provide natural odor control due to their porous structure and ability to absorb volatile compounds (Haile, 2014). By repurposing these agricultural wastes, Furresh addresses both environmental and waste management challenges.

While green innovations in the pet industry are emerging, few have combined biodegradability, compostability, and performance in a single product. This study introduces Furresh, an innovative cat litter

formulated from cassava pulp and ground coffee, designed to meet the dual goals of functionality and sustainability. indent the first line of paragraph following a heading or sub heading. Use single spacing for main document. Note that there is only one space between sentences.

OBJECTIVES

The objectives of this innovation are:

i. To develop a cat litter product derived from cassava pulp and coffee grounds that is fully biodegradable and compostable.
ii. To provide an environmentally sustainable alternative to conventional clay and silica-based litters.
iii. To enhance odour control and clumping properties using natural agricultural by-products.
iv. To contribute to sustainable consumption and waste reduction by valorising agro-waste streams.

METHODOLOGY AND DEVELOPMENT

The development of Furresh involved a systematic process:

1. Raw Material Collection and Preparation – Cassava pulp, a by-product of the starch industry, was dried and finely crushed to enhance absorbency and clumping potential. Coffee grounds were collected post-brewing, dried, and sterilized to eliminate microbial contaminants.
2. Formulation Process – The cassava pulp was mixed with corn flour and baking soda to enhance structural integrity and deodorising capacity. Coffee grounds were incorporated for odour absorption and antibacterial properties. The mixture was pelletised to produce the final litter form.
3. Performance Evaluation – Initial trials assessed Furresh for absorbency, clumping ability, odour control, and biodegradability. Testing methods were adapted from established standards for pet litter evaluation (ASTM, 2015). Comparative analysis was conducted with commercial clay-based litter to benchmark performance.
4. Sustainability Assessment – Environmental impact was qualitatively evaluated by considering biodegradability, composability, and potential for reducing agro-waste.

INNOVATION AND SIGNIFICANCE

Furresh provides several significant innovations:

- Biodegradable and Compostable – Unlike clay-based litter, which is non-renewable and landfill-dependent, Furresh decomposes naturally and can be repurposed as compost, thus contributing to circular economy practices.
- Natural Odor Control – Coffee grounds provide effective absorption of ammonia and other odour-causing compounds, reducing the need for chemical additives.
- Clumping Functionality – The starch-rich cassava pulp allows for effective clumping, making cleaning convenient for pet owners.
- Waste Valorisation – By utilizing agro-waste (cassava pulp and coffee grounds), Furresh reduces food industry by-product disposal, thereby lowering environmental burden.
- Pet and Human Safety – Free from synthetic fragrances or harmful additives, Furresh ensures safe use for cats and their owners.

RESULTS AND DISCUSSION

Preliminary testing indicated that Furresh exhibited strong absorbency and clumping performance, comparable to conventional clay litter. The odor control provided by coffee grounds was particularly effective in reducing ammonia-related smells, confirming literature on the adsorptive properties of spent coffee grounds (Haile, 2014). Biodegradability trials showed significant decomposition within a short period, validating its compostable potential.

The discussion of these findings highlights Furresh's dual impact: improving pet hygiene while reducing ecological footprint. This aligns with the increasing consumer preference for eco-friendly products, especially among environmentally aware pet owners (Yue et al., 2020). Moreover, by addressing waste management issues through the upcycling of cassava and coffee residues, Furresh contributes to sustainable production practices in line with SDG 12 (Responsible Consumption and Production).

However, while laboratory trials were promising, broader consumer testing is necessary to assess long-term usability, dust levels, and clumping durability. Market adoption will also depend on cost competitiveness, availability, and consumer education regarding the environmental advantages of biodegradable litter.

CONCLUSION

Furresh demonstrates the potential of integrating agricultural by-products into innovative pet care solutions. The product provides an eco-friendly, compostable, and effective alternative to clay and silica litters, addressing both environmental and consumer needs. By valorising cassava pulp and coffee grounds, Furresh not only reduces agro-waste but also offers functional benefits, including odor control and clumping performance.

Future research should expand on large-scale biodegradability testing, explore microbial safety in composting applications, and conduct consumer market trials to evaluate acceptance. In doing so, Furresh may become a leading example of sustainable innovation in the pet industry, bridging environmental stewardship with responsible pet ownership.

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PawPurify: A NATURAL CLAY-BASED DETOX INNOVATION FOR ENHANCING PET HYGIENE AND PREVENTING ZOONOTIC RISKS

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ABSTRACT

Pet ownership has been steadily increasing in Malaysia, resulting in greater demand for pet care products that are safe, effective, and environmentally responsible. However, conventional products often expose both pets and humans to harmful chemicals, parasites, and zoonotic diseases. At the same time, organic waste such as tea waste is frequently discarded, contributing to soil and water pollution. Addressing these issues, this project, PAWPURIFY focuses on the development of an innovative and sustainable pet care solution. The main objective of this project is to formulate, produce, and promote a natural clay detox powder for pets using eco-friendly and biodegradable ingredients, including tea waste, turmeric, neem leaves, activated charcoal, and chamomile. This product is designed to improve pet and human health by preventing skin irritation, parasites, and zoonotic infections, while remaining safe, non-toxic, and affordable for all groups of pet owners. The detox clay works as a natural protective powder with strong absorbent and detoxifying properties. It helps to maintain pet hygiene by reducing odours, minimizing irritation, and preventing disease transmission. In addition, the product contributes to sustainability by upcycling tea waste and other natural resources into value-added products, supporting responsible consumption and production practices. The novelty of this innovation lies in its unique combination of natural ingredients, dual function as both detox and preventive care, and eco-friendly approach compared to chemical-based alternatives. With its affordability, safety, and sustainability, the project not only enhances pet well-being but also supports the global effort towards zero-waste and green innovation.

Keywords: Eco-friendly, Detox Powder, Zoonotic Prevention, Waste Upcycling, Sustainable Innovation

INTRODUCTION

Responsible pet ownership has increasingly become an important global issue, particularly as pet populations continue to grow in both developed and developing nations. Pets contribute to emotional well-being and companionship; however, poor hygiene practices can expose both animals and their owners to significant health risks, including zoonotic diseases. The World Health Organization (WHO, 2020) has emphasized that zoonotic pathogens, such as Toxoplasma gondii, Salmonella spp., and Leptospira spp., can be transmitted from animals to humans through contaminated environments, poor sanitation, or direct contact. According to Day (2011), maintaining proper hygiene in pets is critical not only to animal health but also to public health.

Conventional pet hygiene products, such as chemical-based disinfectants and shampoos, have limitations. Many contain synthetic compounds that may cause skin irritation, allergic reactions, or long-term ecological harm (Martínez-Merino et al., 2020). In contrast, natural products have gained traction in veterinary and pet care industries due to their eco-friendly and non-toxic properties (Ali et al., 2021). Natural clays, particularly bentonite and kaolin, have been historically used for detoxification, antibacterial effects, and toxin adsorption (Carretero & Pozo, 2009). However, the integration of clay-based detoxification into mainstream pet hygiene remains underexplored.

This study introduces PawPurify, a clay-based natural detox solution specifically designed to enhance pet hygiene while minimising zoonotic risks. The innovation bridges the gap between effective antimicrobial action and pet safety, providing a sustainable alternative to synthetic products.

OBJECTIVES

The objectives of this innovation are as follows:

i. To develop PawPurify, a natural detox formulation derived from clay, tailored for pet hygiene.
ii. To assess the potential of natural clay in reducing bacterial contamination associated with pets.
iii. To evaluate the role of PawPurify in preventing zoonotic disease transmission while ensuring safety for animals.
iv. To contribute to sustainable and eco-friendly solutions aligned with global health and environmental goals.

METHODOLOGY AND DEVELOPMENT

The development of PawPurify followed a systematic approach:

1. Selection of Natural Clay – Clay samples with proven adsorption and antibacterial properties were identified. Bentonite and kaolin were prioritized for their safety and non-toxicity in topical applications. Studies by Christidis et al. (2011) highlighted clays' capacity to bind microbial toxins and inhibit bacterial proliferation.

2. Formulation – The clay was processed into a fine powder, detoxified through natural purification techniques, and blended with supportive agents that maintain texture, usability, and effectiveness. The formulation was designed to be hypoallergenic, safe for contact with animal skin, and free of harmful chemicals.

3. Antibacterial Evaluation – Laboratory-scale antibacterial testing was conducted based on methodologies adapted from Ali et al. (2021). The clay formulation demonstrated promising antibacterial activity against common pathogens found in pet environments, including E. coli and Staphylococcus aureus.

4. Pet-Safety Assessment – Preliminary safety assessments were performed to ensure that the product caused no irritation or adverse reactions when applied to pets. This stage focused on non-invasive application and close monitoring of animal comfort.

INNOVATION AND SIGNIFICANCE

PawPurify introduces several innovative contributions:

Clay-Based Detox Mechanism – Unlike traditional pet cleansers that rely on synthetic chemicals, PawPurify leverages the adsorption and antibacterial properties of natural clay to neutralise toxins and microbial threats.

Zoonotic Disease Prevention – By reducing bacterial load and maintaining cleaner pets, PawPurify minimizes the likelihood of zoonotic transmission. This aligns with the One Health framework, which emphasises the interconnectedness of human, animal, and environmental health (Destoumieux-Garzón et al., 2018).

Pet-Safe and Eco-Friendly – Free of synthetic irritants and toxic residues, the product ensures animal safety and environmental sustainability. Unlike chemical detergents, clays degrade naturally without ecological harm.

Versatile Application – The product may be utilised across multiple settings, including household pet care, animal shelters, and veterinary practices, making it highly adaptable to various contexts.

RESULTS AND DISCUSSION

The survey on PawPurify, a natural clay-based detox product for pets, was designed to examine consumer perceptions and behavioral intentions towards adopting an eco-friendly innovation. The data was structured around five constructs: Attitude (AT), Subjective Norm (SN), Perceived Behavioral Control (PBC), Environmental Awareness (EA), and Behavioral Intention (INT). Preliminary descriptive results revealed consistently moderate-to-high ratings across all constructs, suggesting a generally positive response towards the product.

Attitude (AT) Towards PawPurify

Attitude is a central determinant of behavioral intention in the Theory of Planned Behavior (Ajzen, 1991). Respondents indicated favorable views of PawPurify, expressing that using the product is both a good idea and beneficial for the environment. This positive perception aligns with previous studies on green consumer behavior, which found that environmentally friendly attributes strongly influence attitudes towards product adoption (Joshi & Rahman, 2015). The data suggests that PawPurify is perceived not only as a functional hygiene product but also as a socially responsible innovation. Such positive attitudes are crucial in shaping long-term behavioral changes in pet care practices.

Influence of Subjective Norms (SN)

The role of subjective norms, which reflect perceived social pressure from important others, emerged as another important factor. Respondents acknowledged that family members and peers would encourage them to purchase and use PawPurify. Prior studies have shown that social influence significantly drives adoption of sustainable products, particularly in collectivist cultures where group opinions hold strong weight (Yadav & Pathak, 2017). The findings imply that marketing strategies for PawPurify should emphasize community endorsement, peer support, and testimonials, thereby reinforcing positive normative pressures that promote adoption.

Perceived Behavioral Control (PBC)

Perceived behavioral control relates to the individual's confidence in their ability to perform a behavior. The data shows that respondents generally agreed they could easily use and purchase PawPurify, indicating minimal barriers to adoption. This is consistent with the work of Paul et al. (2016), who found that consumers are more likely to adopt green innovations when they perceive the products to be accessible, affordable, and convenient. Importantly, a strong sense of PBC increases both intention and actual usage. For PawPurify, this suggests that availability in local markets and affordable pricing will further enhance consumer confidence and uptake.

Environmental Awareness (EA)

A particularly strong construct observed in the dataset was environmental awareness. Respondents expressed heightened awareness of environmental protection, individual responsibility, and willingness to reduce consumption for sustainability. This finding is critical, as prior research emphasizes that environmental consciousness strongly predicts green product adoption (Biswas & Roy, 2015). By positioning PawPurify as an eco-friendly solution that contributes to reducing environmental pollution, the product resonates well with environmentally conscious consumers. The synergy between ecological concern and pet welfare creates a dual value proposition: protecting animals while also safeguarding the planet.

Behavioral Intention (INT)

The construct of intention directly reflects the likelihood of future adoption. Responses indicated strong willingness to purchase and use PawPurify, with many participants expressing plans to choose the product over conventional alternatives. According to the Theory of Planned Behavior, intention is the most immediate predictor of actual behavior (Ajzen, 1991). The data suggests that positive attitudes, supportive social influence, high perceived control, and environmental awareness collectively translate into strong behavioral intentions. This is consistent with prior findings where green attitudes and awareness significantly influenced purchase intentions in the eco-friendly product sector (Nguyen et al., 2017).

Integration and Implications

Overall, the results demonstrate that PawPurify holds substantial potential in the market for sustainable pet hygiene solutions. Attitudes towards the product are favorable, subjective norms reinforce positive

decision-making, and perceived control eliminates adoption barriers. Importantly, environmental awareness not only enhances the intention to adopt but also differentiates PawPurify as an innovation aligned with broader sustainability goals.

From a practical perspective, the findings underscore several key implications:

1. Marketing Strategy – Campaigns should highlight PawPurify's eco-friendly benefits and zoonosis prevention function while leveraging endorsements from veterinarians, pet communities, and eco-conscious influencers to strengthen subjective norms.
2. Product Positioning – Positioning PawPurify as both a pet wellness and environmental protection product will maximize its appeal.
3. Accessibility – Ensuring affordability and availability will maintain strong perceived behavioral control among consumers.
4. Policy Alignment – The product aligns with SDG 3 (Good Health and Well-being) and SDG 12 (Responsible Consumption and Production), creating opportunities for institutional endorsement and potential government or NGO collaborations.

The analysis reveals that PawPurify is well-positioned to be adopted by consumers due to the positive interplay of attitudes, subjective norms, behavioral control, and environmental awareness. The strong behavioral intention identified in this study signals readiness for market entry and provides a foundation for future empirical validation. With continued product development and strategic marketing, PawPurify could serve as both an innovative pet-care solution and a meaningful contribution to sustainable living.

CONCLUSION

The development of PawPurify demonstrates the feasibility of a clay-based detox solution in advancing pet hygiene while addressing zoonotic disease risks. This innovation contributes to Sustainable Development Goal (SDG) 3 (Good Health and Well-being) by promoting healthier interactions between pets and humans, and SDG 12 (Responsible Consumption and Production) through its reliance on natural and sustainable materials.

Future studies should expand antibacterial evaluations to include viral and fungal pathogens, conduct longitudinal safety trials in larger pet populations, and perform market feasibility assessments. Such research would strengthen the scientific basis for broader commercialisation and adoption in the pet care industry. Ultimately, PawPurify represents a novel step toward integrating traditional natural resources into modern solutions for responsible pet ownership and public health.

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FROM RENT TO RESIDENCE: STATISTICAL INSIGHT INTO THE DETERMINANTS OF HOME OWNERSHIP

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ABSTRACT

Home ownership is widely regarded as a key indicator of financial stability and social well-being, especially in developing countries like Malaysia. However, increasing property prices, stagnant wages, and shifting demographic patterns have made owning a home an increasingly complex challenge. This study was conducted to identify the key determinants of home ownership among Malaysian residents and to construct the best binary logistic model to predict ownership likelihood. The independent variables used were income, age, education level, marital status, family size, and living status. The dependent variable was ownership status (1 = Own, 0 = Do not own). Data were collected through a hybrid distribution method from a sample of 293 respondents across Malaysia. The results revealed that income, age, education level, and marital status were significant predictors of home ownership, while family size and living status were not. Evaluation of the model was performed using the Omnibus Test, Wald Statistics, Hosmer-Lemeshow Goodness-of-Fit Test, and Predictive Efficiency Model. Pseudo-R^2 values (Cox & Snell $R^2 = 0.440$ and Nagelkerke $R^2 = 0.603$) supported the model's robustness. The model also demonstrated a high predictive accuracy of 82.4%. These results emphasise the importance of financial and demographic factors in determining home ownership and may inform future housing policy initiatives.

Keywords: Home ownership, Logistic Regression, Malaysia

INTRODUCTION

The growing demand for home ownership in Malaysia has sparked extensive attention from the public, media, and policymakers in recent years. Home ownership is often associated with financial independence, long-term economic stability, and a measure of success in Malaysian. A house not only provides physical shelter but also serves as a critical investment tool for wealth accumulation and intergenerational transfer. According to the National Property Information Centre (NAPIC), property prices in Malaysia have been steadily increasing, especially in urban areas such as Kuala Lumpur and Selangor, making housing affordability a key national concern.

Despite efforts from the government with programs like "My First Home Scheme," many Malaysians still find home ownership out of reach. High housing prices and slow wage growth have made it difficult for people to buy homes without financial struggle. In urban areas, for instance, more than 60% of families can't afford a median-priced home without feeling the financial pinch (Khazanah Research Institute, 2018). The challenges extend beyond just economics. As Malaysia's population ages and more people move to cities, young adults, especially those just starting their careers, face hurdles in saving enough for a down payment. This often leads them to rent for longer periods or stay with family, affecting their independence and financial growth.

Income level remains a major barrier to homeownership, as property prices continue to outpace wage growth, limiting affordability for middle-income earners (Aqlima Ramli et al., 2024). Younger adults also struggle due to job insecurity and career mobility, which delay home-buying decisions and increase reliance on rental housing (Lai et al., 2023). Education plays a crucial role, not only in improving income potential but also in equipping individuals with financial literacy, which is essential for making informed homeownership decisions (Diyana Nadirah Mohd Hadi et al., 2023). Marital status influences homeownership capabilities, with single individuals often struggling more due to limited financial

resources compared to married couples who can pool incomes (Grinstein-Weiss et al., 2011). Family size presents unique challenges, as larger families require more space, which is often financially out of reach (Wahab1 et al., 2023). Those living with family also experience delayed homeownership aspirations, as the lack of immediate housing pressure reduces urgency in entering the market (Khazanah Research Institute, 2023).

With the homeownership rate reported at 76.9% in 2019, a substantial portion of the population remains excluded from property ownership (Rahim et al., 2019). Thus, this research is necessary to identify the factors influencing homeownership in Malaysia. Identifying these determinants will provide insights into consumer behaviour and help policymakers and industry stakeholders address barriers to affordability and accessibility. Ultimately, these findings could contribute to reducing inequality and fostering economic inclusivity in the housing market.

RESULTS AND DISCUSSION

The purpose of this study was to determine the best logistic model for the determinants of home ownership by Malaysians as well as to investigate the factors that significantly impact this determinant. To simplify and make the conclusion easier to understand, Table 1 was created as follows.

Table 1: Model Coefficient

Variable	Estimated Coefficient	Standard Error	p-Value
Income	0.560	0.123	0.000
Age	0.095	0.025	0.000
Education (SPM)	1.614	0.795	0.042
Education (Undergraduate)	2.239	0.691	0.001
Marital Status	-1.083	0.492	0.028
Family Size (Small)	0.322	1.059	0.761
Family Size (Medium)	-0.265	1.094	0.809
Living Status (Family)	-19.995	9991.443	0.998
Living Status (Friend)	-20.508	9991.443	0.998
Constant	13.672	9991.443	0.999

It can be determined that the main factors influencing the determinants of home ownership are income, age, education level and marital status since all the p-values of these variables are less than 0.05. Following is the estimated logit model for the full model obtained:

Logit(Y=1) = 13.672 + 0.560 Income + 0.095 Age + 1.614 SPM + 2.239 Undergraduate -1.083 Marital_Status + 0.322 Family_Small – 0.265 Family_Medium – 19.995 Living_Family – 20.508 Living_Friend

CONCLUSION

Through the analysis of key variables associated with home ownership, this study has illuminated several factors that significantly influence an individual's likelihood of owning a home in Malaysia. The findings demonstrate that older individuals and those with higher incomes are more likely to own a house. This

supports the conventional understanding that with age comes financial stability, and increased income allows for greater investment in long-term assets such as property.

In addition, education emerged as a strong predictor of home ownership. Respondents who completed SPM and those with undergraduate degrees were found to be significantly more likely to own a home compared to those without formal education credentials. This may be because education increases employment opportunities and income potential, which in turn improves the ability to afford home ownership.

Furthermore, marital status also plays an essential role. Single individuals were found to be less likely to own a house, aligning with the idea that married couples often combine financial resources, making it easier to purchase a property. Family size was another influential factor. Respondents with small or medium sizes had lower odds of owning a home compared to larger families, potentially due to different financial priorities or stages in the life cycle.Living status was also found to significantly impact home ownership. Respondents who lived with family or friends were less likely to own a home, suggesting that those living independently may have a stronger motivation or financial need to invest in property.

To further strengthen future research, it is recommended that the sample size be increased beyond 271 respondents to allow for more generalizable results. Additional independent variables such as employment type, loan eligibility, urban versus rural location, and financial literacy could be explored to enrich the model.

From a policy perspective, these findings highlight the need for targeted homeownership assistance programs. For example, financial incentives or special schemes could be introduced for single individuals, young adults, and small families. Moreover, improving access to affordable housing and enhancing public awareness on housing loan programs could help address home ownership disparities.

Finally, institutions such as Bank Negara Malaysia and the Ministry of Local Government Development should continue collaborating with developers and financial institutions to ensure fair access to home financing and promote long-term sustainable home ownership across all demographics in Malaysia.

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MANUAL CLOTH WRINGER

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ABSTRACT

Laundry remains a persistent challenge for students living in hostels where access to washing machines and dryers is limited and electricity supply may be unreliable. Handwashing often leaves garments excessively damp, resulting in prolonged drying times and additional inconvenience. To address this issue, a Manual Cloth Wringer was developed as a low-cost and portable device designed to remove excess water from clothes without relying on electricity. The device was constructed using readily available recycled materials. PVC pipes formed the hand crank while a recycled plastic basket served as the wringer. Assembly was carried out using basic hand tools to ensure that the design remained simple, durable and easy to replicate. In operation, damp clothes were placed inside the basket, secured and manually spun using the PVC crank. The centrifugal force generated expelled water through the perforations, thereby reducing moisture content. Experimental testing demonstrated that the wringer removed a substantial proportion of excess water, enabling faster drying and requiring less physical effort compared to manual wringing. Overall, the device provides a practical, sustainable and affordable solution for students and individuals in resource-constrained environments, enhancing convenience while promoting the reuse of recycled materials.

Keywords: Manual Cloth Wringer, Polyvinyl Chloride (PVC), Recycle, Laundry

INTRODUCTION

Laundry is one of the most basic yet time-consuming chores of daily life, especially for students residing in hostels and dormitories. While washing machines and dryers provide convenience, they are not always accessible or affordable for students in low-resource settings. Consequently, many students rely on handwashing which often leaves garments excessively damp. Without effective wringing, drying time is substantially prolonged particularly in humid or rainy weather conditions. Moreover, inadequate wringing can damage fabric quality, cause unpleasant odors and elevate the risk of mold growth during drying.

In developing regions or in areas with unreliable electricity supply, the lack of affordable laundry solutions further exacerbates this issue. Students and low-income individuals in particular are forced to spend more time and effort on laundry, reducing the time available for academic and personal development. To address this gap there is a pressing need for a practical, low-cost and portable solution that can efficiently remove excess water from clothes without depending on electricity.

DISCUSSION

The primary objective of this project is to design, develop and evaluate an innovative Manual Cloth Wringer that provides an efficient, sustainable and affordable solution for students and individuals living in hostels, dormitories or low-income households. Specifically, Jagushte et al. (2015) state that the goals are:

i. To create a simple laundry aid that removes excess water from clothes without electricity.
ii. To use recycled or easily available low-cost materials to ensure affordability and sustainability.
iii. To design the product in a compact, lightweight and portable form for use in limited living spaces.
iv. To reduce laundry drying time and physical effort while maintaining user convenience.

The Manual Cloth Wringer is a portable hand-operated device constructed primarily from recycled and easily available components. The design uses PVC pipes as the hand-crank mechanism, offering strength, durability and ease of assembly. A recycled plastic basket serves as the wringer drum where clothes are placed for water extraction. The entire structure is assembled with basic hand tools, ensuring accessibility and ease of repair.

The operational process is straightforward. Damp clothes after hand washing are placed into the wringer basket. The basket is then secured and the user rotates the PVC hand crank to spin the basket. Through centrifugal force, water is efficiently expelled from the clothes, draining out of the basket through perforations (Pedal powered clothes washer, n.d.). The mechanism significantly reduces the amount of residual water in clothes, thereby shortening drying time.

This simple yet effective design makes the device particularly suited for small spaces, low-resource settings and student accommodations. It is lightweight enough to be portable, durable for repeated use and affordable for students with limited budgets.

The uniqueness of this project lies in its low-cost, sustainable and student-centered approach. In terms of material innovation, the use of recycled plastic baskets and PVC pipes minimises manufacturing costs, promotes environmental sustainability and ensures that the device can be built or repaired with readily available parts. Unlike electric dryers or wringers, the manual device operates without electricity, making it eco-friendly and practical in areas with limited or no electrical access (Development of eco-friendly washing machine, 2017). This is considered an energy-independent device.

From a portability and accessibility perspective, the compact size and lightweight construction allow users to carry and use the device anywhere, even in hostels or shared dormitory spaces where large appliances are impractical. This is a user-centered design wringer because of its simple hand-crank operation that requires minimal training, making it suitable for students and individuals of all age groups. Lastly, by relying on recycled and inexpensive components, the device provides a cost-effective alternative to washing machines or dryers, addressing the financial limitations of students and low-income users. This means it is an affordable innovation. This combination of features highlights the originality and social value of the Manual Cloth Wringer as a grassroots innovation that merges practicality with sustainability.

CONCLUSION

The Manual Cloth Wringer addresses an often-overlooked challenge faced by students and individuals in resource-limited environments: the need for an affordable, portable and efficient means of drying laundry. By combining recycled materials, simple mechanics and user-friendly design, the device offers a practical solution that reduces drying time, conserves energy and enhances convenience.

Its affordability, sustainability and portability set it apart from conventional laundry solutions, making it particularly beneficial in hostel and dormitory settings where access to washing machines and dryers is limited. Beyond students the device also holds potential value for low-income households, disaster relief situations and off-grid communities.

In conclusion, the Manual Cloth Wringer not only reduces the time and effort required for laundry chores but also contributes to sustainability through the use of recycled materials. As an innovation, it represents a meaningful step toward developing low-cost, eco-friendly technologies that improve everyday life for communities with limited resources.

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AN INNOVATIVE WEB APPLICATION FOR FORECASTING MALAYSIA'S UNEMPLOYMENT RATE USING ARIMA AND EXPONENTIAL SMOOTHING TECHNIQUES

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ABSTRACT

Unemployment is one of the most significant socio-economic issues faced by many countries, as it reflects both economic stability and social well-being. Accurate forecasting of unemployment trends can help policymakers and stakeholders in making informed decisions to improve labour market conditions. This study aims to develop a forecasting model for unemployment rates using time series approaches and deploy it into an interactive Shiny web application. Data were obtained from publicly available unemployment statistics and analysed using ARIMA and ETS models. The forecasting results demonstrated that both models provide reliable projections, with ARIMA showing slightly higher accuracy based on error metrics such as RMSE and MAPE. The Shiny application enables users to visualise historical unemployment data, compare model performance, and generate forecasts interactively. The findings highlight the importance of integrating statistical forecasting with user-friendly technology platforms, providing accessible decision-making tools for researchers, policymakers, and the public.

Keywords: Forecasting, Shiny Application, Time Series Analysis, Unemployment

INTRODUCTION

Unemployment is a critical economic indicator that affects individual livelihoods, government policies, and overall economic growth. High unemployment rates often indicate instability in the job market, reduced productivity, and potential social challenges. Policymakers and economists rely on forecasting methods to anticipate future labor market conditions and plan effective strategies. Traditional statistical models such as ARIMA and ETS have proven to be effective in analysing economic time series data.

The motivation of this study is to create an interactive forecasting tool that combines statistical accuracy with accessibility. By deploying the model on a Shiny platform, the project provides an innovative solution that allows users to analyse unemployment trends dynamically. The objectives of this study are: (i) to analyse unemployment rate data using time series models, (ii) to compare the forecasting accuracy of ARIMA and ETS, and (iii) to develop a Shiny application that serves as a decision-support tool for policymakers, researchers, and the public.

RESULTS AND DISCUSSION

The developed web application features an interactive interface that allows users to select age ranges, choose forecasting methods (ARIMA or ETS), and adjust the forecast horizon to generate real-time unemployment predictions. The dashboard integrates descriptive statistics, dynamic time-series plots, and downloadable outputs, ensuring accessibility for both technical and non-technical audiences.

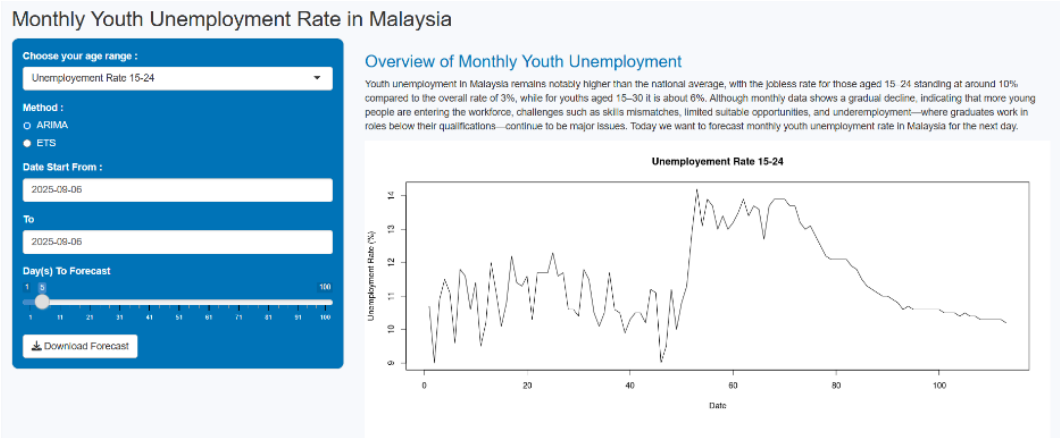

Figure 1: Image of Web Application of Unemployment Rate in Malaysia

The application offers practical benefits to users such as policymakers, researchers, and economists by providing fast, accurate, and interpretable unemployment forecasts without requiring advanced statistical skills. At a societal level, it supports evidence-based workforce planning and policy interventions to address youth unemployment. Beyond academic use, the tool holds commercialisation potential through a freemium model that is a basic feature for public access and advanced analytics for institutional clients. Its novelty lies in combining econometric forecasting with interactive visualisation and built-in accuracy diagnostics, providing a user-friendly yet rigorous platform that bridges advanced modelling with real-world usability. The discussion highlights that while statistical accuracy is important, the usability of forecasting tools also plays a crucial role. The Shiny web interface ensures that complex statistical outputs are translated into intuitive graphs and tables, making the results accessible to non-technical users. This innovation bridges the gap between data science and policy application.

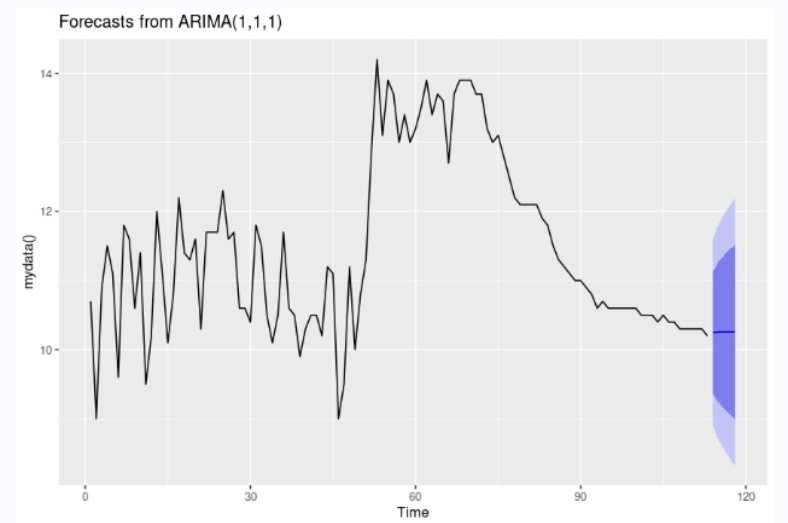

Figure 2: Forecast Unemployment Rate in Malaysia

A pilot study was conducted with 16 participants aged between 20 and 45 years, comprising both male and female individuals, using a convenience sampling method. Table 1 presents the descriptive statistics for the

key constructs measured in this study. The highest mean score was recorded for Overall Perception (X_6), with a mean of 6.29 and a standard deviation of 0.74, indicating a strong overall positive perception of the system. This was followed by Perceived Usefulness (X_1), which had a mean of 6.13 and a standard deviation of 0.75. The mean score of 6.13 suggests that participants generally agreed the system was useful, reflecting a strong positive sentiment. For Perceived Ease of Use (X_2), the mean score was 5.89 with a standard deviation of 0.94, suggesting that participants found the system relatively easy to use, with responses leaning toward agreement. In terms of Perceived Enjoyment or User Experience (X_3), the mean score was 5.90 and the standard deviation was 0.97, indicating that participants tended to agree that the system was enjoyable and provided a positive user experience. The construct related to Perceived Accuracy and Reliability (X_4) showed a mean of 5.98 and a standard deviation of 0.82, suggesting that participants perceived the system as accurate and dependable. The lowest mean score was observed for Intention to Use (X_5), with a mean of 4.61 and a standard deviation of 0.59. Although this was the lowest among all constructs, the score still exceeded the neutral point of the scale, indicating a moderately high intention to use the system. Overall, the construct measuring general perception of the web application demonstrated the highest mean, reinforcing the participants' strong positive perception of the system.

Table 1: Summary of constructs

Variable	Min	Max	Mean	Standard Deviation
Perceived Usefulness (X_1)	4.25	7.00	6.1250	0.75277
Perceived Ease of Use (X_2)	4.25	7.00	5.8906	0.94414
Perceived Enjoyment/User Experience (X_3)	4.00	7.00	5.8958	0.97159
Perceived Accuracy & Reliability (X_4)	4.33	7.00	5.9792	0.82074
Intention to Use (X_5)	3.00	5.25	4.6094	0.59139
Overall Perception (X_6)	5.00	7.00	6.2917	0.73912

A series of one-sample t-tests were conducted to compare the mean scores of each construct to the neutral value of 4 (see Table 2). The results indicated that all constructs were significantly higher than the neutral point ($p < .001$). This suggests that participants generally agreed or strongly agreed with positive statements regarding the system's usefulness, ease of use, enjoyment, accuracy, and reliability, as well as their intention to use it.

Table 2: Statistical Analysis of Constructs.

Variable	Mean	t	Degree of Freedom	p-value
Perceived Usefulness (X_1)	6.1250	11.29	15	< .001
Perceived Ease of Use (X_2)	5.8906	8.01	15	< .001
Perceived Enjoyment/User Experience (X_3)	5.8958	7.81	15	< .001
Perceived Accuracy & Reliability (X_4)	5.9792	9.64	15	< .001
Intention to Use (X_5)	4.6094	4.12	15	< .001
Overall Perception (X_6)	6.2917	12.40	15	< .001

CONCLUSION

This project successfully demonstrates the integration of time series forecasting methods with a Shiny web application to forecast unemployment rates. The results indicate that ARIMA provides slightly better accuracy compared to ETS, while both methods are effective in generating reliable forecasts. The interactive platform enhances accessibility, making it a practical tool for policymakers, researchers, and the community in monitoring and predicting unemployment trends. Future work may involve expanding the dataset, incorporating machine learning approaches, and enhancing the visualisation features for broader applications.

ACKNOWLEDGEMENT

We wish to express our profound appreciation to the Department of Statistics for generously providing the dataset utilised in this study. Our sincere gratitude also goes to SIG DASCA for their guidance and expertise throughout the development process. Furthermore, we extend our heartfelt thanks to the KPP Faculty of Computer and Mathematical Sciences for their continuous support, motivation, and encouragement, which greatly facilitated our participation in this innovation competition. No grants were obtained to support this study (Project ID: SS-2).

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MANGMOISELLE

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ABSTRAK

Projek perniagaan ini bertujuan untuk menangani masalah kulit seperti kulit kering, gatal, dan kulit terbakar akibat sinaran UV matahari. Keunikan produk ini ialah sebuah inovasi penjagaan kulit yang menggabungkan fungsi skrub, pelembap, dan perlindungan anti-UV secara semula jadi dalam satu produk melalui penggunaan bahan semula jadi seperti serbuk kulit manggis, chamomile, serta minyak pati melati (jasmine essential oil).Produk yang dihasilkan ialah losyen skrub penjagaan kulit berasaskan bahan semula jadi yang dinamakan "Mangmoiselle". Pemilihan kulit manggis adalah berdasarkan kandungan bioaktifnya yang mempunyai sifat antioksidan dan antibakteria. Chamomile pula dipilih kerana keberkesanannya dalam melembapkan, menenangkan, serta memberi keselesaan kepada kulit. Minyak pati melati berfungsi menyembuhkan luka dengan sifat anti-radang dan mempunyai antiseptik semula jadi yang membantu melawan jangkitan.Matlamat utama projek ini adalah untuk membangunkan formulasi losyen skrub yang selamat, berkesan, dan mesra kulit, serta mampu mengatasi masalah kulit pengguna. Kaedah Design Thinking digunakan dalam pembangunan projek ini yang merangkumi proses mengenal pasti masalah, penjanaan idea, formulasi produk, dan penambahbaikan berterusan berdasarkan maklum balas pengguna.
Produk ini akan melalui proses ujian makmal bagi memastikan tahap keselamatan dan kualiti produk terkawal. Cadangan penambahbaikan termasuk pengoptimuman formulasi dengan menyeimbangkan nisbah bahan semula jadi serta penambahan bahan sokongan untuk meningkatkan mutu, kestabilan, dan daya tarikan produk di pasaran.

Kata Kunci: Losyen Skrub, Kulit Manggis, Chamomile, Minyak Pati Melati, Penjagaan Kulit

PENDAHULUAN

Industri kosmetik dan penjagaan diri di Malaysia telah menunjukkan pertumbuhan yang pesat, dipacu oleh kesedaran masyarakat terhadap pentingnya menjaga kesihatan kulit dan penampilan diri. Salah satu produk yang semakin mendapat perhatian adalah **losyen badan dan skrub (body lotion),** yang bukan sahaja berfungsi untuk melembapkan kulit, tetapi juga berperanan dalam memberi perlindungan terhadap sinaran UV, anti-penuaan, dan memperbaiki masalah kulit lain. Dengan iklim tropika Malaysia yang panas dan lembap, penggunaan produk penjagaan kulit seperti body lotion menjadi satu keperluan harian yang tidak dapat dielakkan.

Melihat kepada permintaan yang semakin meningkat terhadap produk penjagaan kulit yang lebih inovatif dan berkesan, kami memperkenalkan **Mangmoiselle**, sebuah produk losyen skrub badan yang diformulasi dengan bahan semulajadi yang berkesan, iaitu **kulit manggis, chamomile**, dan **minyak pati melati (jasmine essential oil).** Produk ini dirumus khas untuk memberikan kelembapan yang mendalam, perlindungan terhadap sinaran UV, serta kesan menenangkan pada kulit, menjadikannya pilihan sempurna untuk mereka yang mencari produk penjagaan kulit yang selamat, berkesan, dan berfungsi pelbagai.
Mangmoiselle bukan sekadar losyen biasa, ia menggabungkan manfaat **kulit manggis**, yang terkenal dengan sifat antioksidan yang tinggi dan kemampuannya untuk memperbaiki tekstur kulit, dengan **chamomile**, yang dikenali dengan kemampuannya untuk menenangkan kulit yang iritasi atau sensitif. Tambahan pula, **minyak pati melati** memberikan aroma yang menenangkan serta manfaat dalam merawat kulit kering dan kusam. Formulasi ini menjadikan **Mangmoiselle** lebih daripada sekadar pelembap harian, tetapi juga sebagai satu rawatan untuk memberi perlindungan dan kecantikan kulit yang berpanjangan.

Pasaran body lotion atau skrub di Malaysia menawarkan potensi yang sangat besar kerana permintaan terhadap produk yang mengandungi bahan semulajadi dan berfungsi pelbagai semakin meningkat. Dengan **trends** seperti **kecantikan bersih (clean beauty)** dan **produk multifungsi, Mangmoiselle** hadir untuk memenuhi keperluan pengguna yang semakin bijak memilih produk yang bukan sahaja selamat tetapi juga memberikan manfaat tambahan. Produk ini sesuai dengan kehendak pasaran yang kini lebih mementingkan produk penjagaan kulit yang berkesan, selamat, dan bersih.

Selain itu, dengan fokus pada **mesra alam, Mangmoiselle** berpotensi untuk menarik pasaran tempatan dan antarabangsa, khususnya bagi pengguna yang mencari produk mesra kulit, dan bebas bahan kimia berbahaya. Produk ini berpotensi untuk menguasai pasaran melalui saluran **e-dagang** yang semakin berkembang pesat, di mana pengguna kini lebih suka membeli produk secara dalam talian melalui platform seperti Shopee, Lazada, dan TikTok Shop.

Dengan **Mangmoiselle,** kami berhasrat untuk memenuhi kehendak pasaran yang berkembang pesat ini, menyediakan produk yang bukan sahaja menepati keperluan pengguna tetapi juga memberikan penyelesaian yang berkesan bagi masalah kulit dalam kehidupan seharian. Projek ini bukan sahaja menjawab permintaan terhadap produk berkualiti tinggi dan berfungsi pelbagai, tetapi juga membuka peluang bagi pembangunan jenama yang kukuh dan berpotensi berkembang dalam pasaran global.

OBJEKTIF PROJEK

i. Untuk memperkenalkan Mangmoiselle sebagai losyen semula jadi yang dirumus dengan Serbuk Kulit Manggis, Chamomile, dan Bunga Jasmine.
- Membawa produk unik berasaskan bahan semula jadi yang memberi manfaat kepada kulit.

ii. Untuk menghasilkan produk penjagaan kulit yang berkesan.
- Bukan sahaja memberi kelembapan kepada kulit kering, tetapi juga dapat merawat masalah kulit disamping itu dapat membantu mencerahkan kulit secara semula jadi serta meningkatkan tahap keyakinan diri dengan bau yang menyenangkan dan kulit lebih terjaga.

iii. Untuk menyerlahkan keharuman semulajadi dan manfaat terapeutik bahan-bahan tersebut.
- Produk yang selamat digunakan kerana tidak mengandungi bahan kimia berbahaya, berkaya dengan antioksidan, bersifat menyejukkan, dan memberi bauan yang lembut serta menyenangkan.

Deskripsi

Masalah kulit seperti kekeringan,gatal, dan kulit gelap sering dihadapi oleh mereka yang terdedah kepada persekitaran panas dan lembap, terutamanya pelajar di asrama atau golongan yang tinggal di kawasan tropika. Masalah ini berlaku disebabkan oleh faktor persekitaran yang boleh mengganggu kesihatan kulit dan menyebabkan ketidakselesaan**.**

Mangmoiselle adalah losyen skrub premium yang dirumus khas dengan bahan semulajadi seperti kulit manggis, chamomile, dan minyak pati melati. Ia bertujuan untuk melembapkan kulit secara mendalam, memberikan perlindungan daripada sinaran UV, serta mengatasi masalah kulit seperti kekeringan dan keradangan. Losyen ini juga membantu memperbaiki tona kulit dan memberikan kesan menenangkan pada kulit yang jengkel atau rosak, menjadikannya penyelesaian sempurna untuk penjagaan kulit harian, terutama bagi mereka yang menghadapi masalah kulit akibat persekitaran yang tidak stabil.

Novelti

Mangmoiselle menonjol kerana gabungan unik bahan semulajadi seperti kulit manggis, chamomile, dan minyak pati melati, yang terkenal dengan sifat anti-radang, antioksidan, dan menenangkan. Perlindungan UV yang ditawarkan menjadikannya berbeza di pasaran losyen badan, memenuhi keperluan penjagaan kulit dan perlindungan matahari dalam satu produk. Produk ini juga diformulasikan khusus untuk mengatasi masalah kulit yang biasa dihadapi oleh golongan pelajar atau mereka yang tinggal di asrama, di mana masalah kulit kering, gatal, dan ekzema sering berlaku. Selain itu, ia juga sesuai untuk orang dewasa yang mencari alternatif penjagaan kulit yang efektif dengan bahan semulajadi

KESIMPULANNYA

Secara keseluruhan, Mangmoiselle merupakan inovasi losyen skrub badan berasaskan bahan semula jadi yang menekankan aspek keselamatan, keberkesanan, dan kelestarian. Dengan potensi pasaran yang luas serta strategi pemasaran melalui platform e-dagang, produk ini diyakini mampu memenuhi permintaan pengguna sekali gus membina jenama yang kukuh dan berdaya saing di peringkat tempatan dan antarabangsa.

PENGAKUAN

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SmartRankEDU 360: AN INTELLIGENT WEB PLATFORM FOR BIG DATA- ENHANCED EDUCATIONAL STRATEGY EVALUATION WITH WASPAS

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ABSTRACT

SmartRankEDU 360 is a smart site to rank and assess educational strategies using big data and multi-criteria decision-making. It tackles critical issues of engagement/knowledge retention/cognitive efficiency/accessibility balance, which is typically hard to quantify by traditional means. SmartRankEDU 360 is affordable to educators, researchers, and policy makers because it is open source, light-weight, and runnable in a browser, and it does not require installation, unlike commercial and expensive decision-support systems. The site utilises an assessment technique called the Weighted Aggregated Sum Product Assessment (WASPAS) which synthesises the Weighted Sum Model (WSM) and the Weighted Product Model (WPM) to generate effective and robust rankings. The system normalises, weights, and calculates hybrid scores and the user builds a decision matrix including strategies and criteria. The results are provided in the form of ranked alternatives and interactive plots including normalised matrices, weighted scores, and ranking graphs. It is simple and linear, reduces errors and makes evidence-based decision-making easier, and allows for flexibility in analysis.

Keywords: Educational Strategy Evaluation, WASPAS, Multi-Criteria Decision-Making, Decision Support System, Web-Based Platform.

INTRODUCTION

The need to find clear, data-driven solutions to assess teaching and learning strategies has grown with the increased attention to effective educational planning. However, the criteria educators, policymakers, and institutions tend to use are often conflicting, subjective, and lack standardised structures, which make working with them difficult. Many such difficulties result in subjective or uneven ratings, especially when ratings are done manually rather than systematically (Idris et al., 2011).

Multi-Criteria Decision-Making techniques (MCDM) including the Weighted Aggregated Sum Product Assessment (WASPAS) provide an organized method by integrating the Weighted Sum Model (WSM) and the Weighted Product Model (WPM) into a hybrid decision model. WASPAS, originally proposed by Zavadskas et al. (2014), received extensive application in engineering, management, and policy literature, and was appreciated due to its accuracy, simplicity, and transparency of alternative ranking. The key for its popular use is that it is a combination of the additive and multiplicative models and is more reliable in complex situations for decision-making (Chakraborty and Zavadskas, 2014). However, contemporary educational assessment tools are narrow in focus, primarily static, lack the interaction or free visualisation, and thus are less trusted and flexible by users (Januri et al., 2017).

To address these gaps, this paper proposes the SmartRankEDU 360, an intelligent web-based application that uses the WASPAS approach to rank education strategies. It is a system based on MCDM principles merged with interactive web technologies that provides an easy-to-use, transparent, and scalable solution to multi- dimensional educational evaluation. This project aims to create a decision system with the

WASPAS framework to evaluate educational strategies based on various criteria and compare and rank alternatives to determine the most effective strategies, improve transparency with stepwise outputs and visualizations, and inform educators, institutions, and policymakers with data-driven decisions.

RESULTS AND DISCUSSION

SmartRankEDU 360 is a web-based decision support system that was created as an interactive tool to assess the educational strategies within the WASPAS method. It is written in Python and run using Streamlit so it can be used in its entirety online via any web browser without having to install it. This feature allows teachers, scholars and policy makers to misuse the platform in any circumstances with ease. This works by first inputting the data in either an Excel or CSV format, then building a decision matrix where the user specifies the criteria and weighted them and designates them as either a benefit or a cost. This system then normalises, uses the weights and calculates hybrid scores, and combines the Weighted Sum Model and the Weighted Product Model before producing a ranked list of alternatives.

Figure 1 shows the workflow of SmartRankEDU 360 and Figure 2 shows the integrated interface showing datasets, intermediate calculations and the rankings in real time in bar charts. All the steps of the WASPAS procedure are depicted in a chronological order, which is fully transparent and methodologically clear. The site is open source and can be accessed on https://eduranksyafi-simple.streamlit.app/.

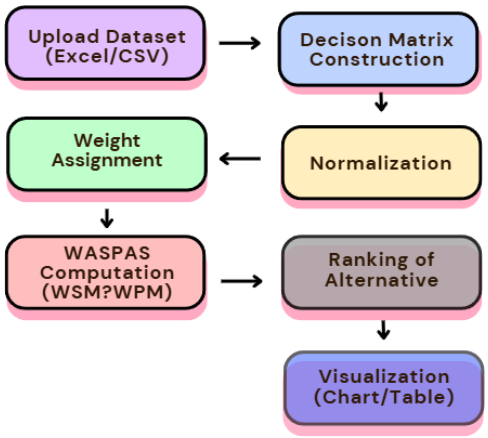

Figure 1: Workflow of SmartRankEDU 360.

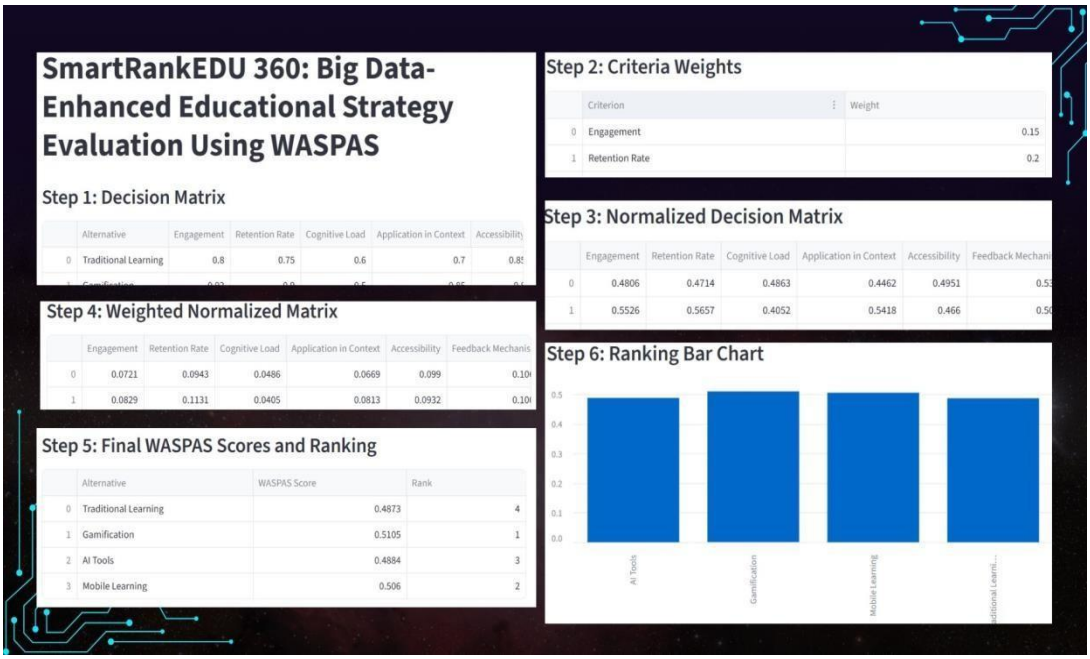

Figure 2: Ranking Visualization of Educational Strategies

SmartRankEDU 360 is unique in that it takes the academic WASPAS approach and turns it into a fully operational web platform, transparent and interactive. Unlike a traditional WASPAS calculation or a spreadsheet model that does not change, SmartRankEDU 360 allows an automated workflow that reduces mistakes and enhances productivity. All the steps involved in the WASPAS process are represented in a highly visualised way which helps build the trust of the user and provides a methodological clarity, which is lacking in traditional tools. It is very scalable because it can support large volumes of data using multiple options and restrictions and it can be used through a browser-based platform, without requiring installation and additional payment. Another feature available on the platform is flexible weight adjustments, which enables users to experiment with various decision scenarios in real-time. This interactivity and openness make SmartRankEDU 360 a unique, open system as compared to commercial decision-support systems which are more likely to be closed and exclusive. Through its scientific work and applied utility, SmartRankEDU 360 can add value to the teachers and policy makers, as well as be used as a teaching and research resource by higher education and training facilities.

CONCLUSION

SmartRankEDU 360 converts the WASPAS approach into a clear, easy to use, and flexible web-based decision support system to examine the educational strategy. It removes the errors and complexity of manually calculated processes by automating data input, normalising, weighting, and computation of hybrid scores. Its dynamism also allows the user to add weights dynamically, to visualise actions along the way and to generate clear ranking results, providing transparency and trust in the decision-making process. In contrast to a traditional spreadsheet model or an expensive commercial suite, SmartRankEDU 360 is free-of-charge, lightweight, and can process various datasets of academic, institutional, and policy scores. It also supports sound educational planning because it allows stakeholders to make informed, responsible decisions that will improve the effectiveness of teaching and learning. More MCDM techniques, more visualisations, and exportable reports could be added in the future, making it even more useful as a decision-support instrument and an educational resource.

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