KEMENTERIAN PENDIDIKAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

KOLEJ KOMUNITI PAYA BESAR

E-PROSIDING

INNOVATION RESEARCH CONFERENCE (INNORE'CON) 2026

SEMINAR PENYELIDIKAN INOVASI KEBANGSAAN 2026

" INNOVATE . RESEARCH . PRESENT "

E-PROSIDING
INNOVATION RESEARCH CONFERENCE (INNORE'CON) 2026

SEMINAR PENYELIDIKAN INOVASI PERINGKAT KEBANGSAAN 2026

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Assalamualaikum warahmatullahi wabarakatuh dan salam sejahtera,

Alhamdulillah, setinggi kesyukuran dipanjatkan ke hadrat Allah SWT kerana dengan izin-Nya, penerbitan e-Prosiding Innovation Research Conference (InnoReCoN) 2026 Peringkat Kebangsaan berjaya direalisasikan. Penerbitan ini merupakan satu manifestasi komitmen berterusan dalam memperkukuhkan budaya penyelidikan, inovasi dan perkongsian ilmu dalam kalangan warga akademik.

Penganjuran seminar ini menyediakan sebuah platform ilmiah yang signifikan untuk para penyelidik, pensyarah dan pengamal bidang berkaitan berkongsi dapatan kajian, idea inovatif serta pengalaman profesional masing-masing. Melalui pengumpulan penulisan ilmiah dalam e-prosiding ini, pelbagai perspektif dan pendekatan baharu dapat diketengahkan bagi memperkaya wacana ilmu, di samping merangsang pemikiran kritis dan kreatif dalam menghadapi cabaran semasa dunia pendidikan dan teknologi.

Sesungguhnya, penerbitan e-prosiding ini bukan sekadar menghimpunkan koleksi penulisan akademik, malah menjadi lambang kesungguhan komuniti penyelidik dalam memperkasa agenda penyelidikan dan inovasi negara. Perkongsian ilmu yang terkandung di dalamnya diharapkan dapat menyumbang kepada pembangunan pengetahuan, memperluas jaringan kolaborasi akademik serta membuka ruang kepada penghasilan penyelidikan yang lebih berimpak pada masa hadapan.

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Akhir kata, saya berharap agar e-prosiding ini dapat dimanfaatkan sepenuhnya sebagai sumber rujukan ilmiah yang bernilai serta menjadi pemangkin kepada usaha berterusan dalam memperkasa budaya penyelidikan dan inovasi. Semoga usaha murni ini terus memberi inspirasi kepada lebih ramai penyelidik untuk menghasilkan karya yang berkualiti demi kemajuan ilmu, pendidikan dan pembangunan negara.

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SHUHAILA BINTI IBRAHIM
Pengarah
Kolej Komuniti Paya Besar

BICARA KATA

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"Ilmu yang berkembang bukan sekadar lahir daripada pembelajaran di bilik kuliah, tetapi daripada keberanian para penyelidik untuk meneroka idea baharu, mencabar pemikiran konvensional dan menghasilkan inovasi yang memberi makna kepada umum."

Dalam dunia yang semakin dipacu oleh kemajuan teknologi dan ekonomi berasaskan pengetahuan, penyelidikan dan inovasi menjadi tunjang penting dalam memacu kemajuan pendidikan serta pembangunan negara.

Selaras dengan aspirasi Malaysia untuk memperkukuh ekosistem Pendidikan dan Latihan Teknikal dan Vokasional (TVET), penganjuran Innovation Research Conference (InnoReCoN) 2026 Peringkat Kebangsaan menjadi platform penting bagi menghimpunkan para penyelidik, pensyarah dan pengamal industri untuk berkongsi hasil kajian, idea inovatif serta amalan terbaik dalam pelbagai bidang.

Penerbitan e-prosiding ini menghimpunkan pelbagai penulisan ilmiah yang mencerminkan komitmen komuniti akademik dalam memperkaya khazanah ilmu pengetahuan serta menyokong perkembangan inovasi dalam Pendidikan di Malaysia. Semoga perkongsian ini dapat menyemarakkan budaya penyelidikan serta menggalakkan kolaborasi yang lebih luas antara institusi Pendidikan.

Setinggi-tinggi penghargaan dirakamkan kepada semua penyumbang kertas kerja, panel penilai serta jawatankuasa yang telah memberikan komitmen dan kerjasama pada kali ini.

Akhir kata, semoga e-prosiding ini dapat dimanfaatkan sebagai sumber rujukan yang bernilai dan menjadi pemangkin kepada penghasilan lebih banyak penyelidikan serta inovasi yang berimpak pada masa hadapan.
Sekian, terima kasih.

Sekian terima kasih.

BASLIZA BINTI MOHAMAD NOOR
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PENGENALAN

E-Prosiding ini merupakan kompilasi kertas penyelidikan bagi *Innovation Research Conference* (INNORE'CON) 2026 - Seminar Penyelidikan Inovasi Peringkat Kebangsaan. E-prosiding ini dihasilkan bagi mengumpul semua kertas penyelidikan pensyarah yang telah menyertai *Innovation Research Conference* (INNORE'CON) 2026 - Seminar Penyelidikan Inovasi Peringkat Kebangsaan di Kolej Komuniti Paya Besar. E-Prosiding ini mengandungi 52 kertas penyelidikan dari pelbagai disiplin. Semoga E-prosiding ini boleh dijadikan rujukan dan panduan oleh pembaca untuk mendapatkan maklumat lanjut berkaitan dengan penyelidikan yang dijalankan.

OBJEKTIF

1. Mempunyai pengetahuan dalam penulisan kajian inovasi mengikut kaedah yang betul dan tersusun.

2. Membentangkan hasil penulisan kertas penyelidikan daripada inovasi yang lengkap dan berkualiti.

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KERTAS PENULISAN PENYELIDIKAN : INOVASI

EFFIROLL CANVAS SYSTEM: DESIGN AND DEVELOPMENT OF A MOTOR-POWERED CANOPY FOLDING TOOL

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Abstract

The handling and storage of canopy canvas in event-based and commercial applications remain a significant challenge due to the reliance on manual rolling methods. These conventional practices are time-consuming, physically demanding, and often result in uneven rolling, leading to material damage and reduced lifespan. This study presents the design and development of the *EffiRoll Canopy System*, a motorized solution aimed at improving the efficiency, consistency, and ergonomics of canopy canvas rolling. The system integrates a DC gear motor with a steel frame structure to automate the rolling process, minimizing human effort while ensuring uniform and controlled operation. The design process involved concept generation, selection through screening and scoring methods, and development using CAD software. Fabrication was carried out using metalworking techniques such as cutting, welding, and assembly, followed by system integration and functional testing. Performance evaluation was conducted through user testing and operational trials, focusing on efficiency, ease of use, and reliability. The results demonstrate that the *EffiRoll* system significantly reduces rolling time and physical strain while improving the quality and consistency of the rolled canvas. User feedback indicates high satisfaction levels, particularly in terms of usability and effectiveness in real-world applications. In conclusion, the *EffiRoll Canopy System* provides a practical and cost-effective solution for small-scale industries and event operators. The system enhances productivity, reduces labor dependency, and extends the lifespan of canopy materials. Future improvements may include adjustable speed control, battery-powered operation, and enhanced safety features to further optimize system performance.

Keywords: Canopy Handling System, Motorized Rolling Mechanism, DC Gear Motor, Product Design and Development, Ergonomic Engineering, Automation System

Abstrak

Pengendalian dan penyimpanan kanvas kanopi dalam aplikasi acara dan komersial masih menjadi satu cabaran utama kerana kaedah penggulungan secara manual yang masih digunakan. Kaedah konvensional ini memerlukan masa yang lama, tenaga fizikal yang tinggi, serta sering menghasilkan gulungan yang tidak sekata, seterusnya menyebabkan kerosakan bahan dan mengurangkan jangka hayat kanvas. Kajian ini membentangkan reka bentuk dan pembangunan EffiRoll Canopy System*, iaitu satu sistem bermotor yang bertujuan meningkatkan kecekapan, konsistensi dan aspek ergonomik dalam proses penggulungan kanvas kanopi. Sistem ini mengintegrasikan motor gear DC dengan struktur rangka keluli bagi*

mengautomasikan proses penggulungan, sekali gus mengurangkan kebergantungan kepada tenaga manusia serta memastikan operasi yang lebih sekata dan terkawal. Proses reka bentuk melibatkan penjanaan konsep, pemilihan reka bentuk melalui kaedah penapisan dan pemarkahan, serta pembangunan menggunakan perisian CAD. Proses fabrikasi dijalankan menggunakan teknik kerja logam seperti pemotongan, kimpalan dan pemasangan, diikuti dengan integrasi sistem dan ujian fungsi. Penilaian prestasi dilakukan melalui ujian operasi dan maklum balas pengguna dengan menilai aspek kecekapan, kebolehgunaan dan kebolehpercayaan sistem. Keputusan menunjukkan bahawa sistem EffiRoll berjaya mengurangkan masa penggulungan dan keletihan fizikal pengguna, di samping meningkatkan kualiti dan keseragaman gulungan kanvas. Maklum balas pengguna juga menunjukkan tahap kepuasan yang tinggi, terutamanya dari segi kemudahan penggunaan dan keberkesanan dalam aplikasi sebenar. Kesimpulannya, EffiRoll Canopy System *merupakan satu penyelesaian praktikal dan kos efektif untuk industri kecil dan pengendali acara. Sistem ini mampu meningkatkan produktiviti, mengurangkan kebergantungan kepada tenaga kerja, serta memanjangkan jangka hayat bahan kanvas. Penambahbaikan pada masa hadapan termasuk kawalan kelajuan boleh laras, penggunaan sumber kuasa mudah alih, serta ciri keselamatan yang lebih baik.*

Kata kunci: *Sistem Pengendalian Kanopi, Mekanisme Penggulungan Bermotor, Motor Gear DC, Reka Bentuk dan Pembangunan Produk, Kejuruteraan Ergonomik, Sistem Automasi*

1.0 INTRODUCTION

Canopy systems are widely used in outdoor applications such as weddings, exhibitions, markets, and temporary commercial setups due to their flexibility and ease of installation. However, the process of handling and storing canopy canvas remains a significant challenge, particularly during dismantling operations. One of the most critical tasks is the rolling of the canopy canvas, which directly affects the durability and usability of the material.

In most cases, manual methods are still used for rolling canopy canvas. These methods are inefficient, time-consuming, and physically demanding, especially when dealing with large and heavy materials. Improper handling can lead to uneven rolling, wrinkles, and structural damage to the fabric, reducing its lifespan and increasing maintenance costs (Lim & Tan, 2020). Furthermore, repeated manual handling can result in user fatigue and reduced productivity (Rahman, 2019). To overcome these challenges, automation and ergonomic design have been increasingly adopted in engineering applications to improve efficiency and reduce physical strain. The integration of motorized mechanisms in material handling systems has been shown to enhance performance and consistency (Groover, 2015). Therefore, this study proposes the *EffiRoll Canopy System*, a motorized rolling mechanism designed to improve efficiency, reduce manual effort, and ensure consistent rolling quality.

1.1 Problem Statement

The manual handling of canopy canvas presents several operational and ergonomic challenges. Firstly, the process of rolling large canopy canvas requires significant physical effort, which can lead to fatigue, discomfort, and reduced productivity among users. This issue becomes more critical in situations where the task is performed frequently, such as in event management and rental services. Secondly, manual rolling often results in inconsistent outcomes. Uneven rolling can cause creases, wrinkles, and potential tearing of the canvas material, ultimately affecting its durability and visual quality. This leads to increased maintenance costs and shorter product lifespan. In addition, existing tools and equipment in the market primarily focus on folding the canopy structure rather than addressing the rolling of the canvas itself. As a result, there is a lack of specialized solutions that can effectively improve this specific process. Therefore, there is a need to develop an efficient, user-friendly, and automated system that can simplify the rolling process, reduce human effort, and improve the overall quality of canopy handling.

1.2 Research Objectives

The main objectives of this project are:

1. To design a motorized canopy rolling system that improves canvas folding techniques.
2. To fabricate the motorized canopy rolling system that portable and user friendly.
3. To evaluate the performance of the system in terms of efficiency.

1.3 Significant of Research

This research contributes to improving the efficiency and ergonomics of canopy handling by introducing a motorized rolling system that reduces manual effort and enhances productivity. The proposed system improves rolling consistency, minimizes material damage, and extends the lifespan of canopy canvas, leading to cost savings for users (Lim & Tan, 2020). This project supports the development of innovative and practical engineering solutions for smallscale industries. By integrating automation and ergonomic design, the *EffiRoll Canopy System* promotes technological advancement, improves operational efficiency, and contributes to sustainable industrial practices (Groover, 2015).

2.0 LITERATURE REVIEW

Previous research has highlighted the inefficiencies associated with manual handling systems in small-scale and industrial applications. Manual operations are often associated with higher physical strain, reduced productivity, and inconsistent outcomes (Groover, 2015). In the context of canopy systems, improper handling can lead to damage such as tearing, deformation, and reduced material lifespan (Lim & Tan, 2020).

Ergonomic studies have shown that the integration of mechanical assistance and automation significantly improves user comfort and operational efficiency. Rahman (2019) reported that ergonomic tools reduce physical workload and enhance performance, particularly in repetitive

tasks. Similarly, Ahmad et al. (2021) emphasized that automation plays a crucial role in improving productivity and reducing human dependency in small-scale operations.

Motorized systems, particularly those using DC gear motors, are widely applied in mechanical design due to their ability to provide high torque and controlled motion. These characteristics make them suitable for applications involving rolling or rotational mechanisms (Bolton, 2015). Additionally, controlled rolling systems inspired by mechanisms such as reel or rewind systems can improve consistency and reduce material damage.

Despite these advancements, existing solutions in the market primarily focus on canopy frame mechanisms rather than the rolling of the canvas itself. This highlights a research gap in the development of specialized rolling systems for canopy handling. Therefore, this study aims to bridge this gap by developing a motorized canopy rolling system that integrates mechanical design, automation, and ergonomic principles.

3.0 RESEARCH METHODOLOGY

The methodology of this project consists of four main stages: design, material selection, fabrication, and testing.

3.1 Design Process

The design process began with problem identification and concept generation. Several design alternatives were developed and evaluated using concept screening and scoring methods to determine the most suitable design. The selected concept was then modelled using CAD software (SolidWorks), allowing for detailed visualization and optimization of the system.

3.1.1 Concept Design Development

There are 3 drawing sketches of product that consist of improvement for a previous product design. 3 drawing sketches which were Concept Design A, Concept Design B and Concept Design C. Each of the concept design have a different features and mechanism but still have the same function as the previous design;

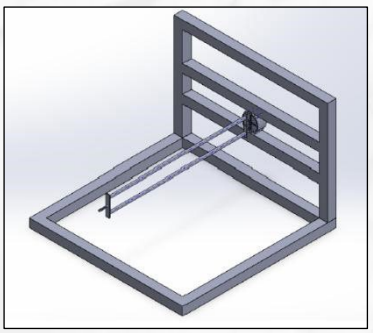


Figure 1: Design A

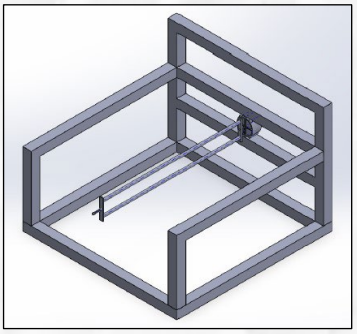


Figure 2: Design B

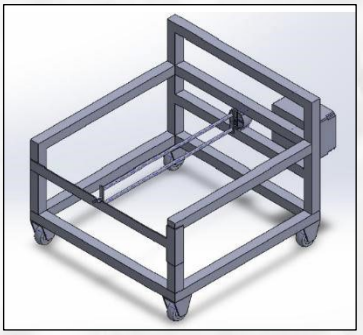


Figure 3: Design C

3.1.2 Concept Screening

Concept screening results show that Concept C achieved the highest net score (5), followed by Concept B (4), while Concept A scored the lowest (0). Therefore, Concept C is selected as the best design for further development due to its superior overall performance.

Table 1: Concept Screening Result

SELECTION CRITERIA	CONCEPT VARIANTS		
	Concept A	Concept B	Concept C
Mass	+	+	+
Time taken to fold canvas	-	+	+
Forced to fold canvas	+	+	0
Material strength	-	+	+
Time to install the product	+	-	+
Pluses	3	4	4
Same	0	0	1
Minuses	2	1	0
Net	0	4	5
Rank	3	2	1
Continue	NO	YES	YES

3.1.3 Concept Scoring

The concept screening (Table 1) and concept scoring (Table 2) methods are used together to evaluate the design alternatives from different perspectives. The concept screening method provides a qualitative comparison, where Concept C achieved the highest net score and was ranked first due to its balanced performance across all criteria. On the other hand, the concept scoring method applies weighted evaluation, which gives more importance to certain criteria such as time to install and time taken to fold the canvas. Based on this method, Concept B obtained a slightly higher total score (12.36) compared to Concept C (11.97). However, despite the slightly higher score of Concept B, Concept C is still selected as the final design. This is because Concept C demonstrates more consistent overall performance, particularly in critical criteria such as:

- Lower force required to fold canvas
- Better mass balance
- No negative (minus) score in screening

In contrast, Concept B shows some weaknesses in certain criteria, which may affect long-term usability and ergonomics. Therefore, by combining both qualitative (screening) and quantitative (scoring) analysis, Concept C is considered the most suitable design for further development due to its overall balance, reliability, and user-friendliness.

Table 2: Concept Scoring Result

SELECTION CRITERIA	WEIGHT	CONCEPTS			
		CONCEPT B		CONCEPT C	
		RATING	WEIGHTED SCORE	RATING	WEIGHTED SCORED
Mass	55%	3	1.65	4	2.20
Time taken to fold canvas	75%	4	3.00	3	2.25
Forced to fold canvas	30%	2	0.60	4	1.20
Material strength	44%	4	1.76	3	1.32
Time to install product	75%	5	3.75	4	3.00
Ease of installation	40%	4	1.60	5	2.00
Total score		12.36		11.97	
Rank		1		2	
Continue		DEVELOP		NO	

3.1.4 Detailed Design and Drawing

The detailed design is being created in the SOLIDWORK software. SOLIDWORK integrated CAD/CAM/CAE, that makes it easy to use. Combines CAD, CAM, and CAE tools, making it a versatile option. It is user-friendly and ideal for all-in-one design and manufacturing.

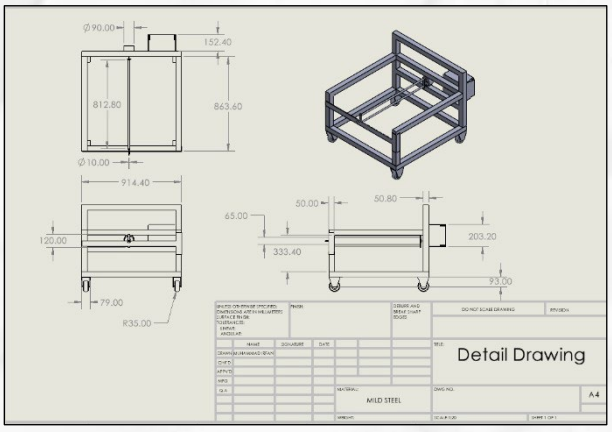


Figure 4 : Detailed Drawing

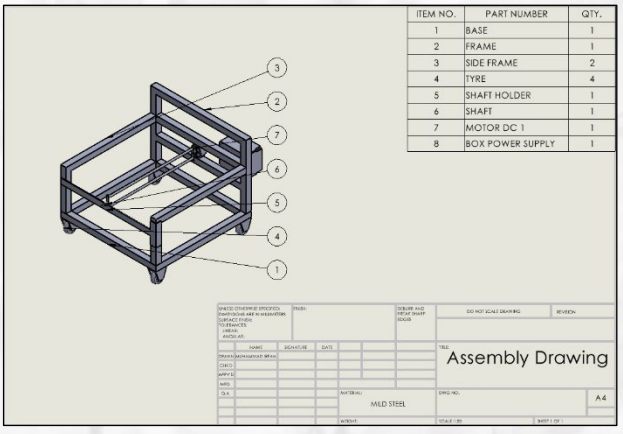


Figure 5: Assembly Drawing

3.2 Material Selection

Material selection was based on strength, durability, and cost considerations. Mild steel was chosen for the structural frame due to its high strength and availability, while corrosion-resistant materials were considered for enhanced durability. A DC gear motor was selected as the main actuator due to its ability to provide high torque and stable rotational motion (Bolton, 2015). Wheels were incorporated to improve mobility and ease of handling.

3.3 Fabrication Process

The fabrication process involved cutting, shaping, and assembling the components. Metal cutting was performed using a cut-off saw, while MIG welding was used to ensure strong and durable joints. The motor and control system were integrated into the frame, followed by final assembly and alignment as in Figure 6.

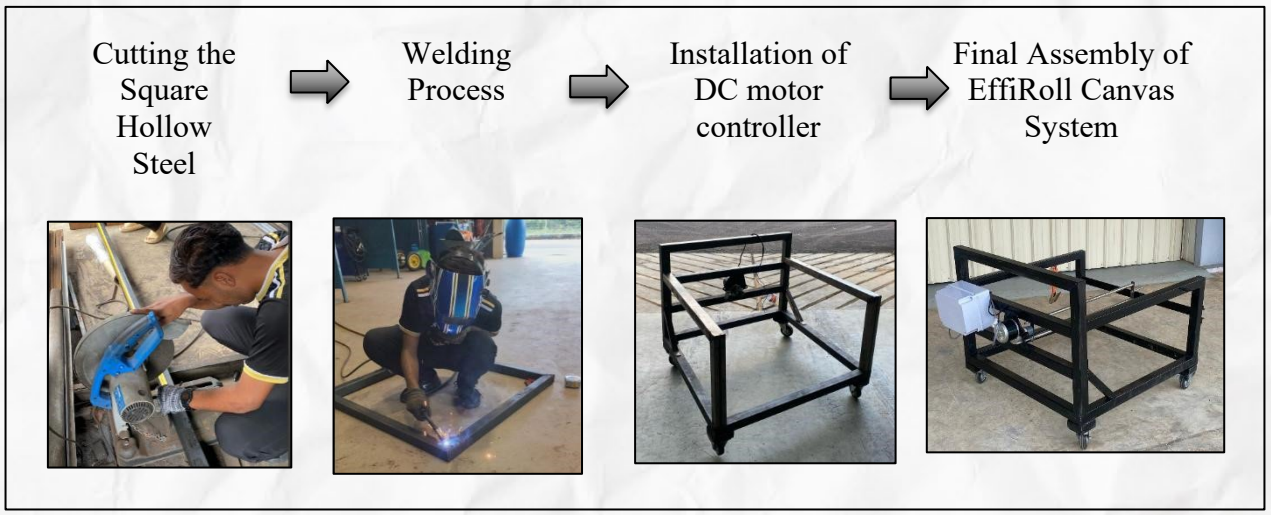


Figure 6: Fabrication Process of *EffiRoll Canvas System*

3.4 Testing and Evaluation

The system was tested under real operating conditions to evaluate its performance. Key performance indicators included rolling efficiency by considering time reduction while folding the canvas.

4.0 RESEARCH FINDINGS AND DISCUSSION

4.1 Testing Result

The results of the system testing have been analysed to determine the performance of the *EffiRoll Canopy System*. The system was tested under real operating conditions to evaluate its efficiency, ease of use, and consistency in rolling the canopy canvas.

The testing shows that the motorized rolling mechanism is able to produce smooth and uniform rolling compared to manual methods. The time required for the rolling process is significantly reduced, while the physical effort required from the user is minimized. In addition, the system demonstrates stable operation without major mechanical issues, indicating good reliability and functionality.

The performance of the system meets the targeted design objectives, particularly in terms of improving efficiency, reducing user fatigue, and ensuring consistent rolling quality.

4.2 Others-optional

The researcher performed data analysis to evaluate the performance of the automated system compared to the manual method as in Table 4.2.1 (Muhammad Irfan Bin Azrul, 2025) as below:

Table 4.2.1: Data Analysis Testing – Automation vs Manual

Attempt	Automation	Manual
1	45	120
2	48	115
3	43	130
4	50	125
5	47	120

The average results show that the *EffiRoll Canopy System* completes the rolling process in 46.6 seconds, compared to 122 seconds for the manual method, representing a significant time reduction of approximately 62%.

4.3 Discussion

The *EffiRoll Canopy System* demonstrates that the integration of a motorized mechanism significantly improves the canopy rolling process compared to conventional manual methods. The use of a DC gear motor provides controlled rotational motion, which ensures consistent rolling and reduces the risk of material damage.

The findings indicate that automation in simple mechanical systems can effectively reduce human effort while improving productivity. This is aligned with previous studies that highlight the importance of ergonomic design and mechanization in enhancing operational efficiency (Rahman, 2019; Groover, 2015).

However, the implementation of such systems also introduces additional considerations, including dependency on power sources and the need for safety mechanisms. These factors must be carefully addressed to ensure the system is practical and safe for real-world applications.

Overall, the results confirm that the *EffiRoll Canopy System* is a viable solution for improving canopy handling processes. The system not only enhances efficiency but also contributes to better material preservation and user comfort, making it suitable for small-scale industries and event management applications.

5.0 CONCLUSION AND RECOMMENDATIONS

In conclusion, the *EffiRoll Canopy System* successfully addresses the limitations associated with manual canopy rolling. The integration of a motorized mechanism improves efficiency, reduces physical strain, and ensures consistent rolling quality. The system is practical, portable, and suitable for real-world applications in event management and small-scale industries. The findings confirm that the proposed solution enhances productivity and reduces operational challenges. Future work may include the integration of adjustable speed control, battery-powered operation, and enhanced safety features to further improve system performance and usability.

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THE EFFECTIVENESS OF FLASHCARDS IN ENHANCING MANDARIN VOCABULARY LEARNING AMONG USIM LEARNERS: A CORRELATIONAL STUDY

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Abstract

The learning of Mandarin vocabulary poses significant challenges for non-native learners in Malaysian universities, particularly due to the complexities of Chinese characters and the tonal system. Flashcards have emerged as an innovative and accessible tool to support vocabulary learning, yet empirical evidence on their effectiveness within the Malaysian Mandarin classroom context remains limited. This quantitative correlational study investigates the effectiveness of flashcards in enhancing Mandarin vocabulary learning among undergraduate students at Universiti Sains Islam Malaysia (USIM). A sample of 126 respondents was drawn from students enrolled in Mandarin foreign language courses using a cluster sampling technique. Data were collected through a structured questionnaire measuring flashcard usage frequency, alongside a vocabulary proficiency test assessing learners' Mandarin vocabulary knowledge based on course syllabus content. Descriptive statistics and Pearson correlation analysis were employed to analyse the data using SPSS version 26. The findings revealed a high level of flashcard usage among respondents (Overall Mean = 3.74). Vocabulary test scores indicated a high level of proficiency across learners (Mean = 22.45 out of 30, 74.8%). Crucially, the Pearson correlation analysis revealed a significant positive correlation between flashcard use and Mandarin vocabulary learning ($r = 0.452$, $p < 0.001$). These findings suggest that learners who frequently utilise flashcards demonstrate higher vocabulary proficiency compared to those who do not. The study contributes to the growing body of literature on innovative language learning tools and provides practical implications for Mandarin educators, curriculum designers, and learners in Malaysian higher education institutions.

Keywords: Flashcards, vocabulary learning, Mandarin, correlational study, USIM.

Abstrak

Pembelajaran kosa kata Bahasa Mandarin menghadapi cabaran yang signifikan bagi pelajar bukan penutur asli di universiti-universiti Malaysia, terutamanya disebabkan oleh kerumitan tulisan Cina dan sistem nada. Kad imbasan telah muncul sebagai alat yang inovatif dan mudah diakses untuk menyokong pembelajaran kosa kata, namun bukti empirikal tentang keberkesanannya dalam konteks bilik darjah Bahasa Mandarin di Malaysia masih terhad.

Kajian korelasi kuantitatif ini menyiasat keberkesanan kad imbasan dalam meningkatkan pembelajaran kosa kata Bahasa Mandarin dalam kalangan pelajar sarjana muda di Universiti Sains Islam Malaysia (USIM). Seramai 126 responden dipilih daripada pelajar yang mendaftar kursus bahasa asing Mandarin menggunakan teknik persampelan kluster. Data dikumpul melalui soal selidik berstruktur yang mengukur kekerapan penggunaan kad imbasan, bersama-sama dengan ujian kecekapan kosa kata yang menilai pengetahuan kosa kata Bahasa Mandarin pelajar berdasarkan kandungan sukatan kursus. Statistik deskriptif dan analisis korelasi Pearson digunakan untuk menganalisis data menggunakan SPSS versi 26. Dapatan kajian menunjukkan tahap penggunaan kad imbasan yang tinggi dalam kalangan responden (Min Keseluruhan = 3.74). Skor ujian kosa kata menunjukkan tahap kecekapan yang tinggi dalam kalangan pelajar (Min = 22.45 daripada 30, 74.8%). Yang penting, analisis korelasi Pearson mendedahkan hubungan positif yang signifikan antara penggunaan kad imbasan dan pembelajaran kosa kata Bahasa Mandarin ($r = 0.452$, $p < 0.001$). Dapatan ini menunjukkan bahawa pelajar yang kerap menggunakan kad imbasan menunjukkan kecekapan kosa kata yang lebih tinggi berbanding mereka yang tidak. Kajian ini menyumbang kepada badan literatur yang semakin berkembang tentang alat pembelajaran bahasa yang inovatif dan memberikan implikasi praktikal kepada pendidik Bahasa Mandarin, pereka bentuk kurikulum, dan pelajar di institusi pengajian tinggi Malaysia.

Kata kunci: *Kad imbasan, pembelajaran kosa kata, Bahasa Mandarin, kajian korelasi, USIM*

1.0 INTRODUCTION

Mandarin has emerged as one of the most popular foreign languages learnt by non-native speakers in Malaysia, driven by the country's multicultural landscape and China's growing global economic influence (Chua, 2025). Beyond the Chinese community, a significant number of non-Chinese Malaysians are capable of speaking Mandarin, reflecting its widespread appeal for personal and professional advancement. The increasing enrolment of non-native learners in Mandarin as a foreign language (MFL) at Malaysian public higher education institutions demonstrates this growing interest (Chan et al., 2018). In higher education, Mandarin is commonly offered as a foreign language course across Malaysian public universities, including Universiti Sains Islam Malaysia (USIM), where it aims to equip students with additional linguistic skills for career competitiveness. The Selangor state government has further supported this trend through initiatives offering free online Mandarin classes, recognising the language's strategic importance in regional and international contexts (Media Selangor, 2025).

Vocabulary learning is fundamental to developing proficiency in any language, serving as the essential building block for effective communication, reading comprehension, and accurate expression (Al-Khawaldeh et al., 2024). For Mandarin as a foreign language, vocabulary knowledge directly influences learners' ability to understand texts, engage in conversations, and convey ideas appropriately. The process involves not merely memorising isolated words but mastering their pronunciation, tonal variations, character forms, and contextual usage (Lu et al., 2019). Research has demonstrated that successful language learners employ a range of

vocabulary learning strategies, and the frequency and type of strategies used often distinguish high proficiency learners from low proficiency ones (Zakharova, 2013). Studies among Malaysian learners have similarly found that vocabulary learning strategy use varies significantly between high and low proficiency students (Lee et al., 2017), highlighting the critical role of strategic approaches in vocabulary development.

However, most of the learners encounter significant challenges when acquiring Mandarin vocabulary due to fundamental differences between the mother tongue language (Malay) and Mandarin language systems. The tonal system presents a major hurdle, as Malay is non-tonal, yet the tone of a Mandarin word can entirely change its meaning (Wong, 2011). Research by Wong (2011) specifically examined tone errors among Malay learners, documenting systematic patterns in pronunciation difficulties. Additionally, Mandarin employs thousands of logographic characters, unlike Malay's familiar Latin alphabet, requiring extensive memorisation and visual recognition skills (Lu et al., 2019). Research has shown that learners' attitudes towards Malay can also influence their production of sounds in other languages, demonstrating the complex interplay between linguistic systems (Chan & Starr, 2025). These compounded challenges often lead to vocabulary retention difficulties, affecting learners' overall language performance and potentially discouraging continued engagement with Mandarin studies (Ju et al., 2023), thereby necessitating the exploration of effective vocabulary learning tools.

1.1 Problem Statement

Malaysian learners of Mandarin as a foreign language (MFL) continue to face significant difficulties in vocabulary learning and retention, despite the language's growing popularity and widespread offering in public universities. Research has demonstrated that Malay learners encounter substantial challenges due to fundamental differences between the Malay and Mandarin language systems, including the tonal nature of Mandarin, the complexity of logographic characters, and pronunciation variations that do not exist in their mother tongue language (Free Malaysia Today, 2023; Talkpal AI, 2024; Wong, 2011). These compounded challenges often result in unsatisfactory vocabulary development, with studies revealing that most Mandarin language learners at Malaysian universities achieve only limited vocabulary sizes (Ju et al., 2023). Such vocabulary limitations adversely affect learners' overall language performance, reading comprehension, and communicative competence, potentially discouraging continued engagement with Mandarin studies (Ju et al., 2023).

Despite the recognised importance of vocabulary learning strategies in facilitating language learning, empirical research on the utilisation of specific vocabulary learning tools within the Malaysian Mandarin classroom context remains limited. A large-scale study involving 330 Malay undergraduates revealed that while high proficiency learners tend to employ strategies such as "recalling the meaning of Mandarin words," low proficiency learners more frequently rely on repetition-based approaches like "saying new Mandarin words repetitively" (Lee et al., 2017, p. 95). Crucially, the findings demonstrated that students from both high and low proficiency groups rarely use flashcards to learn new Mandarin words (Lee et al., 2017). This underutilisation of flashcards is noteworthy given that digital flashcard applications such as

Quizlet have been developed to support language learning, and research conducted at a university in Kelantan found that non-native Mandarin learners demonstrated positive reactions towards Quizlet tools, including flashcards, when integrated into Mandarin courses (Chua & Azlan, 2018). Despite this positive reception, systematic investigation into the effectiveness of flashcards specifically for Mandarin vocabulary learning in Malaysian higher education remains scarce and limited.

At USIM, Mandarin is offered as a foreign language course to undergraduate students from various faculties, yet no empirical study has specifically examined the relationship between flashcard use and Mandarin vocabulary learning among USIM learners. Research has shown that attitude significantly predicts Mandarin course achievement among Malaysian public university learners (Ju et al., 2022), and engagement has been identified as a critical factor in Mandarin learning success (Ju et al., 2023). However, the specific role of flashcards as a vocabulary learning tool within the USIM context has not been investigated. Given that existing research indicates low flashcard usage among Malay learners nationally (Lee et al., 2017), there is a pressing need to examine whether this pattern holds at USIM and whether flashcards can serve as an effective vocabulary learning tool for this specific student population. Such investigation would provide evidence-based recommendations for Mandarin educators at USIM and contribute to the broader understanding of innovative vocabulary learning tools in Malaysian higher education.

1.2 Research Objectives

This study aims to investigate the relationship between flashcard use and Mandarin vocabulary learning among USIM learners. Specifically, the objectives of this study are:

i. To identify the frequency of flashcard use among USIM undergraduate students.
ii. To measure the level of Mandarin vocabulary learning among USIM students.
iii. To determine the correlation between flashcard use and Mandarin vocabulary learning among USIM students.

2. LITERATURE REVIEW

2.1 Theoretical Framework

The cognitive underpinnings of flashcard-based vocabulary instruction can be effectively explained through Dual Coding Theory (DCT), pioneered by Allan Paivio (1986, 2007). DCT posits that human cognition operates through two distinct yet interconnected mental systems: a verbal system specialised for processing and representing language, and a non-verbal (imagery) system dedicated to processing visual information, such as objects, pictures, and sensory experiences (Paivio, 1986; Clark & Paivio, 1991). According to this framework, these two systems function independently but are interconnected through referential connections, allowing information encoded in one system to activate the other. The core principle of DCT is that information encoded through both systems simultaneously creates stronger and more durable memory traces than information processed through only one channel (Paivio, 2007; Sadoski, 2005). This phenomenon, known as the dual coding effect, occurs because dual encoding provides two separates yet linked mental representations for a single concept, thereby

increasing the number of potential retrieval pathways available during recall (Mayer & Sims, 1994). When a learner encounters new vocabulary through both verbal and visual modalities, the probability of successful retention and retrieval is significantly enhanced.

In the specific context of Mandarin Chinese vocabulary learning, Dual Coding Theory holds particular relevance. Unlike alphabetic languages, Mandarin employs logographic characters that frequently contain visual elements, or radicals, which offer cues to meaning (Shen, 2004; Wang & Thomas, 2009). Flashcards operationalise DCT by systematically presenting the Mandarin word in written characters and spoken pinyin (verbal code) alongside images or illustrations representing the word's meaning (visual code). For example, when a learner views a flashcard displaying the character "马" (meaning horse) accompanied by a corresponding picture, their brain creates dual mental representations: one verbal (the character form and pronunciation) and one visual (the image). The referential connections formed between these two representations strengthen the memory trace and facilitate faster lexical access during communication (Basoglu & Akdemir, 2010; Nation, 2013). Empirical studies in second language learning have consistently supported the application of DCT, demonstrating that vocabulary instruction incorporating visual aids leads to superior retention outcomes compared to text-only methods (Chun & Plass, 1996; Yoshii & Flaitz, 2002). Thus, Dual Coding Theory provides a robust theoretical foundation for investigating the relationship between physical flashcard usage and Mandarin vocabulary learning among USIM learners.

2.2 Vocabulary Learning in Mandarin as a Foreign Language

Vocabulary knowledge is fundamental to second and foreign language proficiency and serves as a strong predictor of overall language ability, including reading comprehension, listening comprehension, and communicative competence (Nation, 2022). Research has consistently demonstrated that learners with larger vocabulary sizes perform better across all language skills, making vocabulary learning a priority in language education. For learners of Mandarin specifically, this challenge is particularly acute, as they must memorise approximately 3,000 to 4,000 characters to achieve functional literacy. Each of these characters can then combine with others to form countless vocabulary items. At USIM, for example, learners are required to memorise at least 150 to 200 words per level. By level three, they are expected to have mastered at least 450 words, a threshold that enables them to engage in daily communication. This substantial memorisation burden requires deliberate and systematic vocabulary learning strategies.

However, most previous studies have highlighted the specific and well-documented challenges learners face when acquiring Mandarin vocabulary, challenges that stem from fundamental differences between their mother tongue and the Mandarin language system. For Malay learners, the logographic writing system of Mandarin presents a significant obstacle, as it requires memorising characters that represent morphemes rather than sounds, a stark contrast to Malay's familiar Latin alphabet (Wong, 2011). The tonal system further compounds this difficulty. Because Malay is a non-tonal language, learners must grapple with the fact that a syllable's meaning can change entirely depending on whether it is pronounced with a flat,

rising, falling then rising, or falling tone. Pronunciation differences add another layer of complexity, as certain Mandarin sounds have no equivalent in Malay. Research by Wong (2011) specifically examined tone errors among Malay learners, documenting systematic patterns in pronunciation difficulties that ultimately affect vocabulary learning and retention.

Research on vocabulary learning strategies among Malay undergraduates learning Mandarin has revealed important patterns in how learners approach vocabulary learning. A large-scale study involving 330 Malay undergraduates found that high proficiency learners tend to employ deeper processing strategies such as recalling the meaning of Mandarin words and connecting new words to prior knowledge, while low proficiency learners more frequently rely on surface-level approaches like saying new Mandarin words repetitively and memorising without contextual understanding (Lee et al., 2017). Crucially, Lee's study found that students from both high and low proficiency groups rarely use flashcards to learn new Mandarin words, despite the potential benefits of this tool. This underutilisation of flashcards represents a significant gap between research evidence on effective vocabulary learning tools and actual learner practice, warranting further investigation into whether increased flashcard use could improve vocabulary outcomes for Malay learners.

2.3 Empirical Studies on Flashcards

Empirical research has consistently demonstrated the effectiveness of flashcards for vocabulary learning across multiple languages and learning contexts. Armus et al. (2025) conducted a Classroom Action Research study examining the use of digital Anki flashcards for improving Mandarin vocabulary mastery among eighth-grade students in Indonesia. With 17 students across two cycles, the study found that average student scores improved from 60.78 in the first cycle to 85.09 in the second cycle, a substantial 24.31-point increase. The researchers concluded that digital flashcard applications like Anki offer innovative and responsive learning strategies that suit students' needs and increase engagement in Mandarin vocabulary learning. This study provides strong evidence that structured flashcard interventions can produce meaningful improvements in vocabulary outcomes, even among younger learners with limited prior exposure to Mandarin.

Comparative research has examined the relative effectiveness of different flashcard formats and their superiority over traditional vocabulary learning methods. Li and Hafner (2021) compared digital and paper flashcards among 85 undergraduates using comprehensive assessments for receptive and productive vocabulary knowledge, finding overall advantages for digital flashcards. Yüksel, Mercanoğlu, and Yılmaz (2020) compared digital flashcards to wordlists in a study with 57 pharmacy students, finding that digital flashcards were more effective for technical vocabulary learning. In the Malaysian context, Chua and Azlan (2018) investigated the use of Quizlet application tools, including flashcards, in teaching Mandarin as a third language at a university in Kelantan. Their study found that non-native Mandarin learners demonstrated positive reactions towards Quizlet when integrated into Mandarin courses, suggesting that Malaysian learners are receptive to digital flashcard tools and find them beneficial for vocabulary learning.

However, research also indicates that flashcard effectiveness depends on implementation methods and may require supplementary activities for optimal results. Nicolò (2023) conducted a design-based research study developing contextual flashcards in augmented reality for Mandarin learning, finding that learners reported high satisfaction with innovative flashcard formats that connected vocabulary to real-world contexts. Chirinos (2018) evaluated Say-all-fast-minute-each-day-shuffled (SAFMEDS), a fluency-based intervention using flashcards, for learning Chinese characters and found that the basic flashcard procedure required additional practice for optimal results, with higher levels of correct responding evident when whole deck review supplemental practice was added. This suggests that while flashcards are effective, they should be integrated within broader vocabulary learning strategies that include contextual practice and varied review methods to maximise learning outcomes.

3.0 RESEARCH METHODOLOGY

This study employed a quantitative correlational research design to investigate the relationship between physical flashcard usage and Mandarin vocabulary learning among USIM students. A correlational design was selected as it allows researchers to examine the relationship between two variables (dependent variable and independent variable). The independent variable was flashcard usage, while the dependent variable was Mandarin vocabulary size. The target population consisted of undergraduate students enrolled in Mandarin foreign language courses at USIM (Mandarin Level 1-3). The researcher used a cluster sampling technique, and 126 respondents were drawn from existing Mandarin classes, which is appropriate for educational settings where natural groups already exist (Fraenkel, Wallen, & Hyun, 2019). This sample size exceeds the minimum requirement for correlational studies as recommended by Cohen (1988).

In the actual study, two research instruments were utilised for data collection. The first instrument was a flashcard usage questionnaire adapted and adopted from Komachali and Khodareza (2012), Sinaga (2020), and Nurhaliza and Sari (2023). The questionnaire consisted of two sections: Part A collected demographic information, while Part B measured flashcard usage frequency, preparation methods, and study strategies using a five-point Likert scale ranging from 1 (Never) to 5 (Always). The second instrument was a Mandarin vocabulary test developed based on the USIM Mandarin course syllabus, following the Vocabulary Size Test framework by Nation and Beglar (2007). The test consisted of 30 multiple-choice items assessing receptive vocabulary knowledge, with each item presenting a Chinese word followed by four meaning options in English or Malay. The researcher submitted the instruments to three (3) experts for validation, and several items were revised based on their feedback. After the instrument was revised based on the comments by the panel of experts and pre-test, a pilot study was conducted. A total of 102 valid responses were obtained from the pilot study, thus fulfilling the required minimum sample size of 100 (Awang, 2015; Bahkia et al., 2019). The pilot study data were subjected to exploratory factor analysis (EFA) before the actual survey was administered.

The actual study data collection was conducted during regular class periods with permission from course instructors and the faculty. Respondents were informed about the study's purpose and provided written consent. The questionnaire required approximately 20-25 minutes to complete, while the vocabulary test took 25-40 minutes. Data were analysed using SPSS version 26. Descriptive statistics (frequencies, percentages, means, and standard deviations) were computed to summarise respondent demographics and flashcard usage patterns. To address the research objective, a Pearson product-moment correlation analysis was conducted to determine the relationship between flashcard usage scores and vocabulary test scores, with the significance level set at $p < 0.05$. Ethical considerations including anonymity, confidentiality, and the right to withdraw were strictly observed throughout the research process.

4.0 RESEARCH FINDINGS

4.1 Respondents' Demographic

In this study, the researcher distributed 150 questionnaires, of which 126 were returned as valid responses, resulting in an excellent response rate of 84% (Fincham, 2008). The results revealed that a significantly higher proportion of female Mandarin learners (76.2%) completed the questionnaire compared to male Mandarin learners (23.8%). The age group with the highest participation was 20-24 years old, accounting for 78.5% of respondents, followed by those aged 16-19 years old (21.5%). The vast majority of respondents were Malay (97.6%), with the remaining 2.4% belonging to non-Malay groups. The demographic profile of the respondents is presented in Table 4.1 below:

Table 4.1: Demographic Profile of Respondents

Demographic variables	Category	Frequency	Percentage (%)
Gender	Male	30	23.8
	Female	96	76.2
Age	16 – 19 years old	27	21.5
	20 – 24 years old	99	78.5
Race	Malay	123	97.6
	Others	3	2.4
Education background	Language and Linguistics	43	34.1
	Economics	25	19.8
	Information Technology	8	6.3
	Social Science	8	6.3
	Management	19	15
	Syariah and Law	10	7.9
	Biology or Other Sciences	8	6.3
	Leadership	5	3.9

In terms of educational background, most respondents came from Language and Linguistics (34.1%), followed by Economics (19.8%), Management (15%), Syariah and Law (7.9%), Information Technology (6.3%), Social Science (6.3%), Biology or Other Sciences (6.3%), and Leadership (3.9%).

4.2 Reliability Test

In this study, reliability tests were conducted to assess the internal consistency of each measurement instrument. Cronbach's Alpha (α) coefficient was employed to analyse the internal consistency of the data for each variable, namely flashcard usage, preparation and design, study strategies, and the vocabulary size test. According to Nunnally (1978), Cronbach's Alpha values should exceed 0.7 to indicate that the variables measured in a questionnaire are reliable. As shown in Table 4.2, all Cronbach's Alpha values surpassed this threshold, demonstrating highly satisfactory internal consistency. A higher coefficient value reflects better internal consistency of the data, confirming that the instruments used in this study are reliable for measuring the intended constructs.

Table 4.2 shows that the variable study strategies has the highest Cronbach's Alpha value (α = 0.818), while preparation and design have the lowest (α = 0.796). Based on these results, the reliability values for all variables exceed the acceptable threshold of 0.7, indicating that the items used in the current study are reliable and internally consistent.

Table 4.2: Cronbach's Alpha (α) values of all items

	Variables	**Number of Items**	**Cronbach's Alpha (α)**
	Flashcard Usage	4	0.802
Independent	Preparation and Design	4	0.796
	Study Strategies	4	0.818
Dependent	Vocabulary Size Test	30	0.779

4.3 RQ1. To Identify the Frequency Of Flashcard Use Among Usim Learners

In this study, flashcard usage frequency was measured using a 5-point Likert scale ranging from 1 (Never) to 5 (Always). The interpretation of mean scores according to researcher (Nunally & Bernstein,1994) is shown in Table 4.3, followed by Table 4.4, which presents the mean scores and standard deviations for each item.

Table 4.3: Interpretation Mean Score

Mean Score	**Interpretation**
1.00 – 1.80	Very Low
1.81 – 2.60	Low
2.61 – 3.40	Moderate
3.41 – 4.20	High
4.21 – 5.00	Very High

Table 4.4: Mean Scores for Flashcard Usage Items (n=126)

No.	Item	Mean	Std. Deviation	Interpretation
Frequency of Use (Section B1)				
B1.1	I use physical flashcards when studying Mandarin vocabulary.	3.85	0.92	High
B1.2	I review my Mandarin flashcards regularly outside of class.	3.62	1.04	High
B1.3	I carry my flashcards with me to study during free time.	3.21	1.21	Moderate
B1.4	I spend at least 15 minutes per session reviewing flashcards.	3.58	1.10	High
Section B1 Mean		**3.57**	**0.98**	**High**
No.	**Item**	**Mean**	**Std. Deviation**	**Interpretation**
Preparation and Design (Section B2)				
B2.1	I create my own handwritten flashcards.	4.12	0.87	Very High
B2.2	I write the Chinese character on one side and the meaning/pinyin on the other.	4.35	0.76	Very High
B2.3	I include example sentences on my flashcards.	3.28	1.18	Moderate
B2.4	I use pictures or colours to help me remember the words.	3.45	1.22	High
Section B2 Mean		**3.80**	**0.95**	**High**
No.	**Item**	**Mean**	**Std. Deviation**	**Interpretation**
Study Strategies (Section B3)				
B3.1	I shuffle my cards to ensure I don't just memorise the order.	3.48	1.15	High
B3.2	I practise recalling the meaning before flipping the card.	3.97	0.94	High
B3.3	I separate cards I know well from those I still struggle with.	3.82	1.02	High
B3.4	I use flashcards to prepare for quizzes and exams.	4.08	0.89	Very High
Section B3 Mean		3.84	0.96	High
Overall Mean		3.74	0.92	High

The findings indicate that respondents demonstrated an overall high level of flashcard usage (Overall Mean = 3.74, SD = 0.92). Among the three sections, Study Strategies recorded the highest mean (M = 3.84, SD = 0.96), followed closely by Preparation and Design (M = 3.80, SD = 0.95), while Frequency of Use (M = 3.57, SD = 0.98) was also interpreted as high. The highest mean score was for item B2.2: "I write the Chinese character on one side and the

meaning/pinyin on the other" (M = 4.35, SD = 0.76), which falls within the very high interpretation range. This suggests that students strongly prefer this traditional flashcard formatting method. The lowest mean score was for item B1.3: "I carry my flashcards with me to study during free time" (M = 3.21, SD = 1.21), interpreted as moderate, indicating that while students use flashcards, they may not always utilise them for mobile or opportunistic learning.

4.4 RQ2: To measure the level of Mandarin vocabulary learning among USIM.

To measure the level of Mandarin vocabulary learning among USIM students, a vocabulary test consisting of 30 multiple-choice items was administered to all 126 respondents. The test was developed based on the USIM Mandarin course syllabus, following the Vocabulary Size Test framework by Nation and Beglar (2007). Each item was scored as either correct (1) or incorrect (0), with total scores ranging from 0 to 30. The mean scores and standard deviations for each vocabulary item are presented in Table 4.5 below:

Table 4.5: Mean Scores for Mandarin Vocabulary Test Items (n=126)

No	Chinese Word	Pinyin	English Meaning	Mean	Std. Deviation	Interpretation
C1	爱	ài	love	0.85	0.36	Very High
C2	吃	chī	eat	0.92	0.27	Very High
C3	大	dà	big	0.88	0.33	Very High
C4	小	xiǎo	small	0.91	0.29	Very High
C5	水	shuǐ	water	0.87	0.34	Very High
C6	火	huǒ	fire	0.84	0.37	Very High
C7	学校	xuéxiào	school	0.82	0.39	High
C8	老师	lǎoshī	teacher	0.86	0.35	Very High
C9	学生	xuésheng	student	0.89	0.31	Very High
C10	学习	xuéxí	study	0.79	0.41	High
C11	图书馆	túshūguǎn	library	0.71	0.46	High
C12	高兴	gāoxìng	happy	0.76	0.43	High
C13	朋友	péngyǒu	friend	0.90	0.30	Very High
C14	今天	jīntiān	today	0.83	0.38	High
C15	明天	míngtiān	tomorrow	0.81	0.39	High
C16	昨天	zuótiān	yesterday	0.77	0.42	High
C17	星期	xīngqī	week	0.73	0.45	High
C18	月	yuè	month	0.75	0.44	High
C19	年	nián	year	0.78	0.41	High
C20	一	yī	one	0.95	0.22	Very High
C21	二	èr	two	0.94	0.24	Very High
C22	三	sān	three	0.93	0.26	Very High
C23	四	sì	four	0.88	0.33	Very High

C24	五	wǔ	five	0.89	0.31	Very High
C25	六	liù	six	0.86	0.35	Very High
C26	七	qī	seven	0.84	0.37	High
C27	八	bā	eight	0.85	0.36	Very High
C28	九	jiǔ	nine	0.83	0.38	High
C29	十	shí	ten	0.87	0.34	Very High
C30	好	hǎo	good	0.90	0.30	Very High
Total Vocabulary Score (out of 30)				22.45	4.67	High

The Mandarin vocabulary test consisted of 30 items based on the USIM course syllabus. The overall mean score was 22.45 out of 30 (SD = 4.67), which is equivalent to 74.8% and falls within the high interpretation range. This indicates that respondents demonstrated a solid grasp of basic Mandarin vocabulary covered in their courses. Scores ranged from a minimum of 12 to a maximum of 30, suggesting considerable variability in vocabulary proficiency among the 126 respondents. The standard deviation of 4.67 indicates a moderate spread of scores around the mean. At the individual item level, the highest proportion of correct answers was for basic number words, particularly C20: 一 (yī) "one" (M = 0.95) and C21: 二 (èr) "two" (M = 0.94), both interpreted as Very High. This suggests that students have mastered elementary vocabulary items. The lowest proportion of correct answers was for C11: 图书馆 (túshūguǎn) "library" (M = 0.71), though this still falls within the High interpretation range. Overall, the vocabulary test results indicate that USIM students enrolled in Mandarin language courses possess a high level of receptive vocabulary knowledge based on their syllabus content.

4.5 RQ3: To determine the correlation between flashcard use and Mandarin vocabulary learning among USIM students

To examine the relationship between flashcard usage and Mandarin vocabulary learning among USIM students, a Pearson product-moment correlation analysis was conducted. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity, and homoscedasticity. The flashcard usage score was computed as the mean of all 12 items from the flashcard usage questionnaire, while the vocabulary score was the total correct out of 30 on the Mandarin vocabulary test. The results of the correlation analysis are presented in Table 4. 6 below.

Table 4.6: Pearson Correlation between Flashcard Usage and Vocabulary Scores

		Flashcard Usage	**Vocabulary Score**
Flashcard Usage	Pearson Correlation	1	*.452***
	Sig. (2-tailed)		*.001*
	N		126
Vocabulary Score	Pearson Correlation	*.452***	1
	Sig. (2-tailed)	*.001*	
	N	126	

**. Correlation is significant at the 0.01 level (2-tailed)

As presented in Table 4.6, there was a moderate, positive correlation between flashcard usage and Mandarin vocabulary scores, $r = 0.452$, $n = 126$, $p < 0.001$. This indicates that higher levels of flashcard usage were associated with higher vocabulary test scores. According to Cohen's (1988) guidelines, this represents a moderate effect size**.** The coefficient of determination ($r^2 = 0.204$) indicates that flashcard usage accounts for approximately 20.4% of the variance in vocabulary test scores. This finding confirms that there is a significant positive relationship between flashcard usage and Mandarin vocabulary learning among USIM students.

5.0 CONCLUSION

This quantitative correlational study investigated the relationship between physical flashcard usage and Mandarin vocabulary learning among 126 USIM students. The findings revealed that respondents demonstrated a high level of flashcard usage (Overall Mean = 3.74) and a high level of vocabulary proficiency (Mean = 22.45 out of 30, 74.8%). More importantly, a significant moderate positive correlation was found between flashcard usage and vocabulary scores ($r = 0.452$, $p < 0.001$), indicating that students who frequently use physical flashcards tend to achieve larger Mandarin vocabulary sizes. This finding provides empirical support for Dual Coding Theory (Paivio, 1986), which posits that information encoded through both verbal and visual systems creates stronger memory traces. The study contributes to the growing body of literature on innovative language learning tools and offers practical implications for Mandarin educators and learners in Malaysian higher education institutions. Despite its limitations, this research confirms that physical flashcards remain a relevant and effective tool for Mandarin vocabulary learning, particularly for non-native learners grappling with the complexities of Chinese characters and tones.

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SYNTAX SNAPS; STUDENTS' PERCEPTION AND ITS EFFECTIVENESS IN ENHANCING WRITING SKILLS AMONG SECONDARY SCHOOL LEARNERS

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Abstract

Syntax Snaps is an innovative educational tool designed to overcome the challenges faced by secondary school students in mastering syntax and sentence structure. Based on the principles of game-based learning, Syntax Snaps offers an engaging and interactive approach to language acquisition by integrating gamified elements such as points and leaderboards. The tool provides a variety of activities, including creative sentence building, syntax error detection, and sentence reordering, all aimed at enhancing syntactic accuracy, fluency, and critical thinking skills. By fostering active participation and motivation, Syntax Snaps transforms traditional syntax learning into a much more enjoyable experience in which the students can be more engaged. The innovation also incorporates adaptive levels of difficulty, ensuring that the content evolves with the students' progress and individual needs. Initial implementation and pilot test of Syntax Snaps in classrooms have demonstrated its effectiveness in improving students' syntactic accuracy and writing confidence, specifically among those who struggle with traditional methods. Syntax Snaps represents a significant step forward in the integration of game-based learning and language acquisition. This tool offers a practical, adaptable, and enjoyable solution for enhancing writing skills and fostering a deeper appreciation for the language among students.

Keywords: Syntax Snaps, Writing Skills, ESL Learners, Game-based Learning

Abstrak

Syntax Snaps merupakan sebuah alat pendidikan inovatif yang direka khas untuk membantu mengatasi cabaran yang dihadapi oleh pelajar sekolah menengah dalam menguasai sintaksis dan struktur ayat. Berdasarkan prinsip-prinsip teori pembelajaran berasaskan permainan, Syntax Snaps menawarkan pendekatan yang menarik dan interaktif dalam pemerolehan bahasa dengan menggabungkan elemen permainan mata ganjaran dan carta kedudukan. Alat ini memberikan pelbagai aktiviti, termasuk pembinaan ayat kreatif, pengesanan kesalahan sintaksis, kefasihan dan kemahiran pemikiran kritis. Dengan memupuk motivasi serta penyertaan aktif pelajar, Syntax Snaps dapat mengubah pembelajaran sintaksis tradisional

menjadi pengalaman pembelajaran yang lebih menyeronokkan dan mampu meningkatkan penglibatan pelajar. Inovasi ini juga mempunyai tahap kesukaran yang adaptif bagi memastikan kandungan berkembang selaras dengan keperluan pelajar secara individu. Pelaksanaan awal dan ujian rintis Syntax Snaps di dalam bilik darjah telah menunjukkan keberkesanannya dalam meningkatkan ketepatan sintaksis dan keyakinan menulis para pelajar, terutamanya di dalam kalangan mereka yang menghadapi cabaran dalam pengajaran tradisional Syntax Snaps menjadikan langkah yang bermakna dalam integrasi pembelajaran berasaskan permainan dan pemerolehan bahasa. Alat ini menawarkan penyelesaian yang praktikal, boleh lara, dan menyeronokkan bagi meningkatkan kemahiran menulis serta memupuk penghargaan yang lebih mendalam terhadap bahasa dalam kalangan pelajar.

Kata kunci: *Syntax Snaps, Kemahiran Penulisan, Pelajar ESL, Pembelajaran Berasaskan Permainan*

1.0 INTRODUCTION

Writing is one of the significant components in language learning**.** It is widely known that writing aids in generating new ideas, determining the best approach to articulate ideas into writing, and organizing those ideas into coherent phrases and paragraphs (Botirovna, 2023). In Malaysia, proficiency in writing is highly iterated in the national curriculum as it plays a vital role in ensuring the students achieve academic excellence and to have better future career opportunities. Nevertheless, there are still many students who struggle with writing. This may stem from the fact that writing skills are quite comprehensive with the need for various skills in writing such as grammar, punctuation, vocabulary, spelling, writing style and more (Wulandari, 2022).

Other reasons may be due to lack of appropriate materials, insufficient teacher training and teaching methods that are traditional in which fails to entice the students to be engaged in learning. Writing can be tricky in this case (Syafira Puteri, 2024). Oftentimes this will result in students having poor grammar, disorganized sentence structure and lack of coherence in their writing. To tackle these problems, an educational innovation has been created to overcome these challenges. One such innovation is a game-based learning which is designed to aid students in learning the proper sentence structure in a fun and engaging way. It also gives students the opportunity to be in a healthy competition amongst each other. Writing is made easier with the assistance of media or any kind of application, be it digital or physical, that can facilitate students to be more efficient and effective (Syafira Puteri, 2024).

1.1 Problem Statement

Writing is usually seen as the last language skill to be acquired (Baharudin et al., 2023). Writing is considered a very complex talent that requires a great deal of thinking and cognitive processing which occurs before, during and after the process of writing itself (Botirovna, 2023). Due to this, students often face difficulties in acquiring writing skills. Factors contributing to this include a lack of engaging teaching methods, insufficient practice opportunities, and

limited exposure to effective grammar instruction. The syllabus and teaching methods are inadequate in terms of covering the obstacles that the students need to face during writing (Palanisamy & Aziz, 2021). Traditional methods, such as repetitive drills and rote memorization, oftentimes fail to motivate students, leading to disengagement and a lack of improvement in their writing abilities. This highlights the fact that Malaysian students aren't able to fully express themselves in the form of writing and their ideas aren't being channelled clearly.

Game-based learning (GBL) has been shown to be an effective tool for increasing student engagement and understanding by making the lesson fun and interesting. According to Ningsih, 2023, GBL is a learning method that is specifically designed to turn a lesson into a fun and interesting atmosphere for the students. GBL is able to create an environment in which students are able to have fun and increase their motivation to learn (Saputra et al., 2021). However, there is limited research on its application in teaching syntax and grammar, particularly in the Malaysian context. While tools like Syntax Snap offer promise, there is a need to systematically document the creation process and evaluate its effectiveness to determine whether such tools can address the challenges faced by students in rural areas. This research seeks to fill this gap by designing and evaluating its perceived impact on enhancing students' writing skills.

1.2 Research Objectives

This study mainly focuses on two objectives (1) to document the process of creating and designing the Syntax Snaps card game using the ADDIE model and (2) to investigate the students' perception of using Syntax Snaps in enhancing writing skills.

1.3 Significance of Research

This research aims to contribute to the field of language education in the aspect of:

a) For Educators: Provides an innovative educational tool to turn teaching grammar and writing skills more engaging.
b) For Students: Gives the opportunity for students to learn sentence construction in an interactive way, boosting their confidence and enhancing their writing proficiency.
c) For Researchers: To give the opportunity to dive into the world of game-based learning in the context of language learning.
d) For Policymaker: Offers the integration of innovative teaching tools into the national curriculum to combat challenges faced by students in enhancing their writing skills.

2.0 LITERATURE REVIEW

Constructivism suggests that learners actively construct their own understanding and knowledge of the world through experiences and reflection. In the context of English as a Second language (ESL) classroom, this theory focuses on student-centered learning, where students are given the opportunity to be actively involved in the learning process rather than a teacher-centered learning environment, which passively lets the students receive information from the teacher.

In the context of teaching, ESL teachers can apply this theory into their teaching. In a study conducted by Guo (2024), it explored the application of the theory of constructivism in English Language Teaching (ELT). The study focused on situational learning, task-based teaching and collaborative writing. The results of the study indicated that by applying constructivism theory in ELT, students' communication skills and language proficiency have improved due to the efficiency of the methods.

Teachers must consider the many possible opportunities to apply constructivism theory into their teachings. In this modern era, there is a possibility of integrating technology into the constructivist framework, taking into consideration of the benefits of using technology in a lesson as a source of information while still keeping the foundation of the theory which is active student engagement and collaborative learning (Dedi Jasrial Zaim, 2023).Constructivism learning theory emphasizes the active participation of students in constructing their own understanding through interacting with the environment. In the context of ESL writing, constructivism supports the notion that through a student-centered approach, learners can engage in meaningful and authentic tasks, collaborate with peers and reflect on their own writing.

Vygotsky's, 1978 concept of Zone of Proximal Development (ZPD), emphasizes the importance of scaffolding learners in mastering writing skills. Collaborative writing is a technique that can be used by teachers to promote peer evaluation as well as collaborative learning among students. Students with higher proficiency can guide their peers to achieve lesson objectives. A study conducted by Perumal & Ajit (2022) highlighted the impact of blogs on students' writing skills. The research found that through the use of blogs in the classroom made learning more engaging. The students reported that blogging increased their motivation, provided a platform for collaboration among their peers and authentic communication which in turn led to improved writing proficiency.

GBL is an example of integrating the theory of constructivism as it encourages students to actively participate and build on their critical thinking. Studies have highlighted that GBL increases students' motivation and engagement in class and has become one of the key factors in improving students' proficiency in writing (Vejayan & Yunus, 2022).

Students find writing difficult to master. Some students see it as "not fun" as they need to find ideas on what to write. Even after assistance is given, chances that they despise the title of the writing activity given to them are still high (Rahmat,2021). Unfortunately, if students aren't interested in practicing writing, their proficiency in the skill will decrease. Palanisamy & Aziz (2021) stated that if the students do not practice writing often, they will face more challenges when they further their tertiary education. In addition to that, students also find traditional writing instructions to be less engaging and decreases their motivation to learn. A study conducted by Pham (2022) found that students prefer teachers using modern day teaching methods as compared to traditional methods to help them learn English.

The integration of GBL makes learning and teaching more fun and interactive as well as can lead to enhancement of students' motivation and engagement in language learning (Earichappan & Hashim, 2024). In addition to that, GBL has attractive features and real-time feedback so teachers can come up with several teaching strategies when handing out the materials to the students (Ningsih, 2023). Immediate corrective feedback is important for learners as it has been proven to have a positive effect on learner's accuracy in the target language (Shabani & Safari, 2016). Thus, this gives students the opportunity to rectify their mistakes quickly and efficiently.

Interactive teaching and learning tools can be used to help students of various proficiency to be more focused and engaged in learning as well as enhance their proficiency. According to the study done by Syafira Puteri et al. (2024), on the perception of students using Grammarly, it was found that the participants responded positively to the mechanics of Grammarly for its ability to check their grammar, and provide clarity such as correct vocabulary, punctuation and add in any missing parts of speech to help make their writing much more cohesive. In the context of GBL, students are more likely to respond positively to games for it is engaging nature and promotes collaborative learning. In another study conducted by Nur Maizura Lin et al. (2024), it was found that students to have a positive perception towards the use of GBL in the ESL writing classroom. It has shown to help students in their writing as well as ignited students' interest in learning writing.

The ADDIE model (Analysis, Design, Development, Implementation and Evaluation) is widely used as a structural framework for it is done in sequences (Zulkepli et al., 2024). The Analysis stage was where a problem was identified. The data from a conducted needs analysis serves as an input to design an innovation (Zulkepli et al., 2024). Following the Analysis stage is the Design stage where the initial plan for the mechanics of an innovation and its overall design took place as well as the content structure. The content of an innovation is specifically designed to support the learning objectives (Khasanah & Astuti, 2025). The Development stage is the steps in developing the innovation that takes place. It is where the drafted design turns into a tangible learning tool (Zulkepli et al., 2024). Implementation comes fourth and only after the instructional design has been turned into tangible and usable tools as researchers are to conduct pilot tests in ESL classrooms to determine the validity of the innovation and to gain data for further improvements to be made. The final stage is the Evaluation stage. An assessment is conducted through the use of questionnaires or interviews to gain the perceptions of the intended audience (Mdodana-Zide, 2024). Therefore, the use of the ADDIE model as a structured framework can increase the validity of an innovation as it ensures that it is aligned with the learning objectives and the curriculum standard.

3.0 RESEARCH METHODOLOGY

The research methodology used to achieve the research objectives: (1) to document the process of the creation and design of Syntax Snaps based on the ADDIE model and (2) to investigate the students' perception of using Syntax Snaps in enhancing writing skill.

3.1 Research Design

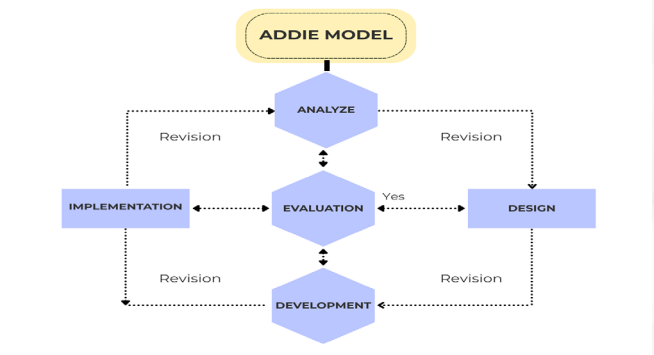


Figure 1: Diagram of ADDIE model

This research follows a design and development research approach (DDR) to document the creation and designing of Syntax Snaps, using the ADDIE model as a sequential guide. The ADDIE model was chosen as this model begins with doing an analysis (Zulkepli et al., 2024). In addition to that, a quantitative survey approach is used to gather and investigate students' perception of the innovation's effectiveness through a 5-point Likert scale questionnaire consisting of 15 questionnaire items which was an adaptation based on Syafira Puteri et al. (2024) research questionnaire.

Qualitative Part: The ADDIE model was used to carefully map out the development process of the card. This model provided a systematic framework for developing Syntax Snaps, ensuring that the educational tool is effective, engaging and aligned with the students' needs.
Quantitative Part: The usage of Likert scale is adapted by using the Post-Study System Usability Questionnaire (PSSUQ). This questionnaire consists of 12 items which was aimed to gather feedback on the student's perception towards the usage of Syntax Snaps. A session of in class lessons was done and time to play the cards was given to the students prior to distributing the feedback form.
Research Sample: 17 Form 3 students from a private Islamic school.
The data was then tabulated and analysed to get the mean of the collected data. To analyse the data collected, descriptive statistics was used. Descriptive statistics was carried out by calculating the mean and standard deviation of responses to each. The questionnaire is divided into three (3) dimensions: Usability, User Satisfaction and Overall Effectiveness. Table 1 shows an interpretation of the mean score, which was adopted from Zaharul Lailiddin Saidon et al., (2021).

Table 1: Mean Score Interpretation adopted from Zaharul Lailiddin Saidon et al., (2021)

Level	Mean Score
High	3.67 - 5.00
Medium	2.34 - 3.66
Low	1.00 - 2.33

3.2 Research Instruments

The table below shows the research instruments used to obtain the research data.

Table 2 Research Instruments

Research Objectives No.	Instruments
Research Objective 1	The ADDIE model is used as a structured framework to document the process of development of Syntax Snaps.
Research Objective 2	5-point Likert scale feedback form consisting of 15 questionnaire items administered to students to obtain their perception towards the effectiveness of Syntax Snaps.

3.3 Data Analysis

Research Objective 1 (Creating and Designing)

Thematic Analysis: To document and analyse the development of Syntax Snaps via the ADDIE model.

Research Objective 2 (Student Perceptions)

Description statistics: To analyze the quantitative data from the administered feedback form. Data is tabulated to be analysed with the use of SPSS.

4.0 RESEARCH FINDINGS

The following shows the findings of the data collected. The results are arranged following the sequence of the research objectives (1) to document the process of the creation and design of Syntax Snaps based on the ADDIE model and (2) to investigate the students' perception of using Syntax Snaps in enhancing writing skill. The findings are supported by relevant literature dated from the year 2020 to 2025.

4.1 Development of Syntax Snaps

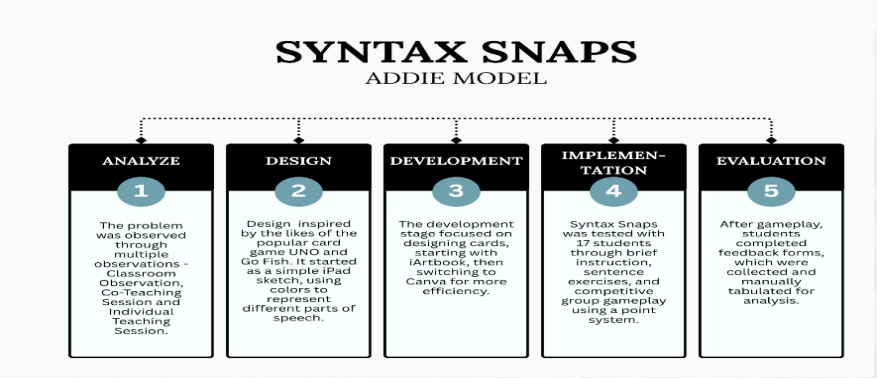


Figure 2: Development process of Syntax Snaps using ADDIE Model

i. Analysis

A problem encountered during Perantis Guru (PG) was that the students kept on writing grammatically incorrect sentences as well as incoherent sentences due to their inability to use the correct sentence structure. The problem was observed through multiple classroom observations. Classroom Observation, Co-Teaching Session and Individual Teaching Session. From time to time, the observed problem recurred in their writings, be it in subjective questions or in their essay writing. This in turn resulted in the decline in quality of students' writing in general.

ii. Design

The design for Syntax Snaps is inspired by the likes of the popular card game UNO and Go Fish. The process of designing the back cover of the card started out as just a simple sketch on an iPad. The different colors indicate different parts of speech. For example, the color red indicates that the word is an action as red symbolizes energy and power. The cards also consist of power cards such as ReShuffle and Wild Card in which the users hold the power to reshuffle their sentences (ReShuffle Card) or to add in a new word in their preferred parts of speech (Wild Card). The game has a point system in which may foster a healthy competition among the students while maintaining the momentum of learning syntax and grammar.

iii. Development

The development stage of Syntax Snaps focuses on the actual designing of the cards. Initially iArtbook was used to create the first design for the back cover of the cards. However, upon needing to save time, the switch to Canva was done to aid in designing multiple cards in a shorter time frame yet more efficiently.

iv. Implementation

A class of 17 Form 3 students from an urban private school participated in the research. The students were first given a series of questions on the whiteboard to determine their proficiency in sentence structure. The researcher explained to the students about the use of Syntax Snaps and how to play. The researcher also wrote the point system unto the whiteboard to further entice their interest to compete with one another. There were two types of game played using Syntax Snaps. The first one was to create as many grammatically correct sentences in a group to help the students to build sentences using the cards as the "building blocks" to help them visualize the structure of a correct sentence. In the competition mode, students have to be in groups of 3 to 5 and compete against each other. This is where the point system comes into play. The points are to be recorded by a teacher or by the appointed score keeper. The students with the highest score win.

v. Evaluation

As soon as the students have finished playing with the cards, feedback forms to gather their feedback on Syntax Snaps. Time was given to the students to fill in the form before collecting it. After feedback was collected, the data was then manually tabulated.

4.2 Students' Perceptions Toward the Effectiveness of Syntax Snaps

The data evaluated in three dimensions: Usability, User Satisfaction and Overall Effectiveness. The mean of each dimension is shown below in Table 3.

Table 3: Mean Score and Standard Deviation of Three Dimensions

Dimension	Mean Score	Standard Deviation
Usability	3.96	1.09
User Satisfaction	3.88	0.86
Overall Effectiveness	3.94	1.17

Dimension 1: Usability

Dimension 1: Usability is to determine the general usability of Syntax Snaps in enhancing writing skills. In Table 1, it can be seen that Syntax Snaps has a relatively high usability index of 3.96 which indicates that the students have a positive perception on the usability of Syntax Snaps. However, with a standard deviation of 1.09, it indicates that there is a moderate variation in responses which means there are still areas in which can be improved to achieve a higher consistency of the students' response to Syntax Snaps' usability.

Dimension 2: User Satisfaction

Dimension 2: User Satisfaction is to determine the student's level of satisfaction towards using Syntax Snaps in enhancing their writing skills. The user satisfaction index, averaging 3.88 with a standard deviation of 0.86, indicates that the Syntax Snaps is effective and is highly appreciated by users. Although satisfaction levels remain steady and above the average, the small difference from a higher mean score suggests there is potential to enhance the system for even greater user satisfaction.

Dimension 3: Overall Effectiveness

The user satisfaction index, with an average score of 3.94 and a standard deviation of 1.17, shows that the system is mostly effective and aligns with user expectations. Nonetheless, the differences in replies indicate that there were varying views within a smaller segment. This emphasizes a chance to refine particular aspects of the system to minimize variability and boost overall satisfaction, aiming for a more uniform and outstanding user experience.

5.0 RESEARCH DISCUSSION

The ADDIE model has continuously been proving its usefulness in ensuring a structured and systematic development of Syntax Snaps. It also ensured that the innovation is aligned with the students' needs. These findings resonate with Zulkepli et al. (2024) that it is important to ensure a systematic approach to instructional design in educational innovations.

With the administration of feedback forms, the perception of students towards Syntax Snaps was able to be analysed in three dimensions: Usability, User Satisfaction and Overall Effectiveness. According to the findings, Syntax Snaps has been found to aid students in

comprehending grammar concepts better. This is in line with Vejayan & Yunus (2022) that GBL helps improve proficiency, especially in writing. Other than that, Syntax Snaps have also been recorded to be able to help students to focus better due to the color coded parts of speech and that the texts on the cards are readable such as mentioned by Ningsih (2023). Finally, students generally agree that Syntax Snaps makes learning grammar much more enjoyable which aligns with the integrations of the theory of constructivism and GBL to further enhance student's proficiency in a more enjoyable way. This finding resonates with Syafira Puteri et al. (2024) that participants responded positively to the mechanics of interactive learning tools.

6.0 CONCLUSION

In conclusion, this research has successfully achieved both research objectives in which it has (1) documented the development of Syntax Snaps through the use of the ADDIE model and (2) investigated the perception of students towards the effectiveness of the innovation in enhancing writing skills. The research also showed the effectiveness of integrating GBL in enhancing writing proficiency as well as increasing students' engagement in the learning process. Syntax Snaps can become a valuable contribution to the world of ESL learning as it offers an innovative approach that can be further studied and refined as well as further developed to meet the needs of various learners in the future.

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ENERGY BALL-NANA: THE DEVELOPMENT OF A SUSTAINABLE BANANA-BASED ENERGY SNACK

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Abstract

Effective nutrition during sports activities is essential for reducing fatigue and improving athlete performance. Although energy snacks are commonly consumed by athletes, many commercially available products contain high levels of added sugar, saturated fat, and excess calories. Carbohydrates are essential for energy replenishment, and bananas provide a natural source rich in carbohydrates, vitamins, and minerals. However, the rapid ripening of bananas often leads to food waste, highlighting a need for sustainable resource management. To address this issue, this study introduces Energy Ball-nana, a banana-based energy snack developed to support athlete recovery and performance while utilizing natural ingredients. Energy Ball-nana is formulated using rolled oats, almonds, and unsalted peanut butter and is available in three natural flavors: nuts, fruits, and dark chocolate, providing a convenient and nutritious snack for athletes to refuel, repair, and recover. A survey of 102 respondents was conducted to examine consumer preferences regarding ingredients, size, nutritional value, purpose, and pricing. The findings revealed that respondents preferred snacks that are small in size, reasonably priced, and nutritionally balanced with protein, vitamins, and minerals. Many respondents also preferred natural, preservative-free ingredients such as fruits, nuts, and chocolate, indicating a growing demand for healthier snack options. Future development should focus on enhancing shelf life and nutritional efficacy to meet Sustainable Development Goals (SDGs).

Keywords: Banana-based energy snack, athlete performance, food waste

Abstrak

Pemakanan yang baik semasa aktiviti sukan adalah penting untuk mengurangkan keletihan dan meningkatkan prestasi atlet. Walaupun snek tenaga sering diambil oleh atlet, banyak produk komersial yang tersedia mengandungi tahap gula tambahan, lemak tepu, dan kalori yang tinggi. Karbohidrat amat penting untuk penambahan tenaga, dan pisang merupakan sumber semula jadi yang kaya dengan karbohidrat, vitamin, dan mineral. Namun begitu, proses pematangan pisang yang cepat sering menyebabkan pembaziran makanan, sekali gus menimbulkan keperluan untuk pengurusan sumber yang lebih mampan. Bagi menangani isu ini, kajian ini memperkenalkan Energy Ball-nana, iaitu snek tenaga berasaskan pisang yang

dibangunkan untuk menyokong pemulihan dan prestasi atlet dengan menggunakan bahan semula jadi. Energy Ball-nana diformulasikan menggunakan oat gulung, badam, dan mentega kacang tanpa garam dalam tiga perisa semula jadi iaitu kacang, buah-buahan, dan coklat gelap. Produk ini menyediakan snek yang mudah dan berkhasiat untuk membantu atlet menambah tenaga, membaiki tisu, dan pulih dengan lebih baik. Satu kajian soal selidik yang melibatkan 102 responden telah dijalankan untuk menilai keutamaan pengguna dari segi bahan, saiz, nilai pemakanan, tujuan, dan harga. Dapatan kajian menunjukkan bahawa responden lebih gemar snek yang bersaiz kecil, dengan harga yang berpatutan, dan seimbang dari segi nutrisi seperti protein, vitamin, dan mineral. Selain itu, ramai responden memilih bahan semula jadi tanpa bahan pengawet seperti buah-buahan, kacang, dan coklat, yang menunjukkan peningkatan permintaan terhadap pilihan snek yang lebih sihat. Pembangunan pada masa hadapan perlu memberi tumpuan kepada peningkatan jangka hayat produk dan keberkesanan nutrisi bagi memenuhi Matlamat Pembangunan Mampan (SDGs).

Kata kunci: *Snek tenaga berasaskan pisang, prestasi atlet, pembaziran makanan*

1.0 INTRODUCTION

Energy snacks have become popular among athletes. They are acknowledged as dietary tools among athletes, with products such as energy gels, bars, nuts, and beverages widely used to sustain performance and support recovery (Erdmann et al., 2021; Jagim et al., 2023). However, energy snacks such as bars, gels, and drinks often contain high sugar and calories, leading to while snacks provide quick energy, overreliance causes blood sugar instability, nutrient gaps, and long-term health issues like obesity and low energy availability (Jagim et al., 2023; Verma et al., 2024). These limitations highlight a critical gap, including the lack of an affordable, convenient, and nutritionally sound energy snack that reliably supports athletic performance and recovery without compromising long-term health.

To address this problem, this study aimed to develop a natural, whole-ingredient energy snack to meet athletes' nutritional, practical, and economic needs while promoting sustainability. Research has demonstrated that bananas are an effective natural energy source for endurance athletes due to their high carbohydrate and potassium content, which sustains prolonged, high-intensity physical activity (Nieman et al., 2012), while also offering potential to reduce food waste. Therefore, this study aimed to develop Energy Ball-nana, a sustainable banana-based energy snack designed to deliver optimal nutritional value, portability, tastiness, and affordability to athletes, thereby improving their sports performance and advancing sustainable functional food innovation.

1.1 Problem Statement

Athletes frequently consume energy snacks to support performance and recovery. However, many commercially available cereal and energy bars are high in sugar, fat, or salt, making them less suitable for optimal health despite being palatable (Kiciak et al., 2022). In addition, many

athletes fail to meet their energy and carbohydrate requirements, highlighting the need for more nutrient-dense snack options (Amawi et al., 2024).

Beyond nutritional concerns, existing energy snacks are not always aligned with user preferences. Studies indicate that athletes prioritize ease of intake, accessibility, and nutritional composition when selecting snacks during physical activity (Reinhard et al., 2022). Nevertheless, many products on the market do not fully meet these expectations, revealing a gap between consumer needs and current offerings.

At the same time, natural resources such as bananas are often underutilized particularly when overripe, leading to avoidable food waste (Aurore et al., 2009). This represents an opportunity to develop value-added, natural energy snacks. Furthermore, research suggests that snack form influences consumer acceptance, with ball-shaped snacks identified as a convenient and appealing alternative to traditional formats (Yano et al., 2024).

Therefore, there is a need to develop an energy snack that is both nutritious and aligned with consumer preferences in terms of convenience, form, and ingredient composition. This study addresses this gap by developing a banana-based energy snack in the form of a ball.

1.2 Research Objectives

The research objectives are the following:

a) To evaluate consumer preference of energy snacks in terms of taste, texture, and nutritional value.
b) To develop a healthy, natural, banana-based energy snack.

1.3 Research Significance

This innovation of Energy Ball-nana would benefit the following parties:

a) Athletes: Provides a natural and healthy energy snack, which is important for their energy recovery, and is most convenient to consume.
b) Researcher: Contributes to food innovation and sustainable research.
c) Food industry: Promotes the sustainable use of natural ingredients and encourages the development of healthy energy snacks.

2.0 LITERATURE REVIEW

2.1 Sports Nutrition and the Role of Energy Snacks

Proper nutrition plays a fundamental role in supporting athletic performance, particularly during high-intensity and endurance-based activities. Adequate nutrient intake before, during, and after exercise helps delay fatigue, enhance performance, and accelerate recovery (Amawi et al., 2024). However, many commercially available products contain high levels of added sugars, saturated fats, and excessive calories, which may negatively affect long-term health (Jagim et al., 2023; Verma et al., 2024). Despite their popularity, such products are often perceived as unhealthy, indicating the need for improved alternatives (Kiciak et al., 2022). Carbohydrates are the primary energy source for athletes, supporting glycogen storage and

endurance performance (Reinhard et al., 2022). Protein is essential for muscle recovery, and combined carbohydrate–protein intake has been shown to enhance performance outcomes (Zhao et al., 2024). Dietary fiber also contributes to satiety and sustained energy release (Chow et al., 2007).

2.2 Consumer Preferences in Energy Snack Selection

Carbohydrates are the primary energy source for athletes, supporting glycogen storage and endurance performance (Reinhard et al., 2022). Protein is essential for muscle recovery, and combined carbohydrate–protein intake has been shown to enhance performance outcomes (Zhao et al., 2024). Dietary fiber also contributes to satiety and sustained energy release (Chow et al., 2007).

2.3 Bananas as a Functional and Sustainable Ingredient

Bananas are rich in carbohydrates and potassium, making them an effective natural energy source (Nieman et al., 2012). Nevertheless, rapid ripening contributes to food waste, as overripe bananas are often discarded despite retaining nutritional value (Huang et al., 2024; Ng et al., 2022).

2.4 Sustainability and Food Waste Reduction (SDG Integration)

Food waste remains a global challenge, particularly for perishable items (Parfitt et al., 2010). Consumer behaviour significantly contributes to waste generation (Aschemann-Witzel et al., 2015). In line with SDG 12.3, reducing food waste is a global priority (Gasper et al., 2019). Utilizing overripe bananas supports sustainable consumption and improves resource efficiency. Energy balls represent an alternative to conventional bars, offering improved portion control, convenience, and consumer appeal (Ho et al., 2016; Yano et al., 2024). There remains a lack of energy snacks that fully integrate nutrition, sustainability, and consumer preferences. This study addresses the gap through the development of Energy Ball-nana.

3.0 RESEARCH METHODOLOGY

This is a quantitative study which adopted a survey-based and product development approach to design and evaluate Energy Ball-nana as a banana-based energy snack. The research was conducted in several stages.

3.1 Research Design

This study adopted a structured research design that integrates both data collection and product development processes, as illustrated in Figure 1. The methodology consists of several sequential stages to ensure the development of a functional and acceptable energy snack.

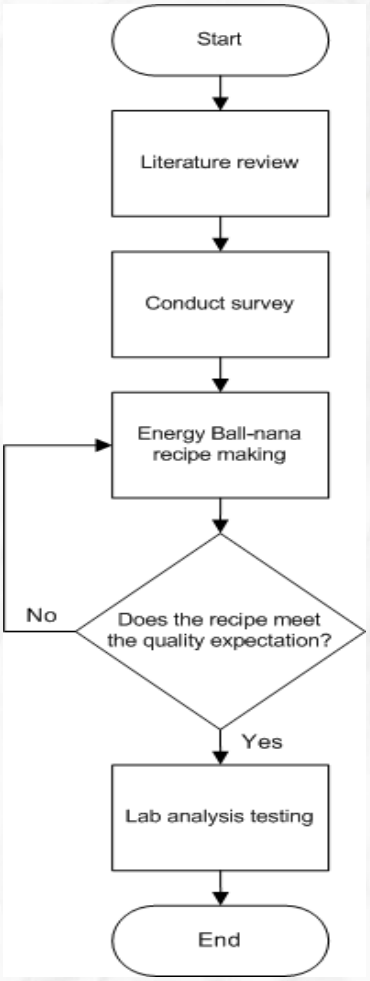


Figure 1: The flowchart of research design

The process begins with the literature review stage, where relevant studies on sports nutrition, energy snacks, consumer preferences, and sustainable food practices were critically examined. Following this, a survey was conducted to gather primary data from respondents, particularly athletes. The survey aimed to identify consumer preferences in terms of taste, texture, nutritional value, portion size, and price. Based on the findings from the survey, the study proceeded to the product development phase, specifically the formulation of the Energy Ball-nana recipe.

This stage involved selecting appropriate ingredients such as bananas, oats, nuts, and other natural components to achieve a balance of carbohydrates, protein, and fiber. Subsequently, the developed product underwent a quality evaluation process. At this stage, the recipe was assessed to determine whether it met the expected quality standards, including sensory acceptance, consistency, and overall suitability as an energy snack. If the product did not meet the required criteria, the formulation process was repeated and refined accordingly. Once the product achieved the desired quality, it proceeded to the laboratory analysis stage.

This phase involved testing the product for its nutritional composition and other relevant parameters to validate its suitability as a functional energy snack. Finally, the process concludes

with the completion stage, where the finalized product is ready for evaluation and potential application. This systematic approach ensures that the product is not only developed based on scientific evidence but also aligned with consumer preferences and quality standards.

3.2 Research Instruments

In this project, the main research instrument used was a 5-point Likert scale survey to evaluate athletes' preferences for energy snacks. The survey was developed to identify key factors such as preferred ingredients, size, nutritional value, intended purpose, and price among the athletes. The use of a Likert scale allowed participants to express their level of agreement or preference for each item in a structured and quantifiable manner.

In terms of participants, purposive sampling was employed to select athlete students from Kolej Poly-Tech MARA Kuantan. This sampling method was chosen to ensure that the respondents met the specific criteria relevant to the study, particularly their involvement in sports-related activities. The sample consisted of 102 students enrolled in the Diploma in Sports Management program, making them an appropriate group for examining preferences related to energy snacks.

3.3 Data Analysis

The data analysis for this project was conducted using Microsoft Excel to analyze the survey data. Descriptive statistics were used to summarize the responses from the Likert scale survey. The survey data were organized and analyzed according to the identified categories, namely ingredients, size, nutritional value, intended purpose, and price.

4.0 RESEARCH FINDINGS AND DISCUSSION

4.1 Demographic Characteristics of Respondents

The respondent's demographic data can be described in this section. It shows that the total (N) of respondents who participated in this study was 102 respondents. Based on the sample collected through the distribution of questionnaires, the majority of the respondents are male, with 65.7%, and female, with 34.3% of respondents.

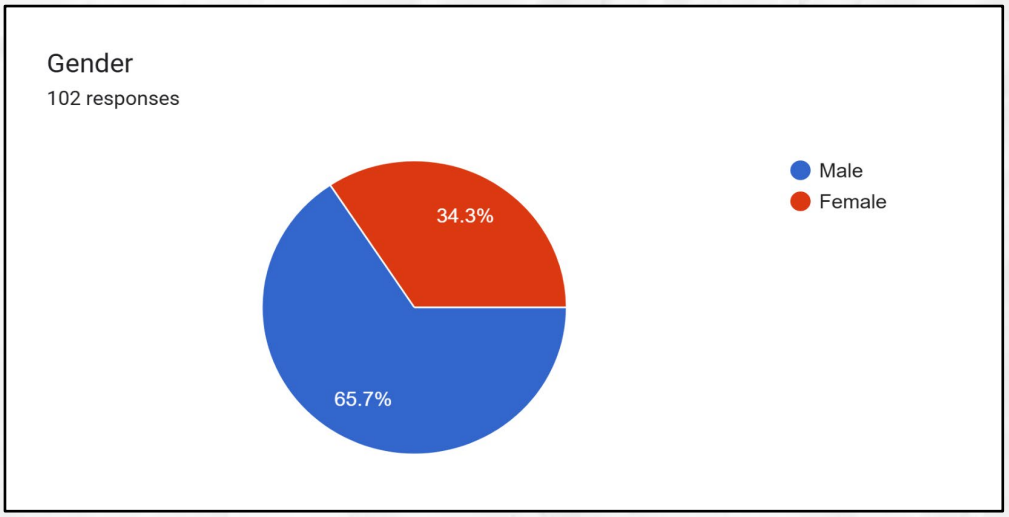


Figure 2: The gender distribution

In terms of their main sports, most of the respondents were futsal & football athletes with 51%; it was followed by badminton athletes with 44.1%. Moreover, track and field athletes with 41.2%. Volleyball athletes were 23.5%, weightlifters were 19.6%, swimming athletes were 17.6%, taekwondo athletes presented with 14.7%, cyclists were 13.7%, and basketball players showed 7.8%. Lastly, tennis and squash athletes with only 2.9%.

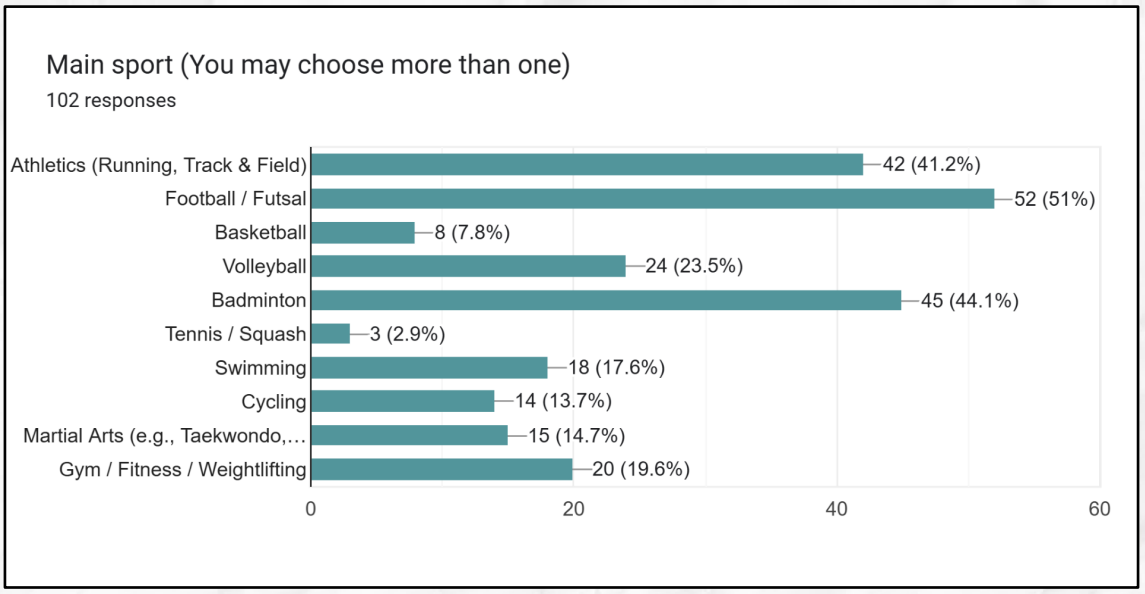


Figure 3: Main sports

4.2 Demand for the Energy Snack

Based on the results, it indicates that participants wanted the recovery bar to be compact and sufficient in portion. This result is in line with a study among military athletes stating that compact food such as chocolate bars or nutrient-dense foods tends to be durable and ready to use through their diet independently (Hadi et al., 2020). Respondents wanted the recovery bar to be affordable and nutritionally valuable. Research has been conducted by Reitano et al. (2024), stating that athletes are considered less important toward influencing sports performance compared with attributes that influence healthiness, safety, and price.

Respondents also stated that it is needed for a bar that is high in protein, enriched with vitamins and minerals, and balanced in nutrients. A meta-analysis study that is in line with the results that are specific to balanced nutrients suggests that the ingestion of protein with carbohydrates is seen to be more effective for endurance athletes than protein intake alone. (Zhao et al., 2024). Lastly, bar with natural ingredients such as fruits, nuts, and chocolates are needed to maintain a healthy lifestyle. This study with Duda-Seiman et al. (2025) shows that bars that include high fiber, grains, vegetables, and fruits reduce cardiovascular disease. Those choices contribute to a balanced diet and healthier lifestyle.

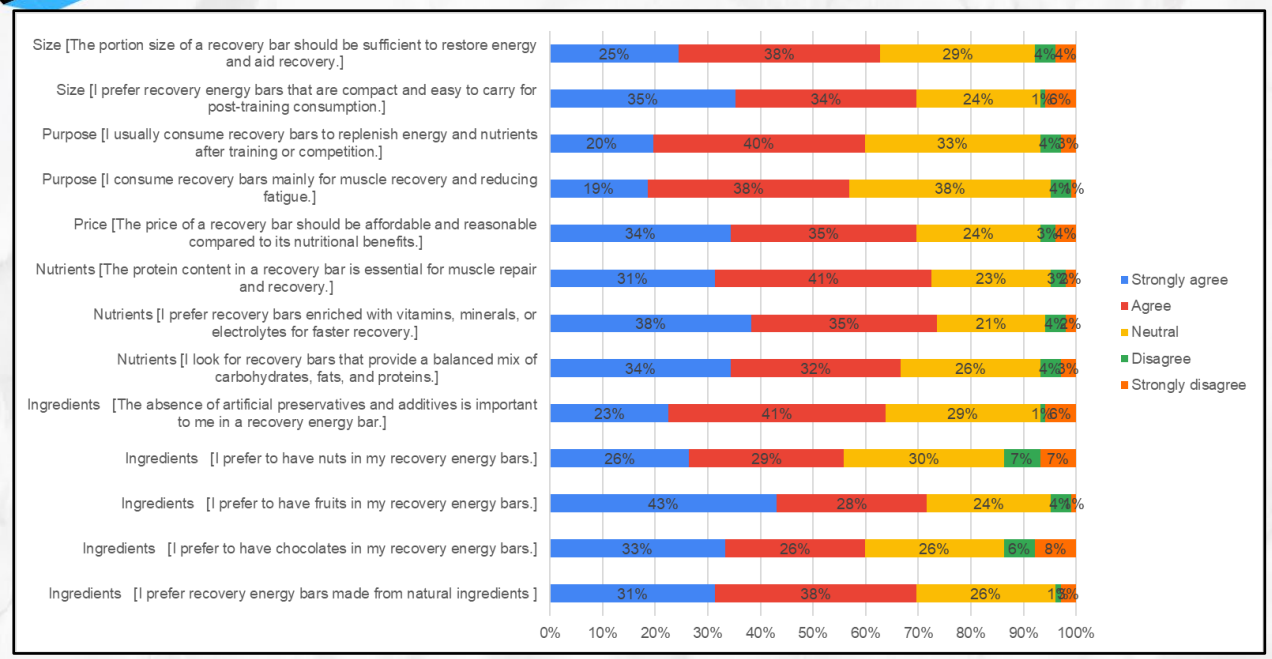


Figure 4: Athletes' preferences of energy bar

4.3 Development of sustainable using banana-based energy balls

In recent decades athletes were keen to use foods that are rich with protein and minerals and be part of additional athletes' supplements. Nutritional bars are seen to be popular since they are considered high in nutritional content and can release quick energy for human metabolic needs (Abdel-Salam et al., 2022). Bananas are known as fruits that can be eaten on their own or used as an ingredient in a variety of dishes. Bananas' wide diversity makes them suitable for use in many different types of food products (Aurore et al., 2009). Moreover, banana processing is also popular as a form and sold as chips (Panagiotou et al., 2024). Ripening of bananas can be seen as processes from peel changes from green to yellow, yellow to brown, and finally becoming black (Huang et al., 2024).

In addition, overripe bananas result in lowering potential purchase intention, featuring such things as dark brown color and squishy consistency of the pulp. Bananas are also often seen as wasted since consumers relate the ripeness of a banana with yellow color (Ng et al., 2022). In this context, the conversion of overripe bananas into banana-based energy balls represents an alternative strategy that aligns with the targets of the United Nations Sustainable Development Goal 12.3, aiming to halve global food waste by promoting responsible consumption and production patterns (Gasper et al., 2019). Nonetheless, the studies aim to upgrade banana waste into energy snacks for sports performance.



Figure 5: The making of Energy Ball-nana

4.4 Nutritional benefits of banana-based snack innovation for athlete satiety and performance.

According to Nieman et al. (2012), bananas can be seen as an effective energy source and are often used by endurance athletes since they are rich in carbohydrates and potassium that support prolonged and high-intensity workouts. The ingredients, such as crushed almonds, chia seeds, and cranberries, did support high fiber. Studies from Chow et al. (2007) state that ingestion of high-fiber snack bars did improve fullness for up to 3 hours compared with snack bars that contain low fiber. Therefore, high fiber in banana balls does improve satiety for athletes.

Innovation from the ball shape is obtained from energy bars or snack bars that can be ideal for delivering energy and electrolytes for athletes (Ho et al., 2016). A study by Yano et al. (2024) using soy balls as a snack indicating its appearance may be an alternative to compare with common sugary snacks that satisfy appetites and nutrition of humans. Thus, the reshaping of the banana bar to a banana ball can be seen to improve athletes' food satisfaction.

5.0 CONCLUSION AND RECOMMENDATIONS

The present study demonstrates the need for improved energy snack options that better reflect athletes' nutritional requirements and evolving consumer expectations. The findings reveal that athletes prioritize products that are practical in size, cost-effective, and nutritionally well-balanced, particularly those formulated with natural ingredients and an appropriate combination of carbohydrates and protein to sustain performance and support recovery. Beyond nutritional considerations, this study also highlights the issue of food waste, especially the underutilization of overripe bananas that are often discarded despite retaining valuable nutrients. Converting such resources into functional food products represents a meaningful approach to promoting sustainable consumption practices, in line with Sustainable Development Goal (SDG) 12.3 on food waste reduction. In this context, the development of

Energy Ball-nana offers a viable and innovative solution. The product integrates nutrient-rich ingredients with a convenient ball-shaped design that improves ease of consumption, portion flexibility, and overall user acceptance.

Several recommendations are proposed, including conducting detailed nutritional analysis, evaluating shelf life and storage stability, and testing the product's effectiveness with athletes under controlled conditions. Future research should also explore variations in ingredients and flavours to enhance consumer acceptance, while strengthening the use of sustainable practices by utilising food waste to support Sustainable Development Goals.

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PEMBANGUNAN PORTAL *E-INTERNSHIP MANAGEMENT SYSTEM* (E-IMS) SEBAGAI PLATFORM PENGURUSAN LATIHAN INDUSTRI BERSEPADU DI KOLEJ KOMUNITI KUANTAN

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ABSTRAK

Latihan industri merupakan komponen wajib dalam kurikulum pengajian di Kolej Komuniti Kuantan bagi memastikan pelajar memperoleh pendedahan sebenar kepada alam pekerjaan. Walau bagaimanapun, proses pencarian penempatan latihan industri secara manual sering menimbulkan pelbagai kekangan seperti maklumat syarikat yang terhad, kesukaran akses dokumen, serta cabaran pemantauan oleh pensyarah. Kajian ini bertujuan untuk menilai keberkesanan Portal *e-Internship Management System* (e-IMS) sebagai satu inovasi digital yang menyokong kelestarian tadbir urus institusi. Portal ini berfungsi sebagai pusat sehenti bagi pengurusan maklumat syarikat, penjanaan dokumen latihan industri, serta pemantauan pelajar secara atas talian. Metodologi kajian melibatkan pembangunan sistem berasaskan web menggunakan HTML, PHP, CSS dan JavaScript, diikuti dengan kajian soal selidik terhadap 60 orang pelajar. Dapatan kajian menunjukkan lebih 90% responden menilai sistem e-IMS sebagai berkesan dan sangat berkesan, sekali gus membuktikan impak positif inovasi ini terhadap pelajar, kakitangan dan industri.

Kata kunci: Inovasi pendidikan, latihan industri, sistem pengurusan, portal atas talian, e-IMS

ABSTRACT

Industrial training is a compulsory component of the academic curriculum at Kolej Komuniti Kuantan, aimed at ensuring that students gain real-world exposure to the working environment. However, the manual process of securing industrial training placements often presents various challenges, including limited access to company information, difficulties in document management, and constraints in monitoring by lecturers. This study aims to evaluate the effectiveness of the e-Internship Management System *(e-IMS) portal as a digital innovation that supports sustainable institutional governance. The portal functions as a one-stop center for managing company information, generating industrial training documents, and enabling online student monitoring. The research methodology involves the development of a web-based system using HTML, PHP, CSS, and JavaScript, followed by a questionnaire survey administered to 60 students. The findings reveal that more than 90% of respondents rated the e-IMS system as effective and highly effective, demonstrating its positive impact on students, staff, and industry stakeholders.*

Keywords: *Educational innovation, industrial training, management system, online portal, e-IMS*

1.0 PENGENALAN

Latihan industri merupakan satu komponen wajib dalam program pengajian di Kolej Komuniti yang bertujuan memberi pendedahan awal kepada pelajar terhadap persekitaran kerja sebenar. Melalui latihan industri, pelajar berpeluang mengaplikasikan pengetahuan dan kemahiran yang dipelajari di institusi ke dalam situasi kerja sebenar. Keberkesanan pelaksanaan latihan industri amat bergantung kepada sistem pengurusan yang cekap, sistematik dan mudah diakses oleh semua pihak yang terlibat.

Seiring dengan perkembangan teknologi maklumat dan keperluan pendigitalan perkhidmatan pendidikan, penggunaan sistem pengurusan berasaskan web dilihat sebagai satu keperluan bagi meningkatkan kecekapan pengurusan latihan industri. Pendekatan manual yang masih diamalkan sebelum ini didapati kurang berkesan kerana melibatkan pengurusan data yang tidak berpusat, penggunaan dokumen fizikal serta kesukaran pemantauan pelajar. Oleh itu, pembangunan Portal *e-Internship Management System* (e-IMS) merupakan satu inisiatif inovatif bagi menyokong pengurusan latihan industri yang lebih sistematik dan bersepadu.

1.1 Pernyataan Masalah

Pengurusan latihan industri di institusi pendidikan lazimnya melibatkan beberapa proses penting seperti pencarian syarikat latihan industri, pengurusan dokumen permohonan, penyelarasan penempatan pelajar serta pemantauan sepanjang tempoh latihan. Namun begitu, sebahagian besar proses ini masih dilaksanakan secara manual melalui penggunaan borang fizikal dan penyimpanan dokumen secara tidak berpusat.

Keadaan ini boleh menyebabkan pelbagai masalah seperti kehilangan dokumen, kesukaran mendapatkan maklumat syarikat, kelewatan proses penempatan pelajar serta kesukaran pensyarah memantau pelajar secara sistematik. Selain itu, komunikasi antara pelajar, pensyarah dan pihak industri juga menjadi kurang efisien apabila tiada platform pengurusan yang bersepadu.

Seiring dengan perkembangan teknologi digital, penggunaan sistem pengurusan berasaskan web dilihat sebagai satu penyelesaian yang lebih sistematik dan efisien. Oleh itu, pembangunan Portal *e-Internship Management System* (e-IMS) diperkenalkan bagi membantu memperkemas proses pengurusan latihan industri melalui satu platform berpusat yang boleh diakses oleh pelajar, pensyarah dan pihak industri.

1.2 Objektif Kajian

Kajian ini dijalankan bagi menilai keberkesanan penggunaan Portal *e-Internship Management System* (e-IMS) dalam pengurusan latihan industri di Kolej Komuniti Kuantan. Objektif kajian adalah seperti berikut:

1. Mengenal pasti tahap kemudahan pelajar dalam mengakses maklumat syarikat latihan industri melalui sistem e-IMS.
2. Menilai keberkesanan sistem e-IMS dalam memudahkan proses penjanaan dokumen permohonan latihan industri.
3. Menilai keberkesanan sistem e-IMS dalam membantu pemantauan dan pengurusan laporan latihan industri.
4. Menentukan tahap kepuasan pelajar terhadap penggunaan sistem e-IMS.
5. Mengenal pasti kesediaan pelajar untuk terus menggunakan sistem e-IMS pada masa hadapan.

1.3 Kepentingan Kajian

Kajian ini penting dalam memberikan gambaran mengenai keberkesanan penggunaan sistem digital dalam pengurusan latihan industri di institusi pendidikan. Bagi pihak **institusi pendidikan**, dapatan kajian ini dapat membantu meningkatkan kecekapan pengurusan latihan industri melalui sistem berasaskan web yang lebih sistematik dan bersepadu. Sistem ini juga menyokong usaha transformasi digital institusi serta meningkatkan kualiti tadbir urus pengurusan pelajar. Bagi **pensyarah dan penyelaras latihan industri**, penggunaan sistem e-IMS dapat memudahkan proses pemantauan pelajar, penyimpanan data serta pengurusan dokumen secara lebih teratur dan efisien.

Bagi **pelajar**, sistem ini memudahkan proses pencarian syarikat latihan industri, penjanaan dokumen serta akses kepada maklumat berkaitan latihan industri secara lebih cepat dan sistematik. Selain itu, bagi **pihak industri**, portal ini menyediakan platform yang memudahkan syarikat menawarkan peluang latihan industri kepada pelajar serta berinteraksi dengan institusi pendidikan secara lebih teratur.

2.0 KAJIAN LITERATUR

Kajian literatur ini memberi tumpuan kepada tiga aspek utama iaitu peranan latihan industri dalam pendidikan TVET, penggunaan sistem pengurusan latihan industri berasaskan web serta kepentingan pendigitalan dalam menyokong kelestarian tadbir urus institusi pendidikan.

2.1 Latihan Industri dalam Pendidikan TVET

Latihan industri merupakan komponen penting dalam pendidikan dan latihan teknikal dan vokasional (TVET) yang bertujuan meningkatkan kebolehpasaran graduan melalui pendedahan kepada persekitaran kerja sebenar. Melalui pengalaman ini, pelajar berpeluang mengaplikasikan pengetahuan teori serta membangunkan kemahiran praktikal dan insaniah yang selari dengan keperluan industri semasa.

Menurut Alias dan Rahman (2020), pelaksanaan latihan industri yang berkesan memerlukan penempatan pelajar yang bersesuaian dengan bidang pengajian serta pemantauan yang sistematik oleh pihak institusi. Kelemahan dalam aspek pengurusan boleh menjejaskan pengalaman pembelajaran pelajar serta pencapaian hasil pembelajaran yang telah ditetapkan.

Selain itu, latihan industri turut berperanan sebagai medium strategik dalam membina hubungan kolaboratif antara institusi pendidikan dan pihak industri. Hubungan ini membolehkan institusi memperoleh maklum balas berkaitan keperluan industri semasa, manakala pelajar mendapat pendedahan kepada budaya kerja sebenar serta pembangunan kemahiran insaniah yang kritikal.

2.2 Sistem Pengurusan Latihan Industri Berasaskan Web

Perkembangan teknologi maklumat telah mendorong penggunaan sistem pengurusan latihan industri berasaskan web sebagai alternatif kepada kaedah manual yang kurang efisien. Sistem ini berupaya menyatukan maklumat pelajar, syarikat dan dokumen latihan industri dalam satu platform berpusat, sekali gus meningkatkan kecekapan pengurusan (Salleh et al., 2021).

Pendekatan ini bukan sahaja memudahkan proses pencarian penempatan dan penjanaan dokumen, malah membolehkan pemantauan pelajar dilaksanakan secara masa nyata. Kajian oleh Hamzah dan Ismail (2019) turut menunjukkan bahawa penggunaan portal latihan industri dapat mengurangkan kesilapan dalam pengurusan data serta menjimatkan masa pensyarah dalam menyelaras penempatan pelajar.

Di samping itu, sistem berasaskan web meningkatkan kebolehcapaian maklumat tanpa kekangan masa dan lokasi, sekali gus menyumbang kepada peningkatan tahap kepuasan pengguna. Hal ini menunjukkan bahawa penggunaan teknologi bukan sahaja meningkatkan kecekapan operasi, malah memperbaiki pengalaman pengguna secara keseluruhan.

2.3 Pendigitalan dan Kelestarian Tadbir Urus Institusi

Pendigitalan sistem pengurusan merupakan antara strategi utama dalam memperkukuh kelestarian tadbir urus institusi pendidikan. Ahmad et al. (2022) menegaskan bahawa pendigitalan bukan sahaja meningkatkan kecekapan operasi, malah menyokong ketelusan, kebolehkesanan data serta pembuatan keputusan berasaskan bukti.

Dalam konteks latihan industri, sistem digital membolehkan institusi menjejak penempatan pelajar, memantau perkembangan latihan, serta mengumpul maklum balas daripada pihak industri secara sistematik. Pendekatan ini menyumbang kepada pengurusan data yang lebih tersusun dan menyokong penambahbaikan berterusan dalam pelaksanaan program latihan industri. Berdasarkan kajian lepas, jelas menunjukkan keperluan kepada pembangunan sistem pengurusan latihan industri yang bersepadu, sistematik dan berasaskan digital. Justeru, pembangunan Portal e-IMS adalah selari dengan keperluan semasa serta agenda transformasi digital dalam pendidikan.

2.4 Penggunaan Sistem Digital dalam Pengurusan Latihan Industri

Penggunaan sistem digital dalam pengurusan latihan industri semakin menjadi keperluan utama dalam institusi pendidikan tinggi, selaras dengan perkembangan pesat transformasi digital. Sistem digital seperti portal berasaskan web dan aplikasi pengurusan latihan industri membolehkan proses pentadbiran dilaksanakan secara lebih cekap, telus dan sistematik. Alshammari et al. (2021) menyatakan bahawa sistem pengurusan latihan industri berasaskan

digital mampu meningkatkan kecekapan operasi melalui automasi proses seperti permohonan penempatan, pemantauan pelajar dan pengurusan laporan. Pendekatan ini bukan sahaja mengurangkan kebergantungan kepada dokumen fizikal, malah meminimumkan risiko kehilangan data.

Selain itu, Rasheed et al. (2020) mendapati bahawa penggunaan platform digital dalam pendidikan meningkatkan kebolehcapaian maklumat serta fleksibiliti pengguna. Dalam konteks latihan industri, pelajar dapat mengakses maklumat syarikat, status permohonan dan laporan latihan secara masa nyata tanpa kekangan lokasi. Dari perspektif pengurusan data, Bond et al. (2018) menegaskan bahawa sistem digital menyokong pengurusan data yang lebih teratur dan berpusat, sekali gus membolehkan analisis berasaskan bukti dilaksanakan dengan lebih berkesan. Hal ini penting dalam menilai prestasi pelajar dan keberkesanan program latihan industri.

Di samping itu, integrasi teknologi dalam sistem pengurusan turut meningkatkan komunikasi antara pihak berkepentingan. Kintu et al. (2017) menyatakan bahawa penggunaan platform digital membantu memperkukuh interaksi antara pelajar, pensyarah dan pihak industri secara lebih efisien. Kajian oleh Ismail dan Hassan (2022) pula menunjukkan bahawa penggunaan sistem e-management dalam latihan industri meningkatkan tahap kepuasan pengguna kerana sistem tersebut lebih mesra pengguna, mudah diakses dan menjimatkan masa. Dapatan ini selari dengan keperluan generasi pelajar masa kini yang lebih cenderung kepada penggunaan teknologi digital.

Secara keseluruhannya, penggunaan sistem digital dalam pengurusan latihan industri bukan sahaja meningkatkan kecekapan operasi, malah menyokong transformasi pendidikan ke arah pendigitalan yang lebih menyeluruh. Oleh itu, pembangunan sistem seperti e-IMS adalah selari dengan keperluan semasa serta disokong oleh dapatan kajian terdahulu.

3.0 METODOLOGI KAJIAN

Kajian ini menggunakan pendekatan kuantitatif dengan reka bentuk kajian tinjauan. Instrumen kajian ialah borang soal selidik yang dibangunkan bagi menilai keberkesanan sistem e-IMS. Soal selidik ini mengandungi lima item utama iaitu kemudahan akses maklumat syarikat, kemudahan penjanaan dokumen permohonan, kemudahan laporan dan pemantauan latihan industri, kepuasan keseluruhan terhadap sistem serta kesediaan untuk terus menggunakan sistem e-IMS pada masa hadapan.
Skala Likert lima mata digunakan bagi mengukur tahap persetujuan responden. Responden kajian terdiri daripada 60 orang pelajar Kolej Komuniti Kuantan daripada beberapa sesi akademik yang telah menggunakan sistem e-IMS semasa dan sebelum menjalani latihan industri. Data yang dikumpul dianalisis secara deskriptif bagi mengenal pasti tahap keberkesanan sistem.

4.0 REKA BENTUK DAN PEMBANGUNAN SISTEM e-IMS

Portal *e-Internship Management System* (e-IMS) dibangunkan sebagai satu sistem berasaskan web yang menyokong pengurusan latihan industri secara bersepadu. Sistem ini dibangunkan menggunakan bahasa pengaturcaraan HTML, PHP, CSS dan JavaScript, manakala pangkalan data diurus menggunakan MySQL. Sistem ini dihoskan menggunakan platform 000webhost bagi membolehkan capaian secara atas talian tanpa had lokasi.

4.1 Reka Bentuk Sistem e-IMS

Reka bentuk sistem e-IMS adalah berasaskan seni bina tiga lapisan (*three-tier architecture*) yang terdiri daripada:

4.1.1 Lapisan Persembahan (*Presentation Layer*)

Antaramuka pengguna (user interface) yang dibangunkan menggunakan HTML, CSS dan JavaScript bagi memastikan sistem mesra pengguna, responsif dan mudah digunakan oleh semua kategori pengguna.

4.1.2 Lapisan Aplikasi (*Application Layer*)

Menggunakan PHP sebagai bahasa pengaturcaraan utama untuk memproses logik sistem seperti pengurusan data pelajar, permohonan latihan industri, penjanaan dokumen dan pemantauan pelajar.

4.1.3 Lapisan Data (*Database Layer*)

Menggunakan pangkalan data MySQL untuk menyimpan maklumat pengguna, data syarikat, rekod penempatan, laporan latihan industri serta dokumen berkaitan secara berpusat dan sistematik.

Reka bentuk ini membolehkan sistem beroperasi secara efisien, selamat dan mudah diselenggara, selain menyokong pengembangan sistem pada masa hadapan.

4.2 Kategori Pengguna Sistem

Sistem e-IMS direka bentuk untuk menyokong empat kategori pengguna utama, iaitu:

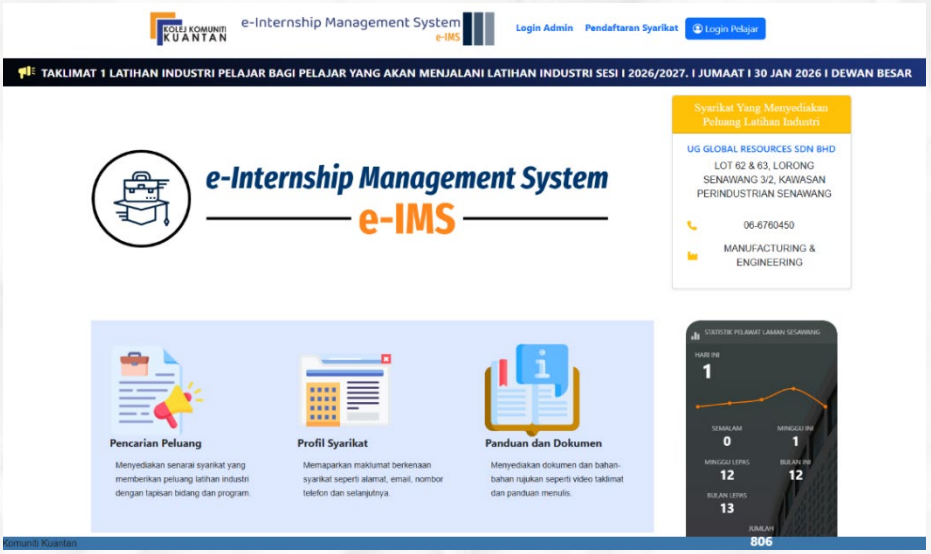
a) **Pentadbir (*Administrator*)** – mengurus keseluruhan sistem termasuk data pengguna, maklumat syarikat dan konfigurasi sistem.
b) **Pensyarah/Penyelaras** – memantau pelajar, menyemak laporan dan mengurus penempatan latihan industri.
c) **Pelajar** – membuat permohonan latihan industri, memuat turun dokumen dan menghantar laporan.
d) **Pihak Industri** – menawarkan peluang latihan industri serta mengemaskini maklumat syarikat.

4.3 Fungsi Utama Sistem e-IMS

Portal e-IMS bertindak sebagai pusat sehenti (*one stop center*) dengan menyediakan beberapa fungsi utama seperti berikut:

4.3.1 Pengurusan Penempatan Latihan Industri

- Carian dan pemilihan syarikat latihan industri
- Pendaftaran dan kemas kini maklumat syarikat
- Permohonan penempatan pelajar secara atas talian



Rajah 1: Paparan pengguna bagi mengakses sistem e-IMS

4.3.2 Penjanaan dan Pengurusan Dokumen

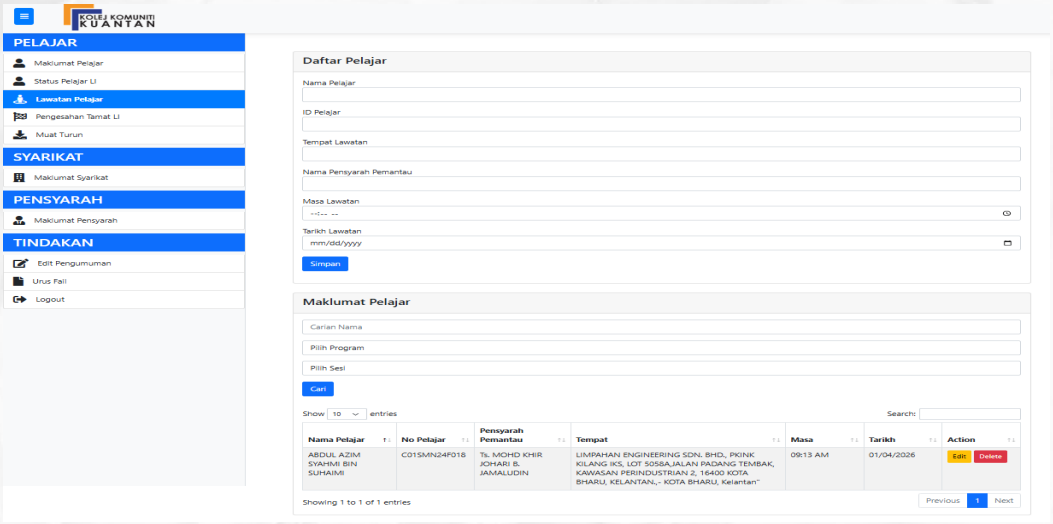
- Penjanaan surat permohonan latihan industri secara automatik
- Muat turun dokumen berkaitan seperti surat tawaran dan borang penilaian
- Penyimpanan dokumen secara digital



Rajah 2: Capaian dokumen yang boleh dimuat turun oleh pelajar

4.3.3 Pemantauan Latihan Industri

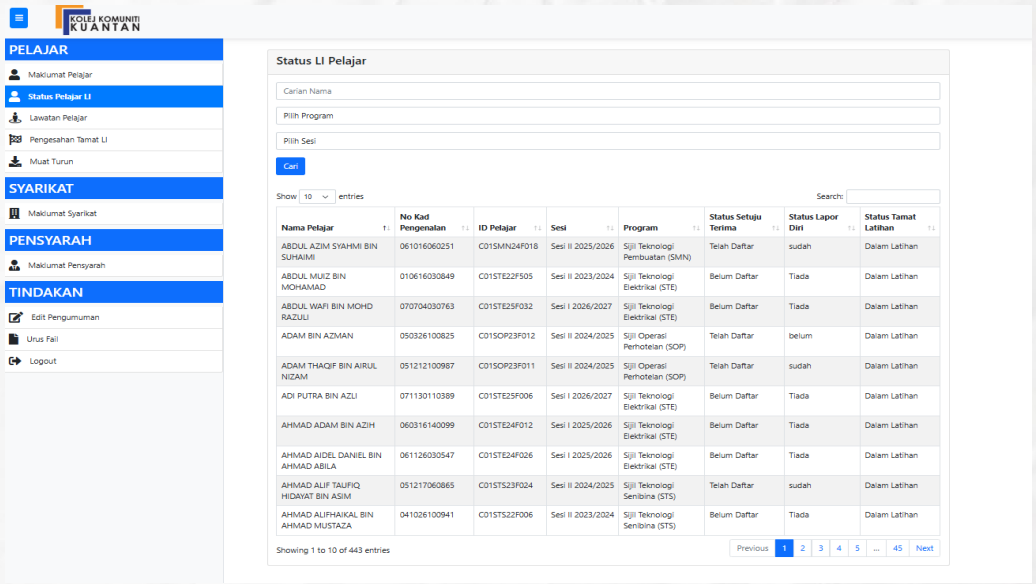
Pemantauan kehadiran dan perkembangan pelajar merangkumi semakan laporan latihan industri oleh pensyarah dan Rekod penilaian pelajar oleh pihak industry



Rajah 3: Pemantauan oleh pensyarah terhadap pelajar

4.3.4 Akses Maklumat Berpusat

- Akses kepada maklumat syarikat latihan industri
- Status permohonan pelajar secara masa nyata
- Pengurusan data pelajar secara sistematik



Rajah 4: Semakan status pelajar

4.3.5 Komunikasi dan Penyelarasan

- Interaksi antara pelajar, pensyarah dan pihak industri
- Penyelarasan maklumat dalam satu platform bersepadu

4.4 Kepentingan Reka Bentuk Sistem

Reka bentuk sistem e-IMS yang bersepadu ini bukan sahaja meningkatkan kecekapan pengurusan latihan industri, malah menyokong pendigitalan proses pentadbiran secara menyeluruh. Sistem ini juga membantu mengurangkan penggunaan dokumen fizikal, meningkatkan ketelusan pengurusan serta memudahkan capaian maklumat oleh semua pihak berkepentingan.

5.0 DAPATAN KAJIAN

Dapatan kajian menunjukkan bahawa tahap keberkesanan sistem e-IMS adalah **tinggi**, dengan purata skor keseluruhan melebihi 4.00. Lebih daripada 80% responden memberikan penilaian positif (skor 4 dan 5), menunjukkan tahap penerimaan yang sangat baik. Item 1 mencatatkan skor min paling rendah (≈3.00), menunjukkan kewujudan masalah sebelum penggunaan sistem. Item-item lain mencatatkan skor tinggi (≈4.00–5.00), khususnya dalam aspek kebolehgunaan, kecekapan dan kepuasan pengguna.

Jadual 1: Min dan Interpretasi Item

Item	Min	Interpretasi
1	3.13	Sederhana
2–10	4.20 – 4.50	Tinggi
11–15	4.10 – 4.40	Tinggi
16–20	4.20 – 4.50	Tinggi

Dapatan juga menunjukkan bahawa sistem membantu dalam penjimatan masa, pengurangan penggunaan kertas serta meningkatkan kecekapan pengurusan latihan industri. Dapatan kajian ini diperoleh daripada analisis soal selidik yang melibatkan seramai **60 orang responden** dalam kalangan pelajar yang menggunakan sistem e-Internship Management System (e-IMS). Instrumen kajian mengandungi 20 item yang diukur menggunakan skala Likert lima mata bagi menilai tahap keberkesanan sistem.

Secara keseluruhannya, dapatan menunjukkan bahawa tahap keberkesanan sistem e-IMS adalah **tinggi**, di mana majoriti responden memberikan skor antara **4 (setuju)** hingga **5 (sangat setuju)** bagi hampir semua item yang dikaji. Ini menunjukkan bahawa sistem e-IMS diterima secara positif dan memenuhi keperluan pengguna dalam pengurusan latihan industri.

Walau bagaimanapun, dapatan bagi **Item 1** menunjukkan skor yang lebih rendah berbanding item lain, dengan majoriti responden memberikan skor antara **1 hingga 3**. Item ini merujuk kepada situasi sebelum penggunaan sistem e-IMS, di mana pelajar menghadapi kesukaran dalam mendapatkan maklumat berkaitan tempat latihan industri. Dapatan ini mengukuhkan keperluan pembangunan sistem e-IMS sebagai satu penyelesaian kepada masalah sedia ada.

Bagi aspek kebolehgunaan dan fungsi sistem (Item 2 hingga Item 10), majoriti responden memberikan skor tinggi, menunjukkan bahawa sistem e-IMS mudah digunakan, mesra pengguna serta memudahkan proses pencarian maklumat dan permohonan latihan industri. Selain itu, sistem ini juga dilihat berupaya menyusun proses secara lebih sistematik dan teratur berbanding kaedah manual. Dari segi kecekapan sistem (Item 11 hingga Item 15), dapatan menunjukkan bahawa sistem e-IMS membantu mempercepatkan proses pengurusan latihan industri serta mengurangkan kebergantungan kepada kaedah manual. Responden juga bersetuju bahawa sistem ini dapat mengurangkan kesilapan dan meningkatkan kecekapan pengurusan data.

Seterusnya, bagi aspek kepuasan pengguna dan impak sistem (Item 16 hingga Item 20), majoriti responden menunjukkan tahap persetujuan yang tinggi terhadap penggunaan e-IMS. Ini menunjukkan bahawa sistem ini bukan sahaja berfungsi dengan baik, malah memberikan pengalaman pengguna yang positif serta membantu pelajar dalam mendapatkan tempat latihan industri dengan lebih mudah. Selain itu, maklum balas terbuka daripada responden turut menunjukkan beberapa cadangan penambahbaikan seperti meningkatkan kelajuan sistem, menambah maklumat syarikat latihan industri serta memperbaiki antaramuka pengguna agar lebih mesra pengguna, khususnya bagi pengguna baharu.

Secara keseluruhannya, dapatan kajian ini membuktikan bahawa sistem e-IMS berjaya meningkatkan kecekapan pengurusan latihan industri, memudahkan akses maklumat serta menyokong pelaksanaan pengurusan yang lebih sistematik dan berkesan. Dapatan ini juga menunjukkan bahawa sistem e-IMS mempunyai potensi untuk diperluaskan penggunaannya dalam konteks institusi pendidikan lain selari dengan keperluan transformasi digital dalam pendidikan TVET.

6.0 PERBINCANGAN

Dapatan kajian ini selari dengan kajian terdahulu yang menyatakan bahawa penggunaan sistem pengurusan latihan industri berasaskan web dapat meningkatkan kecekapan pengurusan dan kepuasan pengguna. e-IMS memudahkan pelajar mendapatkan maklumat syarikat dan dokumen berkaitan latihan industri, manakala pensyarah dapat memantau pelajar secara lebih sistematik dan berkesan.

Dari sudut institusi, sistem e-IMS menyokong pencapaian Petunjuk Prestasi Utama (KPI) berkaitan kelestarian tadbir urus, pengurusan data dan kebolehpasaran graduan. Pihak industri juga mendapat manfaat melalui platform pengiklanan kekosongan latihan industri yang lebih tersusun.

7.0 KESIMPULAN

Secara keseluruhannya, kajian ini membuktikan bahawa Portal *e-Internship Management System* (e-IMS) merupakan satu inovasi yang berkesan dalam pengurusan latihan industri di Kolej Komuniti Kuantan. Sistem ini bukan sahaja meningkatkan kecekapan pengurusan dan

menjimatkan masa, malah menyokong transformasi digital institusi pendidikan. Kajian lanjutan dicadangkan bagi menambah baik sistem ini melalui pembangunan aplikasi mudah alih dan integrasi modul penilaian digital bagi meningkatkan keberkesanan sistem pada masa hadapan.

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KESAN JENIS DAN KEPEKATAN BAHAN PEMEKAT TERHADAP SIFAT FIZIKOKIMIA SOS CILI PEDAS DENGAN AIR KELAPA TUA

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Abstrak

Air kelapa tua kaya dengan mineral semulajadi yang memberikan manfaat kesihatan kepada manusia. Namun, air kelapa tua sering dibuang tanpa dimanfaatkan selepas isinya digunakan. Kajian ini dijalankan untuk menilai kesan jenis dan kepekatan bahan pemekat terhadap sifat fizikokimia sos cili pedas yang diformulasikan menggunakan air kelapa tua sebagai pengganti air. Parameter fizikokimia yang dianalisis ialah pH, jumlah pepejal terlarut (TSS), jumlah keasidan boleh titrat (TTA), kandungan abu dan kelikatan. Tiga jenis bahan pemekat iaitu tepung jagung, tepung ubi kayu dan tepung kentang pada tiga kepekatan iaitu 2.5%, 3.5% dan 4.5% diuji dengan menggunakan reka bentuk rawak lengkap. Data yang diperoleh dianalisis dengan analisis varians dua hala (ANOVA) pada aras keyakinan 95% menggunakan perisian Minitab® 21.4.2. Keputusan menunjukkan bahawa jenis dan kepekatan bahan pemekat memberikan kesan signifikan terhadap semua parameter yang dianalisis. Nilai pH menurun apabila kepekatan bahan pemekat meningkat dengan julat di antara 3.60 ± 0.03 hingga 4.63 ± 0.06. Peningkatan kepekatan bahan pemekat meningkatkan nilai TSS dan kandungan abu, namun nilai TTA menunjukkan trend penurunan apabila kepekatan bahan pemekat meningkat. Nilai TSS berada dalam julat 32.33 ± 0.14 hingga 51.33 ± 0.42, manakala nilai TTA adalah di antara 1.43 ± 0.06 hingga 4.43 ± 0.09. Kandungan abu paling tinggi bagi semua bahan pemekat diperoleh pada kepekatan 4.5% dengan nilai di antara 12.0 ± 2.12 hingga 13.0 ± 0.87. Dari segi kelikatan, peningkatan kepekatan tepung jagung dan tepung ubi kayu menunjukkan penurunan nilai kelikatan, manakala tepung kentang menunjukkan peningkatan kelikatan. Kesimpulannya, sos cili pedas dengan air kelapa tua mengalami perubahan fizikokimia yang dipengaruhi oleh jenis dan kepekatan bahan pemekat. Penemuan kajian ini menunjukkan bahawa tepung jagung, tepung ubi kayu dan tepung kentang mempunyai potensi sebagai alternatif bahan pemekat semulajadi dalam penghasilan sos cili pedas dengan air kelapa tua.

Kata kunci: Sos cili pedas, air kelapa tua, tepung jagung, tepung ubi kayu, tepung kentang

Abstract

Mature coconut water is rich in natural minerals that provide health benefits to humans. However, it is often discarded without being utilized after the coconut flesh is used. This study was conducted to evaluate the effects of different types and concentrations of thickening agents on the physicochemical properties of spicy chili sauce formulated using mature coconut water as a water substitute. The physicochemical parameters analyzed were pH, total soluble solids (TSS), total titratable acidity (TTA), ash content, and viscosity. Three types of thickening agents; corn starch, tapioca starch, and potato starch at three concentrations (2.5%, 3.5%, and 4.5%) were tested using a completely randomized design. The data obtained were analyzed using two-way analysis of variance (ANOVA) at a 95% confidence level with Minitab® 21.4.2. The results showed that both the type and concentration of thickening agents had a significant effect on all parameters analyzed. The pH value decreased as the concentration of thickening agents increased, ranging from 3.60 ± 0.03 to 4.63 ± 0.06. An increase in thickener concentration led to higher TSS values and ash content, while TTA values showed a decreasing trend with increasing thickener concentration. TSS values ranged from 32.33 ± 0.14 to 51.33 ± 0.42, whereas TTA values ranged from 1.43 ± 0.06 to 4.43 ± 0.09. The highest ash content for all thickeners was obtained at 4.5% concentration, with values between 12.0 ± 2.12 and 13.0 ± 0.87. In terms of viscosity, increasing the concentration of corn starch and tapioca starch resulted in a decrease in viscosity, while potato starch showed an increase in viscosity. In conclusion, spicy chili sauce formulated with mature coconut water undergoes physicochemical changes influenced by the type and concentration of thickening agents. The findings of this study indicate that corn starch, tapioca starch, and potato starch have potential as alternative natural thickening agents in the production of spicy chili sauce using mature coconut water.

Keywords: *Spicy chili sauce, mature coconut water, corn starch, tapioca starch, potato starch*

1.0 PENGENALAN

Sos cili merupakan produk makanan yang popular dan digunakan secara meluas sebagai bahan pencicah atau bahan perasa dalam masakan. Secara umumnya, sos cili dihasilkan daripada campuran cili, gula, garam, cuka serta bahan pemekat dan penstabil untuk menghasilkan tekstur yang konsisten dan stabil. Dalam industri makanan, bahan pemekat memainkan peranan penting dalam meningkatkan kelikatan, kestabilan dan kualiti sensori produk sos (Gao et al., 2024). Antara bahan pemekat yang sering digunakan ialah kanji daripada sumber tumbuhan seperti tepung jagung, tepung ubi kayu dan tepung kentang kerana sifatnya yang mampu meningkatkan tekstur dan kestabilan produk makanan.

Dalam penghasilan produk sos, penggunaan air sebagai medium pelarut merupakan komponen utama yang mempengaruhi sifat fizikokimia produk akhir. Namun demikian, terdapat potensi untuk menggantikan air dengan bahan semula jadi lain yang mempunyai nilai pemakanan yang lebih tinggi. Salah satu bahan yang berpotensi ialah air kelapa tua. Air kelapa tua mengandungi pelbagai mineral penting seperti kalium, natrium, magnesium dan kalsium yang memberi manfaat kepada kesihatan manusia (Abdul Rahman et al., 2022). Walaupun kaya dengan nutrien, air kelapa tua sering dibuang atau tidak dimanfaatkan sepenuhnya selepas isi kelapa digunakan dalam pemprosesan makanan. Keadaan ini menyebabkan pembaziran sumber

makanan yang berpotensi untuk dimanfaatkan dalam pembangunan produk makanan bernilai tambah (Aba & Luna, 2024).

Seiring dengan peningkatan kesedaran untuk mengurangkan pembaziran makanan, penggunaan air kelapa tua dalam formulasi produk makanan boleh menjadi satu pendekatan yang inovatif dan mampan. Penambahan bahan pemekat pula diperlukan bagi memastikan kestabilan tekstur serta sifat reologi sos yang dihasilkan. Walau bagaimanapun, jenis dan kepekatan bahan pemekat yang berbeza boleh mempengaruhi sifat fizikokimia produk seperti nilai pH, jumlah pepejal terlarut, jumlah keasidan boleh titrat, kandungan abu dan kelikatan (Himashree et al., 2022). Oleh itu, pemilihan bahan pemekat yang sesuai adalah penting bagi menghasilkan produk sos cili yang berkualiti. Sehubungan itu, kajian ini dijalankan untuk menilai kesan jenis dan kepekatan bahan pemekat terhadap sifat fizikokimia sos cili pedas yang diformulasikan menggunakan air kelapa tua sebagai pengganti air.

1.1 Pernyataan Masalah

Air kelapa daripada buah kelapa matang atau air kelapa tua sering dianggap sebagai hasil sampingan dan tidak dimanfaatkan sepenuhnya. Air kelapa tua biasanya dibuang kerana mempunyai ciri sensori yang kurang menarik seperti rasa yang kurang manis dan aroma yang tidak sekuat air kelapa muda (Abdul Rahman et al., 2022). Akibatnya, sejumlah besar air kelapa tua dibuang sebagai sisa industri walaupun masih mengandungi nutrien penting seperti gula semula jadi, mineral dan bahan bioaktif yang berpotensi untuk dimanfaatkan dalam pembangunan produk makanan bernilai tambah (Shi et al., 2025). Bagi mengatasi isu pembaziran sumber ini, air kelapa tua berpotensi digunakan sebagai bahan mentah alternatif dalam pembangunan produk makanan seperti minuman, produk fermentasi dan sos.

Namun begitu, kajian mengenai penggunaan air kelapa tua dalam formulasi produk sos khususnya sos cili masih sangat terhad. Selain itu, penggunaan bahan pemekat dalam penghasilan sos memainkan peranan penting dalam menentukan sifat fizikokimia seperti kelikatan, kestabilan emulsi dan jumlah pepejal terlarut yang mempengaruhi kualiti produk (Boonditsataporn & Vatthanakul, 2022). Oleh itu, kajian ini dijalankan untuk menilai kesan jenis dan kepekatan bahan pemekat terhadap sifat fizikokimia sos cili pedas yang diformulasikan menggunakan air kelapa tua bagi meningkatkan nilai tambah bahan sisa sampingan serta menyumbang kepada pembangunan produk makanan yang lebih inovatif dan mampan.

1.2 Objektif Kajian

Objektif kajian ini adalah:

1. Untuk menentukan kesan jenis bahan pemekat (tepung jagung, tepung ubi kayu dan tepung kentang) terhadap sifat fizikokimia sos cili pedas dengan air kelapa tua
2. Untuk mengkaji kesan peratus kepekatan bahan pemekat (2.5%, 3.5% dan 4.5%) terhadap sifat fizikokimia sos cili pedas dengan air kelapa tua

1.3 Kepentingan Kajian

Kajian ini penting kerana memberi tumpuan kepada pemanfaatan air kelapa tua, yang sering dianggap sebagai hasil sampingan dan kurang dimanfaatkan dalam industri pemprosesan kelapa walaupun masih mengandungi nutrien yang berpotensi untuk digunakan dalam pembangunan produk makanan bernilai tambah (Shi et al., 2025). Penggunaan bahan ini dalam penghasilan sos cili pedas bukan sahaja dapat membantu mengurangkan pembaziran sumber makanan, tetapi juga menyumbang kepada pendekatan pemprosesan makanan yang lebih mampan.

Selain itu, kajian ini turut memberikan maklumat saintifik mengenai kesan jenis dan kepekatan bahan pemekat berasaskan kanji seperti tepung jagung, tepung ubi kayu dan tepung kentang terhadap sifat fizikokimia sos, termasuk parameter seperti pH, jumlah pepejal terlarut dan kelikatan yang memainkan peranan penting dalam menentukan kualiti dan kestabilan produk sos. Oleh itu, dapatan kajian ini dijangka dapat menyumbang kepada pembangunan formulasi sos cili yang lebih berkualiti serta memberikan panduan kepada industri makanan dalam memilih jenis dan kepekatan bahan pemekat yang sesuai bagi menghasilkan produk sos yang stabil, berkualiti dan berpotensi dikomersialkan.

2.0 KAJIAN LITERATUR

Cili (*Capsicum annuum*) merupakan sayuran rempah yang mempunyai kepentingan komersial dan mampu mensintesis pelbagai sebatian penting seperti kapsaisin, pigmen antosianin dan karotenoid, serta vitamin A, B dan C (Azami, 2023). Mengikut Peraturan-Peraturan Makanan Malaysia 1985, sos cili hendaklah disediakan daripada cili yang baik dan masak dengan kandungan sekurang-kurangnya 5% berat cili segar, 25% jumlah pepejal terlarut dan 0.8% jumlah keasidan. Dalam industri makanan, sos cili dikategorikan sebagai produk emulsi yang memerlukan kestabilan fizikal bagi mengelakkan pemisahan fasa semasa penyimpanan. Oleh itu, formulasi sos lazimnya melibatkan penggunaan hidrokoloid bagi meningkatkan kelikatan serta kestabilan produk (Lazárková et al., 2026). Secara umum, sos cili mempunyai sifat berasid dengan nilai pH sekitar 3.4 hingga 3.9 disebabkan oleh penambahan cuka dalam formulasi produk. Nilai pH yang rendah ini penting untuk meningkatkan kestabilan mikrobiologi serta memanjangkan jangka hayat produk sos cili. Bahan pemekat seperti kanji, gam xanthan, gam guar, pektin dan karboksimetil selulosa (CMC) memainkan peranan penting dalam meningkatkan kelikatan, tekstur dan kestabilan produk melalui keupayaan mengikat air dan membentuk sistem koloid (Williams & Phillips, 2021). Penggunaannya membantu mencegah pemisahan fasa, mengurangkan sineresis dan meningkatkan kestabilan penyimpanan (Tan & McClements, 2021).

Air kelapa merupakan cecair semula jadi yang terdapat dalam buah kelapa dan mengandungi pelbagai nutrien penting seperti gula, mineral, vitamin serta asid amino (Mat et al., 2022). Kelapa tua adalah kelapa yang berusia lebih daripada sembilan bulan (270 hari) selepas pendebungaan (Burns et al., 2020). Pengurangan jumlah gula dan pepejal, serta penghasilan sedikit rasa masam berlaku apabila buah kelapa semakin matang, menyebabkan air kelapa tua kehilangan tahap kebolehterimaan rasanya (Aziz et al., 2023). Disebabkan hal ini, air kelapa tua sering dibuang atau tidak dimanfaatkan selepas pemprosesan isi kelapa walaupun masih mengandungi mineral penting seperti kalium, kalsium, natrium dan fosforus (Mela, 2020). Kajian menunjukkan bahawa air kelapa tua boleh digunakan sebagai medium pemprosesan makanan kerana kandungan gula dan mineralnya yang mampu menyumbang kepada ciri fizikal dan kimia produk (Sagala et al., 2026). Penggunaan air kelapa tua dapat membantu mengurangkan pembaziran hasil sampingan industri kelapa dan meningkatkan nilai tambah bahan mentah tersebut dalam pemprosesan makanan.

3.0 METODOLOGI KAJIAN

3.1 Bahan

Bahan-bahan yang digunakan dalam penghasilan sos cili pedas dengan air kelapa tua seperti cili merah, bawang putih, cili padi, bahan pemekat (tepung jagung, tepung ubi kayu dan tepung kentang), gula dan garam dibeli dari pasaraya sekitar Kuantan, Pahang. Air kelapa tua

diperoleh dari pembekal Santan Zas, Kuantan, Pahang. Bahan-bahan ini disimpan dalam peti sejuk pada suhu 5°C sebelum digunakan. Manakala bahan kimia yang digunakan adalah bergred analitikal iaitu terdiri daripada asid asetik, karboksimetil selulosa (CMC), natrium hidroksida (NaOH) dan fenolftalein.

3.2 Kaedah

3.2.1 Reka bentuk Kajian

Kajian ini merupakan kajian kuantitatif yang menggunakan reka bentuk eksperimen secara reka bentuk rawak lengkap. Penghasilan sos cili pedas dengan air kelapa tua dijalankan menggunakan tiga jenis bahan pemekat iaitu tepung jagung, tepung ubi kayu dan tepung kentang pada tiga kepekatan yang berbeza iaitu 2.5%, 3.5% dan 4.5% (w/w). Peratus kepekatan bahan pemekat ini dipilih berdasarkan kajian awal yang dijalankan bagi menentukan julat kepekatan yang mampu menghasilkan tekstur sos yang stabil tanpa menyebabkan produk menjadi terlalu pekat atau berlaku pembentukan gel yang berlebihan. Selain itu, julat ini juga selari dengan penggunaan bahan pemekat berasaskan kanji dalam formulasi sos yang lazimnya berada dalam lingkungan 1–5% bergantung kepada jenis kanji dan kelikatan sasaran produk (Guimarães et al., 2026). Setiap rawatan dianalisis dalam tiga replikasi.

3.2.2 Formulasi Sos Cili Pedas dengan Air Kelapa Tua

Penghasilan sos cili pedas dengan air kelapa tua merupakan satu proses inovasi untuk mendapatkan formulasi optimum. Sembilan formulasi yang telah dihasilkan dan dikaji ditunjukkan dalam Jadual 1.

Jadual 1: Formulasi sos cili pedas dengan air kelapa tua

Bahan-bahan	Formulasi (%)								
	1	2	3	4	5	6	7	8	9
Cili padi	7	7	7	7	7	7	7	7	7
Cili merah	5	5	5	5	5	5	5	5	5
Air kelapa tua	51.7	51.7	51.7	51.7	51.7	51.7	51.7	51.7	51.7
Gula	23	23	23	22	22	22	21	21	21
Asid asetik	7	7	7	7	7	7	7	7	7
Tepung jagung	2.5	-	-	3.5	-	-	4.5	-	-
Tepung ubi kayu	-	2.5	-	-	3.5	-	-	4.5	-
Tepung kentang	-	-	2.5	-	-	3.5	-	-	4.5
Garam	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Bawang putih	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Karboksimetil selulosa (CMC)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

3.2.3 Penghasilan Sos Cili Pedas dengan Air Kelapa Tua

Penghasilan sos cili pedas dengan air kelapa tua dijalankan mengikut kaedah Saiful Bahri et al. (2013) dengan sedikit pengubahsuaian. Cili padi, cili merah dan bawang putih dibasuh terlebih dahulu bagi menghilangkan kekotoran sebelum dipotong kecil. Seterusnya, bahan-bahan tersebut dikisar bersama air kelapa tua menggunakan pengisar komersial sehingga menghasilkan puri yang homogen. Puri yang terhasil kemudian dimasukkan ke dalam periuk dan dimasak pada suhu 90–95°C selama 20 minit sehingga campuran mendidih. Kemudian campuran gula, CMC dan garam ditambah ke dalam puri dan dikacau sehingga semua bahan larut sepenuhnya.

Bahan pemekat yang terdiri daripada tepung jagung, tepung kentang atau tepung ubi kayu kemudian ditambah ke dalam campuran dan dimasak selama dua minit bagi membolehkan proses pemekatan berlaku. Seterusnya, asid asetik ditambah dan campuran dikacau selama dua minit bagi memastikan semua bahan bercampur secara sekata. Akhir sekali, sos cili pedas berasaskan air kelapa tua diisi secara panas ke dalam botol sos yang telah disterilkan, ditutup rapat dengan penutup botol, dan disimpan pada suhu bilik selama 24 jam sebelum analisis fizikokimia dijalankan.

3.3 ANALISIS FIZIKOKIMIA

3.3.1 Penentuan Nilai pH

Analisis pH dijalankan menggunakan pH meter mudah alih jenis LCD-Blue. pH meter ini dikalibrasi menggunakan larutan *buffer* pH 4.0 dan pH 7.0 sebelum pengukuran dijalankan. Sebanyak lima gram sampel sos cili pedas dengan air kelapa tua dimasukkan ke dalam bikar berisipadu 25 mL. Kemudian, elektrod meter dimasukkan ke dalam sampel sos. Bacaan pH direkodkan selepas bacaan menjadi stabil.

3.3.2 Penentuan Jumlah Pepejal Larut, TSS (°Brix)

Jumlah pepejal larut (*Total Soluble Solid, TSS*) bagi sos cili pedas dengan air kelapa diukur menggunakan refraktometer RPC/ ATC dengan julat pengukuraan 30° hingga 60° Brix. Sebelum pengukuran dijalankan, prisma refraktometer dibilas dengan air suling dan dibersihkan menggunakan tisu. Sebanyak 1 mL sampel sos diletakkan pada permukaan prisma dan bacaan direkodkan.

3.3.3 Penentuan Jumlah Keasidan Boleh Titrat (TTA)

Jumlah keasidan boleh titrat (*Total Titratable Acidity, TTA*) ditentukan dengan menggunakan kaedah titrasi ringkas seperti dalam kaedah AOAC Official Method 942.15 (2023). Sebanyak 10 mL sampel sos cili pedas dengan air kelapa dimasukkan ke dalam kelalang kon 250 mL dan dicairkan dengan 50 mL air suling. Sebanyak 2 – 3 titis larutan fenolftalein 1% ditambah sebagai penunjuk. Kemudian sampel dititrat dengan larutan natrium hidroksida (NaOH) 0.1 N sehingga warna merah jambu diperhatikan. Isipadu NaOH yang digunakan direkodkan. Keputusan dinyatakan sebagai peratus asid asetik (% w/v) seperti persamaan (1) berikut:

$$\text{TTA} = \frac{\text{V x N x 0.060 x 100}}{\text{Isipadu sampel}} \qquad ..(1)$$

Di mana;
V = isipadu NaOH yang digunakan (mL)
N = nilai normaliti NaOH
0.060 = faktor setara asid asetik

3.3.4 Penentuan Kandungan Abu

Penentuan kandungan mineral dijalankan mengikut kaedah AOAC (2012). Sebanyak 2.0 gram sampel ditimbang dalam mangkuk pijar. Sampel dipanaskan di atas penunu bunsen sehingga berasap. Seterusnya sampel dibakar di dalam relau mufel (*Thermo Scientific*) pada suhu 500°C selama dua jam sehingga residu bertukar menjadi warna kelabu keputihan. Selepas pembakaran, mangkuk pijar bersama residu abu disejukkan di dalam desikator. Kemudian berat mangkuk pijar ditimbang dengan penimbang digital. Peratus kandungan mineral dinyatakan sebagai peratus berat kering (%) dan dikira seperti dalam persamaan (2).

$$\text{Peratus kandungan abu (\%)} = \frac{W_2 - W_o}{W_1} \times 100 \quad \text{.. (2)}$$

Di mana; W_0 = berat dalam gram mangkuk pijar
W_1 = berat sampel dalam gram
W_2 = berat dalam gram mangkuk pijar dan abu

3.3.5 Penentuan Kelikatan

Analisis kelikatan ditentukan menggunakan *Bostwick Consistometer*. Sebanyak 75 gram sampel ditimbang dan dimasukkan ke dalam bikar 100 mL. Plat penghadang *consistometer* ditekan ke dalam sampel dan masa 30 saat ditetapkan. Nilai kelikatan sos cili pedas dengan air kelapa ditentukan berdasarkan jarak aliran yang direkodkan sebagai cm/30s.

3.4 ANALISIS DATA

Data yang diperoleh dianalisis menggunakan perisian Minitab® 21.4.2. Kesemua analisis dilakukan sebanyak tiga replikasi. Ujian Analisis Varians (ANOVA) dua hala dan ujian post-hoc Tukey digunakan untuk menentukan perbezaan antara sampel pada aras signifikan 95% ($p<0.05$).

4.0 DAPATAN DAN PERBINCANGAN

4.1 Penentuan Nilai pH

Nilai pH sos cili pedas dengan air kelapa tua ditunjukkan dalam Jadual 2. Keputusan menujukkan bahawa peningkatan kepekatan bahan pemekat didapati dapat menurunkan nilai pH sos cili pedas. Penurunan pH sos cili yang signifikan ($p<0.05$) diperhatikan pada sampel dengan tepung kentang. Penurunan nilai pH ini mungkin disebabkan oleh peningkatan jumlah pepejal dalam sistem makanan yang boleh mempengaruhi keseimbangan ion hidrogen dalam larutan serta interaksi antara komponen kanji dan bahan berasid seperti asid asetik dalam formulasi sos (Ledezma, 2024).

Selain itu, kanji mempunyai keupayaan untuk menyerap air dan membentuk struktur gel semasa proses pemanasan. Proses ini boleh mempengaruhi aktiviti air dan interaksi antara komponen dalam sistem makanan, sekali gus mempengaruhi nilai pH produk akhir. Perbezaan nilai pH antara jenis bahan pemekat juga boleh dikaitkan dengan perbezaan struktur kimia kanji, khususnya nisbah amilosa dan amilopektin dalam setiap jenis tepung. Keputusan menunjukkan rawatan yang menggunakan tepung kentang pada kepekatan 2.5% merekodkan nilai pH 4.63, iaitu melebihi julat pH optimum bagi sos berasid (3.4–3.9). Nilai pH yang lebih tinggi ini boleh meningkatkan risiko pertumbuhan mikroorganisma perosak dan berpotensi menjejaskan kestabilan mikrobiologi serta jangka hayat produk semasa penyimpanan (Azami, 2023).

Oleh itu, formulasi ini mungkin memerlukan penyesuaian kandungan asid asetik atau kawalan proses haba yang lebih ketat bagi memastikan keselamatan produk. Selain itu, penggunaan air kelapa tua sebagai medium dalam formulasi sos juga boleh mempengaruhi nilai pH produk kerana air kelapa secara semula jadi mempunyai julat pH sekitar 4.8 hingga 5.2 serta mengandungi pelbagai mineral dan komponen larut yang boleh mempengaruhi keseimbangan kimia dalam sistem makanan (Appaiah et al., 2015).

Jadual 2: Keputusan analisis pH sos cili pedas dengan air kelapa tua

Sampel	Sos cili dengan tepung jagung	Sos cili dengan tepung ubi kayu	Sos cili dengan tepung kentang
2.5%	3.87 ± 0.12^{a}	3.82 ± 0.02^{a}	4.63 ± 0.06^{a}
3.5%	3.73 ± 0.06^{a}	3.72 ± 0.06^{a}	3.74 ± 0.04^{ab}
4.5%	3.70 ± 0.01^{a}	3.69 ± 0.0^{a}	3.60 ± 0.03^{b}

Data dinyatakan sebagai min ± sisihan piawai (n=3). $^{a-b}$Abjad berbeza pada lajur yang sama menunjukkan perbezaan signifikan ($p<0.05$)

4.2 Penentuan Jumlah Pepejal Terlarut (TSS)

Berdasarkan Jadual 3, nilai jumlah pepejal terlarut (TSS) bagi sos cili pedas dengan air kelapa tua meningkat secara signifikan ($p<0.05$) apabila kepekatan bahan pemekat meningkat daripada 2.5% kepada 4.5%. Peningkatan ini dapat dijelaskan melalui peningkatan jumlah bahan pepejal yang terdapat dalam sistem makanan apabila lebih banyak kanji ditambah dalam formulasi sos. Kanji merupakan polisakarida yang terdiri daripada molekul glukosa yang boleh menyerap air dan mengalami pembengkakan granul semasa proses pemanasan. Proses pembengkakan ini menyebabkan lebih banyak komponen pepejal terlarut berada dalam sistem makanan, sekali gus meningkatkan nilai TSS produk (Jia et al., 2023).

Selain itu, peningkatan kepekatan bahan pemekat turut meningkatkan kepekatan karbohidrat dalam sistem larutan yang secara langsung menyumbang kepada peningkatan bacaan °Brix dalam analisis TSS. Fenomena ini selari dengan kajian Melani dan Kim (2019) yang melaporkan bahawa penambahan bahan pemekat berasaskan kanji dalam produk makanan boleh meningkatkan jumlah pepejal terlarut kerana granul kanji menyerap air dan mengalami pembengkakan semasa pemanasan, seterusnya meningkatkan kepekatan bahan terlarut dalam sistem makanan.

Jadual 3: Keputusan jumlah pepejal terlarut (°Brix) sos cili pedas dengan air kelapa tua

Sampel	Sos cili dengan tepung jagung	Sos cili dengan tepung ubi kayu	Sos cili dengan tepung kentang
2.5%	37.00 ± 0.25^{c}	47.67 ± 0.57^{c}	32.33 ± 0.14^{c}
3.5%	41.00 ± 0.13^{b}	49.33 ± 0.61^{b}	33.67 ± 0.33^{b}
4.5%	44.00 ± 0.02^{a}	51.33 ± 0.42^{a}	40.67 ± 0.53^{a}

Data dinyatakan sebagai min ± sisihan piawai (n=3). $^{a-b}$Abjad berbeza pada lajur yang sama menunjukkan perbezaan signifikan ($p<0.05$)

4.3 Penentuan Jumlah Keasidan Boleh Titrat (TTA)

Keputusan kajian dalam Jadual 4 menunjukkan bahawa nilai jumlah keasidan boleh titrat (TTA) bagi sos cili pedas dengan air kelapa tua menurun secara signifikan ($p<0.05$) apabila kepekatan bahan pemekat meningkat. Penurunan ini mungkin disebabkan oleh kesan pencairan relatif terhadap komponen berasid dalam sistem makanan apabila lebih banyak bahan pemekat ditambah ke dalam formulasi sos. Walaupun jumlah asid yang ditambah dalam formulasi adalah sama, peningkatan kandungan pepejal boleh menyebabkan penurunan kepekatan relatif asid bebas yang dapat dititrat dalam sampel.

Selain itu, interaksi antara molekul kanji dan asid organik juga boleh mempengaruhi keasidan produk (Cai et al., 2020). Semasa proses pemanasan, granul kanji mengalami proses penggelatinan yang melibatkan penyerapan air dan pembengkakan struktur granul. Proses ini menyebabkan molekul air dan komponen lain dalam sistem makanan berinteraksi dengan kumpulan hidroksil pada rantai amilosa dan amilopektin. Interaksi ini boleh mempengaruhi

ketersediaan asid bebas dalam sistem larutan, seterusnya mempengaruhi nilai TTA yang diperoleh. Kajian Tong et al. (2023) menunjukkan bahawa sifat fizikokimia kanji, termasuk kapasiti penyerapan air dan struktur molekulnya, boleh mempengaruhi interaksi dengan komponen lain dalam sistem makanan seperti asid organik dan garam mineral, yang seterusnya memberi kesan kepada keasidan produk makanan.

Jadual 4: Keputusan jumlah keasidan boleh titrat (% w/v) sos cili pedas dengan air kelapa tua

Sampel	Sos cili dengan tepung jagung	Sos cili dengan tepung ubi kayu	Sos cili dengan tepung kentang
2.5%	4.17 ± 0.06^{a}	4.23 ± 0.07^{a}	4.43 ± 0.09^{a}
3.5%	3.47 ± 0.05^{b}	4.13 ± 0.12^{a}	4.17 ± 0.04^{a}
4.5%	2.17 ± 0.09^{c}	1.43 ± 0.06^{b}	1.70 ± 0.05^{b}

Data dinyatakan sebagai min ± sisihan piawai (n=3). $^{a-b}$Abjad berbeza pada lajur yang sama menunjukkan perbezaan signifikan ($p<0.05$)

4.4 Penentuan Kandungan Abu

Berdasarkan Jadual 5, kandungan abu bagi sos cili pedas dengan air kelapa tua menunjukkan peningkatan yang signifikan ($p<0.05$) apabila kepekatan bahan pemekat meningkat. Kandungan abu merujuk kepada jumlah mineral yang terdapat dalam sesuatu bahan makanan selepas proses pembakaran pada suhu tinggi. Peningkatan kandungan abu dalam kajian ini mungkin disebabkan oleh peningkatan jumlah bahan pepejal dalam formulasi sos apabila lebih banyak bahan pemekat ditambah.

Walaupun kanji secara umum mempunyai kandungan mineral yang rendah, peningkatan jumlah bahan pepejal dalam sistem makanan boleh menyumbang kepada peningkatan residu mineral selepas proses pembakaran. Selain itu, penggunaan air kelapa tua sebagai bahan asas dalam formulasi sos juga boleh menyumbang kepada kandungan mineral produk (Mat et al., 2022). Air kelapa diketahui mengandungi pelbagai mineral penting seperti kalium, magnesium, kalsium dan fosforus yang boleh meningkatkan kandungan abu dalam produk makanan yang menggunakannya sebagai bahan asas. Oleh itu, peningkatan kandungan abu yang diperoleh dalam kajian ini mungkin merupakan hasil gabungan antara kandungan mineral semula jadi dalam air kelapa tua dan peningkatan jumlah pepejal dalam formulasi sos akibat penambahan bahan pemekat.

Jadual 5: Keputusan kandungan abu (%) sos cili pedas dengan air kelapa tua

Sampel	Sos cili dengan tepung jagung	Sos cili dengan tepung ubi kayu	Sos cili dengan tepung kentang
2.5%	5.17 ± 1.04^{c}	3.33 ± 1.26^{c}	5.00 ± 2.29^{c}
3.5%	8.67 ± 0.29^{b}	5.17 ± 0.77^{b}	9.33 ± 0.29^{b}
4.5%	13.00 ± 3.46^{a}	12.00 ± 2.12^{a}	13.00 ± 0.87^{a}

Data dinyatakan sebagai min ± sisihan piawai (n=3). $^{a-b}$Abjad berbeza pada lajur yang sama menunjukkan perbezaan signifikan ($p<0.05$)

4.5 Penentuan Kelikatan

Keputusan dalam Jadual 6 menunjukkan bahawa nilai kelikatan sos cili pedas dengan air kelapa tua dipengaruhi secara signifikan ($p<0.05$) oleh jenis dan kepekatan bahan pemekat yang digunakan. Bagi formulasi yang menggunakan tepung jagung dan tepung ubi kayu, peningkatan kepekatan bahan pemekat daripada 2.5% kepada 4.5% menyebabkan penurunan bacaan *Bostwick consistometer* yang menunjukkan peningkatan kelikatan sos, kerana jarak

aliran sos menjadi lebih pendek dalam tempoh 30 saat. Fenomena ini berlaku disebabkan oleh peningkatan jumlah granul kanji dalam sistem makanan yang menyerap air, membengkak dan mengalami gelatinisasi semasa pemanasan, seterusnya meningkatkan pembentukan matriks viskoelastik dalam sos. Gelatinisasi menyebabkan kehilangan struktur kristal granul, pembengkakan, pelarutan sebahagian amilosa dan peningkatan rintangan aliran, sekali gus menghasilkan tekstur yang lebih pekat (Jia et al., 2023).

Namun formulasi yang menggunakan tepung kentang menunjukkan corak yang berbeza, di mana peningkatan kepekatan bahan pemekat menyebabkan peningkatan bacaan *Bostwick consistometer* yang menunjukkan penurunan kelikatan sos. Fenomena ini berkemungkinan berkait dengan sifat unik kanji kentang yang mempunyai granul bersaiz besar, kandungan amilopektin yang tinggi, serta kumpulan fosfat terikat pada struktur amilopektin, yang meningkatkan kapasiti penyerapan air dan pembengkakan granul secara ketara. Ciri ini lazimnya menghasilkan kelikatan yang tinggi pada kepekatan rendah (Dupuis & Liu, 2019).

Jadual 6: Keputusan kandungan kelikatan (cm/30s) sos cili pedas dengan air kelapa tua

Sampel	Sos cili dengan tepung jagung	Sos cili dengan tepung ubi kayu	Sos cili dengan tepung kentang
2.5%	9.60 ± 0.10^{a}	13.50 ± 0.06^{a}	7.43 ± 0.05^{c}
3.5%	2.97 ± 0.06^{b}	9.43 ± 0.04^{b}	10.00 ± 0.01^{b}
4.5%	1.53 ± 0.05^{b}	7.03 ± 0.07^{c}	14.50 ± 0.06^{a}

Data dinyatakan sebagai min ± sisihan piawai (n=3). $^{a-c}$Abjad berbeza pada lajur yang sama menunjukkan perbezaan signifikan ($p<0.05$)

5.0 KESIMPULAN DAN CADANGAN

Secara keseluruhannya, kajian menunjukkan bahawa jenis dan kepekatan bahan pemekat memberi kesan signifikan terhadap parameter fizikokimia sos cili pedas berasaskan air kelapa, termasuk pH, jumlah pepejal terlarut (TSS), jumlah keasidan boleh titrat (TTA), kandungan abu dan kelikatan. Peningkatan kepekatan bahan pemekat daripada 2.5% kepada 4.5% didapati meningkatkan nilai TSS dan kandungan abu serta menurunkan TTA, manakala kesan terhadap kelikatan bergantung kepada jenis bahan pemekat, di mana tepung kentang meningkatkan kelikatan tetapi tepung jagung dan ubi kayu menunjukkan trend penurunan. Kajian ini juga membuktikan bahawa air kelapa tua berpotensi sebagai bahan alternatif yang dapat meningkatkan nilai produk dan mengurangkan pembaziran dalam industri pemprosesan makanan. Bagi kajian lanjutan, dicadangkan agar analisis sensori dijalankan untuk menilai penerimaan pengguna, diikuti kajian jangka hayat penyimpanan melalui analisis mikrobiologi dan perubahan sifat fizikokimia bagi memastikan keselamatan produk. Selain itu, kajian terhadap kandungan nutrisi dan komponen bioaktif seperti mineral dan antioksidan juga boleh dilakukan, di samping menilai penggunaan bahan pemekat lain seperti hidrokoloid semula jadi untuk melihat kesannya terhadap kestabilan, tekstur dan sifat reologi sos.

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PROPOSED AI-ENHANCED USABILITY IMPROVEMENT FOR THE COURSE REGISTRATION MODULE IN THE POLYTECHNIC MANAGEMENT INFORMATION SYSTEM

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Abstract

The iDaftar module within the Polytechnic Management Information System (SPMP) plays a crucial role in supporting students' course registration processes each semester. Although the module functions effectively for students following a standard registration pathway, several usability issues frequently arise among students with special academic circumstances, such as repeat course registration requirements, credit hour imbalances, and other exceptional cases. These challenges not only increase the risk of registration errors and delays but also impose additional burdens on Academic Advisors and departmental management. This study aims to evaluate the usability level of the iDaftar module and to propose artificial intelligence (AI)-based enhancements to improve user experience and academic decision-making support. A quantitative approach was employed involving 207 Semester 2 students from the Diploma in Information Technology and Diploma in Civil Engineering programmes at Politeknik Sultan Abdul Halim Muadzam Shah. Data were collected through a structured questionnaire and analysed using the System Usability Scale (SUS). The findings indicate that the iDaftar module achieved an average SUS score of 59.01, reflecting a low to moderate level of usability. Based on these results and interface observations of the existing system, this study proposes an enhanced iDaftar prototype incorporating AI-driven features, including an automated credit tracker, an intelligent course recommender, an academic support chatbot, and a Graduate-On-Time (GOT) forecasting tool. This study contributes to a data-informed and AI-integrated system improvement approach that can be implemented without requiring a complete overhaul of the existing system, aligning with the operational constraints of higher education institutions.

Keywords: Course registration system; usability evaluation; System Usability Scale (SUS); artificial intelligence integration; academic decision support.

Abstrak

Modul iDaftar dalam Sistem Pengurusan Maklumat Politeknik (SPMP) memainkan peranan penting dalam menyokong proses pendaftaran kursus pelajar pada setiap semester. Walaupun modul ini berfungsi dengan berkesan bagi pelajar yang mengikuti laluan pendaftaran standard, beberapa isu kebolehgunaan kerap timbul dalam kalangan pelajar dengan situasi akademik khas, seperti keperluan pendaftaran kursus mengulang, ketidakseimbangan jam

kredit, dan kes-kes terpencil yang lain. Cabaran ini bukan sahaja meningkatkan risiko ralat dan kelewatan pendaftaran, malah memberi beban tambahan kepada Penasihat Akademik dan pengurusan jabatan. Kajian ini bertujuan untuk menilai tahap kebolehgunaan modul iDaftar dan mencadangkan penambahbaikan berasaskan kecerdasan buatan (AI) bagi meningkatkan pengalaman pengguna serta sokongan dalam membuat keputusan akademik. Pendekatan kuantitatif telah digunakan melibatkan 207 pelajar Semester 2 daripada program Diploma Teknologi Maklumat dan Diploma Kejuruteraan Awam di Politeknik Sultan Abdul Halim Mu'adzam Shah. Data dikumpul melalui soal selidik berstruktur dan dianalisis menggunakan Skala Kebolehgunaan Sistem (SUS). Hasil kajian menunjukkan bahawa modul iDaftar mencapai skor purata SUS sebanyak 59.01, yang mencerminkan tahap kebolehgunaan yang rendah hingga sederhana. Berdasarkan keputusan tersebut dan pemerhatian antaramuka sistem sedia ada, kajian ini mencadangkan prototaip iDaftar yang dipertingkatkan dengan ciri-ciri dipacu AI, termasuk penjejak kredit automatik, syor kursus pintar, bot sembang sokongan akademik, dan alat ramalan Bergraduat Tepat Pada Masa (GOT). Kajian ini menyumbang kepada pendekatan penambahbaikan sistem yang berinformasikan data dan bersepadu AI yang boleh dilaksanakan tanpa memerlukan rombakan menyeluruh terhadap sistem sedia ada, selaras dengan kekangan operasi institusi pengajian tinggi.

Kata Kunci: *Sistem pendaftaran kursus; penilaian kebolehgunaan, Skala Kebolehgunaan Sistem (SUS), integrasi kecerdasan buatan, sokongan keputusan akademik.*

1.0 INTRODUCTION

Course registration is a core component of academic management in Malaysian polytechnics, yet the effectiveness of the iDaftar module within the Polytechnic Management Information System (SPMP) remains inconsistent across diverse student profiles. While functional for standard pathways, the system often fails students managing complex scenarios such as carry modules, credit imbalances, or impending graduation, resulting in "registration leakages" where prerequisite omissions and credit errors are often detected only after the semester begins. These failures disrupt academic planning and impose a heavy administrative burden, highlighting a critical research gap: the need for intelligent AI support layers to augment decision-making within existing legacy systems without requiring a total structural overhaul. Consequently, this study utilizes the System Usability Scale (SUS) to evaluate current usability levels, identify persistent usage barriers, and propose a conceptual AI-enhanced prototype designed to transition iDaftar from a transactional tool into a proactive, student-centered academic ecosystem that supports timely graduation.

1.1 Problem Statement

The core problem addressed by this study is the significant "usability gap" within the iDaftar module of the SPMP system, which hinders effective academic planning and increases the risk of registration errors among polytechnic students. While the system is functionally operational, its design does not account for the cognitive complexities of course registration in a TVET environment.

1.2 Research Objectives

The study is centered on three core objectives:

i. To evaluate the current usability level of the iDaftar module using the System Usability Scale (SUS) to establish an empirical baseline for institutional improvement.
ii. To identify the specific interface barriers and cognitive challenges that lead to course registration errors and administrative bottlenecks.
iii. To design a conceptual framework for an AI-enhanced iDaftar prototype that integrates real-time guidance and predictive tools to support strategic academic planning.

1.3 Research Questions

The research questions are as follows:

i. What is the usability level of the iDaftar module in SPMP?
ii. What key issues contribute to its moderate usability score? and
iii. How can AI feature better support course registration processes and student academic planning more effectively?

2.0 LITERATURE REVIEW

The digitalization of higher education has positioned academic information systems as critical gateways for administrative and learning functions. Course registration systems, in particular, directly impact prerequisite compliance, credit balance, and graduation timelines. However, their effectiveness relies on more than functional completeness; it requires high usability and robust decision support to prevent registration errors and delayed student progression.

2.1 Usability in Educational Systems

Usability defined by effectiveness, efficiency, and satisfaction is vital for reducing cognitive load in complex institutional platforms. Despite widespread adoption, many systems still suffer from interface inconsistency and inadequate feedback (Lu et al., 2022). Research by Fink et al. (2023) emphasizes that interface clarity and task guidance are the primary drivers of user satisfaction. In registration contexts, poor usability specifically disadvantages students with irregular academic trajectories (e.g., carry modules), as the lack of real-time validation leads to miscalculated credit loads.

2.2 AI Integration and Human-Cantered Design

Institutional systems are shifting from static databases toward intelligent, adaptive platforms (Crompton & Burke, 2023). However, human-centered AI principles dictate that these systems must be transparent and augment user capabilities rather than replace human support (Alfredo et al., 2024). To maintain trust and agency, AI should function as an “augmentation layer” embedded within existing architectures to provide interpretable, supportive guidance.

2.3 AI Course Recommendation

Course selection is a high-stakes decision-making task. Traditional systems often place the entire burden of planning on the student. AI-based recommender systems address this by using hybrid AI approaches to provide context-aware suggestions (Algarni & Sheldon, 2023). Cha et al. (2024) found that students value AI most when it assists them in both filtering options and

benchmarking their final decisions. Integrated into a system like iDaftar, these recommenders can significantly reduce "academic leakage" by ensuring prerequisite compliance.

2.4 AI Chatbots and Real-Time Support

Chatbots offer scalable, immediate assistance for procedural and administrative queries. Akiba and Fraboni (2023) highlight the potential of generative AI to empower students in navigating complex graduation rules. While acceptance depends on perceived trustworthiness and reliability (Habibi et al., 2023), effective chatbot design requires clear interaction paths and reliability (Bilquise et al., 2023). For iDaftar, an embedded agent like “IDA” reduces the advisory workload by providing real-time credit and policy clarifications.

2.5 Graduate-on-Time (GOT) Forecasting

Predictive learning analytics are essential for identifying at-risk students and enabling early intervention. Systematic reviews confirm that AI-based models have become foundational for forecasting academic outcomes (Sghir et al., 2023). Advanced ensemble machine learning approaches can now accurately predict retention and graduation timelines (Okoye et al., 2024). When applied to registration systems, these analytics allow for proactive dashboards that visualize student pathways and semester loads.

3.0 RESEARCH METHODOLOGY

This study utilizes a two-phase quantitative survey design. Phase 1 evaluates the existing iDaftar system’s usability, while Phase 2 develops a data-informed, AI-enhanced prototype based on those empirical findings.

3.1 Population and Sample

This section delineates the parameters of the study’s participants, establishing the scope of the research and the systematic process used to select a representative subset for data collection.

3.1.1 Target Population

The target population comprises the total group of individuals from which the study’s findings are drawn. For the purpose of this research, the population is defined as Semester 2 students at Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS) specifically enrolled in the Diploma in Information Technology (DIT) and Diploma in Civil Engineering (DKA) programs. The selection of this cohort is based on their transitional stage in the academic cycle, providing a relevant perspective on the research variables. The total population size is identified as N = 335.

3.1.2 Sample Size

To ensure the statistical validity of the findings and to minimize the margin of error, a subset of the population was selected. According to the formulaic standards for representative sampling (such as Krejcie and Morgan, 1970), a sample size of n = 207 respondents was determined. This sample size is sufficient to achieve a high confidence level, ensuring that the

data collected accurately reflects the characteristics and attitudes of the broader $N = 335$ population.

3.1.3 Sampling Technique

To ensure a balanced representation across the different technical disciplines, this study employs a stratified random sampling technique. The population is first divided into distinct strata based on the students' specific academic programs, namely the Diploma in Information Technology (DIT) and the Diploma in Civil Engineering (DKA). By randomly selecting respondents from each stratum proportional to their actual enrollment numbers, this method eliminates the potential selection bias inherent in simple random sampling. Ultimately, this approach ensures that the unique nuances and requirements of both the IT and Engineering departments are equally and accurately captured within the research analysis.

3.2 Research Instrument

Data were collected using a structured questionnaire comprising five main sections:

i. Section A: Demographic information
ii. Section B: System usability measured using the SUS
iii. Section C: Navigation efficiency
iv. Section D: Usage issues and registration errors
v. Section E: User satisfaction and acceptance

The SUS instrument was included to provide a benchmark usability score ranging from 0 to 100, while additional constructs captured more specific usability concerns relevant to course registration contexts.

3.3 Data Collection Procedure

The questionnaire was distributed online through Google Forms. The survey link was disseminated via Semester 2 Academic Advisors for both DIT and DKA programmes. Responses were collected within the designated registration period to ensure that participants had recent experience using the iDaftar module.

3.4 Data Analysis Techniques

Collected data were analyzed using descriptive statistical methods:

i. Demographic data were summarized using frequency and percentage distributions.
ii. Overall usability was evaluated using the SUS scoring procedure.
iii. Mean scores and standard deviations were computed for navigation efficiency, usage issues, and user satisfaction constructs.

3.5 Validity and Reliability

A pilot study involving 30 respondents was conducted prior to the main survey. The reliability analysis produced a Cronbach's Alpha value of 0.83, indicating high internal consistency and confirming that the questionnaire was suitable for usability evaluation.

3.6 Proposed AI-Enhanced Prototype Development

Responding to identified gaps (moderate SUS scores and high cognitive load), a conceptual "augmentation layer" for the SPMP system was developed. The prototype features include:

i. AI Credit Tracker: Real-time visualization of selected, remaining, and cumulative credits.
ii. AI Course Recommender: Strategic suggestions based on prerequisites and individual academic progress.
iii. AI Chatbot Advisor ("IDA"): Immediate procedural support and policy clarification.
iv. AI GOT Forecasting: Visualized study trajectories to support proactive graduation planning.

It is important to note that this prototype represents a design recommendation and a conceptual blueprint rather than a fully implemented interactive system. The proposed features are intended as a practical enhancement layer that can be integrated into SPMP without requiring complete structural redevelopment.

4.0 RESEARCH FINDINGS

4.1 Demographic Analysis of Respondents

The study sampled 207 Semester 2 students from POLIMAS. The distribution ensures a balanced technical perspective across two major programs.

i. Gender: Male (144), Female (63).
ii. Programme: Diploma in IT (113), Diploma in Civil Engineering (94).

4.2 SUS Analysis

The usability of the iDaftar module was evaluated using the System Usability Scale (SUS), a reliable and industry-standard tool for measuring the perceived ease of use of a system. Based on the data collected from the respondents, the iDaftar module yielded a mean SUS score of 59.01. In the context of academic and industrial benchmarks, a score of 68 is generally accepted as the global average for "average usability." Consequently, a mean score of 59.01 places the iDaftar module in the low-to-moderate category, categorized qualitatively as "Marginal" or "Grade D" on the SUS grading scale. While the score indicates that the system is functionally operational and capable of performing its intended tasks, it highlights significant gaps in the user experience.

4.3 Construct-Level Performance

The granular analysis reveals a discrepancy between functional ease and system reliability as shown in Table 1.

Table 1: Construct Performance

Construct	Mean (*M*)	Mean (*M*)	Std. Deviation (*SD*)	Key Insight
C: Navigation	Ease of use	3.83	0.85	High density; lacks hierarchical layout.
D: Reliability	Issues/Errors	3.19	1.12	High variability; confusion in complex cases.
E: Satisfaction	Acceptance	3.91	0.83	Users accept the system as a “necessity.”

4.4 Visual Evidence of Usability Challenges in the Current Interface

Observational analysis of the current iDaftar interface as shown in Figure 1 confirms that usability gaps are structural rather than purely perceptual. The layout lacks semester-based segmentation, presenting courses in a dense, continuous vertical format that forces manual scanning and increases cognitive load. Furthermore, the absence of real-time credit indicators and contextual warnings directly mirrors the moderate SUS scores and the high variability found in Construct D. Without visual prioritization or dynamic guidance, the interface design itself creates the inefficiencies that hinder student decision-making.

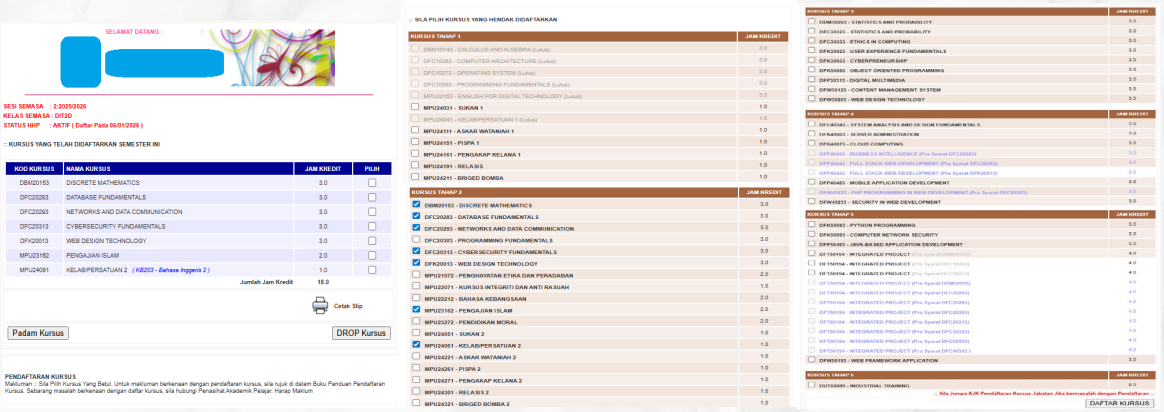


Figure 1: Current iDaftar Interface

5.0 RESEARCH DISCUSSION

5.1 From Transactional to Proactive

The findings confirm that iDaftar currently functions as a transactional tool; it records choices but does not guide them. The moderate SUS score is a direct result of the system's inability to support long-term academic planning. Usability enhancement, therefore, requires more than interface tweaks; it necessitates an intelligent support layer.

5.2 The AI-Enhanced Prototype

To address the identified usability gaps, this study proposes a conceptual framework designed to augment the existing SPMP infrastructure. As illustrated in Figure 2, the prototype integrates four core AI-driven mechanisms to optimize the registration experience:

i. AI Credit Tracker: Facilitates real-time, dynamic visualization of credit distribution to resolve uncertainties in non-standard academic cases.
ii. AI Course Recommender: Proactively suggests modules based on individual student history to minimize "academic leakage" for those managing carry subjects.
iii. Intelligent Digital Assistant (IDA): Serves as a 24/7 advisory interface to provide immediate procedural clarification and standardize user experience across disciplines.
iv. GOT Forecasting: Offers predictive simulations of completion pathways, allowing students to visualize the long-term impact of their current semester choices on their Graduate on Time (GOT) status.

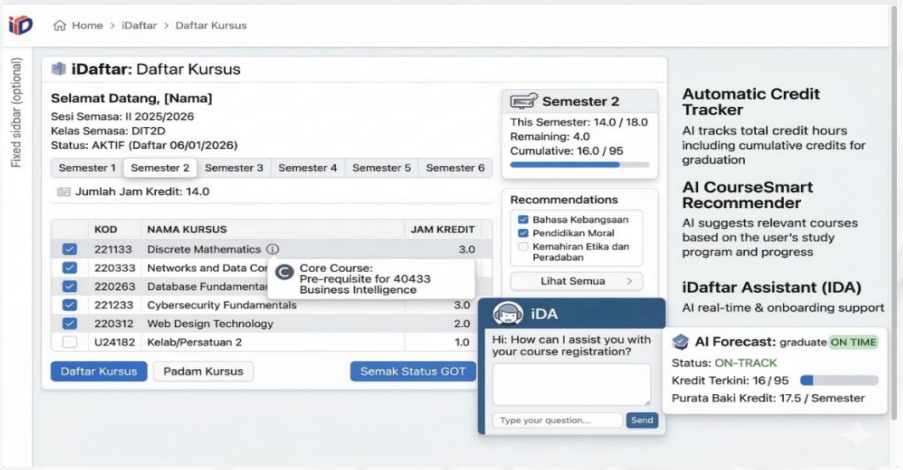


Figure 2: Proposed AI-Enhanced iDaftar Prototype

5.3 Strategic Implications

This “layered enhancement” strategy is particularly vital for public institutions. It demonstrates that intelligent augmentation can occur without the risk or cost of a full-scale system replacement. By embedding AI as an assistive layer, institutions can:

i. Strengthen usability performance.
ii. Reduce the administrative burden of manual credit corrections.
iii. Promote consistent, strategic academic planning behaviors among students.

6.0 CONCLUSION

The evaluation of the iDaftar module reveals a clear “usability gap”: the system is functionally adequate but lacks the intelligent guidance necessary for complex academic planning. A SUS score of 59.01 highlights that procedural stability alone is insufficient for a modern student experience. This research bridges the gap between usability diagnosis and technological innovation. By proposing a conceptual framework involving real-time tracking, AI recommendations, chatbot support, and GOT forecasting, the study provides a scalable pathway for enhancing registration systems. Ultimately, transforming these tools from transactional databases into proactive decision-support platforms is essential for reducing

administrative friction and empowering students to navigate their academic pathways with confidence.

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ARTIFICIAL INTELLIGENCE IN LEARNING: THE ROLE OF AI LITERACY, USAGE STRATEGIES AND META-COGNITION AMONG INFORMATION TECHNOLOGY DIPLOMA STUDENTS

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Abstract

This study aims to identify the level of awareness and the effective use of artificial intelligence (AI) in learning among Semester 4 Diploma in Information Technology students at Politeknik Sultan Abdul Halim Muadzam Shah (POLIMAS). The study employed a cross-sectional survey design involving 126 respondents from a population of 176 students. The research instrument consisted of a questionnaire measuring six main constructs: AI literacy, awareness of AI usage, AI usage strategies, frequency of AI usage, meta-cognition, and learning effectiveness. Data analysis was conducted using descriptive statistics and Pearson correlation. The findings show that the levels of AI literacy, awareness of AI usage, AI usage strategies, meta-cognition, and learning effectiveness are high, while the frequency of AI usage is moderately high. Correlation analysis indicates positive relationships among all the constructs studied. The strongest relationship was observed between meta-cognition and learning effectiveness, followed by AI usage strategies and learning effectiveness. These findings suggest that the effectiveness of learning using AI does not solely depend on how frequently the technology is used, but also on the strategies of its use and the students' ability to reflect on their learning processes. This study provides important implications for Technical and Vocational Education and Training (TVET) institutions in designing learning approaches that integrate AI more effectively.

Keywords: Artificial Intelligence, AI literacy, meta-cognition, self-directed learning, TVET.

Abstrak

Kajian ini bertujuan untuk mengenal pasti tahap kesedaran dan keberkesanan penggunaan kecerdasan buatan (AI) dalam pembelajaran dalam kalangan pelajar Semester 4, Diploma Teknologi Maklumat di Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS). Kajian ini menggunakan reka bentuk tinjauan keratan rentas yang melibatkan 126 responden daripada populasi seramai 176 pelajar. Instrumen kajian terdiri daripada soal selidik yang mengukur enam konstruk utama: literasi AI, kesedaran penggunaan AI, strategi penggunaan AI, kekerapan penggunaan AI, metakognisi, dan keberkesanan pembelajaran. Analisis data dijalankan menggunakan statistik deskriptif dan korelasi Pearson. Dapatan kajian menunjukkan bahawa tahap literasi AI, kesedaran penggunaan AI, strategi penggunaan AI, metakognisi, dan keberkesanan pembelajaran adalah tinggi, manakala kekerapan penggunaan

AI berada pada tahap sederhana tinggi. Analisis korelasi menunjukkan hubungan positif antara kesemua konstruk yang dikaji. Hubungan yang paling kuat diperhatikan antara metakognisi dan keberkesanan pembelajaran, diikuti oleh strategi penggunaan AI dan keberkesanan pembelajaran. Dapatan ini menunjukkan bahawa keberkesanan pembelajaran menggunakan AI tidak hanya bergantung kepada kekerapan teknologi itu digunakan, malah bergantung kepada strategi penggunaannya serta keupayaan pelajar untuk membuat refleksi terhadap proses pembelajaran mereka. Kajian ini memberikan implikasi penting kepada institusi Pendidikan dan Latihan Teknikal dan Vokasional (TVET) dalam merangka pendekatan pembelajaran yang mengintegrasikan AI dengan lebih berkesan.

Kata Kunci: *Kecerdasan Buatan (AI), literasi AI, metakognisi, pembelajaran terarah kendiri, TVET.*

1.0 INTRODUCTION

The rapid development of generative artificial intelligence (AI) technology since 2022 has significantly transformed the educational landscape. Tools such as ChatGPT and other generative AI systems are increasingly used by students as learning support resources to understand concepts, generate ideas, and solve academic problems (Montenegro-Rueda et al., 2023; Chan & Hu, 2023). These technologies enable students to obtain explanations interactively and instantly, making the learning process more flexible and accessible. Recent studies indicate that the effectiveness of AI usage in learning does not depend solely on the technology itself. Instead, it is influenced by several learner-related factors, including students' level of AI literacy, their awareness of responsible AI usage, and the interaction strategies used when communicating with AI systems (Laupichler et al., 2022; Allen & Kendeou, 2024). Students with higher levels of AI literacy tend to better understand the capabilities and limitations of AI technologies, allowing them to utilize these tools more critically and effectively in supporting their learning process.

Within the context of Technical and Vocational Education and Training (TVET), the integration of AI in learning is particularly important because this educational domain emphasizes practical skills, problem-solving abilities, and the application of knowledge in real-world situations. Students enrolled in information technology programs increasingly rely on AI tools to understand programming concepts, debug code, and generate examples of problem-solving solutions (Sun et al., 2024).

1.1 Problem Statement

Despite the surge in educational AI adoption, research remains limited regarding the interplay between AI literacy, usage strategies, and meta-cognition, particularly within Malaysian TVET institutions. While general adoption is documented, there is a significant gap in understanding how students' interaction strategies with AI systems influence the meta-cognitive processes—planning, monitoring, and evaluating—essential for analytical fields like information technology. Without empirical insights into how these interactions support learning regulation,

AI integration risks falling short of its potential to enhance academic outcomes. Therefore, investigating how TVET students utilize AI and the relationship between their literacy levels and meta-cognitive development is essential for optimizing technical education.

1.2 Research Objectives

The objectives of this study are:

a) To identify the levels of AI literacy, awareness of AI usage, AI usage strategies, frequency of AI usage, and meta-cognition among Diploma in Information Technology students at POLIMAS.

b) To evaluate the level of learning effectiveness when AI tools are used as learning support resources among Diploma in Information Technology students at POLIMAS.

c) To analyze the relationships between AI literacy, awareness of AI usage, AI usage strategies, frequency of AI usage, meta-cognition, and learning effectiveness in the context of AI-assisted learning.

1.3 Research Questions

This study is conducted to answer the following questions:

i. What are the levels of AI literacy, awareness of AI usage, AI usage strategies, frequency of AI usage, and meta-cognition among Diploma in Information Technology students at POLIMAS?

ii. What is the level of learning effectiveness when AI tools are used as learning support resources among Diploma in Information Technology students at POLIMAS?

iii. What are the relationships between AI literacy, awareness of AI usage, AI usage strategies, frequency of AI usage, meta-cognition, and learning effectiveness in the context of AI-assisted learning?

2.0 LITERATURE REVIEW

The development of generative AI, such as ChatGPT, holds significant potential in supporting the understanding of complex concepts through more accessible interaction (Adiguzel et al., 2023; Montenegro-Rueda et al., 2023). However, its effectiveness depends on the level of AI literacy, defined as the ability to evaluate information and use technology critically and responsibly (Laupichler et al., 2022, 2023). Beyond literacy, a high awareness of AI's role as a supportive resource (Lee & Park, 2024) and quality interaction strategies—utilizing detailed prompting techniques—are essential to enhance content precision (Lee & Palmer, 2025). Finally, meta-cognition plays a critical role in enabling students to monitor and evaluate the effectiveness of their own learning strategies (Allen & Kendeou, 2024). Although AI positively impacts academic achievement, this impact is highly dependent on usage strategies paired with high levels of awareness and reflection (Doo & Park, 2026).

2.1 Conceptual Framework

The conceptual framework identifies AI literacy, awareness, strategic implementation, and meta-cognition as pivotal factors in educational effectiveness. AI literacy serves as the foundational construct, acting as a precursor to AI awareness and providing the technical

grounding necessary for meaningful technology integration (Laupichler et al., 2022; Lee & Park, 2024). This awareness ensures students utilize AI as a cognitive scaffold rather than a total substitute for intellectual labor, leading to more deliberate strategy adoption. The quality of these usage strategies, characterized by precise prompting and iterative questioning, is a critical determinant of learning efficacy (Lee and Palmer, 2025).

Ultimately, the framework posits that while literacy and awareness drive strategic usage, the impact on learning effectiveness is a collective result of these strategies, usage frequency, and the student's meta-cognitive ability to monitor and adjust their interactions. Synthesizing these theoretical perspectives, the proposed conceptual framework illustrates a multi-layered mechanism for educational success. It posits that while AI literacy and awareness drive the adoption of strategic usage, the ultimate impact on learning effectiveness is a collective result of these strategies, the frequency of AI usage, and the student's meta-cognitive abilities. The integrated model and the hypothesized paths (H1 to H7) are presented in Figure 1.

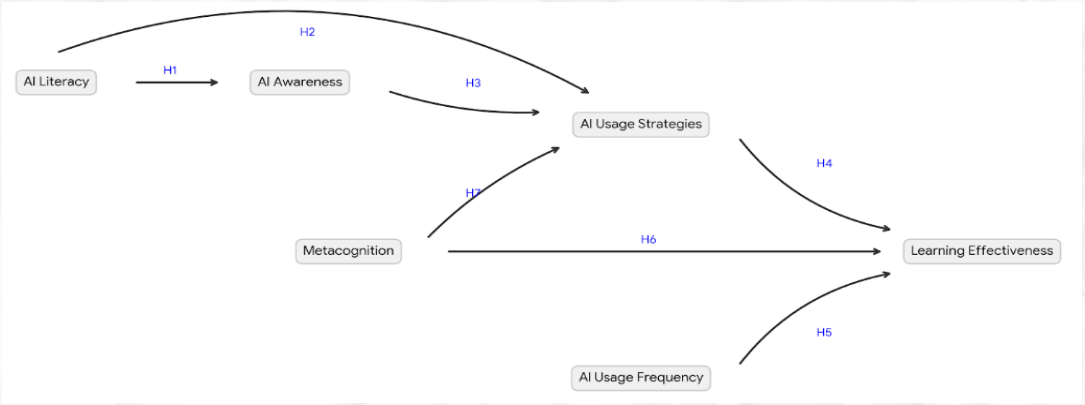


Figure 1: Conceptual Framework

2.2 Research Hypothesis

Guided by the proposed conceptual framework, the following hypotheses have been formulated to examine the interrelationships between the variables:

i. H1: AI Literacy has a significant and positive influence on AI Awareness in a learning context.
ii. H2: AI Literacy significantly and positively influences the adoption of AI Usage Strategies.
iii. H3: AI Awareness significantly and positively influences the implementation of AI Usage Strategies.
iv. H4: AI Usage Strategies have a significant and positive impact on overall Learning Effectiveness.
v. H5: AI Usage Frequency is positively and significantly correlated with Learning Effectiveness.
vi. H6: Students' Meta-cognition serves as a significant positive predictor of Learning Effectiveness.
vii. H7: Meta-cognition significantly and positively influences the selection and execution of AI Usage Strategies.

3.0 RESEARCH METHODOLOGY

3.1 Research Design

This study employs a cross-sectional survey design to identify the level of awareness and the application of Artificial Intelligence (AI) in learning among Diploma in Information Technology (DTI) students at Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS). This design was selected for its efficiency in capturing a snapshot of student perceptions and behaviors at a specific point in time. The study population consists of 176 Semester 4 students within the DTI program, from which a sample of 126 respondents was successfully recruited to participate in the research

3.2 Research Instruments

Data were gathered using an online questionnaire structured into specific sections to measure the core constructs of the study: AI Literacy, AI Awareness, AI Usage Strategies, AI Usage Frequency, Meta-cognition, and Learning Effectiveness. Respondents evaluated items using a five-point Likert scale, ranging from "Strongly Disagree" to "Strongly Agree," to assess their level of agreement with each statement. To ensure the reliability of the instrument, internal consistency was tested; the analysis yielded a Cronbach's alpha value of 0.96, indicating a high level of reliability and suitability for academic inquiry.

3.3 Data Analysis

The collected data were processed using both descriptive and inferential statistics. Descriptive analysis was performed to calculate the mean and standard deviation for each construct. To facilitate the interpretation of the mean scores, the results were categorized into three levels: Low, Medium, and High, based on the interval formula:

$$\text{Interval} = \frac{\text{Highest Score} - \text{Lowest Score}}{\text{Number of Levels}} = \frac{5-1}{3} = 1.33$$

The classification of these levels is summarized in Table 1 below:

Table 1: Mean Score Interpretation

Mean Score Range	Interpretation Level
1.00 – 2.33	Low
2.34 – 3.66	Medium
3.67 – 5.00	High

4.0 RESEARCH FINDINGS

4.1 Descriptive Analysis of Construct

The descriptive analysis, comprising the mean and standard deviation for each construct, is summarized in Table 2. Overall, the results indicate that students at POLIMAS maintain medium to high level of engagement and proficiency with AI tools.

Table 2: Mean score interpretation

Construct	Mean (*M*)	Std. Deviation (*SD*)
AI Literacy	3.87	0.72
AI Awareness	3.90	0.80
AI Usage Strategies	3.69	0.74
AI Usage Frequency	3.66	0.76
Meta-cognition / Reflection	3.81	0.73
Learning Effectiveness	3.75	0.75

4.2 Correlation Analysis

To examine the relationships between the studied variables, a Pearson correlation analysis was conducted. As shown in Table 3, all constructs exhibit a significant and positive correlation with one another at the $p < .01$ level.

Table 3: Pearson Correlation Matrix

Construct	1	2	3	4	5	6
1. AI Literacy	-					
2. AI Awareness	.55**	-				
3. AI Usage Strategies*	.45**	.52**	-			
4. AI Usage Frequency	.28**	.33**	.39**	-		
5. Meta-cognition	.50**	.55**	.70**	.38**	-	
6. Learning Effectiveness	.45**	.50**	.69**	.35**	.80**	-

5.0 RESEARCH DISCUSSION

The primary objective of this study was to evaluate the awareness and strategic application of AI among Diploma in Information Technology students at POLIMAS. Findings indicate that students possess high levels of literacy, awareness, and meta-cognition, alongside a high-medium frequency of usage. This demonstrates that generative AI has successfully integrated into the IT students' pedagogical ecosystem as a functional academic tool. These results reflect a shift from casual AI use toward a more structured and meaningful academic support system.

5.1 The Foundation of AI Literacy and Awareness

A high level of AI literacy (M = 3.87) signifies a robust foundational understanding and a critical perspective toward AI outputs, aligning with essential modern competencies. High AI awareness (M = 3.90) further confirms the technology's role as a cognitive scaffold for idea generation and academic concept clarification. However, students remain vigilant regarding the risks of inaccuracies or “hallucinations” through significant information verification scores. Overall, the digital education background of DIT students facilitates a strategic rather than passive approach to using AI.

5.2 Strategic Interaction and Learning Effectiveness

The positive correlation between AI usage strategies and learning effectiveness (r = .69) proves that the method of interaction determines the pedagogical value derived. Students employing sophisticated strategies, such as clear context provision and iterative prompting, were found to achieve deeper conceptual understanding. These findings support the importance of "prompt engineering" as a decisive factor in ensuring AI effectively enhances the learning process. Ultimately, the quality of interaction between the student and the technology is the primary key to academic performance improvement.

5.3 The Primacy of Meta-cognition over Frequency

Meta-cognition exhibited the strongest relationship with learning effectiveness (r = .80), significantly surpassing the much weaker factor of usage frequency (r = .35). This emphasizes that a student's ability to evaluate and challenge AI outputs based on prior knowledge is far more vital than the quantity of use. High-meta-cognition students do not blindly accept information; instead, they engage in critical reflection to ensure the validity of the content. These results align with the theory that positive learning outcomes are only achieved when technology is paired with strategic intent.

5.4 Implications for TVET and Self-Directed Learning

The findings highlight AI's potential to foster self-directed learning through immediate feedback and step-by-step explanations. This shift toward autonomy allows students to master complex concepts independently, thereby strengthening problem-solving skills within the TVET context. Integrating AI at institutions like POLIMAS is seen as a way to bolster academic efficiency if implemented systematically. However, this success depends on the parallel development of technical access alongside student literacy, strategic awareness, and meta-cognitive reflection.

6.0 CONCLUSION

The findings of this study confirm that the arrival of generative AI in Technical and Vocational Education is not a threat to be managed, but an opportunity to be mastered. Among the students of Politeknik Sultan Abdul Halim Muadzam Shah, AI has already become a central component of the academic experience, providing high levels of perceived learning effectiveness across the IT curriculum. However, this success is not an automatic result of technological access. It is a product of high literacy, strategic awareness, and a robust reflective mindset. The most profound conclusion of this analysis is the primacy of human cognition over technological capability. The 0.80 correlation between Meta-cognition and Learning Effectiveness proves that the most powerful tool in the classroom is not the AI model, but the student's own ability to reflect, verify, and regulate their learning.

By shifting the focus of vocational education from content mastery to "meta-cognitive partnership" and "strategic interaction," TVET institutions can ensure that their graduates are not just survivors of the AI age, but leaders of it. As Malaysia continues its journey toward a high-income, technology-driven economy, the lessons learned from the IT students at

POLIMAS provide a definitive roadmap. Education must evolve to foster a workforce that is critically literate, strategically savvy, and meta-cognitively engaged. By integrating these values into the core of the technical curriculum, we can ensure that the synergy between human intelligence and artificial intelligence creates a future of unprecedented innovation and vocational excellence.

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PENGGUNAAN MEDIA SOSIAL TERHADAP PRESTASI AKADEMIK PELAJAR DALAM KALANGAN PELAJAR JABATAN PERDAGANGAN, POLITEKNIK MUADZAM SHAH

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Abstrak

Pelbagai aspek kehidupan seharian orang ramai telah berubah dengan perkembangan pesat teknologi komunikasi, terutamanya dalam kalangan pelajar institusi pengajian tinggi. Media sosial telah menjadi sebahagian daripada rutin harian pelajar seiring dengan kemajuan teknologi digital dan peningkatan akses internet. Ia boleh mempengaruhi pelbagai aspek kehidupan mereka, termasuk pencapaian akademik mereka. Oleh itu, kajian ini bertujuan untuk menentukan bagaimana penggunaan media sosial mempengaruhi prestasi akademik pelajar Jabatan Perdagangan Politeknik Muadzam Shah. Untuk mendapatkan gambaran empirikal tentang cara pelajar menggunakan media sosial, kajian ini menggunakan reka bentuk tinjauan kuantitatif. Seramai 190 orang responden telah dipilih sebagai sampel kajian. Data yang diperoleh seterusnya dianalisis menggunakan kaedah analisis deskriptif bagi menghuraikan tahap penggunaan media sosial serta implikasinya terhadap prestasi akademik pelajar. Dapatan kajian menunjukkan bahawa tahap penggunaan media sosial dalam kalangan pelajar berada pada tahap yang tinggi. Hasil analisis turut mendapati bahawa tujuan utama penggunaan media sosial adalah bagi memenuhi keperluan hiburan dan komunikasi sosial manakala penggunaannya bagi tujuan akademik didapati berada pada tahap tinggi. Selain itu kajian ini turut menunjukkan bahawa penggunaan media sosial mempunyai implikasi tertentu terhadap prestasi akademik pelajar khususnya dari aspek gangguan terhadap tahap tumpuan pembelajaran serta kelemahan dalam pengurusan masa yang kurang efisien. Secara keseluruhannya kajian ini merumuskan bahawa penggunaan media sosial dalam kalangan pelajar memerlukan pengurusan yang lebih berhemah dan strategik bagi memastikan keseimbangan antara keperluan interaksi sosial dan komitmen akademik dapat dikekalkan. Penggunaan media sosial yang terkawal dan berfokus berpotensi menyokong proses pembelajaran manakala penggunaan yang tidak terkawal berisiko menjejaskan prestasi akademik pelajar.

Kata kunci: media sosial, penggunaan, prestasi akademik.

Abstract

Various aspects of people's daily live have changed with the rapid development of communication technology, particularly among students in higher education institutions. Social media has become part of students' daily routines in line with digital advancements and

increased internet access. It can influence many aspects of their lives, including their academic performance. Therefore, this study aims to determine how social media usage affects the academic performance of students in the Deaprtment of Commerce at Politeknik Muadzam Shah. To obtain an empirical overview of how students use social media, this study employed a quantitative survey design. A total of 190 respondents were selected as the study sample. The data collected were analyzed using descriptive analysis to explain the level of social media usage and its implications on students' academic performance. The findings indicate that the level of social media usage among students is high. The analysis also reveals that the main purposes of social media use are for entertainment and social communication, while its use for academic purposes is also at a high level. In addition, the study shows that social media usage has certain implications for students' academic performance, particularly in terms of distractions that affect learning focus and inefficiencies in time management. Overall, the study concludes that social media usage among students requires more prudent and strategic management to ensure a balance between social interaction needs and academic commitments. Controlled and focuses use of social media has the potential to support the learning process, whereas uncontrolled use may negatively affect students' academic performance.

***Keywords**: social media, usage, academic performance.*

1.0 PENDAHULUAN

Dalam era digital masa kini percambahan pesat platform media sosial telah membawa perubahan ketara dalam cara individu berkomunikasi, mengakses maklumat serta berinteraksi dengan persekitaran. Dalam pendidikan, media sosial kini berperanan sebagai alat pembelajaran yang menyokong perkongsian maklumat, perbincangan serta akses kepada sumber akademik. Menurut Nur Azreen (2023) integrasi teknologi dalam pendidikan membuka peluang untuk meningkatkan keberkesanan pembelajaran dan penyebaran ilmu. Penggunaan platform seperti Facebook, Instagram, TikTok dan WhatsApp yang meluas dalam kalangan pelajar mencerminkan perubahan ke arah pembelajaran berasaskan teknologi. Sehubungan itu, kajian ini dijalankan bagi menilai kesan penggunaan media sosial terhadap prestasi akademik pelajar Jabatan Perdagangan Politeknik Muadzam Shah.

1.1 Pernyataan Masalah

Transformasi ICT telah menjadikan media sosial sebagai medium utama dalam pembelajaran yang fleksibel dan interaktif. Walaupun ia membantu pelajar memahami bahan dan berkongsi maklumat akademik, penggunaan yang tidak terkawal boleh menjejaskan tumpuan pengurusan masa dan penyelesaian tugasan. Situasi ini berpotensi memberi kesan negatif terhadap prestasi akademik. Oleh itu, kajian ini bertujuan mengenal pasti sejauh mana penggunaan media sosial mempengaruhi pencapaian akademik pelajar serta memahami peranannya dalam konteks pembelajaran.

1.2 Objektif Kajian

Kajian ini adalah untuk:

1. Mengenal pasti tahap penggunaan media sosial dalam kalangan pelajar Jabatan Perdagangan.
2. Menentukan tujuan utama pelajar menggunakan media sosial.
3. Menilai kesan penggunaan media sosial terhadap prestasi akademik pelajar.

1.3 Signifikan Kajian

Kajian ini membantu pelajar menggunakan media sosial secara berhemah, menjadi panduan kepada pensyarah dalam merangka strategi pengajaran dan intervensi serta menyumbang kepada literatur berkaitan hubungan antara penggunaan media sosial dan prestasi akademik dalam konteks politeknik.

2.0 SOROTAN LITERATUR

Sorotan literatur ini membincangkan konsep, teori dan dapatan kajian terdahulu berkaitan penggunaan media sosial dalam kalangan pelajar serta kesannya terhadap prestasi akademik. Perbincangan merangkumi definisi media sosial, tahap dan corak penggunaan, tujuan penggunaan serta kesan positif dan negatif terhadap pembelajaran.

2.1 Definisi dan Konsep Media Sosial

Media sosial merujuk kepada platform digital yang membolehkan interaksi, perkongsian maklumat dan pembinaan rangkaian sosial secara dalam talian (Kaplan & Haenlein, 2010). Ia juga membolehkan pengguna membina profil, berinteraksi dan menyebarkan kandungan kepada khalayak luas (Boyd & Ellison, 2007). Dalam pendidikan, media sosial berfungsi sebagai medium pembelajaran alternatif yang menyokong komunikasi dua hala serta pembelajaran kolaboratif (Tess, 2013). Platform seperti Facebook, WhatsApp dan YouTube membolehkan pelajar berkongsi bahan pembelajaran, bertukar idea serta mengakses maklumat dengan lebih pantas (Moran, Seaman & Tinti-Kane, 2011).

2.2 Tahap dan Corak Penggunaan Media Sosial dalam Kalangan Pelajar

Kajian menunjukkan tahap penggunaan media sosial dalam kalangan pelajar adalah tinggi dengan penggunaan harian melebihi 3 jam (Junco, 2012; Pempek et al., 2009). Penggunaan yang berlebihan sering dikaitkan dengan gangguan fokus serta pengurusan masa yang lemah, manakala penggunaan terkawal menyokong pembelajaran. Media sosial juga berpotensi meningkatkan penglibatan dan interaksi akademik (Junco, Heiberger & Loken, 2011), menggalakkan kolaborasi dan perkongsian maklumat (Al-Rahmi & Othman, 2013; Nur Azreen, 2023), serta meningkatkan motivasi melalui pendekatan pembelajaran interaktif (Muhammad Suhaimi, Roslee et al., (2022). Selain itu, penggunaan video seperti di YouTube membantu meningkatkan kefahaman pelajar terhadap sesuatu konsep (Kay, 2012).

2.3 Tujuan Penggunaan Media Sosial

Penggunaan media sosial dalam kalangan pelajar meliputi tujuan hiburan dan sosial seperti mengikut trend dan berinteraksi (Ellison et al., 2007), komunikasi antara pelajar dan pensyarah (Moqbel et al., 2013), serta pembelajaran melalui perkongsian nota, perbincangan dan pencarian sumber akademik (Tess, 2013). Walau bagaimanapun, penggunaan yang lebih tertumpu kepada hiburan boleh mengurangkan masa pembelajaran.

2.4 Kesan Media Sosial terhadap Prestasi Akademik

Media sosial memberi kesan positif dan negatif terhadap prestasi akademik. Dari sudut positif, ia menyokong pembelajaran kolaboratif, komunikasi akademik dan akses maklumat yang luas (Greenhow & Robelia, 2009; Selwyn, 2012), meningkatkan motivasi dan penglibatan pelajar (Junco et al., 2011) serta memudahkan interaksi antara pelajar dan pensyarah (Tess, 2013). Namun, penggunaan berlebihan menjejaskan tumpuan pengurusan masa dan menyebabkan ketagihan digital yang memberi kesan negatif terhadap pencapaian akademik (Kirschner & Karpinski, 2010; Rosen et al., 2013; Jacobsen & Forste, 2012).

2.5 Hubungan Media Sosial dan Prestasi Akademik

Kajian lepas menunjukkan bahawa terdapat hubungan yang signifikan antara penggunaan media sosial dan prestasi akademik pelajar. Menurut Pasek, More dan Hargittai (2009) penggunaan media sosial tidak semestinya memberi kesan negatif jika digunakan secara seimbang dan untuk tujuan akademik. Sebaliknya kajian oleh Kirschner dan Karpinski (2010) mendapati bahawa penggunaan media sosial yang berlebihan tanpa tujuan akademik boleh menjejaskan pencapaian pelajar. Ini menunjukkan bahawa faktor utama yang mempengaruhi prestasi akademik adalah cara penggunaan media sosial itu sendiri.

3.0 METODOLOGI KAJIAN

Metodologi kajian merujuk kepada kaedah yang digunakan untuk mengumpul dan menganalisis data bagi mencapai objektif kajian. Kajian kuantitatif digunakan untuk menilai penggunaan media sosial terhadap prestasi akademik pelajar.

3.1 Reka Bentuk Kajian

Kajian ini menggunakan pendekatan kuantitatif berbentuk tinjauan kerana ia sesuai untuk pengumpulan data secara sistematik daripada sejumlah responden dan membolehkan analisis dibuat secara objektif terhadap penggunaan media sosial. Ia dijalankan dalam kalangan pelajar Jabatan Perdagangan di Politeknik Muadzam Shah dengan menggunakan borang soal selidik sebagai instrumen utama yang berfungsi sebagai penghubung antara pengkaji dan responden (J. Hashim, 2008). Item soal selidik dibina berdasarkan instrumen kajian terdahulu oleh Nur Azreen Zaidel (2023) dan Moriza & Afandi Fikri (2025), namun telah diubahsuai oleh penyelidik mengikut kesesuaian objektif kajian. Menurut Najib (2003), pemilihan item yang tepat akan meningkatkan kebolehpercayaan instrumen dan data dikumpul dalam tempoh masa tertentu bagi memberikan gambaran semasa penggunaan media sosial serta kesannya terhadap prestasi akademik pelajar.

3.2 Populasi dan Sampel

Populasi kajian terdiri daripada pelajar Jabatan Perdagangan Politeknik Muadzam Shah bagi tahun 2025 seramai 360 orang. Berdasarkan jadual Krejcie dan Morgan, saiz sampel yang sesuai adalah sekitar 190 orang. Oleh itu, kajian ini menggunakan kaedah pensampelan mudah (*convenience sampling*) dengan melibatkan 190 responden yang menjawab soal selidik secara dalam talian iaitu *google forms*.

3.3 Instrumen Kajian

Instrumen utama yang digunakan dalam kajian ini ialah borang soal selidik yang dibahagikan kepada beberapa bahagian untuk memudahkan pengumpulan dan analisis data.

- Bahagian A merangkumi maklumat demografi responden rujukan dari Selwyn (2012); Kirschner & Karpinski (2010).
- Bahagian B menumpukan kepada tahap penggunaan media sosial dirujuk dari Junco et al. (2011); Tess (2013).
- Bahagian C pula menilai tujuan penggunaan media sosial oleh pelajar dari Al-Rahmi & Othman (2013); Nur Azreen (2023).
- Bahagian D & E meneliti kesan positif dan negatif daripada penggunaan media sosial. Masing-masing rujukan dari Muhammad Suhaimi et al. (2022); Kay (2012) Kirschner & Karpinski (2010); Rosen et al. (2013); dan Andreassen (2015).
- Bahagian F memberi tumpuan kepada prestasi akademik responden Junco et al. (2011); Pasek et al. (2009); Kirschner & Karpinski (2010).

Soalan yang digunakan adalah dalam bentuk skala Likert (contohnya: sangat setuju hingga sangat tidak setuju) bagi memudahkan analisis data. Penggunaan skala jenis ini adalah mengikut skala di Jadual 1 seperti berikut:

Jadual 1: skala pemeringkatan Likert Item

Skala Pemeringkatan Likert Item	Skala
Sangat Setuju	5
Setuju	4
Kurang Setuju	3
Tidak Setuju	2
Sangat Tidak Setuju	1

Pengkaji menggunakan kaedah kuantitatif untuk menganalisis data soal selidik, yang disusun mengikut urutan soalan. Metodologi kuantitatif ini memerlukan pengumpulan dan penjumlahan data melalui penggunaan teknik analisis statistik. Selain itu, skor minimum juga digunakan untuk menilai penggunaan media sosial oleh pelajar Jabatan Perdagangan terhadap prestasi akademik mereka. Kemudian, statistik deskriptif digunakan untuk menganalisis data yang diperoleh. Jadual 2 menunjukkan empat tahap nilai skor minimum menurut Azhar Ahmad, 2006.

Jadual 2: Interpretasi Skor Purata (Skala Likert)

Skor Purata	Interpretasi
1.00 - 2.00	Rendah
2.01 - 3.00	Sederhana Rendah
3.01 - 4.00	Sederhana Tinggi
4.01 - 5.00	Tinggi

3.4 Pengumpulan dan Analisis data

Soal selidik diedarkan kepada responden dalam tempoh dua minggu melalui Google Form. Setiap peserta diberikan penerangan tentang tujuan kajian dan jaminan bahawa jawapan mereka tidak akan didedahkan kepada orang lain untuk menjamin kesahihan dan kerahsiaan data yang dikumpul. Data soal selidik dikaji menggunakan teknik statistik deskriptif. Teknik ini menentukan corak dan tahap penggunaan media sosial pelajar dengan menggunakan kekerapan, peratusan dan nilai min. Keputusan analisis dipaparkan dalam bentuk jadual dan carta untuk membolehkan perbandingan dan penafsiran data yang lebih jelas dan sistematik.

4.0 DAPATAN KAJIAN

Hasil kajian menunjukkan majoriti pelajar menggunakan media sosial secara kerap setiap hari dan mempuyai masa penggunaan yang agak lama. Platform yang paling kerap digunakan ialah WhatsApp, TikTok dan Instagram. Selain itu, kajian mendapati bahawa media sosial digunakan bukan sahaja untuk hiburan tetapi juga untuk aktiviti pembelajaran seperti berkongsi nota, menonton video pendidikan dan berbincang tentang tugasan dalam talian. Walau bagaimanapun, beberapa pelajar mengakui bahawa penggunaan media sosial yang berlebihan memberi kesan negatif terhadap fokus mereka semasa pembelajaran dan pengurusan masa, menunjukkan bahawa walaupun media sosial membantu akademik, ia harus digunakan dengan berhati-hati dan bijak.

Jadual 3: Nilai Cronbach's Alpha setiap bahagian instrumen

Bahagian	Konstruk	Cronbach's Alpha	Tahap
B	Tahap penggunaan media sosial	0.75	Boleh diterima
C	Tujuan penggunaan media sosial	0.96	Sangat tinggi
D	Kesan positif media sosial	0.94	Sangat tinggi
E	Kesan negatif media sosial	0.84	Baik
F	Prestasi akademik	0.81	Baik

Jadual 3 menunjukkan analisis kebolehpercayaan instrumen kajian menunjukkan bahawa semua bahagian soal selidik mempunyai nilai Cronbach's Alpha yang berada pada tahap boleh diterima hingga sangat tinggi. Bahagian B mencatatkan nilai 0.75 yang menunjukkan tahap kebolehpercayaan yang boleh diterima. Seterusnya, Bahagian C dan Bahagian D masing-masing memperoleh nilai 0.96 dan 0.94 yang menunjukkan tahap kebolehpercayaan yang sangat tinggi, sekaligus menggambarkan bahawa item-item dalam kedua-dua konstruk tersebut

mempunyai konsistensi dalaman yang sangat baik. Bagi Bahagian E dan Bahagian F, nilai Cronbach's Alpha yang diperoleh masing-masing ialah 0.84 dan 0.81, yang berada pada tahap baik. Dapatan ini menunjukkan bahawa keseluruhan instrumen kajian mempunyai tahap kebolehpercayaan yang kukuh dan sesuai digunakan untuk analisis lanjut.

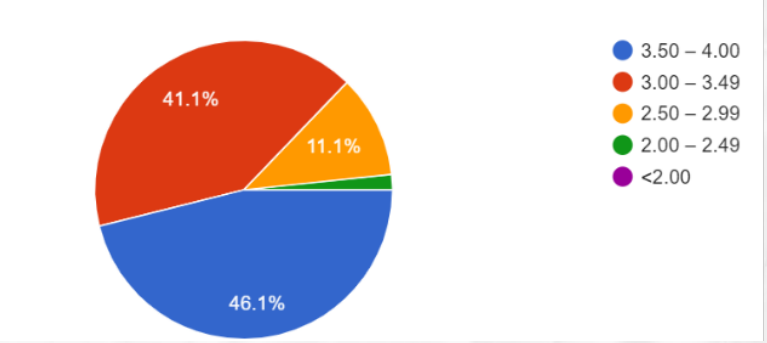
4.1 Analisis Demografi Responden

Berdasarkan Jadual 4, majoriti responden adalah perempuan iaitu seramai 143 orang (75.3%), berbanding lelaki 47 orang (24.7%). Dari segi umur, kebanyakan responden berumur 20–21 tahun seramai 121 orang (63.7%), diikuti oleh umur 18–19 tahun seramai 59 orang (31%) dan 22 tahun ke atas seramai 10 orang (5.3%). Bagi semester pengajian pula, responden tertinggi ialah pelajar semester 3–4 seramai 72 orang (38.1%), diikuti oleh semester 1–2 seramai 63 orang (33.3%) dan semester 5–6 seramai 54 orang (28.6%). Secara keseluruhannya, dapatan menunjukkan majoriti responden terdiri daripada pelajar perempuan, berumur 20–21 tahun dan berada pada semester pertengahan.

Jadual 4: Demografi responden bagi jantina, umur dan semester pengajian

Item	Kategori	N	Peratus (%)
Jantina	Lelaki	47	24.7
	Perempuan	143	75.3
Umur	Umur 18–19	59	31
	Umur 20–21	121	63.7
	Umur 22+	10	5.3
Semester Pengajian	1 - 2	63	33.3
	3 - 4	72	38.1
	5 - 6	54	28.6

Rajah 1 menunjukkan nilai CGPA terkini yang diperolehi oleh responden. Didapati CGPA di antara 3.50 - 4.00 berada pada bilangan yang paling ramai iaitu 79 orang (46.2%). Nilai CGPA yang bilangan yang paling rendah ialah di antara 2.00 - 2.49 hanya 3 orang sahaja (1.8%). Diikuti oleh 3.00 - 3.49 seramai 70 orang (40.9%) dan 2.50 - 2.99 seramai 19 orang (11.1%).



Rajah 1: Purata Gred Keseluruhan CGPA terkini

4.2 Analisis Tahap Penggunaan Media Sosial

Item soalan dalam penggunaan media sosial dianalisis melalui skala Likert yang menjurus kepada tahap penggunaan Media sosial.

Jadual 5: Tahap Penggunaan Media sosial

No	Pernyataan	Min	Kategori
5	Saya menggunakan media sosial setiap hari.	4.68	Tinggi
6	Saya menggunakan media sosial lebih daripada 3 jam sehari.	4.17	Tinggi
7	Saya menggunakan media sosial untuk berkomunikasi dengan rakan-rakan.	4.59	Tinggi
8	Saya menggunakan media sosial untuk berhubung dengan pensyarah.	4.15	Tinggi
	Min keseluruhan	**4.40**	

Jadual 5 menunjukkan tahap penggunaan media sosial dalam kalangan pelajar adalah tinggi memandangkan skor min keseluruhan di bahagian ini adalah 4.40 berada dalam kategori skor yang tinggi. Item yang menunjukkan skor min paling tinggi adalah ‘saya menggunakan media sosial setiap hari’ sebanyak 4.68 dan item skor min yang paling rendah adalah ‘saya menggunakan media sosial untuk berhubung dengan pensyarah’ iaitu sebanyak 4.15.

4.3 Analisis Tujuan Penggunaan Media Sosial

Analisis di bahagian ini adalah berkenaan tujuan utama penggunaan media sosial dihuraikan dalam jadual 6. Jadual 6 menunjukkan tujuan penggunaan media sosial dalam kalangan pelajar adalah juga tinggi memandangkan skor min keseluruhan di bahagian ini adalah 4.42 berada dalam kategori skor yang tinggi. Item yang menunjukkan skor min paling tinggi adalah ‘saya menggunakan media sosial untuk mencari bahan rujukan akademik dan berbincang tugasan dengan rakan’ iaitu kedua-duanya mempunyai 4.40 skor min tinggi. Manakala item skor min yang paling rendah adalah ‘saya menggunakan media sosial untuk tujuan pembelajaran’ iaitu sebanyak 4.38.

Jadual 6: Tujuan Penggunaan Media Sosial

No	Pernyataan	Min	Kategori
9	Saya menggunakan media sosial untuk tujuan pembelajaran.	4.38	Tinggi
10	Saya menggunakan media social untuk mencari bahan rujukan akademik.	4.44	Tinggi
11	Saya menggunakan media sosial untuk berbincang tugasan dengan rakan.	4.44	Tinggi
12	Saya menggunakan media sosial untuk hiburan dan aktiviti santai.	4.43	Tinggi
	Min keseluruhan	**4.42**	

4.4 Analisis Kesan terhadap Prestasi Akademik

Dalam bahagian ini analisis adalah berkenaan dengan analisis kepada kesan positif dan negatif penggunaan media sosial terhadap prestasi akademik pelajar. Jadual 7 menunujukkan kesan positif dan Jadual 8 menunjukkan kesan negatif terhadap akademik pelajar.

Jadual 7: Kesan Positif penggunaan media sosial terhadap prestasi akademik pelajar

No	Pernyataan Kesan Positif	Min	Kategori
13	Media sosial membantu saya memahami topik pembelajaran.	4.43	Tinggi
14	Media sosial memudahkan saya menyiapkan tugasan.	4.48	Tinggi
15	Media sosial meningkatkan motivasi saya untuk belajar.	4.34	Tinggi
16	Media sosial memudahkan komunikasi dengan rakan dan pens yarah.	4.48	Tinggi
	Min keseluruhan	**4.43**	

Seperti yang ditunjukkan dalam Jadual 7, dengan skor min keseluruhan 4.43, penggunaan media sosial mempunyai kesan yang besar terhadap prestasi akademik pelajar. Item "Media sosial memudahkan saya menyiapkan tugasan dan memudahkan komunikasi dengan rakan dan pensyarah" menerima skor min paling tinggi, masing-masing 4.48. Namun, item dengan skor min paling rendah ialah "Media sosial meningkatkan motivasi saya untuk belajar," dengan skor 4.34.

Jadual 8: Kesan Negatif penggunaan media sosial terhadap prestasi akademik pelajar

No	Pernyataan Kesan Negatif	Min	Kategori
17	Media sosial mengganggu fokus saya semasa belajar.	3.10	Sederhana Tinggi
18	Penggunaan media sosial mempengaruhi pengurusan masa saya.	3.33	Sederhana Tinggi
19	Saya kadang-kadang menunda tugasan akibat menggunakan media sosial.	2.95	Sederhana Rendah
20	Saya menghabiskan terlalu banyak masa untuk hiburan di media sosial.	3.18	Sederhana Tinggi
	Min keseluruhan	**3.14**	

Kesan negatif penggunaan media sosial terhadap prestasi akademik pelajar ditunjukkan dalam Jadual 8. Secara keseluruhan, bahagian ini mempunyai skor min 3.14 dan tergolong dalam kategori skor sederhana tinggi. "Penggunaan media sosial mempengaruhi pengurusan masa saya" mendapat skor min paling tinggi, dengan skor 3.33. Namun, item dengan skor min paling rendah, "Saya kadang-kadang menunda tugasan akibat menggunakan media sosial," mendapat skor 2.95.

4.5 Analisis Prestasi Akademik

Analisis di bahagian ini adalah berkenaan dengan prestasi akademik pelajar tentang penggunaan media sosial merujuk jadual di bawah.

Jadual 9: Prestasi akademik pelajar

No	Pernyataan	Min	Kategori
21	Penggunaan media sosial membantu saya meningkatkan pencapaian akademik.	3.94	Sederhana Tinggi
22	Saya dapat mengimbangi masa belajar dan media sosial dengan berkesan.	3.83	Sederhana Tinggi
23	Saya percaya media sosial membantu meningkatkan pemahaman semasa peperiksaan.	3.80	Sederhana Tinggi
24	Prestasi akademik saya terjejas jika penggunaan media sosial tidak dikawal.	3.84	Sederhana Tinggi
	Min keseluruhan	**3.85**	

Jadual 9 menunjukkan prestasi akademik pelajar terhadap penggunaan media sosial. Skor min keseluruhan di bahagian ini adalah 3.85 berada dalam kategori skor yang sederhana tinggi. Item yang menunjukkan skor min paling tinggi adalah 'Penggunaan Media sosial membantu saya menningkatkan pencapaian akademik' sebanyak 3.94. Manakala item skor min yang paling rendah adalah 'Saya percaya media sosial membantu meningkatkan pemahaman semasa peperiksaan' iaitu sebanyak 3.80.

5.0 PERBINCANGAN KAJIAN

Berdasarkan hasil dapatan ia jelas menunjukkan bahawa media sosial memainkan peranan penting dalam kehidupan akademik pelajar Jabatan Perdagangan, Politeknik Muadzam Shah sebagai medium komunikasi, perkongsian maklumat dan sokongan pembelajaran, selari dengan Moriza & Afandi (2025). Penggunaannya yang bersifat multifungsi turut meliputi pencarian bahan rujukan akademik, penyelsaian tugasan dan hiburan seperti yang dinyatakan oleh Nur Azreen (2023), namun kebergantungan ini memerlukan penilaian kritikal terhadap kesahihan maklumat. Walaupun dapatan menujukkan kesan positif lebih dominan dan tidak mengganggu fokus pembelajaran bagi majoriti responden, Brown & Perry (2023) menegaskan bahawa pengurusan masa yang lemah boleh meningkatkan risiko gangguan akademik.

Justeru, impak media sosial didapatu sangat bergantung kepada tahap kawalan kendiri pelajar, di mana penggunaan yang berstruktur mampu meningkatkan komunikasi, kolaborasi dan akses maklumat, manakala penggunaan berlebihan boleh menjejaskan prestasi akademik seperti yang dibuktkan oleh Smith et al. (2021) dan Kirschner & Karpinski (2021) yang mengaitkan penggunaan tidak terkawal dengan penurunan gred serta masalah disiplin.

6.0 KESIMPULAN

Dalam era digital masa kini, penggunaan media sosial semakin meluas dalam kalangan pelajar dan tidak semestinya memberi kesan negatif terhadap prestasi akademik pelajar. Dapatan kajian menunjukkan bahawa penggunaan secara berhemah dan terkawal memberi manfaat seperti memudahkan komunikasi, perkongsian maklumat serta meningkatkan motivasi dan penglibatan dalam pembelajaran melalui platform seperti Facebook dan WhatsApp. Oleh itu, pelajar perlu mengamalkan pengurusan masa yang baik dan menggunakan media sosial secara berfokus kepada akademik.

Namun, penggunaan media sosial yang berlebihan dan tidak terkawal boleh mengganggu tumpuan masa belajar serta menurunkan pencapaian pencapaian akademik apabila lebih tertumpu kepada hiburan dan interaksi sosial. Sehubungan itu, Taat et al. (2025) menegaskan bahawa penggunaan media digital dan pembelajaran atas talian memberi kesan positif terhadap sikap akademik pelajar yang seterusnya mempengaruhi pencapaian akademik secara tidak langsung melaui faktor motivasi, disiplin kendiri dan minat terhadap pembelajaran.

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EVALUATING THE SNAPBOT MODULAR JOINT DESIGN: STUDENTS' AND TEACHERS' PERCEPTIONS OF ASSEMBLY EASE IN PRIMARY SCHOOL ROBOTICS EDUCATION

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Abstract

Educational robotics has become an important tool for promoting Science, Technology, Engineering, and Mathematics (STEM) education through hands-on and collaborative learning experiences. However, many existing robotics kits remain difficult for young learners to assemble, often requiring tools, small components, and complex wiring that can discourage participation and reduce learning engagement. This study evaluates the usability of the SnapBot Modular Joint Design, a robotics system specifically developed to simplify robot assembly for primary school students through a snap-together, tool-free modular mechanism. The evaluation was conducted during the "Mobile Robot Recycler" competition involving six primary schools in the Sabak Bernam district, Malaysia. A total of 27 students and 10 teachers participated in the study. Data were collected using a Likert-scale questionnaire measuring perceptions of assembly ease, usability, motivation, and educational value. Descriptive statistical analysis revealed generally positive perceptions among students, with an overall mean score of 4.01 across all items. Students particularly reported high enjoyment (M = 4.70) and increased interest in robotics and technology (M = 4.67). However, some aspects of independent assembly received moderate scores, suggesting that clearer instructions may further improve usability. Teacher responses showed unanimous agreement across all evaluated aspects, with mean scores ranging from 4.50 to 4.90, indicating strong confidence in the kit's classroom applicability and pedagogical value. The findings suggest that the SnapBot Modular Joint Design effectively reduces mechanical complexity while maintaining high levels of engagement and collaborative learning. The study highlights the importance of simplified modular robotics platforms in supporting accessible and motivating robotics education for primary school learners.

Keywords: Educational robotics, modular robotics design, robotics education, snap-fit mechanism, STEM learning

Abstrak

Pendidikan Robotik telah menjadi satu alat penting dalam mempromosikan pendidikan Sains, Teknologi, Kejuruteraan dan Matematik (STEM) melalui pengalaman pembelajaran secara

hands-on dan kolaboratif. Walau bagaimanapun, banyak kit robotik sedia ada masih sukar untuk dipasang oleh pelajar muda kerana memerlukan penggunaan alat, komponen kecil, serta pendawaian yang kompleks, yang boleh mengurangkan minat dan penglibatan dalam pembelajaran. Kajian ini menilai kebolehgunaan Reka Bentuk Sendi Modular SnapBot, iaitu satu sistem robotik yang dibangunkan khusus untuk memudahkan pemasangan robot bagi murid sekolah rendah melalui mekanisme modular bercantum tanpa penggunaan alat. Penilaian ini dijalankan semasa pertandingan "Mobile Robot Recycler" yang melibatkan enam buah sekolah rendah di daerah Sabak Bernam, Malaysia. Seramai 27 orang pelajar dan 10 orang guru telah mengambil bahagian dalam kajian ini. Data dikumpulkan menggunakan soal selidik skala Likert bagi mengukur persepsi terhadap kemudahan pemasangan, kebolehgunaan, motivasi, dan nilai pendidikan. Analisis statistik deskriptif menunjukkan persepsi yang positif dalam kalangan pelajar dengan skor min keseluruhan sebanyak 4.01 bagi semua item. Pelajar khususnya melaporkan tahap keseronokan yang tinggi (M = 4.70) serta peningkatan minat terhadap robotik dan teknologi (M = 4.67). Walau bagaimanapun, beberapa aspek berkaitan pemasangan secara kendiri memperoleh skor sederhana, menunjukkan bahawa arahan yang lebih jelas boleh meningkatkan lagi kebolehgunaan. Maklum balas daripada guru menunjukkan persetujuan sebulat suara bagi semua aspek yang dinilai, dengan skor min antara 4.50 hingga 4.90, mencerminkan keyakinan yang tinggi terhadap kesesuaian kit ini dalam bilik darjah serta nilai pedagoginya. Dapatan kajian menunjukkan bahawa Reka Bentuk Sendi Modular SnapBot berjaya mengurangkan kerumitan mekanikal sambil mengekalkan tahap penglibatan dan pembelajaran kolaboratif yang tinggi. Kajian ini menekankan kepentingan platform robotik modular yang dipermudahkan dalam menyokong pendidikan robotik yang lebih mudah diakses dan menarik bagi pelajar sekolah rendah.

Kata kunci: *Pendidikan Robotik, reka bentuk robotik modular, pendidikan robotik, mekanisme cantuman snap-fit, pembelajaran STEM*

1.0 INTRODUCTION

Many robotics kits are complex to assemble. For young learners, this creates a significant barrier. Construction often becomes frustrating due to screws, tiny connectors, and wiring. This shifts cognitive focus from programming and problem-solving to mechanical troubleshooting. Research by Ross et al. (2026) shows that even pre-service teachers lack confidence in coding and robotics. If adults find robotics intimidating, young children face even greater difficulty. The concept of ease-of-assembly in robotics is not unfamiliar. For instance, Ghaffari et al. (2026) this principle to a robotic motor for patient rehabilitation. Their robot incorporated modular design, quick-connect docking with spring-loaded latches for tool-less assembly, telescopic links, reconfigurable joints, standardized connectors, and uniform modules. These methods successfully simplified assembly in a rehabilitation context.

However, existing studies have not explicitly examined assembly ease as a primary factor in educational robotics, particularly for primary school users. This indicates a clear research gap

in understanding how simplified joint design influences students' ability to assemble robots independently and engage effectively in learning activities.

Thus, robotics platforms for elementary students must prioritize ease of assembly to ensure that learners focus on problem-solving and programming rather than mechanical difficulties. Integrated STEM activities that involve robotics have been shown to support the development of problem-solving skills, collaboration, and technological literacy among primary school learners (Moynihan et al., 2026. Adapting similar design principles could make educational robotics more accessible, enjoyable, and effective for young learners.

1.1 Problem Statement

Existing educational robotics kits are often too complex for young learners. Assembly requires fine motor skills and tool use those elementary students typically lack. This complexity consumes cognitive resources needed for learning and often leads to frustration. As a result, the educational potential of robotics is not fully realized for this age group. Research has highlighted that effective STEM programs should provide meaningful learning experiences that develop problem-solving, analytical reasoning, and collaborative skills among students (Moynihan et al., 2026).

1.2 Research Objectives

This study aims to develop ease-of-assembly principles for educational robotics targeting elementary students. Drawing from modular design, tool-less assembly, and standardized connectors, the objective is to create a platform that minimizes mechanical complexity. The goal is to preserve cognitive resources for programming and problem-solving, ensuring an engaging and accessible learning experience.

2.0 LITERATURE REVIEW

Educational robotics is frequently used as part of integrated STEM (iSTEM) learning, where science, technology, engineering, and mathematics are taught through connected, real-world activities. Such integrated approaches aim to promote deeper understanding across STEM disciplines and encourage interdisciplinary thinking among students (Moynihan et al., 2026). Robotic systems rely on various mechanical connection and locking mechanisms to ensure that structural components remain stable during operation. One important feature in deployable robots is the ability to lock into a rigid shape when carrying loads. Traditional robots often use mechanical locks, brakes, or latches to achieve this. However, alternative approaches inspired by structural design concepts have also been explored to simplify robotic mechanisms

For example, in origami-inspired robots, the structure itself can lock without requiring additional mechanical components. Liu et al. (2025) developed a robotic arm based on a Foldable Cube Origami (FC-ori) structure that has a natural self-locking property. When the robot is fully deployed in its cube shape, it becomes rigid and cannot be folded easily due to geometric constraints between the panels and angles. However, this same property makes it difficult to fold the robot when needed. To address this limitation, Liu et al. (2025) designed a tendon system that pulls on the side panels instead of only the top and bottom surfaces. This

mechanism enables the robot to fold smoothly while still maintaining its self-locking ability when deployed. As a result, the design eliminates the need for additional locking components, making the robot simpler, lighter, and easier to control.

A similar principle of structural joining can also be observed in traditional architecture. In traditional Malay house construction, wooden structures are commonly assembled using a tanggam system. The tanggam system refers to a traditional method of joining wooden components by inserting and matching specially shaped joints so that the pieces fit tightly together without the use of nails or screws (Rahman et al., 2022). In the Malay architectural context, the term tanggam-menanggam describes the process of inserting and interlocking wooden elements to form a stable structural frame. This technique produces joints that are strong, stable, and can be assembled or disassembled when necessary.

Inspired by this concept, modular robotic designs can adopt similar interlocking joint mechanisms to simplify assembly and improve structural stability. In educational robotics kits such as SnapBot, the joint design follows a tanggam-inspired approach in which robot components are connected through insert-and-lock mechanisms rather than complex fastening parts. This approach enables students to assemble robot modules more easily while maintaining sufficient structural strength during operation.

Table 1: Assembly ease comparison of five robot-related design approaches.

Paper	**Key Design for Easy Assembly**	**Assembly Method**	**Skill Level Needed**
Bezha & Ito (2025) – Soft crawling/rolling robot	Interlocking exoskeleton + cage frames encapsulate soft actuators	Manual assembly of silicone parts into plastic frames; pneumatic connections	Medium (requires careful handling of soft materials)
Merva et al. (2025) – Hook component separation	Not focused on robot assembly; uses standard manipulator	No assembly required (off-the-shelf robot arm)	Low for assembly (but high for programming)
Mesot et al. (2025) – Interlocking ball joint continuum robot	**Snap-fit ball joints** + parametric CAD that auto-generates tolerances	Manual press to snap inner/outer segments; optional glue/welding	**Low** (snap-fit is intuitive, tool-less)
Mo et al. (2026) – Shapable robot batteries with interlocking-damping architecture	Interlocking-damping architecture using viscoelastic electrolyte (rigid PETEA + dynamic MPS domains);	Scalable manufacturing: stack electrodes, infiltrate with viscoelastic electrolyte, cure under pressure; no snap-fit or tool-less	High (materials engineering, battery fabrication; not designed for educational assembly)

	biomimetic mussel-inspired design	assembly for end users	
Esquivias et al. (2025) – Cost-effective educational UGV with snap-fit design	Snap-fit hexagonal male connectors into female slots; peg-and-hole mounting boards; sliding mechanism for adjustable components; fully 3D-printed modular frame	Tool-free assembly: insert and slide downward to lock; pegs inserted into holes; sliding components into slots; no glue or fasteners required	Low (high school students; tested with 22 students, rated 4.64/5 for ease of snap-fit assembly)

3.0 RESEARCH METHODOLOGY

This study evaluates the perceived usability and educational impact of the SnapBot Modular Joint Design, a novel robotics component intended to simplify assembly for novice users. The evaluation was conducted within the context of the "Mobile Robot Recycler" competition, providing an authentic, hands-on environment for primary school students to interact with the technology.

3.1 Context and Participants

The research was embedded in a district-level robotics competition involving six primary schools from the Sabak Bernam district (SK Parit 6, SK Panchang Pedena, SK Seri Makmur, SK Doktor Abdul Latif, SK Seri Bahagia, SK Parit 4, and SK Batu 38). A total of 13 teams (comprising 26 students) participated. This setting provided a diverse sample of young users with varying levels of prior robotics experience, making it an ideal environment to test the intuitiveness of the SnapBot design.

3.2 The Innovation: SnapBot Modular Joints

The core focus of this investigation was the SnapBot Modular Joint system. Unlike traditional robotics kits that often require screws, nuts, or complex wiring, the SnapBot joints are designed with a "snap-together" mechanism. This design prioritizes tool-free assembly, allowing students to connect structural and mechanical components quickly and intuitively. The hypothesis was that this modular, snap-fit architecture would lower the barrier to entry, enabling students to focus more on problem-solving and the competition task rather than struggling with mechanical construction.

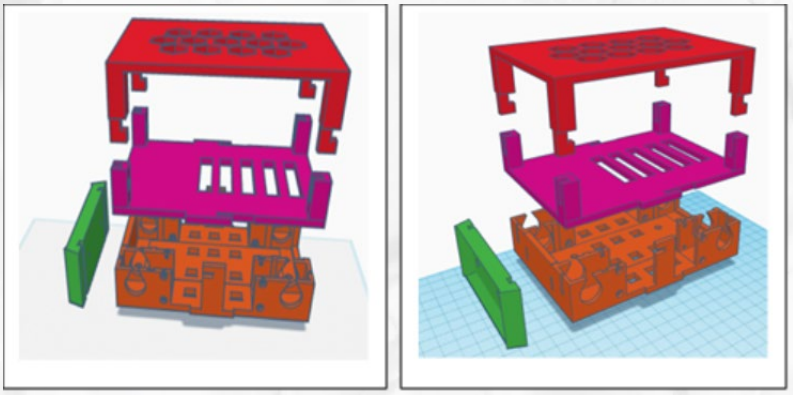


Figure 1: Design of the SnapBot modular joint mechanism used for tool-free robot assembly.

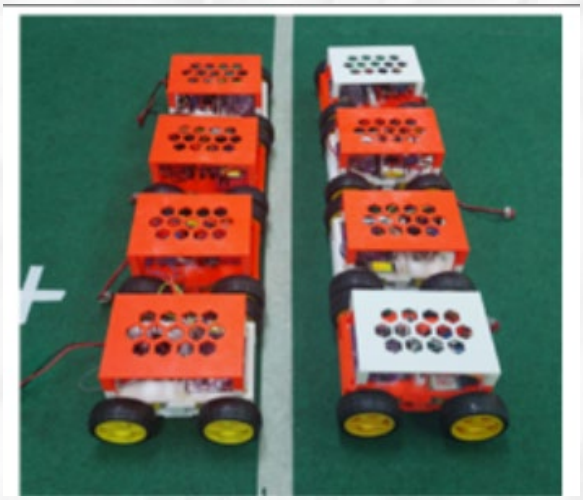


Figure 2: Example of SnapBot modules connected using the snap-fit tanggam-inspired joint system.

3.3 Instrumentation and Data Collection

This study adopts a quantitative research approach to evaluate users' perceptions of the SnapBot Modular Joint Design. Data were collected using a structured Likert-scale questionnaire, enabling the measurement of participants' responses in numerical form. The use of descriptive statistical analysis (mean scores, standard deviation, and percentage of agreement) allows for objective evaluation of assembly ease, usability, and motivational aspects. This approach is appropriate as the study aims to quantify user perceptions and identify general trends across a sample of students and teachers rather than explore in-depth individual experiences. Furthermore, the absence of open-ended responses or qualitative interviews reinforces the suitability of a purely quantitative design for this study.

To assess the effectiveness of the SnapBot design, a quantitative approach was employed, centered on a questionnaire.

1. **Questionnaire Distribution**: A structured questionnaire was distributed to both students and teachers during the competition event. Administering the survey at this specific juncture allowed researchers to capture immediate, first-hand perceptions of the assembly ease while the experience of building and modifying the robots was still fresh in the participants' minds.

2. **Focus of Inquiry**: The questionnaire items were specifically designed to gauge perceptions of the SnapBot Modular Joints. Key areas of investigation included:
    - Ease of Use: How simple was it for students to connect and disconnect the joints without adult assistance?
    - Assembly Time: Did the modular design speed up the building process compared to traditional methods?
    - Intuitiveness: Could students understand the assembly logic without extensive instructions?
    - Durability and Confidence: Did the secure "snap" of the joints give students the confidence to handle and maneuver their robots during the competition tasks?

3.4 Significance of the Collaboration

This collaboration between the university research team and the participating schools, particularly the implementation of the SnapBot kits in a competitive setting, demonstrates a practical application of applied research. By evaluating the modular joint design during a high-engagement event like the "Mobile Robot Recycler" competition, the study gathered authentic feedback on its usability. The positive engagement from teachers and students regarding the assembly process serves as a benchmark for future school-university partnerships, validating how thoughtful modular design can effectively foster 21st-century skills and make robotics education more accessible at the primary school level.

4.0 RESEARCH FINDINGS: DATA ANALYSIS

This section presents the findings from a Likert-scale survey (1 = Strongly Disagree to 5 = Strongly Agree) administered to two respondent groups: 27 primary school students (Tab 1) and 10 teachers (Tab 2). The survey evaluated perceptions of the SnapBot Modular Joint robot kit, with a particular focus on assembly ease and motivation to engage with technology.

4.1 Student's Perceptions (N = 27)

Table 1 and Figure 1 summarise students' responses across 15 Likert-scale items. Overall, students responded positively toward the SnapBot kit, with mean scores ranging from 3.15 (Q7: not needing teacher assistance) to 4.70 (Q5: enjoyment with classmates). The overall mean across all items was 4.01, indicating a generally high level of agreement.

4.1.1 Assemble Ease

Students' perceptions of assembly ease were mixed but largely positive. The majority of students (74.1%) agreed that the instructions were easy to understand (Q12; M = 4.11, SD = 0.85), and 70.4% found the design facilitated easy disassembly and reassembly (Q15; M = 3.74). While 59.3% agreed the kit was not too difficult to assemble (Q9; M = 3.67) and that they understood part connections after a brief explanation (Q3; M = 3.70), the item on independent assembly without teacher help scored the lowest among all items (Q7; M = 3.15, 33.3% agreement), suggesting that some students still relied on guidance during the activity. Notably, Q2 — which assessed whether the assembly process was easy to understand and

complete — returned the lowest mean score among ease-related items (M = 3.30, 29.6% agreement), indicating a need for clearer step-by-step instructions or additional visual aids in future iterations of the kit.

4.1.2 Motivation and Interest in Technology.

The most compelling findings emerged in items related to student motivation and interest in technology. All 27 students (100%) agreed that they enjoyed using the robot kit for learning (Q1; M = 4.48) and that the kit was enjoyable to use with classmates (Q5; M = 4.70), the highest mean score recorded among all student items. Furthermore, 92.6% of students agreed that using the kit increased their interest in technology and robotics (Q13; M = 4.67, SD = 0.48), while an equally high proportion (92.6%) expressed a desire to use the kit again in the future (Q11; M = 4.56). These results suggest that the SnapBot kit is highly effective at stimulating students' intrinsic motivation toward technology learning. The finding is consistent with constructivist learning principles, where hands-on, tangible experiences promote deeper engagement and sustained interest (Papert, 1980).

Additionally, 92.6% of students reported that the kit helped them learn new things about technology (Q6; M = 4.37), and 96.3% felt it supported teamwork skills (Q14; M = 4.44). These figures reinforce the kit's dual utility as both a technical learning tool and a vehicle for collaborative learning.

Table 2: Descriptive Statistics — Student Responses (N = 27)

Item	Statement	Mean	SD	% Agree (≥4)	Interpretation
Q1	I enjoy using the robot kit for learning.	4.48	0.51	**100.0%**	**Very High**
Q2	The assembly process is easy to understand and complete.	3.30	0.72	29.6%	Moderate
Q3	I understand how parts are connected after a brief explanation.	3.70	0.78	59.3%	Mod. High
Q5	The robot kit is enjoyable to use with classmates.	**4.70**	0.47	**100.0%**	**Very High**
Q6	The kit helps me learn new things about technology.	4.37	0.63	92.6%	**Very High**
Q7	I did not need much help from the teacher to assemble the robot.	3.15	0.91	33.3%	Moderate
Q9	The robot kit is not too difficult to assemble.	3.67	0.78	59.3%	Mod. High
Q11	I want to use this robot kit again in the future.	**4.56**	0.58	92.6%	**Very High**
Q12	The instructions are easy to understand.	4.11	0.85	74.1%	High
Q13	Using the robot kit makes me more interested in technology and robotics.	**4.67**	0.48	92.6%	**Very High**
Q14	The kit helps me develop teamwork skills.	4.44	0.58	96.3%	**Very High**
Q15	The design makes it easy to disassemble and reassemble the robot.	3.74	0.76	70.4%	Mod. High

Note: Interpretation thresholds — Very High ≥ 4.5; High 4.0–4.49; Mod. High 3.5–3.99; Moderate < 3.5

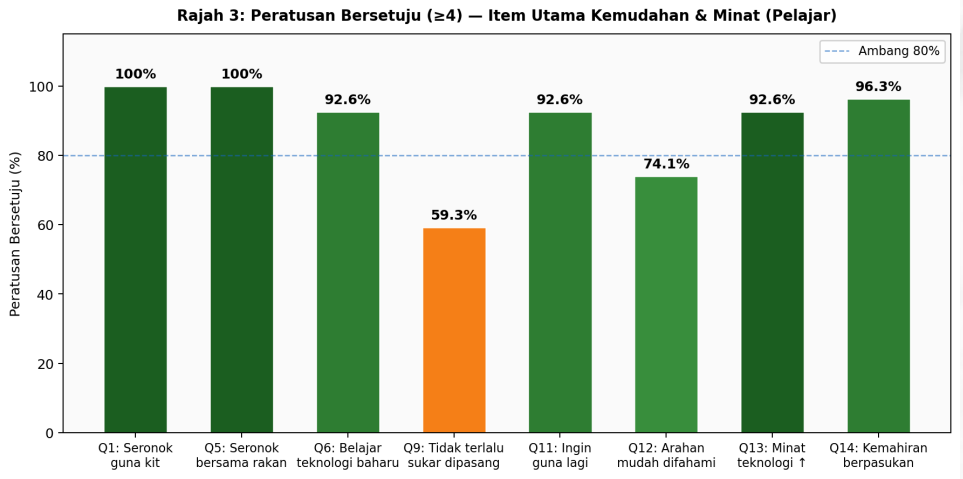


Figure 3: Percentage of Students Agreeing (Score ≥ 4) on Key Ease and Motivation Items.

4.2 Teacher's Perceptions (N = 10)

Teacher responses (Table 2; Figure 3) reflected an exceptionally high level of endorsement for the SnapBot kit. All 15 items received 100% agreement (scores of 4 or 5) from all ten teachers, with mean scores ranging from 4.50 to 4.90. This unanimous positive response signals strong professional confidence in the kit's pedagogical value and practical suitability for primary school settings.

4.2.1 Assembly Ease and Classroom Integration

Teachers broadly affirmed that the SnapBot kit was accessible and easy to deploy in classroom contexts. All teachers (100%) agreed that students could understand the assembly process with minimal guidance (Q2; M = 4.50), and that the instruction manual was clear and easy to follow (Q9; M = 4.80). The kit was also rated highly for its ease of integration into other classroom activities (Q12; M = 4.80), and the assembly time was deemed appropriate for a standard class period (Q6; M = 4.50). These findings indicate that from a teacher's perspective, the kit presents minimal logistical barriers to adoption.

4.2.2 Pedagogical Value and Student Engagement

Beyond ease of use, teachers rated the kit highly for its learning impact. The item on encouraging student collaboration earned the highest mean score across all teacher items (Q7; M = 4.90), indicating near-unanimous strong agreement. Teachers also confirmed that students remained focused and engaged throughout kit use (Q13; M = 4.80), and that the kit effectively developed problem-solving skills (Q8; M = 4.70). All teachers agreed the kit aligned with school learning objectives (Q4; M = 4.80) and that materials were safe for children (Q5; M = 4.80), addressing two critical gatekeeping concerns for classroom adoption.

Table 3: Descriptive Statistics — Teacher Responses (N = 10)

Item	Statement	Mean	SD	% Agree (≥4)	Interpretation
Q1	The robot kit design encourages student engagement.	**4.70**	0.48	**100%**	**Very High**
Q2	Students can understand assembly with minimal guidance.	**4.50**	0.53	**100%**	**Very High**
Q4	The kit aligns with school learning objectives.	**4.80**	0.42	**100%**	**Very High**
Q5	Materials used in the kit are safe for children.	**4.80**	0.42	**100%**	**Very High**
Q6	Assembly time is appropriate for class periods.	**4.50**	0.53	**100%**	**Very High**
Q7	The kit encourages collaboration among students.	**4.90**	0.32	**100%**	**Very High**
Q8	The kit supports development of problem-solving skills.	**4.70**	0.48	**100%**	**Very High**
Q9	The instruction manual is clear and easy to follow.	**4.80**	0.42	**100%**	**Very High**
Q12	The kit is easy to integrate into other classroom activities.	**4.80**	0.42	**100%**	**Very High**
Q13	Students remain focused when using the kit in class.	**4.80**	0.42	**100%**	**Very High**

4.3 Comparative Summary

A comparison between student and teacher data reveals a consistent pattern of positive reception, with teachers reporting higher and more uniform agreement across all dimensions compared to students. This discrepancy is expected: teachers evaluated the kit from a professional standpoint informed by experience, while students' responses reflect first-hand interaction with the assembly process — including its challenges.

The most notable divergence lies in assembly ease. Teachers reported strong confidence (M = 4.50) in students' ability to assemble with minimal guidance, yet students' own perceptions were more moderate (Q7; M = 3.15; Q2; M = 3.30). This gap may reflect the scaffolding teachers naturally provide during activities, which reduces perceived difficulty from their viewpoint. These findings suggest that while the SnapBot kit's modular joint design is broadly accessible, further refinement of the assembly guide particularly through visual step-by-step instructions could help bridge this perception gap.

In terms of motivational impact, both groups demonstrated strong alignment: students overwhelmingly reported increased interest in technology (Q13; M = 4.67) and a desire to continue using the kit (Q11; M = 4.56), while teachers confirmed students remained engaged and focused during sessions (Q13; M = 4.80). Together, these findings provide robust evidence that the SnapBot Modular Joint kit is an effective and motivating tool for introducing robotics education at the primary school level.

5.0 CONCLUSION

This study evaluated the usability and educational value of the SnapBot Modular Joint Design in the context of primary school robotics education. The findings demonstrate that the modular snap-fit mechanism provides a practical solution for simplifying robot assembly, allowing

young learners to construct robotic systems without the need for tools or complex mechanical processes.

Survey results from both students and teachers indicated a generally positive perception of the SnapBot kit. Students reported high levels of enjoyment, increased interest in robotics and technology, and strong engagement in collaborative learning activities. Although some students required guidance during assembly, the overall results suggest that the modular design successfully reduces many of the traditional barriers associated with robotics kit construction. Teachers expressed particularly strong support for the SnapBot system, highlighting its ease of integration into classroom activities, appropriate assembly time for lessons, and its ability to promote teamwork and problem-solving skills among students. These findings indicate that simplified modular robotics designs can significantly enhance accessibility and effectiveness in early robotics education.

Overall, the SnapBot Modular Joint Design demonstrates strong potential as an educational robotics platform for primary schools. Future improvements may focus on enhancing instructional materials, particularly through clearer visual assembly guides, to further support independent student use. Expanding the evaluation to a larger sample of schools could also provide deeper insights into the long-term educational impact of modular robotics systems in STEM learning environments. Future research will apply the tanggam-inspired joint design to a sumo robot platform to evaluate its durability and structural robustness under high-impact competitive conditions.

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KAJIAN CAMPURAN SISA BLOK KONKRIT RINGAN KE ATAS KEKUATAN KONKRIT

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Abstrak

Kepesatan dalam pembinaan bangunan telah menyebabkan banyak sisa-sisa binaan terhasil. Pengurusan sisa pembinaan seperti sisa blok konkrit ringan dan batu bata yang tidak diurus dengan baik boleh mendatangkan masalah kepada persekitaran dan kesihatan terutama manusia. Dalam kajian ini, kesan ke atas kekuatan konkrit dikaji apabila sisa blok konkrit ringan ditambah ke dalam konkrit sebagai bahan pengganti sebahagian pasir dalam konkrit. Sisa blok konkrit ringan dihancurkan dan ditambah dalam bancuhan konkrit pada kadar 0% (konkrit kawalan), 10% dan 20% daripada berat pasir sebelum diuji kadar kebolehkerjaannya menggunakan ujian runtuhan kon. Konkrit basah yang dihasilkan akan dimasukkan dalam kiub bersaiz 150mm x 150mm x 150mm dan diawet sebelum diuji pada umur 28 hari untuk menentukan kekuatan mampatan konkrit. Hasil ujian runtuhan kon menunjukkan kadar kebolehkerjaan konkrit meningkat apabila kadar campuran sisa blok konkrit ringan bertambah. Ini disebabkan oleh sifat sisa blok konkrit ringan yang menyerap air menyebabkan konkrit menjadi semakin cair. Manakala hasil ujian mampatan kiub pula menunjukkan kekuatan konkrit telah berkurang apabila sisa blok konkrit ringan ditambah dalam konkrit. Semakin tinggi kadar campuran sisa blok konkrit ringan di dalam konkrit, semakin rendah kekuatan konkrit. Penurunan kekuatan ini disebabkan oleh sifat penyerapan air oleh konkrit yang tinggi telah menyebabkan wujud rongga dalam konkrit keras dan menjadikan konkrit semakin lemah. Kesimpulannya penambahan sisa blok konkrit ringan dalam konkrit akan menyebabkan kekuatan konkrit menurun dan tidak sesuai untuk ditambah ke dalam bancuhan konkrit tanpa bahan tambah lain yang sesuai. Bahan tambah yang sesuai perlu kenalpasti agar konkrit dapat mencapai kekuatan yang normal sekiranya sisa blok konkrit ringan ingin ditambah menggantikan pasir dalam konkrit.

Kata Kunci: Sisa blok konkrit ringan, kebolehkerjaan, ujian mampatan, kekuatan mampatan

Abstract

Poorly managed construction waste can cause problems for the environment and health, especially for humans. Examples of construction waste include concrete slabs, bricks, lightweight concrete blocks and wood. In this study, lightweight concrete block waste was mixed into concrete mixtures as a replacement for sand before its strength was tested using a concrete compression machine test. The crushed lightweight concrete block waste was mixed into the concrete mixture at a rate of 0% (control concrete), 10% and 20% of the weight of

sand to produce concrete cubes measuring 150mm x 150mm x 150mm. The resulting concrete will be cured and tested at 28 days to determine the compressive strength of the concrete. The results of the concrete workability test showed that the workability of the concrete increased when the mixture rate of lightweight concrete block waste increased. This is due to the nature of lightweight concrete itself which absorbs water, causing the workability of the concrete to increase. Meanwhile, the results of the cube compression test showed that the strength of the concrete decreased when lightweight concrete block waste was added to the concrete. The higher the proportion of lightweight concrete block waste in the concrete, the lower the strength of the concrete. This decrease in strength indicates that the mixture of concrete block waste is not suitable for addition to the concrete mix without other suitable additives. Suitable additives need to be identified so that the concrete can achieve normal strength if lightweight concrete block waste is to be added to replace sand in the concrete.

***Keywords**: Lightweight concrete block waste, workability, compression test, compressive strength*

1.0 PENGENALAN

Sisa pembinaan terhasil daripada kerja pembinaan, kerja pengubahsuaian, kerja merobohkan bangunan daripada semua jenis bangunan sama ada bangunan tempat tinggal atau bangunan bukan tempat tinggal, kerja membaiki jalan raya, kerja membaiki jambatan dan kerja pembersihan yang disebabkan oleh alam semula jadi atau yang disebabkan oleh manusia sendiri. Lebih banyak projek pembinaan akan menghasilkan lebih banyak sisa pembinaan (Ghinaya, Z. dan Masek, A., 2021). Pengurusan sisa pembinaan yang tidak diurus dengan baik boleh mendatangkan masalah kepada persekitaran, kesihatan dan keselamatan pekerja-pekerja binaan. Sebanyak 10 tan sisa buangan telah dihasilkan dari industri pembinaan setiap tahun (Huang, J. et al, 2022). Sisa pembinaan ini boleh mendatangkan masalah kepada persekitaran sekiranya tidak diuruskan dengan betul. Contoh sisa pembinaan termasuklah seperti konkrit, blok konkrit ringan, batu bata dan kayu. Blok konkrit ringan seperti di dalam Rajah 1.1 sering digunakan dalam kerja-kerja pembinaan bangunan kerana sifat fizikalnya yang lebih besar tetapi ringan menyebabkan ia mudah dipasang.



Rajah 1.1: Blok konkrit ringan yang sering digunakan dalam kerja-kerja pembinaan bangunan

1.1 Penyataan Masalah

Sisa-sisa buangan bahan binaan dan juga bahan pertanian seringkali menjadi isu utama dalam media sosial dan akhbar. Pengurusan sisa-sisa binaan yang kurang baik akan memberikan kesan negatif kepada alam sekitar (Dewuyi, T. O., 2020). Bagi mengatasi masalah ini para penyelidik telah menjalankan pelbagai kajian terhadap sisa-sisa bahan buangan ini sebagai bahan kitar semula. Menurut Yang, J. et al (2021), sebanyak 80% sisa-sisa binaan yang terhasil daripada aktiviti pembinaan boleh digunakan semula. Penggunaan sisa binaan merupakan salah satu alternatif mengurangkan sisa binaan di tapak bina. Bialko, M. and Hola, B. (2021) juga mengatakan penggunaan sisa binaan merupakan salah satu alternatif mengurangkan sisa binaan di tapak bina. Salah satu sisa binaan yang dihasilkan di tapak bina ialah blok konkrit ringan (Shakir, A. and Ahmed M, A. (2013). Blok konkrit ringan digunakan secara meluas kerana rupa bentuk fizikalnya yang bersaiz besar tetapi ringan menyebabkan proses pemasangannya menjadi lebih mudah dan cepat (Suryanita, R. et al, 2021), (Maizir, H. et al (2019).

Setiap projek pembinan akan menghasilkan sisa-sisa binaan bergantung kepada jenis pembinaan yang dilakukan. Pengurusan sisa pembinaan yang tidak diurus dengan baik boleh mendatangkan masalah kepada persekitaran dan kesihatan. Contoh sisa pembinaan termasuklah seperti konkrit, batu bata, blok konkrit ringan dan kayu. Dalam kajian ini, sisa blok konkrit ringan ditambah menggantikan sebahagian pasir dalam konkrit. Kerja-kerja pengorekan pasir boleh memberikan kesan yang negatif kepada alam sekitar seperti risiko runtuhan tebing, perubahan struktur tanah, pengurangan kadar resapan air dalam tanah dan masalah kesihatan (Ashraf, M. A. et al, 2011). Sehubungan itu, satu inovasi diperlukan untuk mengurangkan penggunaan pasir dalam industri pembinaan (Zadeh, A. A. et al, 2022).

1.2 Objektif Kajian

Dalam perlaksanaan projek ini, dua objektif telah ditetapkan seperti di bawah:

i. Mengkaji kesan ke atas sifat kebolehkerjaan konkrit apabila sisa blok konkrit ringan ditambah ke dalam konkrit.
ii. Mengkaji kesan ke atas kekuatan konkrit apabila sisa blok konkrit ringan ditambah ke dalam konkrit.

1.3 Kepentingan Kajian

Kajian tentang campuran sisa blok konkrit ringan ke atas kekuatan konkrit sangat penting dalam bidang pembinaan moden. Kajian ini mempunyai beberapa kepentingan seperti mengurangkan sisa pembinaan di tapak bina. Kajian ini secara tidak langsung dapat membantu mengitar semula sisa tersebut sebagai bahan campuran konkrit seterusnya mengurangkan pencemaran. Selain itu, kajian memberi berpeluang untuk menggantikan sebahagian bahan dalam konkrit dengan sisa blok konkrit ringan yang mana ia boleh mengurangkan kos pembinaan dan juga sebagai alternatif kepada bahan yang lebih murah dalam penghasilan konkrit.

2.0 SOROTAN KAJIAN

Beberapa kajian berkaitan penggunaan sisa blok konkrit ringan sebagai bahan tambah dalam konkrit telah dijalankan sebelum ini. Kajian terdahulu juga telah mengkaji kesan penggunaan sisa blok konkrit ringan ke atas kekuatan mampatan terhadap konkrit ringan. Kajian yang telah dilakukan oleh Martina, N. et al (2022) menunjukkan kekuatan konkrit maksimum adalah 24.25 MPa apabila sebanyak 10% sisa blok konkrit ringan dicampur dalam konkrit manakala nilai terendah dicapai apabila sebanyak 30% sisa blok konkrit ringan dicampur dalam konkrit iaitu 18.03 MPa. Ujian ini menggunakan acuan selinder untuk ujian mampatan konkrit. Hasil kajian ini menunjukkan penurunan kekuatan konkrit apabila kandungan sisa blok konkrit ringan menggantikan pasir melebihi 10%. Penurunan kekuatan konkrit disebabkan oleh sifat sisa blok konkrit ringan yang menyerap air dan menjadikan konkrit menjadi lebih rapuh dan lemah. Selain itu, kandungan lumpur dan kelodak yang terhasil dari sisa blok konkrit ringan juga telah menjejaskan ikatan dengan simen. Lumpur dan kelodak didapati telah menyelaputi permukaan agregat menyebabkan ikatan agregat dengan simen semakin lemah (Chaulagai, R. et al, 2017).

Kajian yang dijalankan oleh Singh, R. and Kumar, R. (2021) pula menunjukkan kekuatan mampatan maksimum konkrit telah dicapai apabila sisa blok konkrit ditambah pada kadar 25% dalam konkrit sebelum menunjukkan penurunan. Kedua-dua kajian ini telah memberikan hasil yang berbeza walaupun menggunakan bahan tambah yang sama. Dalam kajian ini, sisa blok konkrit ringan telah ditambah pada kadar 20%, 25%, 30% dan 35% menggantikan batu baur dalam konkrit. Selain itu, kajian oleh Suryadi, A. dan Rochman, T. (2024) juga menunjukkan penggunaan sisa blok konkrit ringan pada kadar 15%, 25% dan 30% bersama-sama dengan 10% wasap silika telah menunjukkan penurunan dari segi kekuatan konkrit berbanding dengan sampel piawai. Sehubungan itu, satu kajian penggunaan sisa blok konkrit ringan sebagai pengganti sebahagian pasir dalam penghasilan konkrit dijalankan untuk mengurangkan kesan negatif ke atas alam sekitar serta mengurangkan kebergantungan kepada sumber semulajadi seperti pasir. Kajian ini juga berfungsi untuk melihat sejauh mana kesan penggantian sisa binaan ke atas kekuatan konkrit berbanding dengan kajian-kajian terdahulu yang telah dilaksanakan agar satu kesimpulan terhadap kesan penggunaan sisa blok konkrit ringan dapat diperolehi.

2.0 METODOLGI KAJIAN

Dalam pelaksanaan kajian ini, beberapa proses telah dilaksanakan seperti penyediaan sampel, pengujian dan membuat analisa ke atas hasil ujian yang diperolehi.

2.1 Penyediaan Sampel

Dalam proses penyediaan sampel, kaedah campuran 1:2:4 telah digunakan iaitu 1 bahagian simen, 2 bahagian pasir, 4 bahagian batu baur. Dalam kajian ini, sisa blok konkrit ringan dihancurkan sehingga menjadi serbuk. Sisa blok konkrit ringan kemudian akan dicampur ke dalam bancuhan konkrit pada kadar campuran 10% dan 20% menggantikan pasir dan hasil ujian akan dibandingkan dengan sampel piawai pada kekuatan 20 MPa. Bancuhan konkrit basah yang dihasilkan akan diuji dengan menggunakan Ujian Runtuhan Kon untuk menentukan kebolehkerjaan konkrit baharu sebelum dimasukkan ke dalam kiub konkrit bersaiz 150mm x 150mm x 150mm. Sembilan sampel yang dihasilkan seterusnya akan diawet secara rendaman dalam air selama 28 hari sebelum diuji kekuatannya menggunakan Ujian Mampatan Kiub. Rajah 3.1.1 menunjukkan sampel-sampel yang telah dihasilkan dalam kajian ini.



Rajah 3.1.1: Sampel Konkrit Yang Dihasilkan

Jadual 3.1.1: Bilangan Sampel Yang Disediakan

Perkara	**Konkrit Kawalan (0%)**	**Konkrit Dengan Campuran 10% Sisa Blok Konkrit Ringan**	**Konkrit Dengan Campuran 20% Sisa Blok Konkrit Ringan**
Bilangan Sampel	3	3	3

2.2 Pengujian Sampel

Dalam kajian ini, 2 ujikaji telah dijalankan iaitu Ujian Runtuhan Kon dan Ujian Mampatan Kiub. Ujian runtuhan kon adalah ujian bagi mengukur kebolehkerjaan untuk semua konkrit manakala ujian mampatan kiub pula dilaksanakan untuk mengukur kekuatan konkrit yang dihasilkan pada umur matang iaitu umur 28 hari menggunakan mesin mamptan kiub. Sembilan sampel kiub disediakan seperti yang ditunjukkan dalam Jadual 1. Kiub-kiub yang telah diawet di dalam air akan diuji pada umur 28 hari untuk menentukan kekuatan sebenar konkrit yang disediakan. Keputusan ujian mampatan ini akan dibandingkan dengan sampal piawai yang direkabentuk untuk konkrit gred 20 MPa. Ujian yang dilaksanakan menggunakan piawaian BS EN 12390-7. *Testing Hardened Concrete. Density of Hardened Concrete.*

3.0 DAPATAN DAN PERBINCANGAN

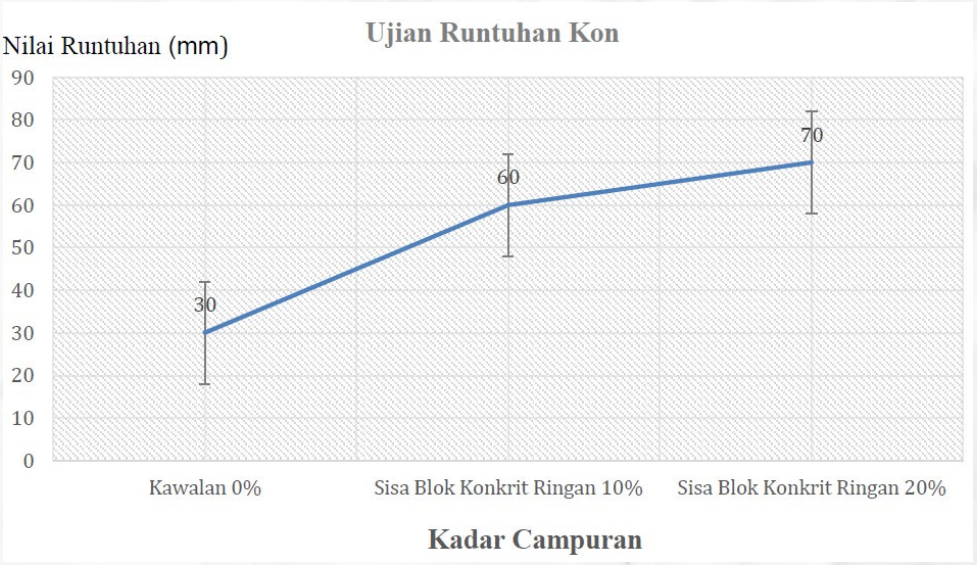
Dapatan yang perolehi dari ujian yang dilaksanakan dianalisa dengan mengkaji kesan penambahan sisa blok konkrit ringan ke dalam konkrit dalam aspek kebolehkerjaan konkrit dan kekuatan konkrit.

3.1 Kesan Ke Atas Sifat Kebolehkerjaan Konkrit

Merujuk kepada keputusan ujian runtuhan kon yang diperolehi (rujuk Jadual 4.21.1), didapati nilai runtuhan semakin meningkat apabila peratus penggantian pasir oleh sisa blok konkrit ringan meningkat. Ini menunjukkan penggantian pasir dengan campuran sisa blok konkrit ringan telah meningkatkan kebolehkerjaan bancuhan konkrit (Punkki, J., 1995). Hasil kajian ini juga seiring dengan hasil kajian yang diperolehi oleh Ihsan, T. et al pada tahun 2024. Peningkatan kebolehkerjaan konkrit ini disebabkan oleh sisa blok konkrit yang menyerap air dan telah mengurangkan sifat kejelekitan konkrit. Sifat kejelekitan konkrit yang berkurang telah menyebabkan kebolehkerjaan konkrit bertambah (Martina, N. et al, 2022). Tren peningkatan kebolehkerjaan konkrit boleh dirujuk di dalam Rajah 4.1.1.

Jadual 4.1.1: Keputusan Ujian Runtuhan Kon

% Sisa Blok Konkrit Ringan	Nilai Runtuhan (mm)
0%	30 mm
10%	33 mm
20%	37 mm



Rajah 4.1.1: Keputusan Ujian Runtuhan Kon

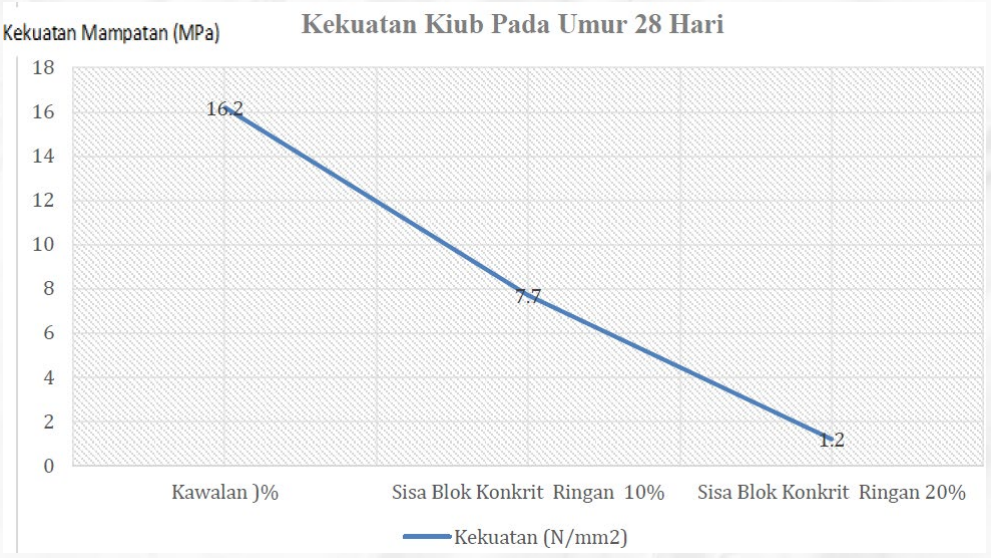
3.2 Kesan Ke Atas Kekuatan Konkrit

Walaupun begitu, kekuatan konkrit didapati menurun apabila sisa blok konkrit ringan di tambah dalam konkrit. Penurunan nilai kekuatan mampatan konkrit boleh dilihat dari hasil ujian mampatan konkrit seperti di dalam Jadual 3. Semakin tinggi kadar campuran sisa blok

konkrit ringan, semakin rendah kekuatan konkrit. Penurunan kekuatan konkrit ini disebabkan oleh sifat sisa blok konkrit ringan yang menyerap air menyebabkan kandungan air yang tinggi di dalam bancuhan. Kandungan air yang tinggi telah menyebabkan konkrit menjadi lebih rapuh seterusnya mengurangkan kekuatan konkrit (Martina, N. et al, 2022). Kehadiran rongga udara dalam konkrit akibat serapan air yang tinggi juga menyebabkan kekuatan mampatan konkrit menurun (Singh, P. R. et al,2018). Tren penurunan kekuatan konkrit ditunjukkan di dalam Rajah 3.

Jadual 4.2.1: Keputusan Ujian Kekuatan Mampatan Kiub Pada Umur 28 Hari

% Sisa Blok Konkrit Ringan	Kekuatan Mampatan Umur 28 Hari (N/mm^2)
0%	16.2
10%	7.7
20%	1.2



Rajah 4.2.1: Keputusan Ujian Mampatan Kiub Pada Umur 28 Hari

4.0 KESIMPULAN DAN CADANGAN

Berdasarkan hasil ujikaji yang dijalankan, didapati penggunaan sisa blok konkrit dalam konkrit telah menyebabkan tahap kebolehkerjaan konkrit meningkat apabila sisa blok konkrit ringan ditambah dalam konkrit. Semakin banyak kandungan sisa blok konkrit, semakin tinggi kebolehkerjaan konkrit. Ini menunjukkan konkrit semakin mudah dikerjakan apabila semakin banyak sisa blok konkrit ringan ditambah ke dalam konkrit. Semakin banyak air diserap menjadikan kemakin cair konkrit yang terhasil. Walaupun begitu, kekuatan mampatan konkrit didapati telah menunjukkan penurunan apabila kandungan sisa blok konkrit ringan semakin bertambah masing-masing sehingga 10% dan 20%. Penurunan kekuatan ini disebabkan oleh kandungan air yang tinggi dalam bancuhan kerana sisa blok konkrit ringan bersifat menyerap air. Keadaan air yang tinggi dalam konkrit akan menyebabkan konkrit semakin cair dan lemah serta menyebabkan konkrit itu

sendiri menjadi lebih rapuh. Rongga-rongga halus yang terbentuk di dalam konkrit setelah mengeras menyebabkan konkrit menjadi semakin lemah. Keadaan ini menunjukkan penambahan sisa blok konkrit ringan ke dalam bancuhan konkrit kurang sesuai dan tidak membantu dalam meningkatkan kekuatan mampatan konkrit.

Cadangan penambahbaikan untuk ujikaji ini ialah dengan menambah bahan tambah yang lain seperti *'superplasticizer'* dan wasap silika pada kadar yang lebih tinggi. Bahan-bahan ini boleh meningkatkan kebolehkerjaan dan kekuatan konkrit. Kesimpulannya, ujikaji lanjutan perlu dijalankan lagi ke atas penggunaan sisa blok konkrit ringan dalam konkrit seperti menambah bahan tambah lain selain dari blok konkrit ringan ke dalam konkrit agar sisa blok konkrit ringan dapat dikitar semula pada masa akan datang.

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DEVELOPMENT AND EVALUATION OF THE CA APP: A MOBILE INTERACTIVE LEARNING TOOL FOR COMPUTER ARCHITECTURE

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Abstract

Computer Architecture is a core subject in Information Technology (IT), typically taken by Semester 1 IT students. However, many students, particularly those from diverse academic backgrounds, find learning programming-related concepts to be challenging. Analysis of student examination performance and classroom observations indicates that students face challenges in understanding and applying these concepts, especially when learning relies on conventional materials such as printed notes and static exercises. These limitations may reduce student engagement and hinder the effective application of theoretical concepts in practical environments. To address these challenges, this study introduces CA App, an interactive mobile learning application designed to support the teaching and learning of Computer Architecture topics. The application was developed using an Agile development approach that supports iterative design, continuous testing, and ongoing improvement. CA App integrates several interactive learning components, including digital notes, instructional videos, gamified quizzes, discussion platforms, and a simulation environment that allows students to visualize how instructions and data move within processor registers. The system was developed using HTML5-based web technologies and deployed through a cloud hosting platform, enabling access through both web browsers and Android mobile devices. This design allows students to access multimedia learning resources flexibly and supports interactive learning beyond the classroom. To evaluate the effectiveness of the application, a survey was conducted involving 255 Semester 2 students from the Department of Information Technology at Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS) and Politeknik Tuanku Syed Sirajuddin (PTSS). The findings indicate a high level of student acceptance, with an overall mean score of 4.63, reflecting positive perceptions of the application's usability and learning benefits. The integration of multimedia learning elements, gamified assessments, and simulation-based learning activities was found to improve student engagement and facilitate better understanding of complex technical concepts. Overall, the findings demonstrate that CA App provides an effective and practical mobile learning solution for enhancing Computer Architecture education in higher learning institutions.

Keywords: Mobile Learning, Interactive Learning Application, Computer Architecture Education, Educational Technology

Abstrak

Seni Bina Komputer ialah mata pelajaran teras dalam Teknologi Maklumat (IT), biasanya diambil oleh pelajar IT Semester 1. Walau bagaimanapun, ramai pelajar, terutamanya mereka daripada latar belakang akademik yang pelbagai, mendapati pembelajaran konsep berkaitan pengaturcaraan adalah mencabar. Analisis prestasi peperiksaan pelajar dan pemerhatian bilik darjah menunjukkan bahawa pelajar menghadapi cabaran dalam memahami dan mengaplikasikan konsep ini, terutamanya apabila pembelajaran bergantung kepada bahan konvensional seperti nota bercetak dan latihan statik. Had ini boleh mengurangkan penglibatan pelajar dan menghalang penggunaan konsep teori yang berkesan dalam persekitaran praktikal. Untuk menangani cabaran ini, kajian ini memperkenalkan CA App, aplikasi pembelajaran mudah alih interaktif yang direka untuk menyokong pengajaran dan pembelajaran topik Seni Bina Komputer. Aplikasi ini dibangunkan menggunakan pendekatan pembangunan Agile yang menyokong reka bentuk berulang, ujian berterusan dan peningkatan berterusan. CA App menyepadukan beberapa komponen pembelajaran interaktif, termasuk nota digital, video pengajaran, kuiz gamified, platform perbincangan dan persekitaran simulasi yang membolehkan pelajar memvisualisasikan cara arahan dan data bergerak dalam daftar pemproses. Sistem ini dibangunkan menggunakan teknologi web berasaskan HTML5 dan digunakan melalui platform pengehosan awan, membolehkan akses melalui kedua-dua pelayar web dan peranti mudah alih Android. Reka bentuk ini membolehkan pelajar mengakses sumber pembelajaran multimedia secara fleksibel dan menyokong pembelajaran interaktif di luar bilik darjah. Bagi menilai keberkesanan permohonan itu, satu tinjauan telah dijalankan melibatkan 255 pelajar Semester 2 Jabatan Teknologi Maklumat di Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS) dan Politeknik Tuanku Syed Sirajuddin (PTSS). Dapatan menunjukkan tahap penerimaan pelajar yang tinggi, dengan skor min keseluruhan 4.63, mencerminkan persepsi positif terhadap kebolehgunaan aplikasi dan faedah pembelajaran. Penyepaduan elemen pembelajaran multimedia, penilaian gamified, dan aktiviti pembelajaran berasaskan simulasi didapati dapat meningkatkan penglibatan pelajar dan memudahkan pemahaman yang lebih baik tentang konsep teknikal yang kompleks. Secara keseluruhan, penemuan menunjukkan bahawa CA App menyediakan penyelesaian pembelajaran mudah alih yang berkesan dan praktikal untuk meningkatkan pendidikan Seni Bina Komputer di institusi pengajian tinggi.

Kata kunci: *Pembelajaran Mudah Alih, Aplikasi Pembelajaran Interaktif, Pendidikan Seni Bina Komputer, Teknologi Pendidikan*

1.0 INTRODUCTION

The integration of digital technology in education has transformed teaching and learning practices in higher education. Mobile learning applications provide flexible access to learning materials and support interactive learning experiences beyond the classroom. Teaching and learning approaches in higher education need to be aligned with the rapid advancement of technology and the demands of 21st-century education. In line with the Malaysia Education

Blueprint (2013–2025), particularly the emphasis on leveraging Information and Communication Technology (ICT), educators are encouraged to integrate digital tools to enhance the quality of teaching and learning.

Today's students, especially those in Information Technology programmes, are highly exposed to digital technologies and mobile devices such as smartphones. This provides an opportunity to integrate mobile-based technologies into teaching and learning practices. Previous studies have highlighted that mobile applications, particularly those based on the Android platform, are increasingly being used in education due to their accessibility, flexibility, and ability to support interactive learning environments (Rafiza et al., 2015).

The advancement of mobile and web technologies has enabled the development of interactive learning applications that combine multimedia elements such as videos, quizzes, and simulations. These technologies support more engaging and effective learning experiences compared to conventional methods. Therefore, integrating mobile learning applications into teaching practices is seen as a practical approach to enhance student engagement and improve understanding of complex subjects. In this context, the development of CA App aims to transform traditional learning materials into an interactive mobile learning platform that supports the teaching and learning of Computer Architecture concepts.

1.0 Problem Statement

Teaching and learning in Information Technology (IT) education involve both theoretical understanding and practical application. In particular, foundational courses such as Computer Architecture are designed to introduce students to fundamental concepts related to how computer systems operate. This course is typically taken by Semester 1 IT students across polytechnics in Malaysia. However, students entering IT programmes often come from diverse academic backgrounds during their secondary education, where they may have had limited exposure to programming or technical computing concepts. As a result, many students face difficulties in understanding abstract topics introduced at the early stage of their studies. Concepts related to instruction execution and system operations are often perceived as complex, especially when learning relies on conventional approaches such as printed notes and static exercises.

Based on classroom observations and analysis of students' academic performance, it was found that many students struggle to understand and apply these concepts effectively. In addition, the lack of interactive and engaging learning materials may reduce student motivation and limit their ability to connect theoretical knowledge with practical applications. This situation becomes more critical as IT students are expected to develop web or mobile applications in their later semesters, including during their final year projects. Without a strong foundational understanding, students may face greater challenges in progressing to more advanced topics.

Therefore, there is a need for a more interactive and flexible learning approach that can support students in understanding complex concepts at an early stage. In this context, the development of CA App aims to provide an engaging mobile learning platform that not only supports the

learning of Computer Architecture but also introduces students to the use of digital technologies that they will apply in their future studies.

1.1 Research Objective

a) To design and develop CA App as an interactive mobile learning application that integrates digital notes, instructional videos, gamified quizzes, discussion features, and simulation elements to support the teaching and learning of Computer Architecture.

b) To evaluate students' perceptions of CA App in terms of its usefulness, usability, and effectiveness in enhancing motivation, independent learning, and understanding of Computer Architecture concepts.

1.2 Significant of Research

This study contributes to the enhancement of interactive learning approaches by integrating multimedia and technology-based features into the learning process. It also supports self-directed learning by providing students with flexible access to learning materials that can be explored at their own pace. In addition, the study promotes the integration of technology in education by demonstrating the potential of mobile learning applications as effective tools to improve teaching and learning practices.

2.0 LITERATURE REVIEW

2.1 Mobile Learning in Higher Education

Mobile learning has become an important approach in higher education as it allows students to access learning materials anytime and anywhere. This flexibility supports self-directed learning and improves accessibility to educational resources. Studies have shown that mobile learning enhances students' engagement and promotes independent learning behaviour (Crompton & Burke, 2018). In addition, mobile learning enables institutions to integrate technology into teaching practices more effectively (Alrasheedi, Capretz, & Raza, 2015).

2.2 Gamification in Learning

Gamification refers to the use of game elements in non-game contexts to enhance user engagement and motivation. In education, gamification has been proven to increase students' interest, participation, and learning performance. According to Hakulinen and Auvinen (2014), gamification can improve student engagement and learning outcomes. Similarly, Connolly and Stansfield (2007) found that digital games can be used as effective tools for learning, assessment, and evaluation.

2.3 Simulation-Based Learning

Simulation-based learning is widely used to support the understanding of complex and abstract concepts. It allows students to visualize processes and apply theoretical knowledge in practical scenarios. Dori and Belcher (2005) highlighted that simulation enhances active learning. Simulation-based learning plays an important role in improving students' problem- solving skills and conceptual understanding. Studies have shown that simulation enhances learners' ability to apply knowledge in practical contexts and supports deeper understanding of abstract concepts (Radianti et al., 2020).

2.4 Research Gap

Although previous studies have highlighted the benefits of mobile learning, gamification, and simulation, the integration of these elements into a single learning application for Computer Architecture remains limited. Therefore, this study aims to address this gap by developing CA App as an interactive mobile learning tool.

3.0 RESEARCH METHODOLOGY

3.1 Research Design

This study adopts an Agile development approach for the design and development of the CA App. The Agile model was selected because it supports iterative development, continuous testing, and ongoing improvement, allowing the application to be refined based on user feedback and system performance. Agile enables flexibility in the development process, where each phase can be revisited and improved continuously. This approach is suitable for developing interactive mobile learning applications that require frequent updates and user-centered enhancements (Laoyan, 2022).



Figure 1: Agile Methodology Framework

a) Plan Phase

The Plan phase focuses on identifying user needs and learning requirements. This involves analysing the Computer Architecture syllabus, identifying topics that students find difficult, and evaluating students' readiness to use mobile and digital learning tools. In addition, appropriate learning components such as digital notes, instructional videos, quizzes, and simulation elements are determined. Insights from classroom observations and student performance analysis are also used to guide the planning of the application development.

b) Design Phase

In the Design phase, the structure and content of the application are carefully planned. This includes designing the application flow and navigation, organising learning modules, and structuring the content layout. The user interface (UI) and user experience (UX) are also designed to ensure ease of use and accessibility. Interactive elements such as quizzes and simulations are incorporated to enhance student engagement. A storyboard is developed to ensure that the content is presented in a clear, systematic, and user-friendly manner.

c) **Development Phase**

In the Develop phase, the CA App is built based on the design specifications. The application is developed using HTML5-based web technologies and deployed through a cloud hosting platform (Netlify). Various supporting tools are integrated to enhance the learning experience, including platforms for instructional videos, online quizzes for self-assessment, and discussion tools for student–lecturer interaction. The application is also converted into an Android- compatible format using a web-to-APK converter to support mobile access.

As illustrated in Figure 2, the CAAPP application can be accessed through two platforms to enhance usability and accessibility. Figure 3 shows the main interface of the application, which includes key modules such as Notes, Video, Quiz, Forum, and Simulator. Figure 4 presents the forum feature that supports student interaction and discussion. Figure 5 illustrates the quiz feature used for interactive assessment. Figure 6 demonstrates the video feature for instructional support, while Figure 7 shows the notes feature for content delivery and independent learning.

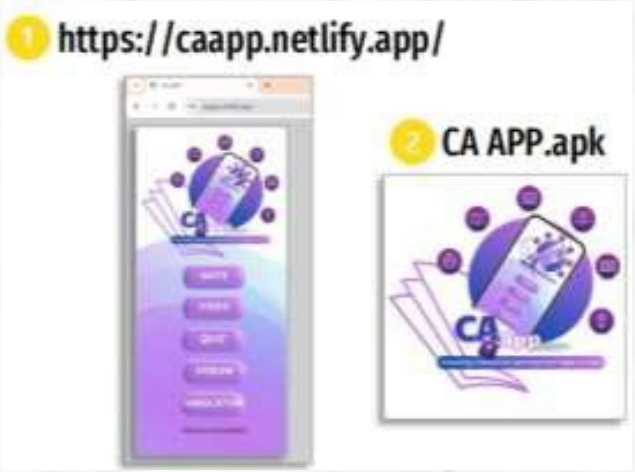


Figure 2: Methods of Accessing the CAAPP Application via Web and Android APK



Figure 3: Methods of Accessing the CAAPP Application via Web and Android APK

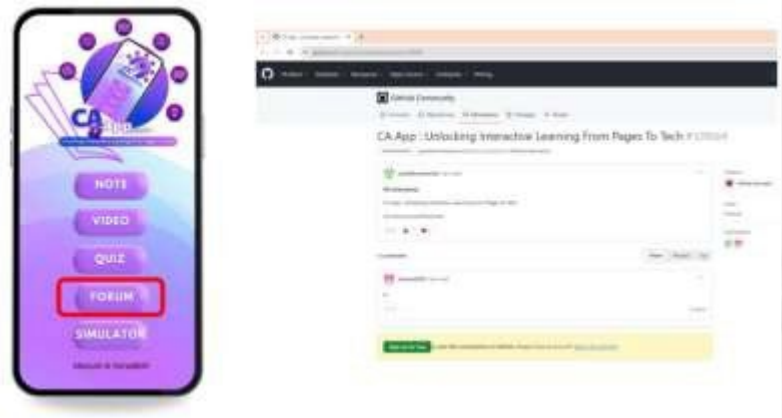


Figure 4: Forum Feature of the CAAPP Application for Online Discussion and Interaction



Figure 5: Quiz Feature of the CAAPP Application for Interactive Learning Assessment



Figure 6: Video Learning Feature of the CAAPP Application for Instructional Support



Figure 7: Notes Feature of the CAAPP Application for Learning Content Delivery

d) **Test and Deployment Phase**

In the Test and Deploy phase, the CA App prototype is tested and implemented to ensure its functionality, usability, and accessibility across platforms. Functional testing is conducted to verify that all features, including digital notes, instructional videos, quizzes, discussion tools, and simulation elements, operate as intended. The application is then deployed for student use via web browsers and Android devices. Feedback from users is collected and used to improve the application continuously, in line with the Agile development approach.

e) Review and Evaluation Phase

In the Review and Evaluation phase, the effectiveness of the CA App is assessed based on students' perceptions. The evaluation is conducted using a questionnaire distributed to students from the Department of Information Technology at Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS) and Politeknik Tuanku Syed Sirajuddin (PTSS), involving a total of 255 respondents.

Prior to the actual study, a pilot study involving 34 students is conducted to test the reliability of the instrument. The reliability analysis using Cronbach's Alpha shows a value of $\alpha = 0.990$ for 12 questionnaire items, indicating a very high level of internal consistency. This suggests that the instrument is reliable and suitable for measuring students' perceptions of the CA App. The findings from this phase are used to evaluate the effectiveness of the application and to support further improvements.

3.2 Research Instruments

A questionnaire using a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) was used as the research instrument. The questionnaire consisted of 12 items and was divided into five sections. Section A collected demographic information, while Sections B to E measured usability, motivation, learning support, and student acceptance.

3.3 Data Analysis

The data collected from the questionnaire were analysed using descriptive statistical analysis. Responses from 255 students were obtained using a five-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5). The analysis involved calculating mean scores and standard deviation for each item to determine the level of students' perceptions toward the CA App. The interpretation of mean scores was used to classify the level of acceptance into three categories: low (1.00–2.33), moderate (2.34–3.66), and high (3.67–5.00), as adapted from Best and Kahn (2006). This analysis focused on key aspects including usability, learning motivation, independent learning, and understanding of Computer Architecture concepts.

4.0 RESEARCH FINDINGS

Descriptive statistical analysis was carried out to examine students' perceptions of the CA App based on mean scores and standard deviation. The results are grouped into four constructs: usability, motivation and learning experience, understanding and learning support, and added value and acceptance.

Table 1 presents the mean score analysis for the usability of the CA App. The overall mean score is high (M = 4.65, SD = 0.65), indicating that students have positive perceptions of the application. All items recorded high mean values, showing that the application is easy to use, well-organised, and functions effectively.

Table 1: Usability of the CA App

No.	Item	Mean	Std. Deviation	Interpretation
1	CA App is easy to use	4.68	0.619	High
2	The navigation and layout are clear and well organised	4.62	0.687	High
3	The application functions well without technical issues	4.64	0.649	High
Overall		**4.65**	**0.65**	**High**

Table 2 presents the mean score analysis for motivation and learning experience. The overall mean score is high (M = 4.61, SD = 0.68), indicating that students are motivated and engaged when using CA App. The results show that the application supports independent learning and enhances the learning experience.

Table 2: Motivation & Learning Experience

No.	Item	Mean	Std. Deviation	Interpretation
1	I am more motivated to learn using CA App compared to traditional notes	4.59	0.686	High
2	CA App encourages independent learning outside class hours	4.60	0.696	High
3	I enjoy using CA App for revision	4.65	0.646	High
Overall		**4.61**	**0.68**	**High**

Table 3 presents the mean score analysis for understanding and learning support. The overall mean score is high (M = 4.64, SD = 0.65), indicating that CA App effectively helps students understand learning topics and supports their learning process.

Table 3: Understanding & Learning Support

No.	Item	Mean	Std. Deviation	Interpretation
1	The content in CA App helps me understand topics better	4.66	0.656	High
2	CA App makes it easier to refer to demonstrations during practice	4.64	0.655	High
3	CA App helps me overcome learning difficulties	4.63	0.663	High
Overall		**4.64**	**0.65**	**High**

Table 4 presents the mean score analysis for added value and acceptance. The overall mean score is high (M = 4.64, SD = 0.66), indicating that students positively accept the application and are willing to continue using it as a learning tool. These findings indicate that CA App not only supports learning but also promotes sustainable practices and encourages continued usage among students.

Table 4: Added Value & Acceptance

No.	Item	Mean	Std. Deviation	Interpretation
1	The content in CA App helps me understand topics better	4.66	0.656	High
2	CA App makes it easier to refer to demonstrations during practice	4.64	0.655	High

3	CA App helps me overcome learning difficulties	4.63	0.663	High
Overall		**4.64**	**0.65**	**High**

5.0 RESEARCH DISCUSSION

The findings of this study indicate that mobile learning through the CAAPP application significantly enhances student engagement. In addition, the incorporation of gamification elements was found to increase students' motivation, while the use of simulation features supports the understanding of abstract concepts in Computer Architecture. These findings are consistent with previous studies on interactive and technology-enhanced learning environments. Based on these findings, several improvements are recommended for future development. These include the addition of more advanced simulation features to further support conceptual understanding, the expansion of the application's implementation to other institutions, and the continuous enhancement of content in alignment with current syllabus updates.

6.0 CONCLUSION

This study developed CA App as a mobile learning application to support Computer Architecture learning. The findings indicate that the application is effective in improving student engagement, motivation, and understanding. Based on these findings, several improvements are recommended for future development. These include the addition of more advanced simulation features to further support conceptual understanding, the expansion of the application's implementation to other institutions, and the continuous enhancement of content in alignment with current syllabus updates.

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DEVELOPMENT OF WELDING DEFECT SPECIMENS AS TEACHING AIDS TO ENHANCE VISUAL INSPECTION SKILLS

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Abstract

Visual inspection is an important skill in welding education to ensure weld quality and structural reliability. However, students often have limited exposure to real welding defects during practical learning sessions. This study developed a set of welding defect specimens to support teaching and learning activities in visual welding inspection. The specimens were fabricated using mild steel plates through the Shielded Metal Arc Welding (SMAW) process by lecturers certified as CSWIP 3.0 Approved Welder. Welding parameters such as current, travel speed and electrode angle were intentionally varied to produce common welding defects including undercut, slag inclusion, porosity, lack of fusion, and incomplete penetration. Additional surface imperfections were also introduced to simulate real industrial conditions. The developed specimens were used as teaching aids during practical sessions to help students observe and understand the characteristics of different welding defects. The results show that the use of realistic defect specimens enhances students' understanding of weld quality and improves their ability to recognize welding defects during visual inspection. These specimens provide a practical learning approach that bridges the gap between theoretical knowledge and industrial practice.

Keywords: Welding defects, welding defect specimens, visual inspection, welding education, teaching aids, SMAW

Abstrak

Pemeriksaan visual adalah kemahiran penting dalam pendidikan kimpalan untuk memastikan kualiti kimpalan dan kebolehpercayaan struktur. Walau bagaimanapun, pelajar sering mempunyai pendedahan terhad kepada kecacatan kimpalan sebenar semasa sesi pembelajaran amali. Kajian ini membangunkan satu set spesimen kecacatan kimpalan untuk menyokong aktiviti pengajaran dan pembelajaran dalam pemeriksaan kimpalan visual. Spesimen tersebut telah difabrikasi menggunakan plat keluli lembut melalui proses Kimpalan Arka Logam Terlindung (SMAW) oleh pensyarah yang disahkan sebagai Jurukimpal yang Diluluskan CSWIP 3.0. Parameter kimpalan seperti arus, kelajuan perjalanan dan sudut elektrod sengaja diubah untuk menghasilkan kecacatan kimpalan biasa termasuk potongan terkecil, kemasukan sanga, keliangan, kekurangan gabungan dan penembusan yang tidak lengkap. Ketidaksempurnaan permukaan tambahan juga diperkenalkan untuk mensimulasikan

keadaan industri sebenar. Spesimen yang dibangunkan digunakan sebagai bahan bantu mengajar semasa sesi amali untuk membantu pelajar memerhati dan memahami ciri-ciri kecacatan kimpalan yang berbeza. Keputusan menunjukkan bahawa penggunaan spesimen kecacatan realistik meningkatkan pemahaman pelajar tentang kualiti kimpalan dan meningkatkan keupayaan mereka untuk mengenali kecacatan kimpalan semasa pemeriksaan visual. Spesimen ini menyediakan pendekatan pembelajaran praktikal yang merapatkan jurang antara pengetahuan teori dan amalan industri.

Kata kunci: *Kecacatan kimpalan, spesimen kecacatan kimpalan, pemeriksaan visual, pendidikan kimpalan, alat bantu mengajar, SMAW*

1.0 INTRODUCTION

Welding is a fundamental process in manufacturing, construction, and infrastructure industries, as it provides the structural integrity required for components such as bridges, pipelines, and machinery. The process joins metals through localized fusion, creating continuous and bonded joints capable of withstanding significant loads. However, the high temperatures and pressures involved during welding make the process susceptible to defects such as porosity, cracks, slag inclusions, and geometric irregularities. These defects can compromise weld quality, thereby affecting structural integrity and service life. Therefore, early and accurate detection of welding defects is essential to maintain safety standards, reduce costly rework, and ensure optimal performance.

In welding education, hands-on training materials play an important role in developing effective visual inspection skills. By incorporating realistic defect specimens into teaching and learning activities, students can observe and interact with different types of welding defects in a controlled environment. Such specimens help bridge the gap between theoretical knowledge and practical application, enabling students to gain a deeper understanding of weld quality and improve their ability to identify defects. Training using defect specimens has been shown to enhance inspection accuracy and increase students' confidence in identifying welding flaws. Despite the importance of visual inspection in weld quality control, structured and effective training programs remain limited. The availability of standardized defect specimens that accurately represent real-world flaws allows students to practice identifying defects, thereby strengthening their practical inspection skills.

In polytechnic institutions such as Politeknik Banting Selangor, the use of controlled defect specimens provides a systematic approach to hands-on training and helps prepare students to meet industry expectations. Furthermore, the use of physical prototypes as teaching aids has been found to enhance students' understanding of complex engineering concepts by encouraging active engagement and problem-solving (García Ramírez, 2025), while the early introduction of prototyping in learning activities can further improve comprehension and student engagement.

1.1 Problem Statement

In polytechnic education, welding is one of the core skills taught in engineering and technical programs, as it prepares students for professional roles that require a strong understanding of weld quality and inspection practices. One of the main challenges in teaching welding is enabling students to accurately assess weld quality by identifying defects such as porosity, slag inclusions, and undercuts. Although theoretical knowledge provides an essential foundation, practical exposure to realistic welding defect specimens is crucial to bridge the gap between classroom learning and industrial application.

However, access to welding defect specimens that replicate real-world flaws is often limited in training environments. Without these specimens, students may face difficulties in developing the observational skills necessary for effective visual inspection, which may affect their readiness for professional responsibilities in welding quality control. In addition, the lack of standardized defect specimens restricts students' exposure to various defect types, making it challenging to ensure consistent training and learning outcomes.

1.2 Research Objectives

The objectives of this study are to develop a comprehensive set of welding defect specimens for educational and training purposes, to facilitate effective visual welding inspection during teaching and learning activities, and to enhance students' familiarity with real industrial applications related to visual welding inspection.

1.3 Significance of Research

The developed specimens assist lecturers in delivering more effective and structured practical training during teaching and learning activities. By bridging the gap between theoretical knowledge and practical application, this research also supports the preparation of students with the necessary competencies required in the welding and manufacturing industries. Ultimately, the use of welding defect specimens can improve the quality of welding inspection training in technical education institutions.

2.0 LITERATURE REVIEW

Welding is one of the most widely used manufacturing processes in the fabrication of metallic structures and components. However, despite the advantages of welding in terms of cost, strength, and efficiency, it is often associated with defects that may compromise the mechanical integrity of joints. Welding defects can arise due to improper process parameters, operator error, environmental conditions, or poor joint preparation. These imperfections are categorized based on their location, type, and origin, and they can significantly affect the performance, service life, and safety of welded components. This literature review discusses common types of welding defects, their causes, consequences, and mitigation strategies, supported by findings

from recent scholarly and industrial publications. Figure 2.0 shows the ideal weld, serving as a reference for identifying and evaluating welding defects.

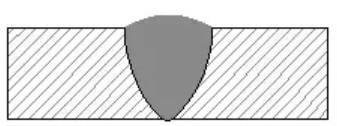


Figure 2.0: Ideal weld

2.1 Types of Welding Defects

Welding defects encompass a broad spectrum of issues that vary in cause, appearance, and severity. Some of the most common defects types include cracks, porosity, slag inclusions, and shape irregularities. All these geometric defects weaken the weld joint by creating stress concentrations and can also impede proper alignment between welded components.

2.1.1 Undercut

Undercut refers to a groove formed at the weld toe that reduces the cross-sectional thickness of the base metal as shown in Figure 2.1.1. It is commonly caused by excessive welding current, high travel speed, or improper electrode angle. Undercut can act as a stress concentrator, which may initiate fatigue cracks and reduce the fatigue strength of welded joints (Ikpe et al., 2023).

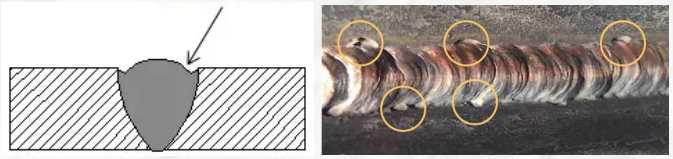


Figure 2.1.1: Undercut

2.1.2 Lack of Fusion

Lack of fusion occurs when the weld metal fails to fuse with the base metal or with the previous weld passes. This defect as shown in Figure 2.1.2 can create discontinuities and voids within the weld joint, which may significantly reduce the structural integrity of the welded component. Lack of fusion is commonly caused by inadequate heat input, contaminated joint surfaces, and improper electrode manipulation. Proper joint preparation, sufficient heat input, and appropriate welding techniques are essential to prevent this defect (Kah et al., 2015).

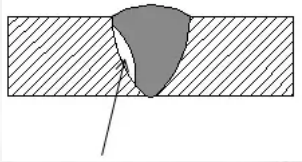


Figure 2.1.2: Lack of Fusion

2.1.3 Arc Strike

Arc strike is a localized area of the base metal that has been affected by the welding arc outside the intended weld zone. While not a structural defect, it can cause localized hardening and increased brittleness. Accidental arc initiation outside the weld area will cause the arc strike on

the metal. Welders need to use proper striking procedures and prevent unintentional electrode contact.



Figure 2.1.3: Arc Strike

2.1.4 Slag Inclusion

Slag inclusion occurs when non-metallic solid materials, typically from flux, are entrapped in the weld metal. These inclusions reduce ductility and corrosion resistance. Poor slag removal between passes and incorrect flux type will result in slag inclusion, as shown in Figure 2.1.4. As mentioned by Rizvia and Alib (2019), slag inclusion often results from improper slag removal and can be mitigated through adequate interpass cleaning. Best practices include cleaning weld surfaces and maintaining appropriate welding techniques.

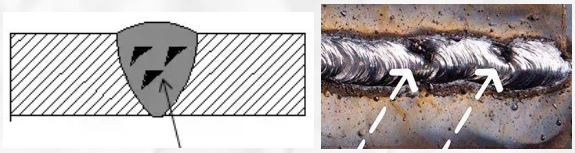


Figure 2.1.4: Slag Inclusion

2.1.5 Cluster Porosity and Single Pores

Porosity refers to gas pockets trapped in the solidifying weld metal as shown in Figure 2.1.5. Cluster porosity involves a localized group of pores, while single pores are isolated defects. Some causes are contaminants, damp electrodes and poor shielding. It is important to clean base materials, use dry electrodes and improve gas coverage.

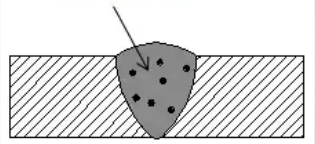


Figure 2.1.5: Porosity

2.1.6 Incomplete Fill/Underfill

Incomplete fill occurs when the weld metal fails to completely fill the joint groove. It reduces the effective throat thickness and thereby compromises strength. It is always caused by inadequate deposition rate or poor joint preparation but can be avoided by adjusting the welding current and electrode size, to ensure groove accuracy.

2.1.7 Spatter

Spatter consists of small droplets of molten metal expelled during welding as shown in Figure 2.1.7, which may adhere to the base material and cause surface imperfections. The cause of spatter are excessive current, long arc and incorrect polarity. It can be avoided by using fine-tune parameters or applying anti-spatter agents.

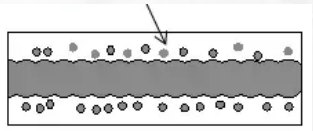


Figure 2.1.7: Spatter

2.1.8 Incomplete Penetration

Incomplete penetration happens when the weld metal does not fully penetrate the joint thickness as shown in Figure 2.1.8. In other words, the weld doesn't go deep enough to fuse the base metals completely along the joint root. There will be a gap or void at the root of the weld. The cause is insufficient welding current, the groove not deep or wide enough and improper welding technique. To prevent it, use the right welding parameters, prepare the joint correctly and select the proper electrode.

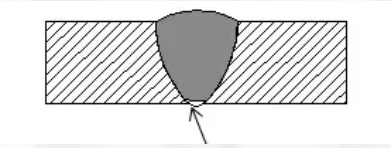


Figure 2.1.8: Incomplete Penetration

2.1.9 Mechanical Damage

Mechanical damage refers to post-weld deformations or abrasions due to improper handling, grinding, or impact. The most happen because of handling errors and excessive finishing operations. The best way is to use controlled finishing methods and protect weld zones.

3.0 RESEARCH METHODOLOGY

The research methodology of this study focused on the development of welding defect specimens to support visual inspection learning. The specimens were fabricated using mild steel plates through the Shielded Metal Arc Welding (SMAW) process, where welding parameters such as current, travel speed, and electrode angle were intentionally varied to produce common welding defects including undercut, porosity, slag inclusion, lack of fusion, and incomplete penetration. Additional surface imperfections were also introduced to simulate real industrial conditions. The fabricated specimens were then used as teaching aids during practical sessions to help students observe and understand the characteristics of different welding defects during visual inspection.

3.1 Fabrication of Welding Defects Specimens

The welding defect specimens were fabricated in a controlled workshop environment using mild steel plates measuring 200 mm × 250 mm × 10 mm to replicate typical welding practice materials. The fabrication process was carried out by a lecturer certified as a CSWIP 3.0 Approved Welder to ensure authenticity and compliance with industry standards. Prior to welding, the base plates were cleaned using a handheld angle grinder to remove surface oxides and contaminants. The Shielded Metal Arc Welding (SMAW) process was used, with intentional variations in welding parameters such as current, voltage, travel speed, and electrode angle to produce common defects including undercut, slag inclusion, and lack of

fusion. Mechanical damage was also simulated using hand tools such as a hammer and chisel to create imperfections like grinder marks, chisel marks, and peening marks. All procedures were conducted following strict safety practices with the use of personal protective equipment (PPE). The completed specimens were then cleaned and used as teaching aids to enhance users' visual inspection skills.



Figure 3.1a: Fabrication of welding defects



Figure 3.1b: Fabrication of mechanical damage

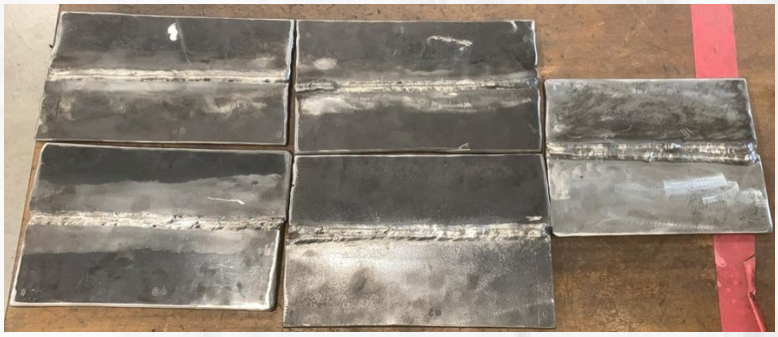


Figure 3.1c: Welding defect specimens

3.2 Research Design

This study adopted a quantitative research approach using a questionnaire survey to collect feedback from the participants. The respondents involved in this study consisted of 48 participants, which included 28 students from a welding practical class as shown in Figure 3.2a and 20 lecturers who participated in the *Program Pembangunan Kompetensi* (PPK) as shown in Figure 3.2b. The questionnaire was designed using a five-point Likert scale, ranging from 1

(Strongly Disagree) to 5 (Strongly Agree), to measure participants' perceptions of the effectiveness of the welding defect specimens. The collected data were analysed using descriptive statistics, such as mean and percentage values, to interpret the responses.

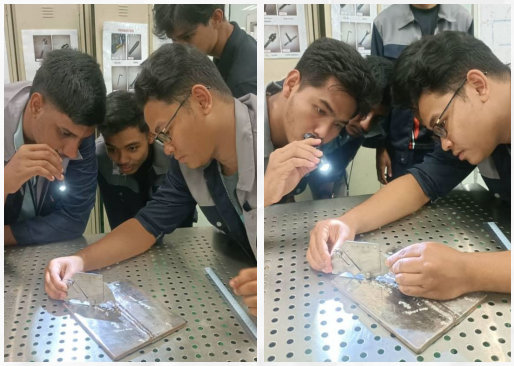


Figure 3.2a: Teaching and learning activities



Figure 3.2b: *Program Pembangunan Kompetensi* (PPK)

3.3 Research Instrument

A structured questionnaire was developed to evaluate students' perceptions of the effectiveness of the welding defect specimens as a teaching aid. The instrument consisted of ten items focusing on key aspects such as students' understanding of welding defects, visual inspection skills, learning engagement, and the ability to relate theory to practical applications. All items were measured using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The questionnaire was designed to ensure clarity and relevance to the learning outcomes of welding inspection.

3.4 Data Analysis

The collected data were analysed using descriptive statistics, specifically mean scores, to determine the overall trend of students' perceptions. In this study, mean scores were used as the main indicator to summarise the overall responses for each item. This approach allows us to easily identify general trends and patterns in getting feedback. To ensure that the results could be interpreted clearly, the mean scores were grouped into three levels as shown in Table 3.4. This classification helps in translating numerical values into meaningful insights, making it easier to explain the overall effectiveness of the teaching aid. The analysis focused on identifying how students responded to different aspects of the welding defect specimens,

including their understanding of welding defects, ability to visually identify defects, level of engagement during learning, and their confidence in applying the knowledge in practical situations. By examining the mean values for each item, the study is able to highlight which aspects of the teaching aid were most effective and which areas may still require improvement.

Table 3.4: Interpretation of Mean Scores

Range	Level
1.00 – 2.33	Low
2.34 – 3.66	Moderate
3.67 – 5.00	High

4.0 RESEARCH FINDINGS

The research findings present the outcomes of the development and implementation of the welding defect specimens used during teaching and learning activities. The findings focus on how the developed specimens support participants' understanding of different welding defects and their application in visual welding inspection.

Table 4.0: Distribution of Respondents by Participant Category

Category	N	Percentage (%)
Students (Welding Practical Class)	28	58.3
Lecturers (PPK course)	20	41.7
Total	48	100

Table 4.0 shows that 28 respondents (58.3%) were students from the welding practical class, while 20 respondents (41.7%) were lecturers who participated in the PPK. The involvement of both students and lecturers provided a broader perspective on the effectiveness of the developed welding defect specimens as a teaching and learning aid.

4.1 Descriptive Statistics

Based on the results presented in Table 4.1, all questionnaire items recorded mean scores above 4.00, which fall under the high interpretation category. This indicates that the respondents had a positive perception of the developed welding defect specimens as a teaching and learning aid. The highest mean score was recorded for Item 1 (Mean = 4.42), indicating that the respondents strongly agreed that the welding defect specimens help to clearly identify different types of welding defects. In addition, Item 9 (Mean = 4.38) also showed a high score, suggesting that teaching aid supports active learning and discussion during class. Overall, the findings suggest that the developed welding defect specimens are effective in supporting teaching and learning activities, particularly in helping students and lecturers better understand and identify welding defects during visual inspection.

Table 4.1: Mean Score for Each Questionnaire Item

Item	Statement	Mean	Interpretation
1.	The welding defect specimens help me clearly identify different types of welding defects.	4.42	High
2.	The physical specimens improve my understanding compared to learning from slides or textbooks alone.	4.35	High
3.	The teaching aid makes it easier to differentiate between various welding defects (e.g., porosity, crack, undercut, incomplete penetration).	4.27	High
4.	The specimens increase my interest in learning welding inspection and quality control.	4.31	High
5.	The use of the welding defect specimens enhances my practical understanding of welding theory.	4.21	High
6.	The teaching aid helps me connect classroom knowledge with real industrial applications.	4.21	High
7.	The specimens improve my confidence in identifying welding defects during practical sessions.	4.10	High
8.	The visual and physical features of the defect specimens are clear and easy to observe.	4.17	High
9.	The teaching aid supports active learning and discussion during class.	4.38	High
10.	Overall, the welding defect specimens are effective as a teaching and learning tool.	4.23	High

5.0 DISCUSSION

The findings of this study show that the use of welding defect specimens significantly enhanced students' visual inspection skills. By interacting directly with the specimens, students were able to observe and analyze common welding defects such as porosity, slag inclusion, undercut, and lack of fusion in a controlled learning environment. This hands-on approach allowed students to connect theoretical knowledge with practical inspection tasks, deepening their understanding of weld quality and defect characteristics. Moreover, engaging with realistic specimens helped students develop critical observation skills and provided a more immersive and effective learning experience that closely mirrors real industrial conditions.

6.0 CONCLUSION

This study successfully developed a set of welding defect specimens to support teaching and learning activities in welding inspection. The results indicate that the use of these specimens improved students' ability to identify welding defects during visual inspection. Overall, the

developed defect specimens serve as effective teaching aids that help enhance students' understanding and practical skills, while also preparing them for real industrial welding inspection practices.

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DEVELOPMENT OF A SMART DELIVERY COLLECTION SYSTEM FOR RESIDENTIAL HOUSING

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Abstract

The rapid growth of online shopping has resulted in an increasing number of parcel deliveries to apartments and condominiums, creating challenges such as missed deliveries, misplaced parcels, and lack of secure storage when residents are unavailable. To address these issues, this study developed a smart delivery collection system designed specifically for multi-unit residential areas. The final product is a smart locker system integrated with user identification, automated compartment allocation, and notification features to ensure secure and accurate parcel delivery. Findings from system testing and user feedback indicate that the system significantly improves parcel management efficiency, reduces the risk of lost items, and enhances user convenience by enabling 24/7 access. The system showed high performance, with IR sensors and RFID achieving 100% success, while SMS notifications reached 90%, indicating overall reliable and effective functionality. The impact of this system includes improved security, better organization of deliveries, and increased reliability for both residents and delivery personnel. In conclusion, the smart delivery collection system provides an effective and practical solution to modern parcel management problems in residential communities.

Keywords: smart delivery system, parcel management, apartment and condominium, residential delivery, Internet of Things (IoT).

Abstrak

Pertumbuhan pesat pembelian dalam talian telah mengakibatkan peningkatan bilangan penghantaran bungkusan ke pangsapuri dan kondominium, menimbulkan cabaran seperti penghantaran terlepas, bungkusan tersalah letak, dan kekurangan tempat penyimpanan selamat apabila penghuni tidak hadir. Untuk menangani isu ini, kajian ini membangunkan sistem pengumpulan penghantaran pintar yang direka khas untuk kawasan kediaman berbilang unit. Produk akhir ialah sistem loker pintar yang diintegrasikan dengan pengenalan pengguna, pengagihan kompartmen automatik, dan ciri pemberitahuan untuk memastikan penghantaran bungkusan yang selamat dan tepat. Penemuan daripada ujian sistem dan maklum balas pengguna menunjukkan bahawa sistem ini meningkatkan kecekapan pengurusan bungkusan dengan ketara, mengurangkan risiko kehilangan barang, dan meningkatkan kemudahan pengguna dengan membenarkan akses 24/7. Sistem menunjukkan prestasi tinggi, dengan sensor IR dan RFID mencapai kejayaan 100%, manakala notifikasi SMS mencapai

90%, menunjukkan fungsi keseluruhan yang boleh dipercayai dan berkesan. Impak sistem ini termasuk peningkatan keselamatan, pengurusan penghantaran yang lebih baik, dan kebolehpercayaan yang meningkat untuk kedua-dua penghuni dan kakitangan penghantaran. Kesimpulannya, sistem pengumpulan penghantaran pintar menyediakan penyelesaian yang berkesan dan praktikal terhadap masalah pengurusan bungkusan moden di komuniti kediaman.

***Kata kunci**: sistem penghantaran pintar, pengurusan bungkusan, pangsapuri dan kondominium, penghantaran kediaman, Internet of Things (IoT).*

1.0 INTRODUCTION

The rapid expansion of e-commerce has significantly transformed the way consumers purchase goods. Online shopping platforms have become increasingly popular due to their convenience, accessibility, and wide range of product offerings. As a result, the number of parcel deliveries to residential areas has grown substantially in recent years. In high-density residential environments such as apartments and condominiums, parcel management has become a significant challenge. Delivery personnel often face difficulties when residents are not available to receive their packages. This situation may result in missed deliveries, parcels being left unattended, or items being misplaced. In some cases, parcels may also be exposed to security risks such as theft or damage. Traditional parcel management systems are often inefficient in handling the increasing volume of deliveries in residential buildings. Many buildings rely on manual handling by security guards or building management, which can lead to organizational issues and delays in parcel collection.

To address these challenges, smart delivery solutions have been introduced in recent years. Smart parcel lockers and automated delivery systems provide secure storage and allow residents to collect their parcels at any convenient time. These systems can significantly improve parcel management efficiency and enhance user satisfaction. Therefore, this study focuses on the development of a smart delivery collection system designed specifically for apartment and condominium residential areas. The system aims to improve the organization, security, and efficiency of parcel delivery management.

1.1 Problem Statement

The increase in online shopping activities has created new challenges in parcel delivery management, particularly in residential buildings such as apartments and condominiums. One of the main issues is missing deliveries when residents are not at home to receive their parcels. Delivery personnel may have to return multiple times, which increases operational costs and delays. Another issue is the lack of security storage for parcels. In many cases, packages are left at building entrances, security counters, or outside residential units. This practice increases the risk of parcels being lost, damaged, or stolen.

Additionally, manual parcel management by building staff can lead to misplacement or confusion in parcel distribution. With a growing number of deliveries, traditional systems are becoming increasingly inefficient. These problems highlight the need for a more organized and secure parcel collection system that can handle the increasing demand for residential deliveries.

1.2 Research Objectives

Designing a smart delivery collection system for apartment and condominium residential area.

1.3 Significant of Research

This research is significant because it addresses the growing challenges associated with parcel delivery management in high-density residential areas for apartments and condominiums. With the increasing popularity of online shopping and home delivery services, residential buildings are experiencing a higher volume of parcel deliveries, which often leads to issues such as missed deliveries, misplaced parcels, and security concerns. The development of a smart delivery collection system provides an effective solution to these problems by offering a more organized and secure method for managing parcel storage and retrieval at MH Platinum 2 Setapak.

The study also contributes to improving the efficiency of parcel management within residential communities. By introducing a system that incorporates digital identification, compartment allocation, and notification mechanisms, the proposed solution helps ensure that parcels are delivered to the correct recipients while reducing the risk of loss or misplacement. In addition, the research benefits residents by providing a convenient way to collect parcels at any time without relying on building management or security personnel. This flexibility enhances user satisfaction and improves the overall delivery experience.

Furthermore, this study contributes to the field of smart residential technologies by demonstrating how digital systems can be applied to solve practical problems in modern housing environments. The findings of this research may also assist developers, property managers, and policymakers in adopting innovative parcel management solutions in residential buildings. Overall, the development of the smart delivery collection system provides a practical and scalable solution that enhances parcel security, improves delivery efficiency and supports the evolving needs of apartment and condominium communities.

2.0 LITERATURE REVIEW

The growth of e-commerce has significantly increased parcel delivery volumes worldwide. According to Chen F. (2025), technological advancements play a crucial role in improving system efficiency and user accessibility. However, residential buildings remain one of the most challenging environments for parcel delivery due to limited storage space and varying resident availability. To address these challenges, smart parcel locker systems have been introduced, allowing delivery personnel to store parcels securely while enabling recipients to access them using authentication methods such as QR codes, PIN numbers, or mobile applications.

Previous studies have shown that smart delivery systems can improve delivery efficiency, reduce failed deliveries, and enhance user convenience. Research by Deng L. and Yang X. (2025) further supports that digital systems enhance efficiency and user engagement, which can be applied to smart delivery solutions. In addition, automated parcel management systems help reduce the workload of building management and security staff, while digital notification systems such as SMS and mobile applications provide real-time updates to users for parcel collection.

Despite these advantages, many existing market systems are complex and costly, as they rely on advanced features such as cloud integration, real-time tracking, and multi-factor authentication. In contrast, the Smart Delivery Collection System developed in this project focuses on simplicity and affordability while maintaining reliable performance, with 100% success in RFID authentication and parcel detection, and 90% success in SMS notifications. Therefore, there is a need to develop customized and cost-effective smart delivery solutions that address the specific requirements of residential housing, particularly for small-scale implementations such as apartments and condominiums.

3.0 RESEARCH METHODOLOGY

This research followed four phases to develop a secure and efficient parcel management system. It began with requirement analysis to identify system limitations and define user needs, objectives, and requirements. System design planned hardware and software architecture, including microcontroller, RFID, GSM, and sensors. In development and implementation, components were integrated, programmed, and tested for reliability, access control, and notifications. Finally, the system was deployed and maintained, with ongoing monitoring and updates to ensure long-term efficiency, security, and sustainability. The research process consisted of four main phases:

i. **Requirement Analysis**
   The first phase is **requirement analysis**, where the existing problems and limitations of the current parcel management system are identified. In this phase, user needs, system requirements, and research objectives are analyzed to ensure that the proposed system addresses issues such as parcel security, accessibility, and delivery efficiency.

ii. **System Design**
   The second phase is **system design**, which involves planning the overall framework of the proposed system. This includes the design of hardware components such as the microcontroller, RFID scanner, GSM module, magnetic lock, and sensors, as well as the software architecture and data flow required for system operation.

iii. **Development and Implementation**
   The third phase is development and implementation, where the actual system is constructed by integrating both hardware and software components. The Arduino microcontroller is programmed to manage system operations, while modules such as RFID, GSM, relay, and IR sensors are connected and configured to perform their respective functions. Next, testing and validation are carried out to evaluate the

performance and functionality of the developed system. This phase ensures that the system operates accurately, reliably, and meets the required objectives and performance standards. Several tests are conducted to verify component integration, response time, access control, and notification functions.

iv. Deployment and maintenance

Finally, the system proceeds to the deployment and maintenance phase, where it is implemented for real-world usage. Continuous monitoring, updates, and improvements are performed to maintain long-term efficiency, reliability, and system sustainability.

3.1 Research Design

This study employed a product development research design to design, develop, and evaluate a smart delivery collection system for residential housing, particularly in apartments and condominiums. The research design focuses on creating a functional prototype and assessing its usability and effectiveness in improving parcel management. The study was conducted in several stages. The first stage involved identifying the problem related to parcel delivery management in residential buildings. Information was gathered through preliminary observations and a review of existing delivery practices in apartment and condominium environments. This stage helped determine the key features required for the proposed system.



Figure 1: Sketch of Smart Delivery Collection System

The second stage involved the system design and development process. Based on the identified requirements, the smart delivery collection system was designed to include features such as user identification, automated compartment allocation, and parcel notification mechanisms. A prototype of the system was then developed to demonstrate how parcels can be securely stored and retrieved by residents.

The third stage involved usability testing and evaluation of the developed system. A group of respondents was selected to test the functionality and convenience of the system. Data were collected through a structured questionnaire to evaluate user satisfaction, system efficiency, and ease of use.

The collected data were analyzed using descriptive statistical methods, such as frequency, percentage, and mean scores, to determine the effectiveness of the smart delivery collection

system. The results of the analysis were used to assess whether the system successfully improves parcel management in residential environments.

Overall, the research design allowed the researchers to systematically develop and evaluate a practical smart delivery solution that addresses the challenges of parcel management in apartment and condominium residential areas.

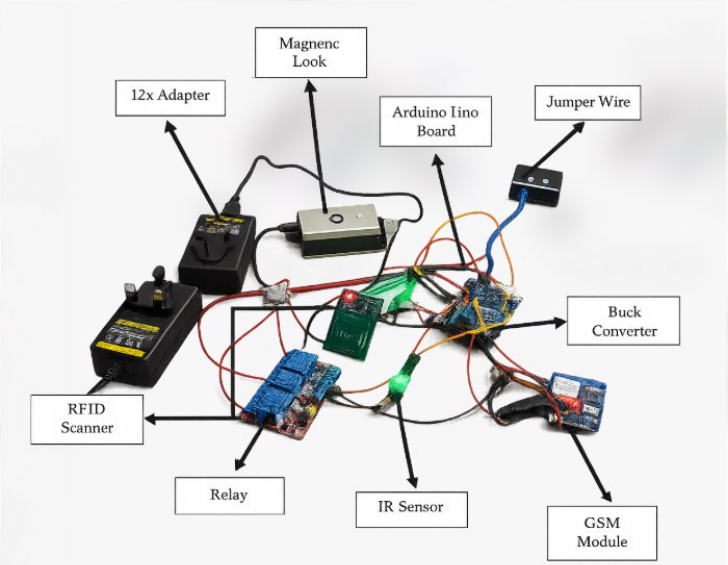


Figure 2: Components of Smart Delivery Collection System

4.0 RESEARCH FINDINGS

The results of the usability testing indicate that the smart delivery collection system provides several benefits in managing residential parcel deliveries. Firstly, the system significantly improves the organization of parcel storage. Each parcel is placed in a designated compartment, reducing confusion and misplacement. Secondly, the system enhances security by ensuring that parcels are stored in locked compartments that can only be accessed by the intended recipient. Thirdly, the notification mechanism allows residents to receive alerts when their parcels arrive, enabling them to retrieve items at their convenience. Overall, participants reported a high level of satisfaction with the system. The ability to collect parcels at any time was identified as one of the most valuable features.

This section presents the findings obtained from the development and testing of the Smart Delivery Collection System. The system was evaluated based on its functionality in detecting items, sending notifications, and allowing secure access to users.

1. The IR sensors installed in both parcel and letter compartments were able to successfully detect the presence of items and letters. Upon detection, the system triggered an SMS notification to the registered user.

2. The SMS notification system functioned effectively, providing real-time alerts to users when a parcel or letter was delivered into the pigeonhole.
3. Users were able to send SMS commands such as “OPEN” to unlock the pigeonhole. The system accurately interpreted and executed the command.
4. The “CLOSE” command was successfully implemented, allowing users to lock the pigeonhole after placing or retrieving items.
5. The system provided dual access methods, where users could open the pigeonhole using either SMS commands or an RFID card, increasing flexibility and convenience.
6. RFID authentication worked reliably, as only registered RFID cards were able to unlock the pigeonhole, ensuring system security.

4.1 Simulation Result

Simulation and testing were conducted to evaluate the system performance under different conditions. The results are discussed based on key system attributes.

- **Security**
  The simulation results showed that the system effectively restricts access to authorized users only. RFID authentication allowed access only to registered cards, while SMS commands were accepted only from predefined phone numbers. Unauthorized attempts were successfully blocked.
- **Reliability**
  The system demonstrated high reliability during testing, as it consistently responded to sensor inputs and user commands without failure. However, SMS functionality depended on the availability of mobile network service and sufficient user credit, which may slightly affect reliability in certain situations.
- **Performance**
  The GSM module performed efficiently in sending and receiving SMS notifications. The response time was observed to be fast under stable network conditions. However, delays may occur in areas with weak signal coverage.
- **Maintainability**
  Simulation results indicated that the system is easy to maintain and modify. Changes such as updating authorized phone numbers or RFID cards can be implemented through the Arduino IDE without requiring major system redesign.
- **Usability**
  The system was found to be user-friendly and suitable for residential environments such as apartments and condominiums. The contactless delivery feature enhances convenience and safety, especially in situations requiring minimal physical interaction.

4.2 Simulation Results (Quantitative Analysis)

The system performance was evaluated through multiple test scenarios to measure accuracy, response time, and reliability.

4.2.1 System Functional Performance

The results in Table 1.1 show that the system achieved a high level of functional performance. The IR sensors and RFID authentication recorded a perfect success rate of 100%, indicating reliable detection and secure access. SMS-related functions showed slightly lower success rates, with SMS notification achieving 90%, likely due to network-related factors. Overall, the system demonstrates strong reliability and effectiveness in performing its intended functions.

Table 1.1: System Functional Performance

No.	Function Tested	Total Tests	Successful Tests	Success Rate (%)
1	IR Sensor Detection (Parcel)	20	20	100%
2	IR Sensor Detection (Letter)	20	19	95%
3	SMS Notification Sending	20	18	90%
4	SMS Command “OPEN” Execution	20	19	95%
5	SMS Command “CLOSE” Execution	20	19	95%
6	RFID Authentication Access	20	20	100%

4.2.2 System Response Time

Table 1.2 shows the average response time of the system for different functions. The results indicate that the system performs efficiently, with most operations completed within a short time. RFID card detection recorded the fastest response time at 1.0 seconds, followed closely by IR sensor detection at 1.2 seconds, demonstrating quick system reaction to physical inputs. SMS command processing took slightly longer, with an average response time of 3.8 seconds, as it involves communication between the user and the system through the GSM network. The longest response time was observed in SMS notification delivery at 4.5 seconds, which is expected due to network transmission delays. Overall, the response times are within an acceptable range, indicating that the system is responsive and suitable for real-time usage in residential parcel management.

Table 1.2: System Response Time

No.	Function Tested	Average Response Time (seconds)
1	IR Sensor Detection	1.2 s
2	SMS Notification Delivery	4.5 s
3	SMS Command Processing	3.8 s
4	RFID Card Detection	1.0 s

4.2.3 Reliability Testing

Table 1.3 shows the reliability testing under different conditions shows that the system’s performance is highly dependent on GSM signal strength. Under strong GSM signal conditions, the system achieved a 100% success rate with all 15 tests completed successfully and no delays observed, indicating optimal performance. In moderate signal conditions, the

success rate slightly decreased to 93%, with minor delays in SMS delivery, but the system still maintained a high level of reliability. However, under weak GSM signal conditions, the success rate dropped to 80%, and noticeable delays in SMS communication were observed. This indicates that while the system remains functional in weaker network conditions, its efficiency and responsiveness are affected. Overall, the results demonstrate that the system performs reliably under normal conditions but is influenced by network stability.

Table 1.3: Reliability Testing Under Different Conditions

Condition	Tests Conducted	Successful	Success Rate (%)	Remarks
Strong GSM Signal	15	15	100%	No delay
Moderate GSM Signal	15	14	93%	Minor delay in SMS
Weak GSM Signal	15	12	80%	Noticeable delay in SMS

4.3 Research Support for Smart Parcel as IoT Solutions

Researchers such as Yuk Ming Tang and colleagues (2021) found that smart parcel lockers are an effective Internet of Things (IoT) solution because they provide convenience, reliability, and 24/7 accessibility, allowing users to collect parcels at any time without relying on delivery personnel; these features significantly improve user satisfaction by reducing issues such as missed deliveries and lost parcels, while also enhancing the efficiency of the last-mile delivery system in e-commerce, demonstrating that smart parcel lockers are a beneficial and practical IoT application.

4.0 RESEARCH DISCUSSION

The findings of this study demonstrate that smart delivery collection systems can effectively address many challenges in residential parcel management. The integration of digital identification and compartment allocation enhances the accuracy of parcel distribution, while the notification system ensures residents are informed immediately upon delivery. Compared to traditional methods, the smart system reduces reliance on manual handling, minimizes the risk of lost or misplaced parcels, and provides greater convenience for residents and improved operational efficiency for delivery services and building management.

These results align with previous research showing that smart parcel locker systems improve delivery efficiency, reduce failed deliveries, and enhance user engagement through digital authentication and notifications (Chen, 2025; Deng & Yang, 2025). Importantly, while many commercial systems are complex and costly, the Smart Delivery Collection System developed in this study demonstrates a simpler, cost-effective approach, achieving reliable RFID authentication, parcel detection, and SMS notifications. This highlights the potential for customized, affordable smart delivery solutions that meet the specific needs of residential environments, particularly in small-scale settings such as apartments and condominiums.

6.0 CONCLUSION

This study successfully developed a smart delivery collection system tailored for apartment and condominium settings, offering a secure, efficient, and organized approach to managing parcel deliveries. By integrating features such as user identification, compartment allocation, and automated notifications, the system not only streamlines the delivery process but also significantly enhances user convenience and satisfaction. The findings demonstrate that the system effectively minimizes parcel misplacement and improves the overall collection experience for residents, while providing a practical, scalable solution for residential property management.

Future research could explore the incorporation of mobile applications, advanced multi-factor authentication, or IoT-enabled monitoring systems to further expand the system's functionality, enabling real-time tracking, predictive analytics, and adaptive optimization to meet the evolving demands of smart urban logistics.

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TRANSFORMASI PEMBELAJARAN ANGGARAN KOS BANGUNAN MELALUI INOVASI PDP BERASASKAN *BLENDED LEARNING*

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Abstrak

Dalam usaha memastikan kurikulum Kolej Komuniti sentiasa terkini dan seiring dengan perkembangan industri, penambahbaikan berterusan merupakan aspek penting dalam meningkatkan kualiti pembelajaran dan pembelajaran (PdP) termasuklah membangunkan alat bantu mengajar yang inovatif berunsurkan *blended learning*. Kajian ini dijalankan bagi pembangunan produk mengguna pakai reka bentuk pengajaran model ADDIE, yang melibatkan lima fasa iaitu analisis, reka bentuk, pembangunan, pelaksanaan dan penilaian. Reka bentuk kajian ini adalah melibatkan penyelidikan dan pembangunan yang berbentuk penyelidikan kuantitatif menggunakan soal selidik sebagai instrumen kajian, dimana pelajar dipilih secara persampelan bertujuan bagi mengenal pasti penerimaan pelajar terhadap penggunaan inovasi PdP ini. Hasil dapatan menunjukkan majoriti pelajar sangat bersetuju bahawa aplikasi ini mudah digunakan dan membantu dalam aktiviti amali. Kesimpulannya, pembangunan produk inovasi PdP berasaskan *blended learning* terbukti memberi impak positif terhadap pengalaman pembelajaran pelajar di kolej komuniti, terutama ketika sesi pelaksanaan amali. Kajian ini menekankan kepentingan inovasi pembelajaran berasaskan teknologi dalam memperkukuh kemahiran praktikal, meningkatkan motivasi, dan mencadangkan model pembelajaran yang boleh diguna pakai secara meluas untuk mempertingkat kualiti PdP di peringkat kolej komuniti dan institusi lain yang menawarkan kursus Anggaran Kos Bangunan.

Kata kunci: inovasi PdP, *blended learning*, Anggaran Kos Bangunan

Abstract

Continuous improvement is a very important aspect of quality improvement in teaching and learning (T&L) in order to make sure that Kolej Komuniti curricula is up to date and in line with the progress of the industry. This involves creating new teaching resources based on blended learning practices. This paper explains how to develop a product based on the ADDIE instructional design model that consists of five different steps such as analysis, design, development, implementation, and evaluation. The study design is based on a Research and Development (R&D) approach, which uses quantitative methods. The questionnaire was used as the main research tool whereby, students were sampled through purposive sampling to determine the level of acceptance of this T&L innovation. The results show that most students strongly believe that the application is easy to use, and it greatly aids practical sessions. To

sum up, innovation in blended learning-based T&L has shown to have a positive effect on the student learning experience in the Kolej Komuniti especially in the practical sessions. This paper highlights the significance of innovation in pedagogical methods that are technology-based to enhance practical skills and motivation. Moreover, it suggests a learning model that can be embraced by many stakeholders to improve the quality of T&L in Kolej Komuniti and other institutions providing Building Cost Estimation courses.

Keywords: *T&L innovation, blended learning, Building Cost Estimation.*

1.0 PENGENALAN

Penggunaan teknologi dalam ekosistem pendidikan tinggi kini bukan lagi satu alternatif, malah menjadi keperluan mendesak untuk memastikan kurikulum semasa kekal relevan dan efisien. Berdasarkan kajian Neeroshan & Mohd Erfy Ismail, 2025, cabaran utama dalam bidang TVET di Malaysia ialah kurikulum yang tidak relevan. Kolej Komuniti, sebagai salah satu institusi peneraju dalam Pendidikan dan Latihan Teknikal dan Vokasional (TVET), memikul tanggungjawab besar untuk menawarkan kaedah PdP yang lebih dinamik dan fleksibel. Transformasi melalui pendekatan *blended learning*, iaitu gabungan pembelajaran konvensional dan digital, dilihat lebih efektif dalam merangsang minat pelajar generasi Z yang cenderung kepada teknologi. Kursus Anggaran Kos Bangunan di bawah program Sijil Penyelenggaraan Bangunan merupakan subjek berasaskan pengiraan berprosedur, yang memerlukan ketelitian tinggi, terutama bagi topik pengukuran kuantiti dan kadar bina harga.

Walau bagaimanapun, ketiadaan modul interaktif sebelum ini menyebabkan pelajar sering menghadapi kesukaran untuk menguasai topik ini disebabkan mereka perlu merujuk kepada pelbagai dokumen sebelum membuat pengiraan. Keadaan ini diburukkan lagi dengan kaedah kuliah yang statik yang mengakibatkan pelajar menjadi hilang fokus, cepat berasa jemu, dan akhirnya menjejaskan pencapaian amali mereka. Disinilah tenaga pengajar memainkan peranan yang sangat signifikan dalam menyesuaikan strategi pengajaran bagi menyantuni kepelbagaian gaya pembelajaran pelajar secara lebih efektif (Muhammad Ehsan Kamba & Saturia Amiruddin, 2025). Sehubungan itu, inovasi TOQ+ dibangunkan untuk merapatkan jurang kemahiran digital dan kemahiran numerasi dalam kalangan pelajar Sijil Penyelenggaraan Bangunan. Walaupun pembelajaran digital berkembang pesat, aplikasinya dalam bidang teknikal masih perlu diperkasakan agar selari dengan perkembangan teknologi semasa. Melalui pembangunan aplikasi mudah alih TOQ+ ini, diharapkan PdP Anggaran Kos Bangunan dapat ditransformasikan daripada pendekatan konvensional kepada satu bentuk pembelajaran yang lebih progresif dan efisien.

1.1 Penyataan Masalah

Peningkatan automasi dan evolusi teknologi digital hari ini boleh menyebabkan peluang pekerjaan yang sukar buat individu yang gagal menguasai kemahiran digital berbanding kemahiran konvensional (Rangka Tindakan Ekonomi Digital Malaysia, 2021). Cabaran ini

menyebabkan tenaga pengajar di Politeknik dan Kolej Komuniti turut terkesan dan dituntut untuk menerapkan amalan digitalisasi dan AI secara holistik supaya bidang TVET dapat diperhebat (Rancangan Pendidikan Negara 2026 – 2035).

Namun begitu, penyampaian sesi amali bagi kursus Anggaran Kos Bangunan di Kolej Komuniti pada masa kini masih banyak bergantung kepada demonstrasi secara bersemuka dan rujukan manual bercetak yang bersifat statik. Kaedah konvensional ini sering menimbulkan masalah apabila bilangan pelajar yang ramai menyukarkan mereka untuk melihat demonstrasi pensyarah dengan jelas, selain rujukan manual yang banyak menyebabkan cara pengiraan sukar difahami secara visual. Akibatnya, pelajar sering melakukan kesilapan teknikal berulang, yang bukan sahaja melambatkan proses pembelajaran malah meningkatkan pembaziran bahan amali serta menyebabkan penilaian individu menjadi rendah.

Ketiadaan platform digital yang fleksibel turut menyebabkan pelajar sukar untuk membuat persediaan awal sebelum menghadiri kelas atau melakukan rujukan pantas semasa sesi praktikal berlangsung. Jurang antara teori dan amali ini menjadi lebih ketara apabila sebilangan pelajar hilang fokus dan tidak termotivasi kerana tidak dapat mengikuti rentak PdP yang pantas. Oleh itu, satu inovasi alat bantu mengajar berasaskan *blended learning* sangat diperlukan bagi menyediakan kandungan interaktif yang boleh diakses tanpa had masa dan lokasi, sekaligus memastikan kemahiran praktikal pelajar dapat ditingkatkan dengan lebih efektif.

1.2 Objektif Kajian

Objektif kajian ini adalah:

a) Membangunkan aplikasi mudah alih TOQ+ sebagai alat bantu mengajar bagi kursus Anggaran Kos Bangunan.
b) Mengenal pasti tahap penerimaan pelajar terhadap penggunaan inovasi PdP tersebut dalam proses pembelajaran.

1.3 Kepentingan Kajian

Kajian ini diharapkan dapat memberi sumbangan yang signifikan kepada pelbagai pihak berkepentingan dalam landskap pendidikan TVET seperti berikut:

1.3.1 Pelajar

Inovasi ini menyediakan platform pembelajaran yang lebih fleksibel melalui elemen *blended learning*. Pelajar dapat mengakses dokumen berkaitan topik dan contoh amali secara berulang kali menerusi platform percuma, yang seterusnya membantu meningkatkan kefahaman konsep pengiraan sistematik yang kompleks. Selain itu, penggunaan gajet dalam PdP mampu meningkatkan motivasi dan fokus pelajar untuk terlibat aktif dalam aktiviti amali dalam kelas.

1.3.2 Tenaga Pengajar

Kajian ini membekalkan pensyarah dengan satu alat bantu mengajar (ABM) yang sistematik untuk memudahkan proses penyampaian ilmu. Dengan adanya inovasi ini, beban tugasan

untuk melakukan demonstrasi secara berulang-ulang dapat dikurangkan, membolehkan pensyarah memfokuskan peranan mereka sebagai fasilitator dan memberikan perhatian lebih kepada pelajar yang memerlukan bimbingan khusus. Ia juga bertindak sebagai pemangkin kepada pensyarah untuk terus membudayakan inovasi digital dalam pengajaran.

1.3.3 Institusi TVET

Dapatan kajian ini menyokong usaha Kolej Komuniti dalam memperkasakan kurikulum yang relevan dengan arus pendigitalan pendidikan. Kejayaan pembangunan produk ini menggunakan model ADDIE membuktikan komitment institusi dalam menghasilkan kualiti PdP yang bermutu tinggi. Selain itu, ia boleh dijadikan sebagai bahan penanda aras (*benchmarking*) atau model contoh untuk program-program lain di dalam institusi bagi membangunkan inovasi serupa.

1.3.4 Negara

Secara makronya, kajian ini menyumbang kepada aspirasi negara dalam mentransformasikan pendidikan TVET sebagai pilihan utama. Dengan melahirkan graduan yang mahir teknologi dan cekap dalam kemahiran praktikal, negara dapat membekalkan tenaga kerja yang kompeten selari dengan keperluan Revolusi Industri 4.0 (IR 4.0). Inovasi ini juga menyokong dasar kerajaan dalam mendigitalkan sektor pendidikan bagi memastikan Malaysia kekal berdaya saing di peringkat global.

3.0 KAJIAN LITERATUR

Blended Learning merupakan gabungan interaksi bersemuka konvensional dengan sumber digital dalam talian. Kajian lepas menunjukkan bahawa integrasi teknologi dalam TVET bukan sahaja meningkatkan penglibatan pelajar di dalam kelas tetapi juga menggalakkan pembelajaran kendiri (Maarof & Zakaria, 2025). Model ADDIE dipilih sebagai kerangka kerja pembangunan inovasi kerana sifatnya yang sistematik, dan memenuhi ciri-ciri aplikasi digital dan objektif pembangunan inovasi (Zaharah, 2024). Chen dan Chan (2024) juga ada membincangkan bahawa pendekatan ini terbukti berkesan dalam merangsang pembelajaran kendiri serta memperkukuh semangat kolaboratif dalam kalangan pelajar. Dengan mengintegrasikan inovasi pembelajaran ini, para pendidik mampu menyantuni pelbagai keperluan pembelajaran secara lebih inklusif dan efektif.

Perkembangan industri pembinaan yang semakin dinamik menuntut tenaga kerja yang bukan sahaja kompeten dari sudut teknikal, malah berupaya mengurus aspek kewangan projek secara sistematik dan tepat. Dalam konteks ini, kursus Anggaran Kos Bangunan dilihat sebagai komponen kritikal dalam melahirkan tenaga kerja yang berdaya saing. Walau bagaimanapun, kursus ini sering dianggap mencabar oleh pelajar kerana melibatkan gabungan kemahiran pengiraan matematik, kefahaman terhadap spesifikasi bahan, serta keupayaan mentafsir pelan bangunan secara tepat menyebabkan tenaga pengajar juga menghadapi cabaran bagi mencipta aktiviti pembelajaran yang lebih berkesan (Nazra, 2015). Situasi ini menunjukkan bahawa penguasaan kursus bukan sekadar bergantung kepada kebolehan kognitif, tetapi juga memerlukan pendekatan pembelajaran yang lebih kontekstual dan aplikatif. Khairul Bariyah

Masrakin et al. (2024) mendapati bahawa integrasi penyelesaian digital ini berupaya mengoptimumkan kecekapan pengurusan instruksional pensyarah, di samping mewujudkan persekitaran pembelajaran yang lebih anjal dan interaktif bagi para pelajar.

Seiring dengan itu, pendekatan pengajaran dan pembelajaran (PdP) konvensional yang berpusatkan pensyarah dilihat semakin kurang relevan dalam memenuhi keperluan pembelajaran masa kini. Noor Hadzlida Ayob et al. (2021) membincangkan bahawa pemerkasaan aspek pendidikan digital harus dijadikan agenda utama bagi memastikan kelangsungan kualiti pengajaran. Kaedah konvensional menghadkan penglibatan aktif pelajar serta kurang memberi ruang kepada pembelajaran kendiri dan pengalaman autentik. Justeru, integrasi inovasi digital berupaya memangkin transformasi yang signifikan dalam metodologi pengajaran dan pembelajaran (PdP) selaras dengan keperluan pendidikan masa kini (Salma Shokri et al., 2021). Perkara ini semakin mendapat perhatian sebagai satu alternatif yang lebih responsif terhadap keperluan pendidikan TVET. Para penyelidik sepakat bahawa terdapat peralihan gaya pembelajaran yang ketara dalam kalangan pelajar masa kini berbanding generasi terdahulu. Sehubungan itu, penguasaan set kemahiran baharu adalah sangat kritikal bagi menjamin kejayaan mereka dalam mendepani cabaran abad ke-21 (Muhamad Azhar Stapa et al., 2017).

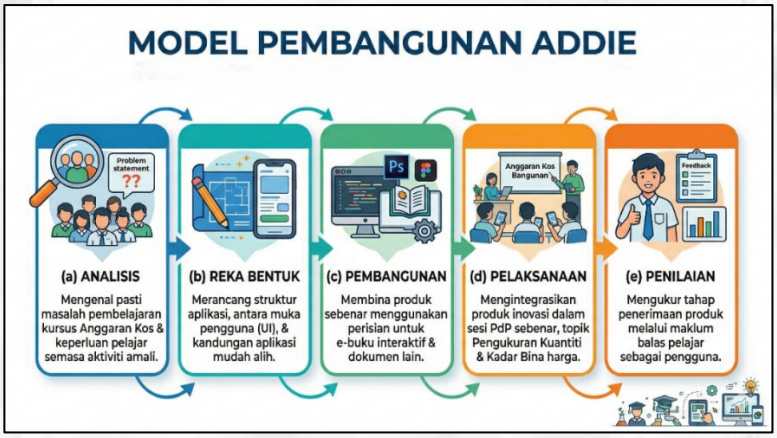
Blended Learning menggabungkan kelebihan interaksi bersemuka dengan fleksibiliti pembelajaran atas talian, sekali gus mewujudkan persekitaran pembelajaran yang lebih dinamik. Nurul Husnina Kamarudin dan Aizan Ali @ Mat Zin (2024) menjelaskan bahawa penerapan *blended learning* meningkatkan akses sumber pendidikan, sekali gus memberikan peluang pembelajaran yang lebih luas dan mudah capai bagi para pelajar. Pendekatan ini berupaya merapatkan jurang antara teori dan amali melalui penggunaan modul interaktif, simulasi digital serta akses kepada sumber pembelajaran secara masa nyata. Dalam konteks Anggaran Kos Bangunan, pelajar berpeluang mengakses data kadar harga bahan terkini, membuat rujukan melalui e-buku interaktif, dan banyak lagi. Pendekatan ini secara tidak langsung menyokong pembelajaran autentik yang menekankan konsep *learning by doing* dalam suasana yang lebih fleksibel dan berpusatkan pelajar (Nursyawalina Sulong & Siti Sulong, 2022).

3.0 METODOLOGI KAJIAN

Kajian ini menggunakan reka bentuk penyelidikan dan pembangunan melalui pendekatan kuantitatif, dengan menggunakan soal selidik sebagai instrumen bagi mengenal pasti tahap penerimaan pelajar terhadap penggunaan inovasi ini.

3.1 Model Pembangunan ADDIE

Proses pembangunan produk ini melalui lima fasa kritikal iaitu seperti ditunjukkan pada Rajah 1 berikut:



Rajah 1: Model Pembangunan ADDIE

(a) Analisis:

Fasa ini melibatkan proses mengenal pasti masalah yang berlaku semasa proses pembelajaran kursus Anggaran Kos dan mengenal pasti keperluan pelajar semasa aktiviti amali kursus ini.

(b) Reka Bentuk:

Fasa ini merupakan aktiviti merancang struktur aplikasi, antara muka pengguna, dan kandungan dalam aplikasi mudah alih. Fasa ini mengambil tempoh yang lebih lama berbanding fasa lain kerana kekangan kemahiran dalam bidang teknologi maklumat.

(c) Pembangunan:

Fasa ini melibatkan pembinaan produk sebenar menggunakan pelbagai perisian sesuai untuk mencipta e-buku interaktif dan dokumen lain. Semua dokumen kemudiannya dimuat naik ke platform percuma dalam talian untuk tujuan capaian pengguna. Berikut merupakan paparan antara muka bagi Aplikasi Mudah Alih TOQ+:



Rajah 2: Kandungan dalam TOQ+

(d) Pelaksanaan:

Mengintegrasikan produk inovasi ke dalam sesi PdP sebenar bagi kursus Anggaran Kos Bangunan, dalam topik Pengukuran Kuantiti dan Kadar Bina harga.

(e) Penilaian:

Mengukur tahap penerimaan terhadap produk inovasi melalui maklum balas pelajar sebagai pengguna.

3.2 Instrumen Kajian

Instrumen yang digunakan dalam kajian ini adalah borang soal selidik. Penggunaan borang soal selidik sebagai instrumen kajian bertujuan untuk mengumpul data secara sistematik dan konsisten daripada responden dalam tempoh masa yang singkat. Set soal selidik ini dibina berasaskan objektif kajian dan disesuaikan dengan konteks inovasi PdP dalam bidang penyelenggaraan bangunan bagi memastikan setiap item yang dikemukakan mampu menjawab persoalan kajian yang ditetapkan. Borang soal selidik ini menggunakan menggunakan skala Likert empat mata (daripada 'Tidak Setuju' hingga 'Sangat Setuju'). Secara keseluruhannya, borang soal selidik ini dibahagi kepada beberapa bahagian utama, iaitu:

Bahagian A: Demografi

Bahagian ini merangkumi maklumat peribadi responden seperti jantina, umur, program pengajian, semester pengajian, bangsa dan pengalaman dalam kursus Anggaran Kos Bangunan

Bahagian B: Penggunaan Produk Inovasi

Bahagian ini mengandungi item-item berkaitan persepsi responden semasa menggunakan produk inovasi.

Bahagian C: Keberkesanan Dalam Pelaksanaan Amali

Bahagian ini mengandungi item-item berkaitan impak penggunaan produk inovasi kepada prestasi dan pemahaman pelajar semasa proses pembelajaran.

Bahagian D: Pengalaman dan Penerimaan Pelajar

Bahagian ini mengandungi item-item berkaitan hubungan penggunaan produk inovasi dengan pengalaman pembelajaran dan motivasi pelajar.

Bagi memastikan kualiti data yang diperoleh, kajian ini menggunakan kaedah persampelan bertujuan. Teknik persampelan bukan kebarangkalian ini dipilih kerana penyelidik ingin memfokuskan kepada kumpulan subjek yang mempunyai kriteria spesifik dan pengetahuan mendalam mengenai topik yang dikaji iaitu Kursus Anggaran Kos dalam program pengajian Sijil Penyelenggaraan Bangunan.

Oleh itu, responden kajian ini terdiri daripada pelajar Program Sijil Penyelenggaraan Bangunan di Kolej Komuniti Segamat yang sedang menuntut di Semester 3 dan Semester 4. Pemilihan kumpulan responden ini adalah berasaskan pengalaman pelajar yang telah mengambil kursus Anggaran Kos Bangunan, sekali gus membolehkan mereka memberikan maklum balas yang matang dan tepat berdasarkan pengalaman pembelajaran mereka.

4.0 DAPATAN KAJIAN DAN PERBINCANGAN

Bahagian ini membincangkan hasil analisis data yang diperoleh daripada borang soal selidik yang telah diedarkan kepada pelajar semester 3 dan 4 dari program Sijil Penyelenggaraan Bangunan. Analisis difokuskan kepada penerimaan pelajar terhadap inovasi PdP dalam proses pembelajaran kursus Anggaran Kos Bangunan.

4.1 Analisis Profil Responden

Seramai 19 orang responden dari Kolej Komuniti Segamat telah terlibat dalam kajian ini. Kumpulan ini dipilih melalui persampelan bertujuan kerana mereka telah mengambil kursus Anggaran Kos Bangunan yang ditawarkan dalam pengajian program Sijil Penyelenggaraan Bangunan, menjadikan maklum balas mereka lebih relevan dan boleh dipercayai.

Jadual 1: Profil Responden

Kategori	Sub-Kategori	Kekerapan (f)	Peratusan (%)
Jantina	Lelaki	13	68.4%
	Perempuan	6	31.6%
Semester	Semester 3	6	31.6%
	Semester 4	13	68.4%

4.2 Tahap Penerimaan Penggunaan Inovasi

Berdasarkan analisis skor min, didapati bahawa aplikasi mudah alih TOQ+ memberikan impak yang signifikan kepada responden. Secara keseluruhannya, purata skor min bagi persepsi keberkesanan adalah 4.41, yang berada pada tahap Tinggi.

[Skala Likert: 4=Sangat Setuju (SS), 3=Setuju (S), 2=Kurang Setuju (KS), 1=Tidak Setuju (TS)]

Aspek Penggunaan Produk Inovasi: Responden menyatakan bahawa penggunaan inovasi ini memudahkan mereka memahami prosedur anggaran kos bangunan yang kompleks berbanding kaedah konvensional, dengan skor min keseluruhan ialah 4.51.

Jadual 2: Penggunaan Produk Inovasi

	Item Soal Selidik	(SS)	(S)	(KS)	Min	Interpretasi
A	Penggunaan Produk Inovasi				4.51	Sangat Tinggi
1	Produk mudah digunakan semasa PdP	10	9	0	4.53	Sangat Tinggi
2	Penggunaan produk mudah difahami	9	10	0	4.47	Sangat Tinggi
3	Membantu mengikuti aktiviti amali	10	9	0	4.53	Sangat Tinggi

Aspek Keberkesanan Pembelajaran: Responden memberikan maklum balas positif bahawa aplikasi ini sangat membantu pelaksanaan amali semasa di dalam kelas, dengan skor min keseluruhan ialah sebanyak 4.38.

Jadual 3: Keberkesanan Pembelajaran

	Item Soal Selidik	(SS)	(S)	(KS)	Min	Interpretasi
B	Keberkesanan Pembelajaran				4.38	Tinggi
4	Memahami langkah kerja dengan jelas	8	11	0	4.42	Tinggi
5	Meningkatkan kemahiran amali	7	12	0	4.37	Tinggi
6	Memudahkan tugasan dalam kelas	8	11	0	4.42	Tinggi
7	Gabungan pembelajaran (Blended) berkesan	6	13	0	4.32	Tinggi

Aspek Pengalaman dan Penerimaan: Responden memberikan maklum balas yang positif juga dari aspek pengalaman dan motivasi di dalam kelas dengan skor min keseluruhan ialah 4.35.

Jadual 4: Pengalaman dan Penerimaan

	Item Soal Selidik	(SS)	(S)	(KS)	Min	Interpretasi
C	Pengalaman & Penerimaan				4.35	Tinggi
8	Kelas menjadi lebih menarik	8	11	0	4.42	Tinggi
9	Lebih berminat untuk belajar	7	12	0	4.37	Tinggi
10	Sesuai digunakan dalam kursus ini	7	11	1	4.26	Tinggi

4.3 Perbincangan

Dari aspek penerimaan produk inovasi, majoriti pelajar memberikan skor 4 dan 5 bagi setiap item, menunjukkan inovasi TOQ+ diterima dengan sangat baik. Aspek penggunaan produk pula mencatatkan skor min tertinggi (4.53) pada Item A1 dan A3, membuktikan TOQ+ sangat mesra pengguna dan membantu dalam aktiviti amali. Skor min yang tinggi dalam aspek "pembelajaran lebih menarik" membuktikan bahawa transformasi pembelajaran digital yang berlaku dimana peralihan daripada kaedah nota konvensional kepada inovasi TOQ+ berjaya menarik minat pelajar generasi Z. Ini selaras dengan keperluan PdP masa kini yang memerlukan elemen interaktif. Dapatan ini secara tidak langsung menyokong kenyataan Anesman Buangraya Wenge (2022) bahawa kaedah pengajaran berasaskan digital lebih menarik minat pelajar berbanding kaedah konvensional.

Keputusan responden yang ingin terus menggunakan TOQ+ membuktikan bahawa inovasi ini menunjukkan kebolehgunaan yang tinggi, bukan sekadar alat bantuan sementara, tetapi telah menjadi keperluan dalam rutin pembelajaran mereka. Reka bentuk yang mudah diakses membolehkan pelajar boleh melakukan rujukan kendiri di luar waktu kuliah. Hal ini juga selari dengan dapatan dari kajian Khairul Bariyah Masrakin et al. (2024) dimana responden menyatakan penggunaan aplikasi mudah alih mampu meningkatkan pemahaman dan penguasaan amali pengukuran kuantiti melalui pembelajaran kendiri yang berulang.

Berdasarkan maklum balas responden pada soalan terbuka, kelebihan utama produk ini adalah ia "senang digunakan", "mencepatkan amali", dan "mudah mendapatkan maklumat". Dapatan keseluruhan menunjukkan bahawa *blended learning* memberikan impak positif kepada proses PdP kursus teknikal kerana ia bertindak sebagai jambatan visual semasa sesi amali. Pelajar tidak lagi bergantung sepenuhnya kepada demonstrasi pensyarah secara sekali imbas,

sebaliknya boleh merujuk aplikasi mudah alih ini secara berulang kali. Ini secara langsung memperkukuh kemahiran praktikal mereka dan meningkatkan penguasaan topik yang dipelajari.

5.0 KESIMPULAN

Secara keseluruhan, inovasi TOQ+ telah berjaya mencapai objektifnya dalam meningkatkan kualiti penyampaian PdP bagi program Sijil Penyelenggaraan Bangunan bagi kursus Anggaran Kos Bangunan. Tahap persetujuan responden yang sangat tinggi membuktikan inovasi ini mempunyai potensi besar untuk disebar luas ke program teknikal yang lain. Kajian ini membuktikan bahawa inovasi PdP berasaskan teknologi adalah keperluan, dan bukannya alternatif, terutama dalam ekosistem TVET secara umumnya, dan Kolej Komuniti khasnya. Aplikasi model ini boleh diadaptasi oleh program-program lain di Kolej Komuniti dan Politeknik terutama kluster Kejuruteraan dan Alam Bina yang menawarkan kursus Anggaran Kos bagi meningkatkan kualiti penyampaian PdP.

Sebagai cadangan kajian lanjutan pada masa hadapan, kajian lanjutan diperlukan bagi melihat kepada keberkesanan jangka panjang inovasi ini terhadap pencapaian akademik pelajar terutama bagi kursus Anggaran Kos Bangunan.

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INOVASI EZSULAM: EPEMBELAJARAN SULAMAN DENGAN INTEGRASI CHATBOT PINTAR

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Abstrak

Kajian ini bertujuan membangunkan dan menilai keberkesanan platform e-pembelajaran EzSULAM yang mengintegrasikan multimedia interaktif dan chatbot pintar dalam kursus Sulaman di institusi Pendidikan dan Latihan Teknikal dan Vokasional (TVET). Kajian ini menggunakan pendekatan kualitatif berbentuk kajian kes melibatkan lima peserta terdiri daripada dua pensyarah dan tiga pelajar di Kolej Komuniti Temerloh. Pembangunan platform dilaksanakan berasaskan model ADDIE yang merangkumi fasa analisis, reka bentuk, pembangunan, pelaksanaan dan penilaian. Data dikumpul melalui temu bual separa berstruktur dan pemerhatian, serta dianalisis menggunakan analisis tematik reflektif. Dapatan menunjukkan bahawa pelajar memerlukan bahan pembelajaran visual, fleksibel dan interaktif bagi menyokong pembelajaran kendiri. Platform EzSULAM berjaya menyediakan kandungan tersusun, mudah diakses serta meningkatkan penglibatan pelajar, di samping menilai persepsi pengguna terhadap kebolehgunaan, reka bentuk kandungan dan sokongan pembelajaran kendiri melalui penggunaan platform tersebut. Integrasi chatbot pintar didapati menyokong maklum balas segera, meningkatkan kefahaman serta menggalakkan autonomi pembelajaran. Kajian ini menunjukkan bahawa keberkesanan e-pembelajaran dalam TVET bergantung kepada keselarasan antara reka bentuk kandungan, kebolehgunaan sistem dan sokongan teknologi AI. Secara keseluruhannya, kajian ini menyumbang kepada pembangunan pedagogi digital berasaskan kemahiran melalui pendekatan bersepadu yang menyokong pembelajaran interaktif dan berpusatkan pelajar.

Kata Kunci: e-pembelajaran, sulaman, chatbot pintar, TVET digital, inovasi pendidikan.

Abstract

This study aims to develop and evaluate the effectiveness of the EzSULAM e-learning platform, which integrates interactive multimedia and an intelligent chatbot for an Embroidery course in Technical and Vocational Education and Training (TVET) institutions. The study adopts a qualitative case study approach involving five participants, comprising two lecturers and three students from Kolej Komuniti Temerloh. The platform was developed based on the ADDIE model, encompassing the phases of analysis, design, development, implementation, and

evaluation. Data were collected through semi-structured interviews and observations, and analyzed using reflective thematic analysis. The findings indicate that students require visual, flexible, and interactive learning materials to support self-directed learning. The EzSULAM platform successfully provides structured and accessible content, enhances student engagement, and evaluates users' perceptions of usability, content design, and support for self-directed learning. The integration of an intelligent chatbot was found to facilitate real-time feedback, improve understanding, and promote learner autonomy. This study demonstrates that the effectiveness of e-learning in TVET depends on the alignment between content design, system usability, and AI-driven technological support. Overall, the study contributes to the development of skill-based digital pedagogy through an integrated approach that supports interactive and student-centered learning.

Keywords: *e-learning, embroidery, smart chatbot, digital TVET, educational innovation.*

1.0 PENGENALAN

Transformasi digital dalam pendidikan telah memperluas penggunaan e-pembelajaran, multimedia interaktif dan kecerdasan buatan (AI) bagi meningkatkan keberkesanan PdP dalam TVET ((Lim et al., 2024). Dalam bidang fesyen dan tekstil, penguasaan kemahiran praktikal memerlukan pendekatan pembelajaran yang visual, interaktif dan fleksibel (Ali et al., 2025). Namun, pengajaran kursus sulaman masih bergantung kepada demonstrasi bersemuka dan bahan konvensional, manakala platform e-pembelajaran sedia ada bersifat pasif serta kurang menyediakan maklum balas masa nyata (Fan et al., 2024; Baxter & Hainey, 2024). Dalam konteks ini, chatbot pintar berpotensi berfungsi sebagai tutor maya yang menyokong interaksi dan pembelajaran kendiri (Ahmad et al., 2023; Kim et al., 2025). Sehubungan itu, kajian ini memperkenalkan EzSULAM sebagai platform e-pembelajaran bersepadu yang menggabungkan multimedia interaktif dan chatbot pintar bagi menyokong pembelajaran sulaman secara sistematik dan fleksibel dalam konteks TVET di Kolej Komuniti Temerloh, dengan memberi tumpuan kepada pembangunan dan penilaiannya dalam situasi sebenar.

1.1 Penyataan Masalah

Walaupun kursus Sulaman penting dalam bidang fesyen dan tekstil, pelaksanaan PdP masih berdepan cabaran yang menjejaskan penguasaan kemahiran pelajar, khususnya di Kolej Komuniti Temerloh (Shukri et al., 2026). Kekurangan bahan rujukan digital serta kebergantungan kepada demonstrasi bersemuka mengehadkan pembelajaran kendiri, manakala kekangan masa pengajaran menyukarkan penyampaian visual dan panduan langkah demi langkah secara menyeluruh (Shah & Hamdan, 2025). Selain itu, platform e-pembelajaran sedia ada yang kurang interaktif dan tidak menyediakan maklum balas segera turut menghadkan penglibatan pelajar (Baxter & Hainey, 2024). Oleh itu, pembangunan platform digital bersepadu yang menggabungkan multimedia interaktif dan sokongan masa nyata melalui teknologi AI seperti EzSULAM adalah diperlukan bagi mengatasi jurang ini serta meningkatkan keberkesanan PdP dalam konteks TVET (Lim et al., 2024; Ali et al., 2025; Jalil & Foong, 2025).

1.2 Objektif Kajian

Kajian ini dijalankan menggunakan model ADDIE bagi mencapai tiga objektif utama seperti berikut:

(1) Menganalisis keperluan pembelajaran pelajar dalam kursus Sulaman di institusi TVET.

(2) Membangunkan platform EzSULAM berasaskan elemen multimedia interaktif dan chatbot pintar.

(3) Menilai persepsi pengguna terhadap kebolehgunaan, reka bentuk kandungan serta sokongan pembelajaran kendiri melalui penggunaan platform EzSULAM dalam kalangan pelajar dan pensyarah di Kolej Komuniti Temerloh.

1.3 Kepentingan Kajian

Kajian ini memberi beberapa kepentingan dalam konteks pendidikan TVET, khususnya bidang fesyen dan tekstil di Kolej Komuniti Temerloh. Dari segi teori: memperluas aplikasi model ADDIE dalam konteks pembelajaran berasaskan kemahiran. Seterusnya, amalan: menyediakan model platform e-pembelajaran interaktif untuk kursus tekstil. Selain itu, TVET: menyokong transformasi digital serta pembelajaran kendiri pelajar. Akhir sekali warisan: memelihara seni sulaman melalui pendigitalan.

2.0 KAJIAN LITERATUR

2.1 Keperluan E-Pembelajaran dalam Pendidikan TVET

Perkembangan teknologi digital telah mentransformasikan pendidikan TVET dengan menuntut integrasi teknologi bagi meningkatkan keberkesanan PdP dan melahirkan tenaga kerja berkemahiran tinggi (Ali et al., 2025). E-pembelajaran membolehkan penyampaian kandungan secara fleksibel melalui platform digital dan multimedia interaktif, sekali gus menyokong pembelajaran kendiri serta meningkatkan motivasi dan kefahaman pelajar ((Lim et al., 2024). Namun, keberkesanannya dalam bidang kemahiran bergantung kepada penyampaian kandungan secara visual dan demonstratif, justeru memerlukan elemen multimedia, interaktiviti dan sokongan kendiri yang kukuh.

2.2 Inovasi Digital dalam Pengajaran Kemahiran Tekstil

Bidang tekstil memerlukan gabungan kemahiran teknikal, kreativiti dan estetika yang lazimnya diajar secara praktikal. Namun, kekurangan bahan digital dan kebergantungan kepada demonstrasi manual mengehadkan pembelajaran kendiri. Penggunaan video demonstrasi dan multimedia interaktif didapati meningkatkan kefahaman prosedur teknikal, mengurangkan beban kognitif serta meningkatkan keyakinan pelajar (Fan et al., 2024). Pendekatan ini selari dengan konstruktivisme yang menekankan pembelajaran aktif, sekali gus menyokong PdP berpusatkan pelajar (Lim et al., 2024).

2.3 Penggunaan dan Integrasi Chatbot Pintar dalam Pendidikan

Kemajuan AI telah memperkenalkan chatbot sebagai alat sokongan pembelajaran yang menyediakan interaksi dan maklum balas masa nyata (Ahmad et al., 2023). Chatbot didapati meningkatkan penglibatan, motivasi dan pembelajaran berterusan, serta berfungsi sebagai tutor

maya (Kim et al., 2025). Namun, penggunaannya dalam pembelajaran kemahiran praktikal seperti sulaman masih terhad, khususnya dalam konteks TVET.

Integrasi e-pembelajaran dan chatbot pintar membolehkan pelajar bukan sahaja mengakses kandungan, tetapi juga berinteraksi secara langsung untuk mendapatkan maklum balas segera (Ahmad et al., 2023). Pendekatan ini berpotensi menyokong pembelajaran kemahiran melalui panduan teknikal dan pengulangan prosedur secara fleksibel. Walau bagaimanapun, kajian dalam bidang tekstil, khususnya kursus sulaman, masih kurang, menunjukkan jurang penyelidikan yang signifikan.

2.4 Model ADDIE dalam Pembangunan E-Pembelajaran

Model ADDIE menyediakan kerangka sistematik yang merangkumi fasa analisis, reka bentuk, pembangunan, pelaksanaan dan penilaian dalam pembangunan e-pembelajaran (Branch, 2009; Molenda, 2015). Model ini menekankan keperluan pengguna, perancangan kandungan serta integrasi teknologi seperti chatbot, diikuti penilaian keberkesanan sistem (Abuhassna et al., 2024). Oleh itu, model ini sesuai digunakan bagi memastikan pembangunan platform yang terancang dan relevan dengan keperluan TVET.

Secara keseluruhannya, literatur menunjukkan bahawa e-pembelajaran, multimedia interaktif dan chatbot pintar berpotensi meningkatkan keberkesanan PdP dalam TVET. Namun, penerapannya dalam kursus berasaskan kemahiran seperti sulaman masih terhad, khususnya dari segi integrasi elemen visual, pembelajaran kendiri dan sokongan masa nyata dalam satu platform yang sistematik. Sehubungan itu, kajian ini mengisi jurang tersebut melalui pembangunan platform EzSULAM berasaskan model ADDIE yang menggabungkan e-pembelajaran interaktif dan chatbot pintar serta menilai pengalaman pengguna secara kontekstual.

3.0 METODOLOGI KAJIAN

Kajian ini menggunakan pendekatan kualitatif berbentuk kajian kes yang dijalankan di Kolej Komuniti Temerloh. Sampel terdiri daripada lima peserta (2 pensyarah, 3 pelajar) yang dipilih secara *purposif* berdasarkan pengalaman menggunakan platform EzSULAM. Saiz sampel yang kecil adalah selaras dengan pendekatan kajian kualitatif berbentuk kajian kes yang menekankan penerokaan mendalam terhadap pengalaman peserta dalam konteks tertentu berbanding generalisasi (Al-Dosari et al., 2024). Kajian ini tidak bertujuan untuk membuat inferens statistik terhadap populasi yang lebih besar, sebaliknya memberi tumpuan kepada pemahaman secara mendalam terhadap pengalaman pengguna awal *(initial user experience)* terhadap penggunaan platform EzSULAM.

Oleh itu, pemilihan peserta secara *purposif* adalah sesuai bagi mendapatkan maklumat yang kaya dan kontekstual berkaitan reka bentuk, kebolehgunaan serta penerimaan awal platform. Pembangunan platform dilaksanakan berasaskan model ADDIE: (i)Fasa Analysis → mengenal pasti keperluan pembelajaran. (i)Fasa Design & Development → membangunkan platform. (iii) Fasa Implementation & Evaluation → menilai keberkesanan penggunaan.

Data dikumpul melalui temu bual separa berstruktur dan pemerhatian, serta dianalisis menggunakan analisis tematik reflektif (Braun & Clarke, 2021). Walaupun kajian ini menilai pengalaman pengguna secara kualitatif melalui temu bual dan pemerhatian, penilaian kuantitatif seperti *System Usability Scale (SUS)* tidak dilaksanakan dalam kajian ini. Hal ini kerana kajian ini berada pada peringkat penerokaan awal *(exploratory phase)* yang memberi fokus kepada pembangunan dan pemahaman pengalaman pengguna secara mendalam. Walau bagaimanapun, penggunaan instrumen kuantitatif seperti SUS dicadangkan dalam kajian lanjutan bagi mengukur tahap kebolehgunaan sistem secara lebih objektif dan menyokong dapatan kualitatif melalui pendekatan triangulasi data. Oleh itu, penilaian dalam kajian ini lebih menekankan aspek pengalaman pengguna dan kebolehgunaan sistem secara kualitatif berbanding pengukuran kuantitatif.

3.1 Penerangan Platform EzSULAM

Bagi tujuan kajian ini, platform e-pembelajaran yang dikenali sebagai EzSULAM telah dibangunkan bagi menyokong proses pengajaran dan pembelajaran kursus Sulaman. Platform ini mengintegrasikan pelbagai elemen pembelajaran digital seperti nota interaktif, video demonstrasi, visual langkah demi langkah, kuiz interaktif serta chatbot pintar bagi membantu pelajar memahami teknik sulaman secara lebih sistematik dan berkesan. Antara muka platform EzSULAM direka bentuk secara mesra pengguna dengan susun atur yang teratur bagi memudahkan navigasi pelajar. Paparan utama platform ini ditunjukkan dalam Rajah 1 yang menunjukkan struktur asas platform yang digunakan dalam kajian bagi menyokong pembelajaran berasaskan kemahiran dalam kursus sulaman.

4.0 DAPATAN KAJIAN DAN PERBINCANGAN

Bahagian ini membentangkan dapatan kajian berdasarkan analisis tematik reflektif yang disusun selari dengan objektif kajian serta model ADDIE, **serta menunjukkan pengalaman, persepsi serta penerimaan pengguna terhadap pembangunan dan penggunaan platform EzSULAM secara sistematik.** Dapatan dihuraikan mengikut tiga objektif utama kajian bagi memastikan keselarasan antara tujuan kajian, analisis data dan perbincangan.



Rajah 1: Paparan antara muka platform EzSULAM

4.1 Objektif 1: Keperluan Pembelajaran Pelajar dalam Kursus Sulaman

Dapatan menunjukkan bahawa pelajar menghadapi kesukaran dalam memahami teknik sulaman secara kendiri akibat kekurangan bahan rujukan digital serta kebergantungan kepada demonstrasi bersemuka. Pelajar menyatakan keperluan terhadap bahan pembelajaran visual seperti video demonstrasi dan panduan langkah demi langkah, di samping keperluan kepada akses pembelajaran yang fleksibel. Secara analitikal, dapatan ini menunjukkan bahawa pembelajaran kemahiran sulaman memerlukan pendekatan yang bersifat visual, demonstratif dan berulang.

Keperluan ini selari dengan kajian Fan et al. (2024) yang menegaskan bahawa penggunaan visual dapat mengurangkan beban kognitif dalam pembelajaran teknikal. Namun demikian, dapatan kajian ini memperluas kefahaman tersebut dengan menunjukkan bahawa cabaran utama bukan sekadar kekurangan bahan, tetapi ketidakpadanan antara bentuk penyampaian kandungan dengan sifat pembelajaran kemahiran. Dalam konteks ini, pelajar memerlukan pembelajaran yang menyokong pengulangan, pemerhatian dan aplikasi secara kendiri. Implikasinya, pembangunan e-pembelajaran dalam TVET, khususnya di Kolej Komuniti Temerloh perlu mengambil kira keperluan pembelajaran yang lebih kontekstual dan berpusatkan pengguna, khususnya bagi kursus berasaskan kemahiran seperti sulaman.

4.2 Objektif 2: Pembangunan Platform EzSULAM Berasaskan Multimedia dan Chatbot Pintar

Dapatan menunjukkan bahawa platform EzSULAM berjaya dibangunkan dengan mengintegrasikan elemen multimedia interaktif dan chatbot pintar dalam satu persekitaran pembelajaran yang sistematik. Kandungan pembelajaran disusun secara berperingkat daripada pengenalan alat dan bahan sehingga kepada penghasilan projek akhir. Penggunaan elemen multimedia seperti video demonstrasi, ilustrasi langkah demi langkah dan nota interaktif didapati membantu meningkatkan kefahaman pelajar terhadap teknik sulaman. Reka bentuk kandungan yang tersusun secara prosedural membolehkan pelajar mengikuti aliran kerja sebenar dengan lebih jelas.

Dari perspektif teori, dapatan ini menyokong pendekatan konstruktivisme yang menekankan pembelajaran aktif melalui interaksi dengan bahan pembelajaran (Lim et al., 2024). Namun, dapatan kajian ini turut menunjukkan bahawa keberkesanan pembelajaran tidak hanya bergantung kepada elemen visual, tetapi juga kepada struktur penyampaian kandungan yang selari dengan proses kerja sebenar kemahiran. Selain itu, integrasi chatbot pintar dalam platform EzSULAM menambah nilai kepada sistem pembelajaran dengan menyediakan sokongan interaktif secara masa nyata. Chatbot berfungsi sebagai pembantu maya yang membantu pelajar mendapatkan maklumat dengan cepat serta menyokong pembelajaran kendiri. Secara keseluruhannya, pembangunan platform EzSULAM menunjukkan bahawa integrasi antara multimedia interaktif dan teknologi AI berupaya menghasilkan persekitaran pembelajaran yang lebih dinamik, responsif dan berpusatkan pelajar dalam konteks TVET, khususnya di Kolej Komuniti Temerloh.

4.3 Objektif 3: Persepsi Pengguna terhadap Kebolehgunaan, Reka Bentuk dan Sokongan Pembelajaran Kendiri

Dapatan menunjukkan bahawa pengguna memberikan persepsi positif terhadap kebolehgunaan, reka bentuk kandungan serta sokongan pembelajaran kendiri melalui penggunaan platform EzSULAM. Platform ini didapati mudah digunakan, mesra pengguna dan boleh diakses melalui pelbagai peranti tanpa kekangan masa dan lokasi. Dari segi reka bentuk, kandungan yang tersusun secara sistematik serta penggunaan elemen visual membantu meningkatkan kefahaman pelajar terhadap teknik sulaman. Pelajar juga menunjukkan tahap penglibatan yang lebih tinggi melalui penggunaan video pembelajaran dan interaksi dengan chatbot. **EzSULAM berpotensi membantu penguasaan kemahiran sulaman dan dapat digunakan secara efektif dalam menyokong pembelajaran kendiri**, selaras dengan keperluan pembelajaran berpusatkan pelajar dalam TVET. Fleksibiliti capaian membolehkan pelajar mengawal kadar pembelajaran sendiri, sekali gus meningkatkan autonomi dan motivasi pembelajaran. Dari sudut teknologi, integrasi chatbot pintar didapati memainkan peranan penting dalam menyediakan maklum balas segera serta meningkatkan interaktiviti pembelajaran. Dapatan ini selari dengan kajian Ahmad et al. (2023) dan Kim et al. (2025) yang menunjukkan bahawa chatbot meningkatkan penglibatan dan motivasi pelajar.

Walaupun kajian ini tidak mengukur hasil pembelajaran secara langsung, dapatan yang diperoleh adalah selari dengan kajian lepas yang menunjukkan bahawa penggunaan

multimedia interaktif dan sokongan masa nyata melalui teknologi AI berupaya meningkatkan kefahaman konsep dan pembelajaran kendiri dalam konteks TVET, khususnya di Kolej Komuniti Temerloh. Secara kritikal, dapatan kajian menunjukkan bahawa keberkesanan platform e-pembelajaran tidak bergantung kepada satu elemen tunggal, tetapi kepada integrasi antara reka bentuk kandungan, kebolehgunaan sistem dan sokongan teknologi chatbot pintar dalam satu ekosistem pembelajaran yang bersepadu.

5.0 KESIMPULAN DAN CADANGAN

Kajian ini membangunkan dan menilai platform e-pembelajaran EzSULAM bagi menyokong pembelajaran sulaman dalam TVET di Kolej Komuniti Temerloh. Dapatan menunjukkan bahawa integrasi kandungan multimedia, kebolehgunaan sistem yang tinggi dan chatbot pintar meningkatkan kefahaman, motivasi serta pembelajaran kendiri pelajar. Penggunaan model ADDIE memastikan pembangunan yang sistematik dan menyokong keberkesanan platform. Kajian ini menyumbang kepada literatur dengan memperluas aplikasi ADDIE dalam pembelajaran kemahiran serta menonjolkan peranan chatbot sebagai sokongan kognitif. Kebaharuan kajian terletak pada integrasi e-pembelajaran, chatbot pintar dan pendekatan holistik dalam ekosistem pembelajaran digital bidang tekstil.

Walau bagaimanapun, kajian ini mempunyai beberapa limitasi yang perlu diambil kira. Antaranya ialah saiz sampel yang kecil yang hanya melibatkan lima orang peserta, sekali gus mengehadkan kebolehumuman dapatan. Selain itu, penilaian platform adalah berdasarkan data kualitatif tanpa sokongan instrumen kuantitatif seperti melalui ujian pra dan pasca, penilaian prestasi atau perbandingan dengan kaedah pengajaran tradisional. Oleh itu, dapatan kajian hanya menggambarkan persepsi dan pengalaman pengguna terhadap penggunaan platform EzSULAM. Oleh itu, kajian masa hadapan disarankan untuk melibatkan sampel yang lebih besar serta menggunakan pendekatan kaedah campuran *(mixed methods)* bagi mendapatkan dapatan yang lebih komprehensif dan boleh digeneralisasikan.

Di samping itu, kajian lanjutan juga boleh mempertimbangkan penggunaan reka bentuk kuasi-eksperimen bagi menilai impak platform terhadap pencapaian dan penguasaan kemahiran pelajar secara lebih empirikal.

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DEVELOPMENT OF PLANT-BASED SATAY AS A MEAT ANALOG: EVALUATION OF CHEMICAL AND SENSORY PROPERTIES

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ABSTRACT

The increasing demand for sustainable and plant-based protein sources has driven the development of alternative meat analog products. This study aimed to develop a plant-based satay as a substitute for conventional chicken satay and to evaluate its chemical and sensory properties. The plant-based satay was formulated using koro bean, tempeh, tapioca flour, vital wheat gluten, isolated soy protein (ISP), and textured vegetable protein (TVP) to mimic the fibrous structure of meat. The product was marinated with traditional satay spices to replicate the characteristic flavor of conventional satay. Chemical analysis showed that the crude protein content of the control (chicken satay) was 18.5%, while formulations F1, F2, and F3 recorded protein contents of 17.8%, 21.46%, and 24%, respectively. Among the formulations, F3 exhibited the highest protein content, indicating the potential of plant-based ingredients to provide comparable or higher protein levels than conventional satay. Sensory evaluation was conducted to assess colour, flavour, hardness, aroma, appearance, and overall acceptability. The results showed that F3 obtained the highest overall acceptance score (5.65 ± 0.84), followed by F2 (5.44 ± 1.26), which were comparable to the control sample (5.58 ± 1.29). These findings suggest that the developed plant-based satay, particularly formulation 3, demonstrated favorable sensory characteristics and high protein content. In conclusion, the formulated plant-based satay shows promising potential as a nutritious and sustainable meat alternative with acceptable sensory properties and enhanced protein content.

Keywords: Plant-based protein, crude protein, sensory evaluation, satay

ABSTRAK

Peningkatan permintaan terhadap sumber protein yang mampan dan berasaskan tumbuhan telah memacu pembangunan produk analog daging alternatif. Kajian ini bertujuan untuk membangunkan sate berasaskan tumbuhan sebagai pengganti sate ayam konvensional serta menilai sifat kimia dan sensorinya. Sate berasaskan tumbuhan ini diformulasikan menggunakan kacang koro, tempe, tepung ubi kayu, gluten gandum vital, pencilan protein soya (ISP), dan protein tumbuhan bertekstur (TVP) untuk meniru struktur gentian daging. Produk ini diperap dengan rempah-ratus sate tradisional bagi menyamai profil rasa sate konvensional. Analisis kimia menunjukkan bahawa kandungan protein kasar bagi sampel kawalan (sate ayam) adalah 18.5%, manakala formulasi F1, F2, dan F3 masing-masing mencatatkan kandungan protein sebanyak 17.8%, 21.46%, dan 24%. Antara formulasi tersebut, F3 mempamerkan kandungan protein tertinggi, menunjukkan potensi bahan berasaskan tumbuhan dalam membekalkan tahap protein yang setara atau lebih tinggi

daripada sate konvensional. Penilaian sensori dijalankan untuk menilai warna, rasa, kekerasan, aroma, rupa bentuk, dan penerimaan keseluruhan. Keputusan menunjukkan bahawa F3 memperoleh skor penerimaan keseluruhan tertinggi (5.65 ± 0.84), diikuti oleh F2 (5.44 ± 1.26), di mana kedua-duanya adalah setanding dengan sampel kawalan (5.58 ± 1.29). Dapatan ini mencadangkan bahawa sate berasaskan tumbuhan yang dibangunkan, terutamanya formulasi F3, menunjukkan ciri-ciri sensori yang baik dan kandungan protein yang tinggi. Kesimpulannya, formulasi sate berasaskan tumbuhan ini menunjukkan potensi yang memberangsangkan sebagai alternatif daging yang berkhasiat dan mampan dengan sifat sensori yang boleh diterima serta kandungan protein yang ditingkatkan.

***Kata Kunci**: Protein berasaskan tumbuhan, protein kasar, penilaian sensori, sate*

1.0 INTRODUCTION

Plant-based meat analogs are designed to replicate the sensory and nutritional properties of conventional meat using plant-derived ingredients such as soy protein, legumes, and wheat gluten. These ingredients are widely used due to their functional properties, including water-holding capacity, gel formation, and ability to mimic the fibrous structure of meat (Kyriakopoulou et al., 2019). Among these, textured vegetable protein (TVP) and isolated soy protein (ISP) are commonly utilized to enhance protein content and improve texture in meat analog products (Bakhsh et al., 2021). In addition, the increasing adoption of plant-based and vegan diets, driven by ethical, environmental, and health considerations, has further accelerated the demand for meat alternatives (Jang & Lee, 2024). According to Cheong et al. (2020), approximately one in twenty adults in Malaysia follow a vegetarian diet, representing about 4.9% of the adult population. Consumers are increasingly seeking food products that align with their dietary preferences while maintaining desirable taste and nutritional value.

Satay is a traditional and widely consumed dish in Southeast Asia, typically prepared from marinated meat skewers such as chicken, beef, or lamb. Despite the growing popularity of plant-based foods, there is limited development of plant-based alternatives for traditional dishes like satay. Most existing research focuses on Western-style meat analogs, leaving a gap in culturally relevant plant-based product development. Therefore, this study aims to develop a plant-based satay using a combination of plant-based ingredients and to evaluate its chemical and sensory properties in comparison with conventional chicken satay.

1.1 Problem Statement

Despite the increasing popularity of plant-based meat alternatives, the industry faces ongoing technical challenges in mimicking the organoleptic properties of animal tissue, a critical requirement for ensuring the success of plant-based meat analogues as viable alternatives (Kumari et al., 2023). In addition, concerns have been raised regarding the nutritional adequacy of plant-based alternatives, especially in terms of protein quality and content compared to conventional meat (Bohrer, 2019). While plant proteins such as soy and legumes are widely

used, achieving both high protein content and desirable sensory characteristics simultaneously remains a challenge (Bakhsh et al., 2021).

In addition, Jang and Lee, 2024 stated that the expanding trend of vegan diets, driven by ethical, environmental, and health considerations, has consequently intensified the demand for fully plant-based food products. Furthermore, there is limited development of plant-based alternatives for traditional foods such as satay, particularly in the Southeast Asian context. Most research has focused on Western-style meat analogs, leaving a gap in the development of culturally relevant plant-based products. Therefore, there is a need to develop a plant-based satay that not only mimics the sensory characteristics of chicken satay but also provides comparable or enhanced nutritional value, particularly in terms of protein content, while meeting the dietary requirements of vegan consumers.

1.2 Research Objectives

a) To formulate plant-based satay using different ingredient compositions (F1, F2, F3).

b) To analyze the chemical properties in term of crude protein content of the developed formulations.

c) To evaluate the consumer acceptability (colour, flavour, aroma, hardness, appearance and overall acceptability) of the plant-based satay.

1.3 Significant of Research

This study provides valuable insights into the use of plant-based ingredients such as koro bean, tempeh, isolated soy protein, and textured vegetable protein in producing meat analog products. The findings may benefit food technologists and researchers by demonstrating how different ingredient combinations can influence protein content and sensory characteristics.

From a nutritional perspective, this study highlights the potential of plant-based satay to provide comparable or even higher protein content than conventional chicken satay. This is particularly important for consumers seeking healthier or alternative protein sources, including vegetarians and individuals reducing meat consumption.

2.0 LITERATURE REVIEW

2.1 Meat Analog

Meat analogs, also known as meat substitutes, are food products designed to imitate the sensory and nutritional characteristics of conventional meat using plant-based ingredients. These products are developed to address environmental, ethical, and health concerns associated with animal-based protein consumption (Zahari et al., 2022). Meat analogs typically utilize plant proteins such as soy, wheat gluten, and legumes due to their high protein content and functional properties.

The structure of meat analogs aims to replicate the fibrous texture of animal muscle. This is commonly achieved through processing techniques such as extrusion, which aligns plant proteins to form meat-like textures (Kyriakopoulou et al., 2019). Ingredients such as textured

vegetable protein (TVP) and isolated soy protein (ISP) are widely used due to their ability to retain water, bind ingredients, and create a firm, chewy structure similar to meat (Bakhsh et al., 2021). In recent years, the development of meat analogs has expanded rapidly due to the increasing demand for plant-based and vegan diets. However, despite technological advancements, challenges remain in achieving the same sensory quality and nutritional profile as conventional meat (Kumari et al., 2023).

2.2 Characteristic of Plant Based Meat Analog

Plant-based meat analogs must possess key characteristics that closely resemble conventional meat, including texture, flavour, aroma, appearance, and nutritional composition. Among these, texture is considered one of the most critical attributes, as it directly influences consumer perception and acceptance. The fibrous and chewy structure of meat is difficult to replicate and requires the use of functional ingredients such as wheat gluten and soy protein (Kyriakopoulou et al., 2019). Flavour and aroma are also essential factors in determining the success of meat analog products. Plant-based proteins often have inherent “beany” or undesirable flavours, which must be masked or modified using seasonings, spices, and flavour enhancers (Bakhsh et al., 2021). The use of traditional spices, such as those found in satay marinade, plays an important role in improving sensory acceptability.

Nutritionally, plant-based meat analogs are expected to provide adequate protein content comparable to conventional meat. Soy-based proteins, legumes, and other plant sources contribute to the overall protein quality of the product (Bohrer, 2019). However, achieving both high protein content and desirable sensory characteristics simultaneously remains a challenge (Kumari et al., 2023). In addition, appearance, including colour and shape, influences consumer acceptance. Meat analogs must visually resemble real meat to enhance appeal and acceptance among consumers (Zahari et al., 2022).

2.3 Satay

Satay is a traditional Southeast Asian dish consisting of skewered and grilled meat, commonly served with peanut sauce. It is widely popular in countries such as Malaysia, Indonesia, and Thailand, and is typically made using chicken, beef, or lamb that has been marinated with a mixture of spices before grilling. The characteristic flavor of satay is derived from its marinade, which usually includes ingredients such as turmeric, lemongrass, garlic, coriander, and cumin. These spices contribute to the distinctive aroma and taste that define satay (Tso & Forde, 2021). The grilling process further enhances flavor through caramelization and the development of smoky notes.

Texture is another important attribute of satay, as it is expected to be tender, slightly firm, and juicy. Replicating these characteristics in plant-based satay presents a challenge, particularly in achieving the desired chewiness and mouthfeel associated with meat. Despite the popularity of satay, research on plant-based alternatives for this traditional dish remains limited. Most studies on meat analogs focus on Western-style products such as burgers and sausages, highlighting a gap in the development of culturally relevant plant-based foods. Therefore, the

development of plant-based satay represents an important step in expanding plant-based food innovation within the Southeast Asian context.

3.0 RESEARCH METHODOLOGY

This study employed an experimental research design to develop and evaluate plant-based satay formulations. Three different formulations (F1, F2, and F3) were prepared and compared with a control sample (conventional chicken satay). The study focused on assessing both chemical properties and consumer acceptability through sensory evaluation of the developed products.

3.1 Material

3.1.1 Production of plant-based satay

Raw ingredients: Textured vegetable protein (TVP), Isolated soy protein (ISP), Sodium tripolyphosphate (STPP), Vital wheat gluten, Tempe, Koro beans, Tapioca flour, satay marinate (garlic powder, onion powder, ginger powder, cumin, coriander, turmeric, and lemongrass powder) and flavor enhancer.

3.1.2 Chemical Analysis

Crude protein content: Sulfuric acid (H_2SO_4), Kjeldhal catalyst tablet, Hydrochloric acid (HCL), Boric acid (H_3BO_3), Sodium Hydroxide (NaOH), Methyl red and Bromocresol green.

3.2 Methodology

3.2.1 Production of plant-based satay

The plant-based satay samples were prepared by first grinding tempeh, textured vegetable protein (TVP), and koro beans into a smooth and uniform paste. All other ingredients, including vital wheat gluten, tapioca flour, sugar, salt, isolated soy protein (ISP), garlic powder, onion powder, flavor enhancer, serai, and spices (*ketumbar, jintan manis, halia, jintan putih, and kunyit*), as well as sodium tripolyphosphate (STPP). Three formulations were developed by varying the proportions of vital wheat gluten and tapioca flour. Formulation 1 (F1) contained 30 g of vital wheat gluten and 20 g of tapioca flour, Formulation 2 (F2) contained 40 g of vital wheat gluten and 10 g of tapioca flour, while Formulation 3 (F3) contained 50 g of vital wheat gluten without the addition of tapioca flour.

The remaining ingredients were kept constant across all formulations, consisting of 25 g TVP, 30 g tempeh, 22 g koro beans, 7 g sugar, 5 g salt, 5 g ISP, 5 g garlic powder, 5 g onion powder, 3 g flavor enhancer, 2 g serai, the specified spices, and 1 g STPP. All ingredients were thoroughly mixed in a mixing bowl until a homogeneous mixture was obtained. The mixture was then portioned into 10 g samples and shaped into satay forms. Once shaped, the satay samples were pre-cooked by steaming at 100°C for 10 minutes. The steaming process facilitated partial protein denaturation, which contributed to improved texture and structural integrity of the final product. After steaming, the samples were allowed to cool at ambient temperature before being subjected to the grilling process. The control sample (chicken satay) was prepared using the same formulation and processing methods as the plant-based samples.

The only difference was that chicken meat was used as the primary ingredient and marinated with the same satay seasoning prior to cooking.

3.2.2 Chemical property (Determination of crude protein)

Approximately 2g of the sample was weighed and transferred into a digestion tube. A total of 20 mL of concentrated sulfuric acid (H_2SO_4) and 8 g of catalyst mixture were added. The mixture was then digested using a digestion unit until a clear solution was obtained, indicating complete digestion. A blank sample (without the test sample) was prepared and subjected to the same procedure. The digested sample was transferred into a distillation tube and diluted with 40 mL of distilled water. The tube was then connected to the distillation apparatus, and 60 mL of 40% sodium hydroxide (NaOH) solution was added to neutralize the acid and release ammonia. Separately, 50 mL of 2% boric acid solution was prepared in a 500 mL conical flask, and a few drops of mixed indicator were added. The released ammonia was distilled into the boric acid solution for 3 minutes. Afterward, the receiving flask was replaced with another flask containing 100 mL of distilled water, and distillation was continued for an additional 2 minutes. The condenser tip was rinsed with distilled water to ensure complete transfer of ammonia. The collected distillate was titrated with 0.5 N hydrochloric acid (HCL) until a pinkish endpoint was observed, indicating the completion of the reaction.

3.2.3 Consumer acceptability- Sensorial analysis (Hedonic test)

Sensory evaluation was conducted to comprehensively assess the acceptability of the plant-based satay formulations in terms of appearance, colour, aroma, flavour, texture, and overall acceptability. A 7-point hedonic scale was used, where 1 means “dislike very much” and 7 means “like very much,” allowing panelists to show how much they liked each sample in a simple way across different sensory aspects. The sensory panel consisted of 40 untrained panelists drawn from students and staff in the Food Technology department. The use of untrained or semi-trained panelists is appropriate for consumer acceptability studies, as it reflects general consumer perception. Panelists were briefed on the evaluation procedures, provided with neutral palate cleansers such as water, and instructed to evaluate each sample individually without discussion to minimize bias. Samples were randomly coded with unique three-digit numbers and presented in randomized order to avoid bias. Each satay sample was prepared and served under controlled laboratory conditions, maintaining consistent temperature, lighting, and portion size to reduce variability.

3.3 Data Analysis

All quantitative data from crude protein content and sensory scores, were analyzed using Statistical Package for the Social Sciences (SPSS) Version 19.

4.0 RESEARCH FINDINGS

4.1 Chemical Property (Crude protein content)

The Kjeldahl method is the standard laboratory technique used to determine the nitrogen content in organic substances, which is then used to calculate the crude protein content in food. The results show that the crude protein content varies among the plant-based satay formulations (F1, F2, and F3) and the control (chicken satay). The percentage of crude protein content for each sample is shown in Table 4.1.

Table 4.1: Percentage (%) of crude protein content in plant-based satay and control (chicken satay)
*Analyzed by Lotus Laboratory

Sample	% of crude protein content
Control	18.5 ± 0.20^{c}
F1	17.8 ± 0.10^{d}
F2	21.46 ± 0.15^{b}
F3	24 ± 0.00^{a}

4.2 Consumer acceptability

The sensory evaluation results in Table 4.2 demonstrate the acceptability of the plant-based satay formulations (F1, F2, and F3) in comparison to the control sample (chicken satay) based on colour, flavour, hardness, aroma, appearance, and overall acceptability.

Table 4.2: Hedonic scale score

Sample	Colour	Flavour	Hardness	Aroma	Appearance	Overall Acceptance
Control	5.44 ± 1.00^{a}	4.53 ± 1.62^{c}	5.35 ± 1.27^{a}	5.84 ± 1.23^{a}	5.53 ± 1.14^{b}	5.58 ± 1.29^{b}
F1	4.58 ± 1.35^{d}	4.42 ± 1.53^{d}	4.40 ± 1.14^{d}	4.93 ± 1.29^{d}	4.72 ± 1.16^{c}	4.37 ± 1.35^{d}
F2	5.30 ± 1.15^{c}	5.07 ± 1.35^{b}	4.98 ± 0.86^{c}	5.58 ± 1.03^{c}	5.56 ± 0.96^{a}	5.44 ± 1.26^{c}
F3	5.33 ± 0.81^{b}	5.28 ± 1.18^{a}	5.14 ± 0.86^{b}	5.70 ± 0.86^{b}	5.53 ± 1.14^{b}	5.65 ± 0.84^{a}

5.0 RESEARCH DISCUSSION

5.1 Chemical Property (Crude protein content)

The control sample recorded a protein content of 18.5 ± 0.20%, which serves as a benchmark for comparison. Among the plant-based formulations, F1 recorded the lowest protein content (17.8 ± 0.10%), which is slightly lower than the control. This may be due to a lower proportion of high-protein ingredients such as vital wheat gluten in the formulation, resulting in reduced overall protein concentration. Formulation F2 showed an increased protein content of 21.46 ± 0.15%, which is higher than both F1 and the control. This indicates that increasing the proportion of protein-rich ingredients contributes positively to the overall protein content of the product. Formulation F3 exhibited the highest protein content at 24.00 ± 0.00%, significantly higher than the control and other formulations. This can be attributed to the highest

inclusion level of vital wheat gluten and the absence of tapioca flour, which is primarily a carbohydrate source with minimal protein content.

Yang et al. (2023) found that conventional meat provides more than 25 g/100 g of protein, whereas plant-based meat analogues exhibit lower protein levels within the range of 14.1–19.8 g/100 g. The comparable crude protein content observed in formulations F1, F2, and F3 relative to the control sample (chicken satay) is likely attributed to the inclusion of high-protein ingredients such as tempeh, textured vegetable protein (TVP), koro beans, vital wheat gluten, and isolated soy protein (ISP). Ingredients such as textured vegetable protein (TVP) and isolated soy protein (ISP) are widely utilized in meat analog formulations due to their ability to retain water, bind ingredients, and form a firm, chewy structure that mimics meat (Bakhsh et al., 2021). In addition, protein isolates and concentrates derived from soy, peas, and wheat are commonly used as core ingredients in the development of plant-based meat products (Jang & Lee, 2024).

5.2 Consumer acceptability

For sensory analysis, F3 achieved the highest overall acceptability score (5.65 ± 0.84), indicating that it was the most preferred formulation. F2 (5.44 ± 1.26) demonstrated comparable acceptability to the control (5.58 ± 1.29), while F1 (4.37 ± 1.35) recorded the lowest score, reflecting lower consumer preference. In term of flavor, F3 (5.28 ± 1.18) also obtained the highest score, followed by F2 (5.07 ± 1.35), control (4.53 ± 1.62) and F1 (4.42 ± 1.53) recorded the lowest score, indicating less acceptable taste.

On the other hand, control sample showed significantly highest score as compared to others sample in term of colour, hardness and aroma attribute showed. For color attribute, control sample (5.44 ± 1.00) exhibited the highest score as compared to F2 (5.30 ± 1.15) and F3 (5.33 ± 0.81) and F1 (4.58 ± 1.35). As for hardness attribute, Control sample (5.35 ± 1.27) showed the highest score This score followed by F3 (5.14 ± 0.86), F2 (4.98 ± 0.86) and F1 (4.40 ± 1.14) had the lowest score. According to Sha and Xiong, 2020, this probably due to different in texture formation and water immobilization as compared to plant-based ingredients.

For aroma, control (5.84 ± 1.23) recorded the highest aroma score followed by F3 (5.70 ± 0.86), F2 (5.58 ± 1.03) and F1 (4.93 ± 1.29) showed a significantly lower score. The formation of characteristic meat flavour during heat treatment is largely attributed to sulfur-containing amino acids, such as lysine and cysteine, which act as important precursors of volatile aromatic compounds (Ma et al., 2019). Berrazaga et al. (2019) reported that plant-based proteins are deficient in certain essential amino acids, including sulfur amino acids and lysine. Based on the sensory evaluation results, it was concluded that among the plant-based samples, F3 exhibited the greatest potential, representing the most competitive alternative with characteristics most similar to conventional chicken satay.

6.0 CONCLUSION

This study successfully developed plant-based satay formulations (F1, F2, and F3) and evaluated their crude protein content and sensory properties in comparison with conventional chicken satay. The results demonstrated that formulation significantly influenced both nutritional value and consumer acceptability. In terms of crude protein content, formulation F3 recorded the highest value (24%), exceeding that of the control sample (18.5%), followed by F2 (21.46%) and F1 (17.8%). This indicates that usage of protein-rich ingredients such as vital wheat gluten, isolated soy protein (ISP), textured vegetable protein (TVP), koro beans and tempeh can significantly enhance the protein content of plant-based products. Sensory evaluation results revealed that F3 achieved the highest overall acceptability score, comparable to or slightly higher than the control sample, while F2 also showed acceptable sensory performance. In contrast, F1 recorded the lowest scores across most attributes, indicating lower consumer preference. The improved sensory performance of F3 may be attributed to its optimized formulation, which enhanced texture, flavor, and overall palatability.

Overall, the findings suggest that plant-based satay, particularly formulation F3, has strong potential as a nutritious and acceptable alternative to conventional chicken satay. The product not only provides higher protein content but also achieves comparable sensory characteristics, making it suitable for consumers seeking sustainable and plant-based food options, including vegans.

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FORMULATION AND EVALUATION OF SUNSCREEN LOTION STICK WITH *HIBISCUS ROSA-SINENSIS* EXTRACT: IMPACT ON PH, SENSORY AND SPF ANALYSIS

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Abstract

This study explores the development and evaluation of a sunscreen stick formulation incorporating *Hibiscus rosa-sinensis* extract, aiming to address common drawbacks associated with conventional sunscreen products, such as greasiness and inconvenience of application. Multiple formulations were developed and assessed for physicochemical properties including pH, sensory attributes (texture, odour, and moisturizing properties) and sun protection efficacy. Sun Protection Factor (SPF) was determined using UV spectrophotometry, with further validation using the Mansur method. Among the formulations, F3 demonstrated most favorable results in terms of moisturizing effect, texture, odour, user preference, and SPF performance. The SPF of F3 was calculated to be 17.626, indicating significant UVB protection when applied properly. All tested formulations maintained a pH range of 6.0 to 6.3, indicating skin compatibility. Overall, the *Hibiscus rosa-sinensis* sunscreen stick was found to be safe, effective, and well-suited for daily use across a range of skin types. It presents a promising natural alternative to conventional chemical sunscreens, offering visible and measurable benefits without the need for high-cost investment.

Keywords: Sunscreen, *Hibiscus rosa-sinensis*, pH, Sensory, and SPF

Abstrak

Kajian ini meneroka pembangunan dan penilaian formulasi pelindung matahari berbentuk stik yang menggabungkan ekstrak Hibiscus rosa-sinensis, bertujuan untuk menangani kelemahan biasa yang berkaitan dengan produk pelindung matahari konvensional, seperti rasa berminyak dan kesulitan penggunaan. Pelbagai formulasi telah dibangunkan dan dinilai untuk sifat fizikokimia termasuk pH, ujian sensori (tekstur, bau dan kesan pelembapan) dan keberkesanan perlindungan matahari. Faktor Perlindungan Matahari (SPF) ditentukan menggunakan spektrofotometri UV, dengan pengesahan selanjutnya menggunakan kaedah Mansur. Antara formulasi, F3 menunjukkan keputusan yang paling baik dari segi kesan pelembap, tekstur, bau, pilihan pengguna dan prestasi SPF. SPF F3 dikira sebagai 17.626, menunjukkan perlindungan UVB yang ketara apabila digunakan dengan betul. Semua formulasi yang diuji mengekalkan julat pH 6.0 hingga 6.3, menunjukkan keserasian kulit. Secara keseluruhan, pelindung matahari Hibiscus rosa-sinensis didapati selamat, berkesan dan sesuai untuk kegunaan harian merentasi pelbagai jenis kulit. Ia memberikan alternatif semula jadi yang menjanjikan kepada

pelindung matahari kimia konvensional, menawarkan manfaat yang boleh dilihat dan boleh diukur tanpa memerlukan pelaburan kos tinggi.

***Kata kunci**: Pelindung matahari, Hibiscus rosa-sinensis, pH, sensori, dan SPF*

1.0 INTRODUCTION

Sunscreen is a must for protecting our skin from harmful UV rays that can cause lasting damage. However, many of the products available are in liquid form and often contain harsh chemicals. This study focuses on creating a more practical sunscreen in stick form easy to carry around with its compact, pocket-friendly packaging and simple to apply without that sticky feeling. Made with natural ingredients like *Hibiscus rosa-sinensis* extract and coconut oil, this sunscreen is not only safe but also provides effective, all-natural protection for daily use.

As concerns about the harmful effects of UV rays on skin health grow, more people are turning to sunscreen for protection. However, many of the products currently on the market come in liquid form, which can be messy and inconvenient to use daily. In addition, some of these sunscreens hold harsh chemicals that may not be the best choice for sensitive skin or long-term use. Some natural ingredients, such as *Hibiscus rosa-sinensis* extract, offer valuable antioxidant and soothing good for the skin, making them a great option for skincare. However, there is a lack of focus on sunscreen products in stick form made with these natural ingredients. This research aims to fill that gap by creating a more practical and effective sunscreen stick that is easy to carry, apply, and safe for daily use.

1.1 Problem Statement

Sunscreen creams are essential for protecting the skin from harmful ultraviolet (UV) radiation, which can cause sunburn, premature aging, and increase the risk of skin cancer. However, many commercially available sunscreens contain synthetic chemicals such as oxybenzone, parabens, and artificial fragrances that may pose potential health risks, particularly with long-term use. These concerns have led to increasing demand for safer and more skin-friendly alternatives that still provide effective UV protection. A key challenge in sunscreen development is formulating a “next generation” product that not only offers broad-spectrum protection against UV radiation but is also safe, stable, and user-friendly. Replacing conventional chemical UV filters with natural or less harmful ingredients often affects product performance and stability. For example, mineral-based sunscreens may leave a white residue or feel greasy on the skin, reducing user acceptance and regular usage.

In addition to effectiveness, sensory properties such as texture, spreadability, and fragrance play an important role in consumer satisfaction. A sunscreen that feels light, non-greasy, and has a pleasant scent is more likely to be used consistently. However, improving these qualities without relying on synthetic additives remains a significant formulation challenge. Another critical factor is maintaining the sunscreen at an optimal pH level. The pH should be compatible with the skin’s natural barrier, which is slightly acidic, to prevent irritation and support skin health. An improper pH may reduce the effectiveness of active ingredients and cause skin

sensitivity. Therefore, developing an ideal sunscreen requires balancing multiple factors, including effective UV protection, safe ingredients, appealing sensory characteristics, and proper pH, to ensure both product efficacy and user acceptance.

1.2 Research Objectives

The objectives of this study are:

a) To develop a convenient sunscreen lotion stick formulated using *Hibiscus rosa-sinensis* extract as safer alternatives to conventional chemical-based sunscreens.
b) To assess the sensory properties of the developed sunscreen lotion stick, focusing on moisturizing properties, texture, odour and overall acceptance.
c) To characterize the sunscreen lotion stick by evaluating its pH value and Sun Protection Factor (SPF).

1.3 Significant of Research

This study is important because it addresses the growing demand for sunscreens that are both effective and gentle on the skin. By developing a sunscreen lotion stick made with natural ingredients like Hibiscus rosa-sinensis extract and coconut oil, this research offers a great alternative to traditional liquid sunscreens, which can often feel sticky and contain harsh chemicals. The result is a more user-friendly sunscreen that not only protects against harmful UV rays but also provides a safer, more natural option for everyday use. Beyond that, this work has the potential to inspire new innovations in skincare especially in creating products that are kinder to both our skin and the environment. By focusing on safety, comfort, and natural ingredients, it responds to the rising demand for healthier skincare choices. The findings could pave the way for even better sunscreens and open up exciting possibilities for natural skincare products in the future.

2.0 LITERATURE REVIEW

Hibiscus rosa-sinensis, commonly referred to as the shoe or hibiscus flower, is a tropical plant widely cultivated for its ornamental and medicinal properties. In recent years, it has gained significant interest within the cosmetics industry due to its rich phytochemical profile and multifunctional benefits for skin health (Ashiilah et al., 2023). This extract contains high levels of bioactive compounds such as flavonoids, anthocyanins, phenolic acids, and polysaccharides, which contribute to its potent antioxidant, anti-inflammatory, and moisturizing activities (Chen & Li, 2020; Zhao et al., 2021).

The antioxidant properties of hibiscus extract are particularly valuable in skincare. Free radicals generated by UV radiation and environmental pollutants accelerate skin aging by damaging collagen and elastin fibers. Hibiscus anthocyanins and flavonoids scavenge these reactive oxygen species, reducing oxidative stress and cellular damage (Ashiilah et al., 2023). A study by Ashiilah et al. (2023) demonstrated that ethanol extracts of hibiscus flowers exhibited significant radical scavenging activity using DPPH and ABTS assays, suggesting its potential in protecting skin from premature aging. Furthermore, these antioxidant compounds also

stimulate collagen synthesis, which helps in maintaining skin firmness and elasticity (Wang & Zhou, 2022).

The integration of hibiscus extract in sunscreen formulations has been explored due to its complementary protective properties. Beyond traditional UV filters, hibiscus provides antioxidant defense against UV-induced oxidative damage and inflammation, potentially enhancing the overall efficacy and skin compatibility of sunscreens (Zhao et al., 2021). Formulations containing hibiscus extract have demonstrated improved skin hydration and reduced irritation, contributing to increased user comfort during sun exposure (Chen & Li, 2020). Additionally, the rising consumer demand for natural, sustainable, and plant-based ingredients in skincare aligns well with hibiscus extract's profile. Its biodegradable and renewable nature appeals to environmentally conscious consumers, making it a favorable ingredient in green cosmetic formulations (Wang & Zhou, 2022).

Zinc oxide (ZnO) is one of the most trusted ingredients in mineral sunscreens, loved for its ability to shield the skin from both UVA and UVB rays (Lin & Wu, 2021). Unlike chemical sunscreens that absorb UV rays which can sometimes irritate sensitive skin, zinc oxide works by sitting on top of the skin, physically reflecting and scattering harmful radiation (Zhao et al., 2023). One of the biggest advantages of zinc oxide is how stable it is in sunlight. It does not break down easily, which means it keeps protecting your skin for longer periods outdoors (Lin & Wu, 2021). Modern formulations now use tiny zinc oxide particles that are less visible on the skin. That means no chalkier white cast just smooth, lightweight protection (Zhao et al., 2023).

To make zinc oxide even safer, these tiny particles are often coated with materials like silica or dimethicone. This helps prevent them from reacting with sunlight in a way that could produce harmful free radicals (Li et al., 2022). Studies have also shown that coated zinc oxide does not go beyond the surface layer of the skin, so it's considered safe for regular use, even on sensitive skin (Li et al., 2022). Because it's gentle and non-irritating, zinc oxide is a popular choice for babies, people with sensitive skin, and anyone who prefers a more natural sunscreen. It also helps sunscreen stick to the skin better, making it more water-resistant (Zhao et al., 2023).

3.0 RESEARCH METHODOLOGY

This study uses a combination of descriptive and experimental methods to thoroughly observe and evaluate a sunscreen lotion made with *Hibiscus rosa-sinensis* extract. The descriptive part focuses on detailing the key features of the formulation, such as the choice of ingredients, how the product was made, and sensory qualities like texture and scent. At the same time, the experimental part involves testing important factors like pH levels and sun protection effectiveness (SPF) using UV spectroscopy. The research collected both qualitative and quantitative data. Qualitative data came from sensory feedback on aspects like texture, smell, color, and how comfortable the lotion feels on the skin. Quantitative data was gathered through lab tests measuring pH and SPF, providing precise and scientific results.

Overall, this approach allowed for a well-rounded evaluation of the lotion, covering its physical and chemical properties as well as how users perceive it. It also sets a solid foundation for future research and product improvements. The overall research methodology is presented in Figure 3.1, following the ADDIE model framework that systematically guides the processes of analysis, design, development, implementation, and evaluation.

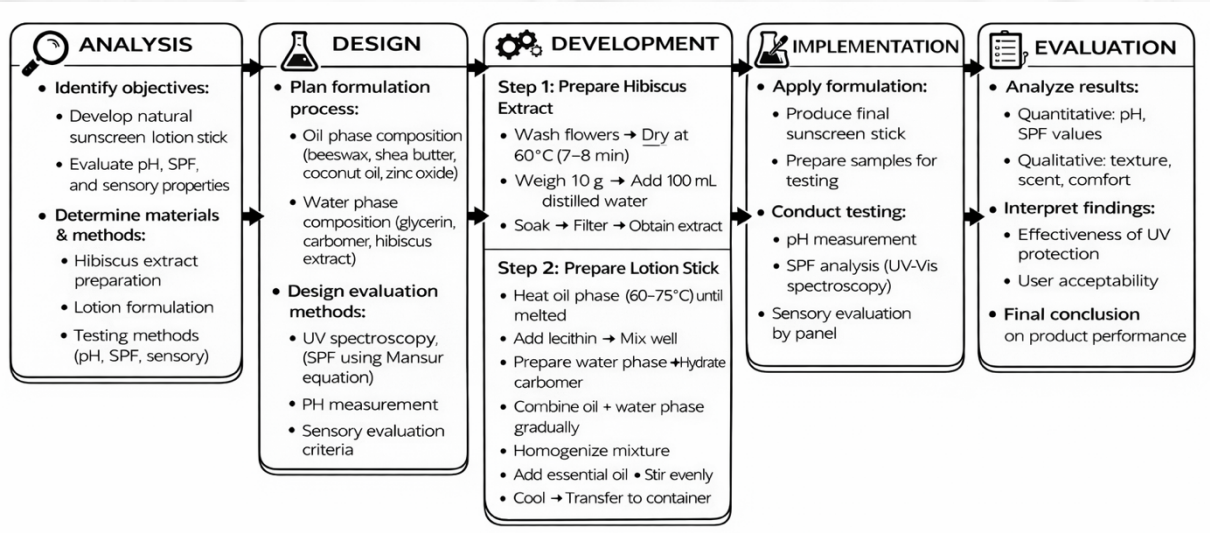


Figure 3.1: Methodology by ADDIE model framework

3.1 Preparation of Hibiscus Extract

The hibiscus extract was prepared using a standard aqueous extraction method adapted from M. O. and Marshall, M. R. (2011). Fresh hibiscus (*Hibiscus rosa-sinensis*) flowers were first thoroughly washed with clean water to remove dirt and surface impurities. The cleaned flowers were then dried in an oven at 60°C for approximately 7–8 minutes to reduce moisture content while preserving the bioactive compounds. After drying, 10 grams of the hibiscus material were accurately weighed and transferred into a clean container. Subsequently, 100 mL of distilled water was added, and the mixture was allowed to soak for a period of time to facilitate the extraction of pigments and beneficial phytochemicals. Once the extraction process was complete, the mixture was filtered, and the solid petals were separated, yielding a clear, concentrated hibiscus extract for further use.

3.2 Preparation of Sunscreen Lotion Stick

The oil phase is prepared by mixing beeswax, shea butter, coconut oil, and zinc oxide in a beaker. This mixture is heated using a water bath at a controlled temperature 60-75 °C until all ingredients are completely melted and homogeneous (mixed). Lecithin is then added to the melted mixture and stirred until combined. In a separate container, the water phase is prepared by dissolving glycerin, carbomer and hibiscus extract in distilled water. This mixture is stirred continuously until the carbomer is fully hydrated and produces a gel-like consistency solution.

The oil phase is gradually added to the water phase while stirring continuously to produce a stable and homogeneous. The temperature of the homogeneous is monitored to ensure proper mixing conditions. Once both phases are mixed, the mixture is homogenized to obtain a

smoother texture. After the mixture is homogenized, the essential oil is added. Continuous stirring is carried out to ensure even distribution of both ingredients throughout the mixture. The final product is then allowed to cool to room temperature before being transferred into a suitable container for further evaluation.



Figure 3.2: Finished product of lotion sunscreen stick

3.3 Data Analysis

Data for this study were collected using two main approaches. The first involved gathering quantitative data through precise scientific measurements. The pH values of the formulations were measured using a calibrated pH meter to ensure the product's compatibility with skin. Additionally, the Sun Protection Factor (SPF) was determined through UV spectroscopy analysis and Mansur equation, providing an objective assessment of the lotion's ability to protect against harmful UV radiation.

The second approach focused on qualitative data collected from sensory evaluations. A panel of trained assessors was invited to test the product and share their impressions regarding key sensory attributes such as texture, scent, moisturizing properties and overall comfort during use. Their feedback helped to gauge how users might perceive the lotion in real-world conditions, offering valuable insights into its acceptability and potential appeal to consumers. Together, these methods provided a comprehensive understanding of both the scientific performance and user experience of the sunscreen lotion.

4.0 RESEARCH FINDINGS

4.1 pH Analysis

The pH analysis has been carried out for all three formulations (F1, F2, and F3). According to pH testing, all three formulations fell between 6.3 and 6.6, which is the safe range for human skin and helps to preserve the skin's natural balance without irritating it.

Table 4.1: pH values of lotion sunscreen sticks

Sample	pH Value
Formulation 1	6.3

Formulation 2	6.4
Formulation 3	6.6

4.2 Sensory Evaluation

In addition to pH stability, Formulation 3 received the highest ratings for moisture, texture, odour, and general acceptability from a panel of thirty people. The panelists preferred Formulation 3 due to its smooth texture, pleasant scent, and effective moisturizing ability.

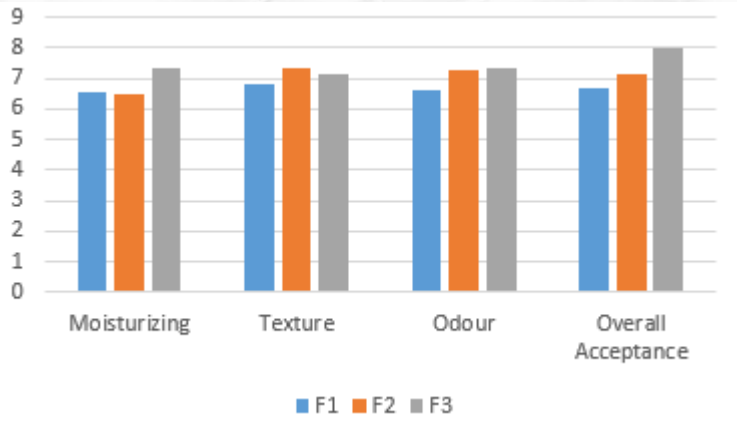


Figure 4.1: Sensory evaluation results

4.3 Sun Protection Factor (SPF) Value

Additionally, the Lotion Sunscreen Stick obtained an SPF value of 17.626, determined by Mansur equation which indicates adequate protection against UVB radiation for everyday use, according to analysis conducted using UV-Vis Spectroscopy.The product's potential as a top option in the sunscreen market is demonstrated by its stable pH, pleasant sensory experience, and effective UV protection. A simple, rapid, and reliable in vitro method for determining SPF involves measuring the product's absorbance across wavelengths of 290–320 nm at 5 nm intervals. The data obtained for the analysis is as per Table 4.2 below.

Table 4.2: Absorbance of lotion sunscreen stick

Wavelength (nm)	EExI	Absorbance
290	0.015	0.03105
295	0.081	0.16130
300	0.287	0.51780
305	0.327	0.56850
310	0.186	0.31760
315	0.083	0.13780
320	0.018	0.02850
Total		1.7626

5.0 RESEARCH DISCUSSION

5.1 pH Analysis

The pH analysis was the first test conducted on the Lotion Sunscreen Stick formulations. Results showed that all three formulations had pH values ranging from 6.3 to 6.6, which falls within the safe and skin-friendly range of 5.5 to 7.0. Maintaining this range is important to support the skin's natural acid mantle, a protective layer that helps defend against harmful microorganisms and environmental pollutants while keeping the skin hydrated. Cosmetic formulations, particularly cleansers and emulsions, are often developed within a pH range of 6–7 to optimize surfactant performance, product stability, and skin compatibility (Lukić et al., 2021).

Formulation 1 recorded a pH of 6.3, making it slightly more acidic but still suitable for skin application. This mild acidity may benefit individuals with oily or combination skin by helping regulate sebum production. Formulation 2, with a pH of 6.4, is well-balanced and appropriate for most skin types. Meanwhile, Formulation 3 showed a pH of 6.6, closest to neutral, making it the gentlest option and particularly suitable for sensitive skin. Overall, all formulations demonstrate good pH stability and are safe for daily use.

5.2 Sensory Evaluation

Sensory evaluation was conducted to assess user experience of the Lotion Sunscreen Stick formulations. A total of 30 panelists evaluated moisturizing ability, texture, aroma, and overall acceptability. The results showed that Formulation 3 achieved the highest scores in all categories, indicating superior performance.

Formulation 3 recorded a moisturizing score of 7.37, demonstrating its ability to hydrate the skin effectively without leaving an oily or sticky feel. Panelists noted that their skin remained soft and moisturized for an extended period. In terms of texture, it scored 7.13, reflecting a lightweight and smooth consistency that was easy to apply and suitable for daily use, with no heavy residue.

For aroma, Formulation 3 scored 7.33, described as natural, fresh, and pleasant without being overpowering. The use of hibiscus extract and essential oils contributed to this appealing scent. Overall, it achieved a high score of 7.97, indicating strong user acceptance and suitability as a daily sunscreen product.

5.3 UV-Vis Spectroscopy

UV-Vis spectroscopy was used to evaluate the ability of the Lotion Sunscreen Stick to absorb harmful UVB rays. The Erythemal Effectiveness Index (EEI) was multiplied by the absorbance at specific wavelengths and adjusted using a correction factor to obtain an SPF value of 17.626. This indicates that the formulation can block approximately 94% of UVB radiation, placing it in the "good protection" category. SPF values within the range of 15–20 are commonly used as reference levels in sunscreen efficacy studies, representing moderate protection against UVB radiation; therefore, an SPF value of approximately 17 can be considered acceptable within this category (Granger et al., 2019).

Standard skin protection guidelines recommend the use of broad-spectrum sunscreen with a minimum SPF of 15, applied at 2 mg/cm² and reapplied every two hours. Effective formulations must demonstrate protection against both UVA and UVB radiation, exhibit water

resistance, and be evaluated using validated methods such as SPF determination. Additionally, sunscreen should be used in combination with other protective measures such as clothing and shade to ensure optimal photoprotection (World Health Organization, 2002; Osterwalder & Herzog, 2010; Diffey, 2001).

This method provides a reliable and comprehensive assessment as it considers a range of UV wavelengths. However, while the SPF is suitable for daily use, it may not be sufficient for prolonged outdoor exposure. Improvements such as enhancing UV filters or photostability could increase effectiveness. Overall, the project successfully developed a safe and user-friendly sunscreen stick. Formulation 3 performed best, with balanced pH, good texture, and pleasant aroma. The use of hibiscus extract adds antioxidant benefits. Future work should focus on improving SPF and product durability.

6.0 CONCLUSION

In conclusion, this study successfully developed a natural-based Lotion Sunscreen Stick using hibiscus (*Hibiscus rosa-sinensis*) extract and coconut oil as key ingredients. The formulation demonstrated promising results in terms of safety, effectiveness, and user acceptability. The pH analysis confirmed that all formulations were within the skin-friendly range of 5.5 to 7.0, ensuring compatibility with the skin's natural barrier and minimizing the risk of irritation. Among the formulations, Formulation 3 showed the most balanced pH, making it especially suitable for sensitive skin.

The sensory evaluation further supported the superiority of Formulation 3, as it achieved the highest scores in moisturizing ability, texture, aroma, and overall acceptability. Its lightweight, non-sticky feel and pleasant natural scent contributed to a positive user experience, which is essential for encouraging consistent daily use. Additionally, UV-Vis spectroscopy analysis revealed that the sunscreen provides good UVB protection with an SPF value of 17.626, making it suitable for daily activities. Overall, the findings indicate that a natural, eco-friendly sunscreen stick can be both effective and appealing. Future improvements should focus on enhancing SPF and long-term stability.

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OPTIMIZATION OF PALM WAX AND TREATED WASTE COOKING OIL (WCO) FORMULATIONS FOR ENHANCED JAR CANDLE PERFORMANCE

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Abstract

This research addresses the sustainability and performance limitations of paraffin candles by upcycling Waste Cooking Oil (WCO) into a palm wax matrix. Pure palm wax candles often suffer from brittleness, surface cracking, and inefficient "tunneling" during combustion. The primary objectives of this study were to develop binary lipid formulations (F1- F4) evaluate their mechanical hardness, and determine their combustion efficiency. The methodology involved a melt-blending process at 80oC mixing palm wax with varying WCO concentrations (0g, 10g, 20g, and 30g) while maintaining constant levels of stearic acid (15g) and additives (5g). Mechanical hardness was quantified as Peak Load (N) using a Brookfield CT3 Texture Analyzer, and combustion performance was assessed through a 4-hour gravimetric burn test to calculate the Specific Burn Rate (g/hr). Results indicated a direct correlation between WCO concentration and texture, as the oil acted as a potent plasticizer. Hardness successfully decreased from ~45 N in the control (F4) to ~18 N in the 30g blend (F3). Combustion data revealed that the pure palm wax control (F4) had the highest and least efficient burn rate at 4.91 g/hr due to tunneling. In contrast, F2 (20g WCO) emerged as the optimal formulation, achieving the slowest and most stable burn rate of 3.53 g/hr—a 28% increase in fuel efficiency compared to the control. Discussion of these findings suggests that the liquid triglycerides in WCO disrupt the rigid palm wax crystals, allowing for better thermal distribution and a full melt pool. In conclusion, the F2 formulation provides the ideal balance of structural integrity and burning performance. This study proves that recycling WCO into palm-based candles creates a high-quality, eco-friendly product that outperforms standard vegetable wax formulations.

Keywords: palm wax, waste cooking oil, jar candle, sustainable materials, candle formulation

Abstrak

*Kajian ini menangani isu kelestarian dan kekangan prestasi lilin tradisional dengan mengitar semula minyak masak terpakai (*Waste Cooking Oil*, WCO) ke dalam matriks lilin sawit. Lilin sawit tulen sering mengalami masalah kerapuhan, keretakan permukaan, dan pembakaran tidak sekata yang menyebabkan fenomena "*tunneling*". Objektif utama kajian ini adalah untuk*

membangunkan formulasi lipid binari (F1–F4), menilai kekerasan mekanikal, dan menentukan kecekapan pembakaran. Metodologi yang digunakan melibatkan proses pencairan dan pencampuran pada suhu 80°C dengan mencampurkan lilin sawit bersama kepekatan WCO yang berbeza (0 g, 10 g, 20 g, dan 30 g) sambil mengekalkan jumlah asid stearik (15 g) dan bahan tambahan (5 g) yang malar. Kekerasan mekanikal diukur sebagai Beban Puncak (N) menggunakan Brookfield CT3 Texture Analyzer, manakala prestasi pembakaran dinilai melalui ujian pembakaran gravimetrik selama 4 jam untuk mengira Kadar Pembakaran Spesifik (g/jam). Keputusan menunjukkan hubungan langsung antara kepekatan WCO dan tekstur, di mana minyak bertindak sebagai pemplastik yang berkesan. Kekerasan berjaya dikurangkan daripada kira-kira 45 N bagi kawalan (F4) kepada sekitar 18 N bagi campuran 30 g (F3). Data pembakaran menunjukkan bahawa lilin sawit tulen (F4) mempunyai kadar pembakaran tertinggi dan paling tidak cekap iaitu 4.91 g/jam akibat fenomena tunneling. Sebaliknya, F2 (20 g WCO) muncul sebagai formulasi optimum dengan kadar pembakaran paling perlahan dan stabil iaitu 3.53 g/jam, menunjukkan peningkatan kecekapan bahan api sebanyak 28% berbanding kawalan. Perbincangan dapatan ini mencadangkan bahawa trigliserida cecair dalam WCO mengganggu struktur kristal tegar lilin sawit, sekali gus membolehkan pengagihan haba yang lebih baik dan pembentukan kolam lebur penuh. Kesimpulannya, formulasi F2 memberikan keseimbangan ideal antara integriti struktur dan prestasi pembakaran. Kajian ini membuktikan bahawa pengitaran semula WCO ke dalam lilin berasaskan sawit dapat menghasilkan produk berkualiti tinggi, mesra alam, dan mengatasi prestasi formulasi lilin sayuran standard.

***Kata kunci**: lilin sawit, sisa minyak masak, lilin balang, bahan lestari, formulasi*

1.0 INTRODUCTION

The global shift toward sustainable candle production is driven by the environmental and health risks of paraffin wax, which is known to release harmful volatile organic compounds (VOCs) during combustion (Manzoor et al., 2022). While palm wax offers a renewable and biodegradable alternative, its high degree of molecular saturation results in a rigid β crystalline structure that causes significant volumetric contraction and brittleness, leading to "sinkholes" and surface cracking (Karaman et al., 2022). To resolve these structural failures, this research explores an optimized binary lipid formulation using treated Waste Cooking Oil (WCO) as a functional plasticizer. By disrupting the tight crystal packing of the palm wax matrix, the integration of WCO aims to increase flexibility and reduce shrinkage, providing a high-performance, eco-friendly candle while effectively upcycling hazardous oil waste (Suharyani et al., 2023).

1.1 Problem Statement

Conventional candle production relies heavily on paraffin wax, a non-renewable petroleum derivative linked to significant environmental degradation and the emission of hazardous volatile compounds during combustion. While palm wax offers a renewable and biodegradable alternative, its application in jar candles is often hindered by physical defects such as surface

cracking, significant shrinkage, and thermal instability, which compromise both aesthetic appeal and functional performance.

Simultaneously, the improper disposal of waste cooking oil (WCO) presents a major environmental challenge, leading to the pollution of water systems and soil. While the potential for recycling WCO into value-added products is recognized, there is currently a lack of optimized formulations that successfully integrate treated WCO with palm wax to overcome the structural limitations of bio-waxes. This research addresses the need for a sustainable, high-performance candle formulation that promotes a circular economy by transforming a common waste product into a functional consumer good.

1.2 Research Objectives

The research aims to:

1. develop a sustainable candle by first identifying the most stable binary lipid formulation through the testing of various mixing ratios of palm wax and treated Waste Cooking Oil (WCO).
2. determine hardness of the candle with addition of treated WCO acts as a plasticizer for formulated candle.
3. evaluate the combustion efficiency of the resulting candle in term of specific burn rate.

1.3 Significant of Research

This study is significant as it addresses critical environmental, technical, and health challenges within the candle manufacturing industry by promoting a transition toward a circular economy (Rahardja, 2025; Umar et al., 2026). By replacing petroleum-derived paraffin with a renewable blend of palm wax and treated waste cooking oil (WCO), the research directly reduces the carbon footprint and environmental degradation associated with conventional consumer products (Hadi Lubis et al., 2024).

Furthermore, the study offers a practical "waste-to-wealth" solution by repurposing Treated WCO a common environmental pollutant into a functional additive that enhances the structural integrity of bio-waxes (Umar et al., 2026). From a technical perspective, identifying an optimized formulation that mitigates common defects like surface cracking and shrinkage provides a vital roadmap for producing high-quality, eco-friendly candles that are commercially viable. Ultimately, this research contributes to public health by offering a cleaner-burning alternative that minimizes the release of toxic compounds in indoor environments, successfully balancing environmental sustainability with functional excellence (Hashim et al., 2024).

2.0 LITERATURE REVIEW

Conventional candle production relies primarily on paraffin wax, a petroleum-derived byproduct composed of long-chain alkanes. While paraffin offers consistent combustion, it is increasingly criticized for its environmental impact and the release of harmful volatile organic

compounds (VOCs), such as benzene and toluene, during burning. Research indicates that bio-based waxes, particularly palm wax, offer a renewable and biodegradable alternative with a significantly lower carbon footprint. However, the transition to pure vegetable waxes is hindered by their chemical composition, as they often lack the physical flexibility required for high-performance jar candles.

The primary challenge in using 100% palm wax lies in its high concentration of palmitic acid, which leads to a rigid and highly ordered β' (beta-prime) crystal lattice. This crystalline structure causes significant volumetric contraction as the wax transitions from a liquid to a solid, frequently resulting in "sinkholes" and delamination from the container walls. Furthermore, the lack of molecular diversity in pure palm wax creates extreme brittleness; without a flexible matrix, the wax cannot withstand thermal stress, leading to macro-structural cracks on the candle surface that compromise both aesthetic and functional quality.

To mitigate these defects, current studies focus on the development of binary lipid formulations that utilize secondary oils as plasticizers. Waste Cooking Oil (WCO), characterized by a complex mixture of unsaturated fatty acids, has emerged as a viable additive to "soften" the rigid palm wax structure. By introducing the liquid-phase molecules of treated WCO into the palm wax matrix, the tight packing of the crystal lattice is disrupted, increasing the material's flexibility and reducing shrinkage. This approach not only enhances the mechanical performance of the candle but also provides a sustainable solution for upcycling WCO, preventing its hazardous disposal into soil and water systems.

3.0 RESEARCH METHODOLOGY

The research methodology followed a systematic three-phase approach, beginning with the Development of Binary Candle Formulations through a controlled melt-blending process where palm wax was incrementally substituted with treated Waste Cooking Oil (WCO) at 10g (F1) 20g (F2) and 30g (F3) levels, while maintaining constant concentrations of stearic acid (15g) and additives (5g) at a processing temperature of 80 ±5°C. Following a 24-hour stabilization period at 25°C, the structural integrity of the resulting matrices was evaluated via Hardness Analysis using a Brookfield CT3 Texture Analyzer equipped with a 30° conical probe (TA17), which measured the Peak Load (N) at a 5 mm penetration depth and a test speed of 2.0 mm/s to quantify the plasticizing effect of the liquid lipids.

Finally, the Combustion Efficiency Analysis was performed through a 4-hour gravimetric burn test in a draft-free environment, where the Specific Burn Rate was quantified by measuring the hourly mass of fuel consumed, ultimately allowing for a direct correlation between the chemical formulation, mechanical firmness, and the long-term burning performance of the optimized bio-wax candle.

3.1 Development of Binary Candle Formulations

The development of the binary lipid formulations (F1-F4) was executed through a controlled melt-blending process to ensure molecular homogeneity between the saturated palm wax and

the unsaturated Waste Cooking Oil (WCO). The formulations were prepared based on a total mass of 100 g per sample, with F4 (80g Palm Wax, 0g WCO) serving as the experimental control to establish a performance baseline (Ooi, 2024). For the experimental blends, palm wax was incrementally substituted with treated WCO at ratios of 10 g (F1), 20 g (F2) and 30 g (F3), while the concentrations of stearic acid 15 g and additives 5 g remained constant across all samples to provide structural "backbone" and opacification (Liu et al., 2022b).

Thermal processing was conducted using a digital heating mantle at a temperature of 80 ± 5 ºC, exceeding the melting points of both palm wax and stearic acid to ensure a complete phase transition and uniform distribution of the lipid chains (Ushikubo et al., 2020). The mixtures were agitated continuously for 15 minutes to prevent phase separation between the high-melt-point solids and the liquid WCO. Upon achieving a clear, homogenous state, the molten wax was cooled to a pouring temperature of 70 ºC and cast into standardized glass jars equipped with centered cotton wicks. The finished formulations were allowed to stabilize at a controlled ambient temperature of 25 ºC for 24 hours to facilitate the formation of a stable β' crystalline lattice before undergoing mechanical and combustion testing (Suharyani et al., 2023).

3.2 Hardness Analysis of Formulated Candle

The hardness of the formulated candles (F1–F4) was evaluated using a Brookfield CT3 Texture Analyzer, following a methodology adapted from the ASTM D937-92 standard for semi-solid waxes (AMETEK Brookfield, 2024). This approach is consistent with established research on the mechanical properties of vegetable-based waxes, where texture analysis is used to determine the structural integrity of hydrogenated oils (Rezaei et al., 2020) and the utilization of palm products in candle making (Ooi, 2024).

Prior to analysis, each sample was stabilized at for 24 hours to ensure a uniform crystalline network. The analyzer, equipped with a 30° conical probe (TA17) and a 10 kg load cell, measured the resistance of the palm wax and treated waste cooking oil (WCO) blends (Anggraini & Kurniasih, 2024a; Liu et al., 2022a). The probe penetrated the center of each candle at a test speed of 2.0 mm/s with a 5 g trigger force. Hardness was quantified as the Peak Load (N) at a 5 mm depth, providing a baseline for correlating mechanical firmness with burning efficiency and additive concentration (Rodzi & Iskandar, 2024).

3.3 Combustion Efficiency Analysis of Formulated Candle

The methodology for evaluating Combustion Efficiency focused primarily on the Specific Burn Rate (Rb), which quantifies the consumption of the wax-WCO matrix over time. Each formulated candle (F1- F4) was first weighed on a high-precision digital balance (0.01g sensitivity) to record the initial mass (m_i). The candles were then ignited and allowed to burn for a continuous period of 4 hours in a draft-free environment at a controlled ambient temperature of 25^0C to ensure that environmental factors did not interfere with fuel consumption (Manzoor et al., 2022). After the 4-hour cycle, the candles were extinguished, and the final mass (m_f) was recorded. The burning efficiency was calculated using the gravimetric formula:

$$R_b \left(\frac{g}{hr}\right) = \frac{m_i - m_f}{4}$$

This analysis serves to identify how the substitution of palm wax with treated Waste Cooking Oil (WCO) which typically lowers the melting point—affects the rate of capillary action through the wick. By comparing the burn rate of the treated WCO blends (F1-F3) against the pure palm wax control (F4), the study determines the optimal formulation that ensures a steady, efficient fuel supply without causing the wick to "drown" or the wax to consume too rapidly (Suharyani et al., 2023).

4.0 RESEARCH FINDINGS

4.1 Development of Binary Candle Formulations

Table 4.1 shows the ratio of palm wax to treated waste cooking oil (WCO) content in the developed formulations. Based on the developed formulations, F4 as control shows the hardest, most brittle and cracking compared to other formulation. As observed, increasing the proportion of WCO influenced the physical appearance of the candles. The visual evaluation showed that F1 exhibited an uneven surface with a moderate sinkhole near the wick. F2 produced a smoother and more uniform candle surface with minimal shrinkage. In contrast, F3 displayed a glossy and softer structure with a more pronounced central depression, likely due to the higher proportion of waste cooking oil.

Table 4.1: Ratio of palm wax to waste cooking oil (WCO) content

Code	Palm Wax (g)	WCO (g)	Candle Outlook
F1	70	10	Hard surface with moderate sinkhole, rough top finish
2	60	20	Reduced sinkhole, smoother and more uniform top surface
F3	50	30	Soft texture, pronounced central sink (melt pool-like), glossy appearance
F4 (control)	80	0	Hard, sinkhole in the middle (wick), cracking

The results of this study, where formulation F2 (60% palm wax and 20% treated waste cooking oil) showed the best performance, are consistent with previous studies reporting that blending wax with liquid oils improves candle properties. Research on waste cooking oil–based candles found that pure waste cooking oil produces soft and unstable candles, but blending with other wax materials enhances burning time and structural stability. (Liu et al., 2022).

This indicates that a balanced formulation is necessary to obtain desirable candle characteristics. Similarly, the present study showed that moderate addition of treated waste cooking oil improved surface appearance, reduced cracking, and promoted better melting behavior compared to 100% palm wax. These findings support earlier work demonstrating that optimized oil incorporation improves combustion performance and candle quality.



(a) (b) (c)

Figure 4.1 (a) formulated candle F1, (b) formulated candle F2 and (c) formulated candle F3

4.2 Hardness Analysis of Formulated Candle

The results of this analysis in Table 4.2 show formulation F4(80:0) recorded the highest hardness value of 86.18 N, followed by F1 with 25.27 N. Formulation F2 showed a lower hardness of 15.96 N, while F3 exhibited the lowest hardness value at 12.55 N. This result demonstrates a clear correlation between the concentration of treated waste cooking oil (WCO), the mechanical hardness of the wax, and the resulting combustion efficiency.

Table 4.2 The Hardness and Outlook of the Formulated Candle (Palm wax: WCO)

Code	Hardness (N)	Hardness Outlook
F1 (70:10)	25.27	Moderately hard
F2 (60:20)	15.96	Soft
F3 (50:30)	12.55	Very soft
F4 (control)	86.18	Very hard with rigid structure

4.3 Combustion Efficiency Analysis of Formulated Candle

Table 4.3 shows the results of the combustion efficiency analysis demonstrate that the integration of treated waste cooking oil (WCO) significantly stabilizes the burning process compared to the pure palm wax control (Suharyani et al., 2023). The burn rate serves as a critical indicator of fuel consumption efficiency, where a lower, steadier rate generally indicates a longer-lasting and more sustainable candle (Manzoor et al., 2022). This stabilization is primarily attributed to the improved capillary flow and thermal distribution within the WCO-modified matrix, which prevents the rapid, uneven consumption and "tunneling" effects often observed in unmodified, highly crystalline vegetable lipids (Karaman et al., 2022).

Table 4.3 Burn Rate of formulated candle (Palm wax: WCO)

Sample	Initial Mass (g)	Final Mass (g)	Total Mass Loss (g)	Burn Rate (g/hr)	Flame Stability
F1 (70:10)	99.27	84.02	15.25	3.81	Steady flame, full melt pool reached.
F2 (60:20)	99.60	85.50	14.10	3.53	Steady flame, rapid melt pool.
F3 (50:30)	98.70	83.62	15.08	3.70	Large melt pool, slight flickering.
F4 (Control)	98.79	79.17	19.62	4.91	High flame, potential tunneling.

5.0 RESEARCH DISCUSSION

5.1 Development of Binary Candle Formulations

The hardness of candle formulations, determined by the ratio of palm wax to treated waste cooking oil (WCO), significantly dictates both the total burning time and the physical surface texture of the jar candle. Formulation F4 is the hardest at 86.18 N due to its high palm wax content (80g) and absence of liquid oil, creating a dense, high-melting-point crystalline structure. While this increased hardness leads to a longer total burning time by slowing the wax consumption rate, it also makes the candle highly brittle. Harder waxes undergo greater thermal contraction as they cool, and because F4 lacks the plasticity provided by oil, it is much more prone to surface cracking and pulling away from the glass walls (wet spots).

5.2 Hardness Analysis of Formulated Candle

The hardness results clearly show that increasing the waste cooking oil (WCO) content significantly reduced the mechanical strength of the candles. Formulation F4 recorded the highest hardness value (86.18 N), indicating a very rigid structure that may lead to slow burning characteristics and the possibility of “wet spots” due to poor adhesion to the container wall. While this increased hardness leads to a longer total burning time by slowing the wax consumption rate, it also makes the candle highly brittle (Nugrahini, & Setiawati, 2025). When WCO was incorporated in F1, the hardness decreased to 25.27 N, producing a moderately firm candle suitable for both pillar and container applications. (Anggraini & Kurniasih, 2024).

Further addition of WCO in F2 reduced the hardness to 15.96 N, resulting in a softer wax with improved glass adhesion, which is desirable for container candles. The lowest hardness was observed in F3 (12.55 N), indicating a very soft formulation. This softness can enhance fragrance diffusion and melt pool formation but may compromise structural stability, making it more suitable for small container candles (Rezaei et. al 2020).

5.3 Combustion Efficiency Analysis of Formulated Candle

Sample F4 exhibited the highest burn rate at 4.91 g/hr. While this indicates a high consumption of fuel, the observed "high flame" and "potential tunneling" suggest poor overall efficiency (Nugrahini & Setiawati, 2025). In jar candles, tunneling occurs when the heat fails to spread to the edges, melting only a narrow center column. This results in a high mass loss from a small area without utilizing the entire wax surface, essentially wasting the fuel located on the outer rim and shortening the candle's lifespan (Karaman et al., 2022).

Conversely, the most efficient formulation was F2, which recorded the lowest burn rate of 3.53 g/hr. This represents a 28% reduction in fuel consumption compared to the control. The "steady flame" and "rapid melt pool" indicate that the blend has reached a thermal equilibrium; the heat is distributed efficiently across the surface to create a full pool, yet the consumption of wax remains controlled (Suharyani et al., 2023). This suggests that the 20g WCO level provides the optimal balance of capillary action and fuel delivery, effectively stabilizing the combustion kinetics of the palm wax matrix (Manzoor et al., 2022).

6.0 CONCLUSION

As conclusion, sample F2 emerged as the most efficient formulation. It achieved the slowest burn rate (3.53 g/hr), representing a 28% increase in longevity compared to the control, while maintaining sufficient hardness (~30 N) for a stable, smooth finish. This research successfully achieved the optimization of a sustainable jar candle matrix by integrating treated Waste Cooking Oil (WCO) into a palm wax base. By evaluating the binary formulations across three key objectives—structural development, mechanical hardness, and combustion efficiency. This study provides a clear roadmap for upcycling lipid waste into high-value consumer products.

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KEBERKESANAN *PLASTIC INTERLOCKING BLOCK* DALAM MENINGKATKAN KEFAHAMAN PELAJAR BAGI KURSUS TEKNOLOGI BINAAN

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ABSTRAK

Kajian ini dijalankan adalah untuk mengenalpasti keberkesanan penggunaan *Plastic Interlocking Block* sebagai alat bantu mengajar (ABM) dalam meningkatkan kefahaman pelajar bagi kursus Teknologi Binaan. Kursus Teknologi Binaan merupakan salah satu kursus bagi Program Sijil Teknologi Pembinaan Bangunan (STP). Kursus ini memerlukan pelajar memahami konsep asas pembinaan seperti sistem ikatan blok kekunci, kestabilan struktur dan aplikasi pembinaan sebenar. Walau bagaimanapun, pengajaran secara teori semata-mata didapati menyebabkan pelajar sukar membayangkan situasi sebenar di tapak binaan serta kurang penglibatan aktif di dalam kelas. Sehubungan itu, satu inovasi berbentuk model fizikal berasaskan konsep *interlocking block model* telah dibangunkan bagi menyokong pembelajaran secara *hands-on* dan berpusatkan pelajar. *Plastic Interlocking Block* merupakan model blok kekunci yang direkabentuk daripada blok kekunci sebenar tetapi telah diskalakan dalam saiz yang lebih kecil seakan-akan permainan lego. Material yang digunakan adalah plastik menjadikan ia lebih ringan dan mudah dibawa sebagai ABM. Metodologi kajian yang digunakan adalah kajian tinjauan dengan menggunakan instrumen soal selidik (*survey research*) bagi menilai tahap kefahaman, minat serta persepsi pelajar terhadap penggunaan bahan tersebut. Kajian ini melibatkan 44 orang responden yang terdiri dari pelajar program STP yang telah didedahkan dengan amali pemasangan blok kekunci yang terdapat dalam kursus Teknologi Binaan. Data dianalisis melalui statistik deskriptif menggunakan perisisan SPSS 27. Skor min tahap kefahaman konsep, minat dan motovasi pelajar di tahap tinggi iaitu di antara 4.39 sehingga 4.52. Manakala Ujian parametrik iaitu ujian-t antara dua kumpulan (I*ndependent-Sample T-Test*), didapati nilai t=0.0514 dan tahap signifikan p=0.612 di mana tahap signifikan bagi kedua-dua item ini adalah melebihi 0.05 ($p > 0.05$). Dapatan kajian menunjukkan penggunaan *Plastic Interlocking Block* dapat membantu mengukuhkan tahap kefahaman pelajar terhadap konsep pemasangan blok kekunci sebelum kerja amali di tapak dijalankan di samping meningkatkan tahap motivasi dan penglibatan aktif pelajar semasa sesi pengajaran dan pembelajaran (PdP). Kesimpulannya, *Plastic Interlocking Block* berpotensi menjadi satu inovasi pedagogi yang efektif dalam memperkukuh pemahaman konsep pembinaan serta menyokong amalan pengajaran yang lebih interaktif dalam bidang TVET.

Kata Kunci: *Plastic Interlocking Block, inovasi PdP, alat bantu mengajar.*

ABSTRACT

This study aims to determine the effectiveness of the Plastic Interlocking Block as a teaching aid in enhancing students' understanding in the Construction Technology course under the Certificate in Building Construction Technology (STP) programme. The course requires students to master basic concepts such as interlocking block systems, structural stability, and practical construction applications. However, conventional theory-based teaching often limits students' ability to visualise real construction scenarios and reduces active participation. To address this issue, a scaled-down, Lego-like Plastic Interlocking Block model was developed to support hands-on, student-centred learning. A survey method using questionnaires was employed, involving 44 STP students who had undergone practical exposure to interlocking block installation. Data were analysed using descriptive statistics and an Independent Samples T-Test via SPSS 27. The findings showed high mean scores (4.39–4.52) for understanding, interest, and motivation. The t-test result (t = 0.0514, p = 0.612) indicated no significant difference (p > 0.05). Overall, the use of Plastic Interlocking Block improved students' conceptual understanding, motivation, and active engagement in learning.

Keywords: *Plastic Interlocking Block, teaching innovation, teaching aid.*

1.0 PENGENALAN

Kaedah Pengajaran dan Pembelajaran (PdP) yang pelbagai adalah penting dalam penyampaian pendidikan yang lebih efektif bagi menarik minat pelajar dalam sesebuah kursus. Inovasi dalam pendidikan adalah penting bagi memastikan kaedah PdP yang dilaksanakan seiring dengan perkembangan semasa. Kursus Teknologi Binaan merupakan salah satu komponen penting dalam Program Sijil Teknologi Pembinaan Bangunan (STP) yang menekankan pemahaman konsep asas pembinaan seperti sistem ikatan blok, kestabilan struktur serta aplikasi sebenar di tapak binaan. Namun begitu, pendekatan pengajaran secara teori semata-mata sering kali menyebabkan pelajar menghadapi kesukaran untuk memahami konsep yang abstrak dan kompleks. Oleh itu, penggunaan alat bantu mengajar (ABM) yang bersifat praktikal dan interaktif amat diperlukan bagi membantu meningkatkan kefahaman pelajar. *Plastic Interlocking Block* merupakan model 3D kepada *IBS Interlocking Block* yang dicetak menggunakan mesin CNC *3D Printer.* Bentuk dan saiz bata kekunci IBS yang diskalakan kepada saiz yang lebih kecil dicetak sebanyak 500 unit bagi kegunaan pemasangan binaan ruang rumah yang ringkas bagi tujuan PdP. Pelan lantai binaan bangunan juga disediakan untuk memudahkan pelajar menyusun *Plastic Interlocking Block* semasa sesi PdP.

1.1 Penyataan Masalah

Pengajaran kursus Teknologi Binaan yang lebih berfokus kepada teori didapati kurang berkesan dalam membantu pelajar memahami konsep sebenar pembinaan. Pelajar sering menghadapi kesukaran untuk membayangkan struktur binaan sebenar, terutamanya berkaitan sistem blok kekunci dan kestabilan struktur. Selain itu, kekurangan penggunaan ABM yang

bersifat praktikal mengurangkan minat pelajar dan menyebabkan tahap penglibatan pelajar dalam kelas menurun. Situasi ini boleh menjejaskan minat, motivasi serta pencapaian akademik pelajar. Oleh itu, satu pendekatan pengajaran yang lebih interaktif dan praktikal perlu diperkenalkan bagi mengatasi masalah ini. Muhammad Izzuddin bin Mohd Yusoff et.al. (2025) di dalam kajiannya menyatakan bahawa gabungan teori dan aplikasi praktikal melalui ABM membantu pelajar menguasai konsep serta mengaplikasikannya dalam situasi sebenar. Sehubungan itu, penggunaan *Plastic Interlocking Block* diperkenalkan sebagai satu inovasi dalam PdP. Model ini direkabentuk berasaskan konsep batu bata kekunci IBS *(IBS Interlocking block)* sebenar tetapi dalam bentuk yang lebih kecil, ringan dan mudah dikendalikan seperti permainan lego. Penggunaan *Plastic Interlocking Block* sebagai ABM diharap dapat membantu pelajar memahami konsep pembinaan secara lebih jelas melalui pendekatan pembelajaran secara *hands-on* dan berpusatkan pelajar.

1.2 Objektif Kajian

Objektif kajian ini adalah:

1. Mengenalpasti tahap kefahaman konsep, tahap minat dan motivasi pelajar terhadap penggunaan *Plastic Interlocking Block.*
2. Menganalisa tahap keberkesanan *Plastic Interlocking Block* sebagai Alat Bantu Mengajar (ABM).
3. Menghubungkan demografi pelajar dengan tahap kefahaman konsep, minat dan motivasi pelajar terhadap keberkesanan penggunaan *Plastic Interlocking Block* sebagai ABM.

Sehubungan itu, dua persoalan kajian telah dibina oleh pengkaji iaitu:

i) Adakah terdapat perbezaan yang signifikan tahap kefahaman konsep, minat dan motivasi terhadap penggunaan *Plastic Interlocking Block* sebagai ABM di antara pelajar yang pernah mengikuti kursus pembinaan sebelum ini dengan pelajar yang tidak pernah mengikuti kursus pembinaan sebelum ini?

ii) Adakah terdapat hubungan yang signifikan terhadap peningkatan kefahaman konsep asas ikatan blok kekunci dengan tahap minat pelajar mengikuti sesi PdP yang menggunakan *Plastic Interlocking Block* sebagai ABM?

1.3 Kepentingan Kajian

Kajian ini penting dalam memberikan sumbangan kepada pelbagai pihak. Kepada pensyarah, kajian ini dapat membantu dalam mempelbagaikan kaedah pengajaran agar lebih menarik dan efektif. Kepada pelajar pula, penggunaan *Plastic Interlocking Block* dapat meningkatkan kefahaman serta minat terhadap kursus Teknologi Binaan.

Selain itu, kajian ini juga memberi sumbangan kepada institusi pendidikan khususnya dalam bidang TVET untuk menggalakkan penggunaan inovasi dalam pengajaran. Ia juga boleh dijadikan rujukan bagi kajian lanjutan berkaitan penggunaan ABM dalam meningkatkan kualiti pembelajaran.

2.0 Kajian Literatur

Kajian literatur menunjukkan bahawa penggunaan alat bantu mengajar (ABM) yang bersifat interaktif dan berasaskan pengalaman praktikal mampu meningkatkan kefahaman serta minat pelajar dalam proses pengajaran dan pembelajaran (PdP). Pendekatan ini amat penting khususnya dalam bidang teknikal seperti Teknologi Binaan yang memerlukan kemahiran visualisasi dan pemahaman konsep secara konkrit. Mohd Alfathi Md Udin et al. (2025) di dalam kajiannya berpendapat penggunaan alat bantu mengajar (ABM) dalam proses PdP bertujuan memudahkan pensyarah menyampaikan isi pelajaran dengan lebih jelas, tersusun dan menarik. ABM membantu mengelakkan kebosanan dalam kalangan pelajar serta meningkatkan penglibatan mereka sepanjang sesi pembelajaran. Tengku Farahnorfadhilah Engku Azman (2023) menekankan bahawa ABM yang mempunyai ciri komunikatif tinggi berupaya memberi pengalaman pembelajaran bermakna serta menyokong perkembangan sikap, ilmiah, sosial dan emosi pelajar.

Menurut Abdul Rashid et al. (2012), penggunaan bahan pembelajaran interaktif berjaya meningkatkan keberkesanan PdP serta mewujudkan suasana pembelajaran yang lebih menyeronokkan. Dapatan ini menunjukkan bahawa elemen interaktif mampu membantu pelajar memahami sesuatu konsep dengan lebih mudah berbanding kaedah konvensional. Selain itu, kajian oleh Mohd Fairuz (2011) mendapati bahawa pelajar menunjukkan minat yang tinggi terhadap penggunaan bahan pembelajaran yang mempunyai elemen visual seperti lakaran dan gambar. Kajian tersebut juga menunjukkan bahawa penggunaan bahan interaktif dapat meningkatkan kemahiran visualisasi pelajar, yang merupakan aspek penting dalam memahami konsep teknikal dan kejuruteraan.

Berdasarkan sorotan kajian lepas, dapat disimpulkan bahawa penggunaan bahan bantu mengajar yang interaktif seperti multimedia dan model fizikal mampu meningkatkan kefahaman, minat serta penglibatan pelajar. Sehubungan itu, penggunaan *Plastic Interlocking Block* sebagai model fizikal berasaskan konsep *hands-on* dilihat berpotensi besar dalam membantu pelajar memahami konsep pembinaan dengan lebih jelas dan berkesan, khususnya dalam kursus Teknologi Binaan.

3.0 Metodologi Kajian

Metodologi kajian merupakan kaedah dan pendekatan yang digunakan bagi mencapai objektif kajian yang telah ditetapkan. Kajian ini menggunakan pendekatan kuantitatif berbentuk kajian tinjauan bagi menilai keberkesanan penggunaan *Plastic Interlocking Block* dalam meningkatkan kefahaman pelajar bagi kursus Teknologi Binaan.

3.1 Rekabentuk Kajian

Kajian ini menggunakan reka bentuk kajian tinjauan (*survey research*) yang melibatkan pengumpulan data melalui soal selidik. Reka bentuk ini dipilih kerana ia sesuai untuk mendapatkan maklumat berkaitan persepsi, minat serta tahap kefahaman pelajar terhadap penggunaan alat bantu mengajar yang diperkenalkan.

3.2 Instrumen Kajian

Instrumen utama yang digunakan dalam kajian ini ialah borang soal selidik. Soal selidik ini dibangunkan dan diubah suai berdasarkan kajian-kajian lepas serta disesuaikan dengan objektif kajian. Borang soal selidik ini terbahagi kepada tiga bahagian utama iaitu:

- **Bahagian A:** Demografi
- **Bahagian B:** Tahap kefahaman konsep
- **Bahagian C:** Tahap minat dan motivasi
- **Bahagian D:** Keberkesanan *Plastic Interlocking Block* sebagai Alat Bantu Mengajar (ABM)

Setiap item dalam Bahagian B, C dan D menggunakan skala likert lima mata bagi mengukur tahap persetujuan responden.

3.3 Populasi dan Sampel Kajian

Populasi kajian ini adalah pelajar semester satu sehingga pelajar semester empat bagi Program Sijil Teknologi Pembinaan (STP) bagi Sesi II 2025/2026. Semua pelajar mempunyai peluang yang sama untuk dipilih sebagai sampel kajian. Berdasarkan rekod dari Unit Pengambilan Kolej Komuniti Bentong, pelajar STP adalah seramai 50 orang yang mengikuti pengajian secara sepenuh masa seperti di Jadual 1 berikut. Mengikut jadual Krejcie Morgan, 1970 menyatakan populasi adalah 50 responden dan sampel yang dicadangkan adalah 44 responden.

Jadual 1: Taburan Pelajar Mengikut Semester

Semester	Sesi Kemasukan	Bilangan Pelajar (orang)
1	Sesi II 2025/2026	4
2	Sesi I 2025/2026	21
3	Sesi II 2024/2025	5
4	Sesi I 2024/2025	20
	Jumlah Pelajar	50

3.4 Pengumpulan Data

Data kajian dikumpulkan melalui pengedaran borang soal selidik kepada responden selepas mereka menggunakan ABM *Plastic Interlocking Block* dalam proses PdP. Responden diminta memberikan maklum balas berdasarkan pengalaman mereka menggunakan ABM tersebut dalam memahami konsep pembinaan menggunakan blok kekunci.

3.5 Analisis Data

Data primer diperoleh daripada responden melalui *google form* telah dianalisis dengan menggunakan perisian SPSS versi 27 bagi mencapai objektif-objektif kajian. Analisis yang digunakan adalah statistik deskriptif seperti min, peratusan dan sisihan piawai bagi melihat tahap kefahaman, minat serta persepsi pelajar terhadap penggunaan *Plastic Interlocking Block*.

4.0 Dapatan dan Analisa Data

Dua jenis statistik yang di gunakan untuk menganalisis data kajian ini adalah statistik deskriptif dan statistik inferensi. Pemboleh ubah bebas bagi kajian ini adalah pelajar manakala pemboleh ubah bersandar pula adalah tahap keberkesanan *Plastic Interlocking Block* sebagai alat bantu mengajar.

4.1 Kesahan dan Kebolehpercayaan Soal Selidik

Hasil analisis di Jadual 2 menunjukkan bahawa item soal selidik yang digunakan mempunyai ketekalan yang baik di mana nilai *Cronbach Alpha* yang diperolehi adalah 0.988. Hal ini menunjukkan bahawa soal selidik ini merupakan satu instrumen yang boleh digunakan dalam kajian sebenar kerana mempunyai tahap kebolehpercayaan yang tinggi (Cresswell, 2012).

Jadual 2: Nilai Kesahan dan Kebolehpercayaan Cronbach Alpha

Item	*Cronbach Alpha if Item Deleted*	*Cronbach Alpha*
Kefahaman Konsep	0.956	0.965
	0.956	
	0.959	
	0.965	
	0.960	
	0.952	
Minat & Motivasi	0.967	0.970
	0.960	
	0.959	
	0.966	
	0.964	
Keberkesanan Produk Sebagai ABM	0.961	0.973
	0.962	
	0.969	
	0.968	
	0.970	

4.2 Demografi Pelajar

Jadual 3 berikut adalah dapatan demografi pelajar. Sasaran pelajar adalah 50 orang pelajar namun hanya 44 orang responden sahaja yang menjawab soal selidik dalam tempoh yang ditetapkan.

Jadual 3: Dapatan Demografi Pelajar

Demografi		Frekuensi	Peratus (%)	Peratus Kumulatif (%)
Jantina	Lelaki	36	81.8	81.8
	Perempuan	8	18.2	100.0
Umur	18 tahun	2	4.5	4.5
	19 tahun	27	61.4	65.9

	20 tahun	14	31.8	97.7
	21 tahun	1	2.3	100.0
	melebihi 21 tahun	0	0	100.0
Sesi Kemasukan	Sesi II 2025/ 2026	4	9.1	9.1
	Sesi I 2025/ 2026	19	43.2	52.3
	Sesi II 2024/ 2025	5	11.4	63.6
	Sesi I 2024/ 2025	16	36.4	100.0
Pernah Mengikuti Kursus Pembinaan Sebelum ini	Ya	24	54.5	54.5
	Tidak	20	45.5	100.0

Jumlah responden kajian ialah 44 orang, terdiri daripada 81.8% lelaki dan 18.2% perempuan. Majoriti pelajar berumur 19 tahun (61.4%), diikuti 20 tahun (31.8%), manakala selebihnya berumur 18 dan 21 tahun. Dari segi kemasukan, kebanyakan pelajar mendaftar pada Sesi I 2025/2026 (43.2%), diikuti Sesi I 2024/2025 (36.4%), manakala selebihnya pada sesi lain. Selain itu, 54.5% pelajar pernah mengikuti kursus pembinaan, manakala 45.5% tidak mempunyai pengalaman tersebut.

4.3 Tahap Kefahaman Konsep, Minat dan Motivasi Pelajar

Bagi menjawab objektif pertama, tahap kefahaman, minat dan motivasi pelajar selepas penggunaan *Plastic Interlocking Block* diukur menggunakan statistik deskriptif seperti frekuensi, peratusan, min dan sisihan piawai. Skor min dikategorikan kepada tiga tahap iaitu rendah (1.00–2.33), sederhana (2.34–3.66) dan tinggi (3.67–5.00), di mana skor rendah menunjukkan tahap yang rendah dan skor tinggi menunjukkan tahap yang tinggi, berdasarkan panduan Nor Syazwanie Mohamad Zamal (2022). Petunjuk skor min bagi setiap kategori soalan adalah seperti Jadual 4 manakala dapatan tahap kefahaman konsep, minat dan motivasi pelajar adalah seperti ditunjukkan dalam Jadual 5 berikut.

Jadual 4: Interpretasi skor min

Skor Min	Intepretasi
1.00 – 2.33	Rendah
2.34 – 3.66	Sederhana
3.67 – 5.00	Tinggi

Jadual 5: Skor Min Terhadap Tahap Kefahaman Konsep, Minat dan Motivasi Pelajar

Item	Min	Sisihan Piawai
Tahap Kefahaman Konsep		
B1. Plastic Interlocking Block membantu saya memahami konsep asas ikatan blok kekunci dengan lebih jelas.	4.59	0.871

B2. Saya lebih mudah memahami struktur binaan melalui aktiviti *hands-on* menggunakan *Plastic Interlocking Block.*	4.55	0.848
B3. Plastic Interlocking Block membantu saya membayangkan situasi sebenar di tapak bina.	4.52	0.876
B4. Saya dapat mengenalpasti kesilapan dalam susunan blok kekunci melalui penggunaan *Plastic Interlocking Block.*	4.50	0.928
B5. Penggunaan *Plastic Interlocking Block* meningkatkan kefahaman saya terhadap kursus Teknologi Binaan.	4.55	0.875
B6. Saya lebih memahami konsep kestabilan struktur selepas menngunakan *Plastic Interlocking Block.*	4.52	0.849
Tahap Minat dan Motivasi		
C1. Saya lebih berminat mengikuti sesi pembelajaran apabila P*lastic Interlocking Block* digunakan di dalam kelas.	4.57	0.900
C2. Aktiviti menggunakan *Plastic Interlocking Block* menjadikan sesi pembelajaran lebih menyeronokkan.	4.55	0.875
C3. Saya lebih fokus apabila sesi pembelajaran menggunakan *Plastic Interlocking Block.*	4.57	0.873
C4. Saya lebih yakin untuk melaksanakan kerja amali berkaitan ikatan blok kekunci apabila telah mempelajari teori menggunakan *Plastic Interlocking Block.*	4.50	0.876
C5. *Plastic Interlocking Block* meningkatkan motivasi saya untuk mempelajari Kursus Teknologi Binaan.	4.52	0.902

Kajian ini menunjukkan bahawa tahap kefahaman, minat dan motivasi pelajar terhadap penggunaan *Plastic Interlocking Block* adalah tinggi. Hal ini dipengaruhi oleh komitmen pensyarah dalam menyediakan bahan dan pendekatan PdP yang menarik, sokongan institusi serta sikap pelajar yang positif terhadap inovasi ini. Selain itu, penggunaan model ini berjaya meningkatkan minat dan penglibatan aktif pelajar dalam kelas. Inisiatif pensyarah memperkenalkan kaedah hands-on ini juga membantu mengatasi kekangan PdP konvensional dan mendapat sambutan yang baik daripada pelajar.

4.4 Keberkesanan *Plastic Interlocking Block* Sebagai Alat Bantu Mengajar

Bagi menjawab objektif kedua kajian, keberkesanan penggunaan *Plastic Interlocking Block* sebagai ABM diukur dengan menggunakan statistik deskriptif dalam bentuk frekuensi, peratusan, min dan sisihan piawai. Dapatan tahap keberkesanan penggunaan *Plastic Interlocking Block* sebagai ABM adalah seperti ditunjukkan dalam Jadual 6 berikut.

Jadual 6: Skor Min Terhadap Tahap Keberkesanan Plastic Interlocking Block sebagai ABM

Item	Min	Sisihan Piawai
Tahap Keberkesanan *Plastic Interlocking Block* sebagai ABM		
D1. *Plastic Interlocking Block* sesuai digunakan sebagai ABM dalam Kursus Teknologi Binaan	4.43	0.95
D2. *Plastic Interlocking Block* mudah digunakan dalam sesi pengajaran dan pembelajaran (PdP)	4.41	0.923
D3. *Plastic Interlocking Block* membantu meningkatkan penglibatan pelajar dalam sesi PdP	4.39	0.920
D4. *Plastic Interlocking Block* lebih berkesan semasa PdP berbanding teori semata-mata	4.45	0.951
D5. *Plastic Interlocking Block* wajar diteruskan sebagai ABM dalam sesi PdP Kursus Teknologi Binaan	4.52	0.902

Jadual 6 menunjukkan bahawa keberkesanan penggunaan *Plastic Interlocking Block* sebagai ABM berada pada tahap yang tinggi. Penggunaan *Plastic Interlocking Block* juga dilihat dapat membantu meningkatkan penglibatan pelajar secara aktif dalam sesi PdP dengan skor min di tahap tinggi iaitu di antara 4.39 sehingga 4.52. Rekabentuknya yang kompak dan ringan menjadikan ia mudah di bawa ke kelas semasa sesi PdP dijalankan menjadikan ianya wajar dijadikan ABM bagi kursus Teknologi Binaan.

4.5 Hubungan Demografi dengan Keberkesanan *Plastic Interlocking Block* Sebagai Alat Bantu Mengajar (ABM)

Objektif ketiga kajian dianalisis menggunakan statistik inferensi bagi melihat hubungan demografi pelajar dengan tahap kefahaman, minat dan motivasi selepas penggunaan *Plastic Interlocking Block* sebagai ABM. Ujian-t digunakan untuk membandingkan perbezaan antara pelajar yang mempunyai dan tidak mempunyai pengalaman kursus pembinaan, manakala ujian korelasi Pearson digunakan untuk mengenal pasti hubungan antara peningkatan kefahaman konsep dengan tahap minat pelajar dalam PdP. Terdapat 2 persoalan kajian yang telah ditetapkan di awal kajian ini iaitu:

Adakah terdapat perbezaan yang signifikan tahap kefahaman konsep, minat dan motivasi terhadap penggunaan *Plastic Interlocking Block* sebagai ABM di antara pelajar yang pernah mengikuti kursus pembinaan sebelum ini dengan pelajar yang tidak pernah mengikuti kursus pembinaan sebelum ini?

H_0 = Tiada perbezaan yang signifikan tahap kefahaman konsep, minat dan motivasi pelajar terhadap penggunaan *Plastic Interlocking Block* sebagai ABM di antara pelajar yang pernah mengikuti kursus pembinaan sebelum ini dengan pelajar yang tidak pernah mengikuti kursus pembinaan sebelum ini.

H_1 = Terdapat perbezaan yang signifikan tahap kefahaman konsep, minat dan motivasi pelajar terhadap penggunaan Plastic Interlocking Block sebagai ABM di antara pelajar yang

pernah mengikuti kursus pembinaan sebelum ini dengan pelajar yang tidak pernah mengikuti kursus pembinaan sebelum ini.

Jadual 7: Perbezaan Tahap Kefahaman Konsep, Minat dan Motivasi Pelajar Terhadap Penggunaan *Plastic Interlocking Block* sebagai ABM

Item	Pernah Mengikuti Kursus Pembinaan Sebelum Ini	Bil	Min	Sisihan Piawai	Nilai - t	Nilai - t Tahap Signifikan (p-value) *sig 2tailed*
Tahap Kefahaman Konsep	Ya	24	4.58	0.83	-0.062	0.951
	Tidak	20	4.60	0.94	-0.062	0.951
Tahap Minat dan Motivasi	Ya	24	4.46	0.884	-0.514	0.610
	Tidak	20	4.60	0.940	-0.511	0.612

Berdasarkan dapatan kajian, nilai ujian-t menunjukkan tiada perbezaan signifikan tahap kefahaman, minat dan motivasi antara pelajar yang pernah dan tidak pernah mengikuti kursus pembinaan ($p>0.05$), sekali gus menerima hipotesis nul. Namun, analisis korelasi Pearson menunjukkan terdapat hubungan positif yang kuat dan signifikan antara minat pelajar dengan peningkatan kefahaman konsep asas ikatan blok kekunci ($r = 0.808$). Ini bermakna semakin tinggi minat pelajar terhadap PdP menggunakan *Plastic Interlocking Block*, semakin tinggi tahap kefahaman mereka. Berdasarkan penyelidik (Ridhuan, 2008), tahap Korelasi Nilai R adalah seperti berikut:

Jadual 9: Korelasi Nilai R

Interval Correlation	*Level of Correlation*
0.80 – 1.000	Sangat Kuat
0.60 – 0.799	Kuat
0.40 – 0.599	Memuaskan
0.20 – 0.399	Lemah
0.00 – 0.199	Sangat Lemah

5.0 PERBINCANGAN KAJIAN

Hasil kajian menunjukkan bahawa penggunaan *Plastic Interlocking Block* sebagai alat bantu mengajar (ABM) memberikan impak yang positif terhadap kefahaman, minat, dan penglibatan pelajar dalam kursus Teknologi Binaan. Pendekatan ini selaras dengan prinsip pembelajaran berpusatkan pelajar serta kaedah hands-on yang menekankan pengalaman langsung dalam proses pembelajaran. Dari aspek kefahaman, pelajar didapati lebih mudah memahami konsep asas pembinaan seperti sistem ikatan dan kestabilan struktur apabila menggunakan model fizikal. Pendekatan yang bersifat visual dan manipulatif ini membantu menjadikan konsep yang abstrak lebih konkrit dan jelas. Selain itu, penggunaan model ini turut meningkatkan minat pelajar terhadap pembelajaran. Sesi pengajaran dan pembelajaran menjadi lebih menarik dan

menyeronokkan, sekali gus mendorong motivasi serta membentuk persepsi positif terhadap kursus yang dipelajari.

Jadual 8: Dapatan Hubungan Keberkesanan Penggunaan *Plastic Interlocking Block* sebagai ABM dan Pengalaman Pelajar Mengikuti Kursus Pembinaan Sebelum ini

Item	B1. *Plastic Interlocking Block* membantu saya memahami konsep asas ikatan blok kekunci dengan lebih jelas.	C1. Saya lebih berminat mengikuti sesi pembelajaran apabila Plastic Interlocking Block digunakan di dalam kelas.	Tahap Signifikan (p-value) *sig 2tailed*	N
B1. *Plastic Interlocking Block* membantu saya memahami konsep asas ikatan blok kekunci dengan lebih jelas.	1	0.808	0.000	44
C1. Saya lebih berminat mengikuti sesi pembelajaran apabila *Plastic Interlocking Block* digunakan di dalam kelas.	0.808	1	0.000	44

*p>0.01 (2-tailed)

Penglibatan pelajar juga menunjukkan peningkatan apabila mereka lebih aktif bertanya, berkongsi idea dan menyertai aktiviti hands-on. Interaksi ini selari dengan pendekatan konstruktivisme yang menekankan pembelajaran melalui pengalaman dan kolaborasi. Secara keseluruhannya, penggunaan *Plastic Interlocking Block* bukan sahaja membantu meningkatkan pemahaman pelajar terhadap teori pembinaan, malah menyokong amalan pengajaran yang lebih interaktif dan berkesan, khususnya dalam bidang TVET yang memerlukan visualisasi dan aplikasi konsep teknikal.

6.0 KESIMPULAN

Dapatan kajian yang dianalisis menggunakan statistik deskriptif melalui perisian SPSS 27 menunjukkan tahap kefahaman, minat dan motivasi pelajar berada pada tahap tinggi dengan skor min antara 4.39 hingga 4.52. Ujian-t dua sampel bebas pula mencatatkan nilai t=0.0514 dan p=0.612 (p > 0.05), menunjukkan tiada perbezaan signifikan antara kumpulan yang dikaji. Secara keseluruhannya, penggunaan *Plastic Interlocking Block* didapati berkesan dalam meningkatkan kefahaman pelajar terhadap konsep pemasangan blok kekunci sebelum kerja amali, di samping meningkatkan minat, motivasi dan penglibatan aktif pelajar dalam PdP. Pelajar lebih mudah memahami konsep secara konkrit, lebih berminat terhadap kursus, serta

lebih aktif dalam pembelajaran. Pendekatan hands-on menggunakan model fizikal ini juga sesuai dijadikan strategi pedagogi dalam pendidikan TVET.

Walau bagaimanapun, kajian ini terhad kepada pelajar di Kolej Komuniti Bentong sahaja. Oleh itu, kajian lanjutan dicadangkan untuk diperluaskan ke institusi lain bagi mendapatkan dapatan yang lebih menyeluruh mengenai keberkesanan penggunaan *Plastic Interlocking Block* sebagai alat bantu mengajar.

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IOT ENABLED SMART FARMING SYSTEM FOR SUSTAINABLE FOOD PRODUCTION IN EDUCATIONAL INSTITUTIONS

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Abstract

This study explores the implementation of an Internet of Things-based smart farming system within an urban farming project at Bentong Community College to enhance resource efficiency and student engagement. Adopting a survey approach, the research integrated IoT sensors and automated irrigation systems to monitor soil moisture, environment conditions and water usage, specifically focusing on onion cultivation. Data was collected from 30 participating students through structured observation, system performance monitoring, and a survey based on the Technology Acceptance Model (TAM). The findings indicate high positive perceptions across all dimensions, with perceived usefulness recording the highest mean score (M=4.38), followed by learning engagement and efficiency and productivity (M=4.28), and system reliability (M=4.15). Correlation analysis further revealed strong relationships between perceived usefulness and learning engagement (r=0.71) and between learning engagement and efficiency and productivity (r=0.69). Ultimately, the integration of IoT technology demonstrated significant potential in optimizing resource utilization, supporting experiential learning, and promoting sustainable food production, as evidenced by more even plant growth and improved crop yields.

Keywords: Urban farming, smart farming, Internet of Thing, experiential learning, education

Abstrak

Kajian ini meneroka pelaksanaan sistem pertanian pintar berasaskan Internet of Thing (IoT) dalam projek pertanian bandar di Kolej Komuniti Bentong untuk meningkatkan kecekapan sumber dan penglibatan pelajar. Mengguna pakai pendekatan tinjauan, penyelidikan menyepadukan penderia IoT dan sistem pengairan automatik untuk memantau kelembapan tanah, keadaan persekitaran dan penggunaan air, khususnya memfokuskan pada penanaman bawang. Data dikumpul daripada 30 pelajar yang mengambil bahagian melalui pemerhatian berstruktur, pemantauan prestasi sistem, dan tinjauan berdasarkan Model Penerimaan Teknologi (TAM). Dapatan menunjukkan persepsi positif yang tinggi merentas semua dimensi, dengan persepsi kebergunaan merekodkan skor min tertinggi (M=4.38), diikuti dengan penglibatan pembelajaran dan kecekapan dan produktiviti (M=4.28), dan kebolehpercayaan sistem (M=4.15). Analisis korelasi seterusnya mendedahkan hubungan yang kukuh antara

persepsi kebergunaan dan penglibatan pembelajaran (r=0.71) dan antara penglibatan pembelajaran dengan kecekapan dan produktiviti (r=0.69). Akhirnya, penyepaduan teknologi IoT menunjukkan potensi yang ketara dalam mengoptimumkan penggunaan sumber, menyokong pembelajaran berasaskan pengalaman, dan menggalakkan pengeluaran makanan yang mampan, seperti yang dibuktikan oleh pertumbuhan tumbuhan yang lebih sekata dan hasil tanaman yang lebih baik.

Kata kunci: *Pertanian bandar, pertanian pintar, Internet of Thing, pembelajaran melalui pengalaman, pendidikan*

1.0 INTRODUCTION

Agriculture plays a critical role in ensuring food security and supporting global economic development. However, the agricultural sector is increasingly facing challenges such as climate change, inefficient resource utilization and limited agricultural land. Rapid smart farming increases the demand of utilization of Internet of Things (IoT) promoting innovation solutions enable food solutions especially onion cultivation while promoting environments sustainability. Smart farming refers to the use of advanced technologies - especially IoT to manage agricultural processes more efficiently. It integrates data, automation, and connectivity to improve productivity, quality, and sustainability in farming. Furthermore, the integration of IoT technology into agricultural projects provides valuable learning opportunities in education institutions. Students engage in experiential learning by participating in smart farming projects, fostering awareness of sustainable skills and digital innovation. Therefore, this study aims to explore the implementation of an IoT-based smart farming system within an urban farming project at Bentong Community College. Specifically, the study investigates the effectiveness of the system in improving farming efficiency and examines student perceptions regarding the use of IoT technology in onion cultivation agriculture projects.

1.1 Problem Statement

Agriculture faces ongoing challenges from climate change, inefficient resource use and the demand for sustainables practices. In onion cultivation, traditional irrigation often results of water wastage, uneven yields and labors needs. Recent technological advancements, IoT application created new opportunities to improve Bentong Community College smart farming through digital monitoring and automation. IoT technology allows sensors and devices to collect real time environmental data, such as soil moisture and humidity, thus producing efficient crop management practices.

1.2 Research Objectives

The objectives of this study are:

1. To examine the effectiveness of an IoT-based smart farming system in improving resource efficiency and crop monitoring in urban farming environments.
2. To analyse students' perceptions and learning engagement towards the use of IoT technology in urban farming based on the Technology Acceptance Model (TAM).

1.3 Significant of Research

This study contributes significantly to smart agriculture and education innovation by using the Technology Acceptance Model (TAM) to IoT-enabled urban farming within educational contexts. It provides empirical evidence on system reliability and perceived usefulness impact on student engagement and overall farming productivity. Practically the research offers actionable insight for education, policy makers and agriculture practitioners on integrating IoT in farming. This aligns with sustainable development goals by promoting responsible consumption and smart farming practices.

2.0 LITERATURE REVIEW

2.1 IoT Smart Farming System

Smart Farming has gained increasing attention as a strategy to improve food security. According to previous studies, smart farming contributes to local food production. The Internet of Things (IoT) has emerged technology in modern agriculture, enabling the integration of sensors, communication networks and cloud-based platforms (Zamin et al., 2019) into smart farming ecosystem. In Malaysia, IoT has been identified as key driver in advancing agriculture 4.0 by enhancing productivity, improving resource efficiency and supporting data driven decision-making (Ismail & Salleh, 2021; Justin et al., 2023). Rosli et al., (2023) developed an IoT-based fertigation system capable of monitoring and controlling via smart phones application. Similarly, Mohd Hanifa et al., (2023) proposed a smart crop watering system (SCWS) automated irrigated system improving water-use efficiency. In the context of constraints and need for efficient resource management, IoT integrated hydroponic system enables precise control and real time monitoring. Likewise, (Thinakaran et al., 2025) demonstrated smart vertical farming systems enhance crop growth compared to the conventional method. Overall, IoT smart farming system represents an integrated technological framework in supporting agriculture sectors.

2.2 System Reliability

The IoT has transformed industries into more management agricultural activities towards the integration of sensors, communication networks and data analytics to monitor agricultural environment in real time. Sensor's placement in the soil can collect data related to moisture levels, temperature and humidity which helps in crop and irrigation management critical factors of system reliability. Failures in sensor accuracy or network connectivity may lead to inefficient resource use and reduced crop performance. Several studies, Ahmad et al., (2025) reported that their IoT-based irrigation system operated without downtime over a three-month period, indicating strong system stability. Similarly, (Ibrahim et al., 2023) with green house monitoring system transit data at regular intervals with accurate environmental readings. Mohd Ariffin et al., (2020), supported on minimizing resource use. Focusing on the communication technologies, the reliability of IoT systems produce Lora-based IoT with wireless sensor networks (Ting & Chan, 2024) and wireless delivery real time alerts (Saad et al., 2024). Overall reliable system performance plays a role in shaping positive Malaysia youth user perceptions (Samsudin & Sumin, 2025).

2.3 Perceive Usefulness

One of the technology adoption model constructs is perceived usefulness, which user believe for system performances enhancement. In the context of IoT smart farming, perceived usefulness reflected in improved efficiency, reduced costs and better decision making. Numerous studies highlighted the practical benefits of IoT in agriculture such as improving productivity (Justin et al., 2023), delivering water based real-time soil conditions (Mohd Hanifa et al., 2023) and reductions in irrigation time and water consumption for crop growth (Ahmad et al., 2025). In urban farming application, perceived usefulness associated with convenience and precision. Abdul Halim et al., (2024) found IoT-enabled hydroponic system provide efficient monitoring and control. Wan Abdullah & Nazren, (2025) developed an IoT-based mobile application that provides real time monitoring, customized agricultural advice and enhancing system usability and value. The findings indicate perceived usefulness is driven as a factor in farming improvement outcomes including resource efficiency, productivity and ease management.

2.4 Learning Engagement

The integration of digital technologies into educational projects has been widely recognized as effective method for enhancing experiential learning. Smart farming provides students with theory and practical knowledge, developing students with decision making and problem-solving skills. The integration IoT into STEM education through problem based learning increase student engagement theory and real world application (Saad et al., 2024). Similarly, Thiagarajah et al. (2025) found that IoT-based smart farming workshops improved students' awareness of STEM concepts and increased their interest in technology-related careers. The role of youth in smart farming adoption is further highlighted by Samsudin and Sumin (2025), who reported that optimism and perceived benefits positively influence students' readiness to adopt IoT technologies. In addition, Philimon et al., (2022) suggested that combining IoT with gamification can enhance engagement by promoting environmental awareness and behavioural change. These studies suggest that IoT smart farming systems provide interactive, interdisciplinary, and practical learning experiences that foster higher levels of student engagement.

2.5 Efficiency and Productivity

Efficiency and productivity, one of the key outcomes of IoT smart farming systems refers the optimal use of water, energy and labour and productivity focus on the crop yield performance improvement. Empirical evidence on the positive impact of IoT implementation Mohd Hanifa et al. (2023) demonstrated that smart irrigation systems reduce water wastage, while Ahmad et al. (2025) reported a 25% reduction in water usage and significant time savings. Rosli et al., (2023) further indicated that IoT-based fertigation systems can reduce operational costs and enhance production. Productivity improvements have also been widely reported. Additionally, Narendran et al., (2024) highlighted that IoT-enabled monitoring systems improve decision-making and profitability in agricultural production. Despite these benefits, some studies note that efficiency gains do not always translate into increased income for small-scale farmers due to contextual challenges such as infrastructure limitations and digital skills gaps (Rosnan &

Yusof, 2023). Therefore, while IoT enhances operational performance, its broader socio-economic impact may vary.

The conceptual framework of this study was adapted from the Technology Acceptance Model (TAM) proposed by Davis (1989) and smart agriculture technology adoption models. The conceptual framework explains how the reliability of IoT system influence users perceived usefulness of the technology. The student engagement improves farming productivity and efficiency.

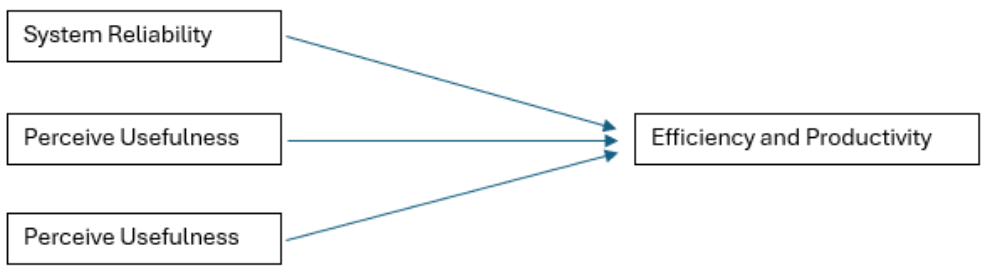


Figure 1: Conceptual Framework of IoT-Based Smart Urban Farming (Adapted from TAM)

3.0 RESEARCH METHODOLOGY

The study adopted a survey to investigate the implementation of IoT-based smart farming in Bentong Community College. The study was conducted at Bentong Community College, where the project was being carried out. A total of 30 students who participated in the smart farming project were selected as a population and the sample size sampling frame by Krejie and Morgan 1970 is 28 respondents.

3.1 Research Design

The study employed a quantitative descriptive design to evaluate student perceptions of the smart farming system involving 30 students as participants. Data collected integrates multiple approaches such as structured observation to assess physical interaction and operational process, IoT system logs for real-time monitoring of system performance and photographic documentation to visualize growth and development. The adaptation of the questionaires based on the Technology Acceptance Model (TAM) is used to analyse mean scores and correlation relationship among variables. This multi-method approach ensures comprehensive data triangulation, enabling a systematic evaluation of system reliability, user perception, and operational efficiency within the IoT-based urban farming context.

3.2 Research Instruments

In this project, data were collected through the following methods; structured observation; photographic documentation; IoT system monitoring and questionnaire survey used questionnaires in the form of five-point Likert scale (1 = strongly agree, 5 = strongly disagree) and to collect data in this study, the researchers have distributed on their own the set of questionnaires to the students. The adaptation of the instrument following as table below:

Table 1: Instrument Adaptation

Construct	TAM Position	Source
System Quality & Reliability	External Variables	(DeLone & McLean, 2003) (Atchariyachanvanich et al., 2011)
Perceived Usefulness	Core TAM	(Davis, 1989) (Atchariyachanvanich et al., 2011)
Learning Outcomes & Engagement	Attitude / Extended PU	(Kolb, 1984)
Efficiency & Productivity	Actual Use Outcome	(Ballarini et al., 2009)

3.3 Data Analysis

The collected data were analyzed using descriptive statistics, particularly mean score analysis, and correlation analysis to evaluate student perceptions.

4.0 RESEARCH FINDINGS AND DISCUSSION

This project is implemented as an effort to overcome the challenges faced by the onion cultivation project in Bentong Community College. Figures 2 – 4 shows planting system operated through manual irrigation and observation, while Figures 5 – 7 shows the condition of crops after installation of IoT-based smart farming system.



Figure 2: Manual crop inspection



Figure 3: Uneven plant growth

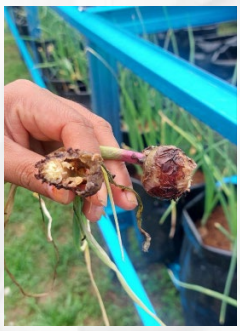


Figure 4: Poor crop yield



Figure 5: IoT system installation



Figure 6: Plant growth is more even



Figure 7: Better crop yields

4.1 Mean Analysis Result

The study's first objective indicates positive perception towards the IoT-based smart farming system implemented in the smart farming project according to table 2 below:

Table 2: Student Perception Towards IoT Smart Farming System

Dimension	Mean Score	Interpretation
System Reliability	4.15	High
Perceived Usefulness	4.38	Very High
Learning Engagement	4.28	Very High
Efficiency and Productivity	4.28	Very High

The result indicates that the perceived usefulness recorded the highest mean score (M=4.38), indicating that students strongly agreed that IoT-based farming system enhanced farming efficiency and monitoring capabilities. The dimension of learning engagement (M=4.28) also recorded a high score, suggesting that students were actively involved in smart farming activities and gained valuable practical learning experiences. Similarly, efficiency and productivity (M=4.28) demonstrated that the system helped improve irrigation management and resource wastage. These findings support previous studies that highlighted the benefits of IoT technology in improving agricultural efficiency and promoting sustainable farming practices. The interpretation data (Jum C. Nunnally, 1994) is on the table below:

Table 3: Mean Scores Interpretation

Score Min	**Intepretation**
1.00 – 2.33	Low
2.34 – 3.66	Moderate
3.67 – 5.00	High

4.2 Correlation Analysis

The study's second objective indicates the positive correlation relationship towards the IoT-based smart farming system implemented in the smart farming project according to table 4 as below:

Table 4: Correlation Scores

Variable	**SR**	**PU**	**LE**	**EP**
System Reliability (SR)	1			
Perceived Usefulness (PU)	0.62	1		
Learning Engagement (LE)	0.55	0.71	1	
Efficiency & Productivity (EP)	0.58	0.65	0.69	1

SR → PU shows moderate positive correlation (r=0.62)
PU → LE shows strong relationship (r=0.71)
LE → EP shows positive relationship (r=0.69)

The Pearson correlation analysis indicates all the variable have a positive and moderate to strong relationships. Specifically, System Reliability (SR) shows a moderate positive

correlation with Perceived Usefulness (PU) (r=0.62), Learning Engagement (LE) (r=0.55) and Efficiency and Productivity (EP) (r-0.58), indicates that more reliable system enhances users' perceptions of usefulness, engagement, and performance outcomes. Furthermore, Perceived Usefulness (PU) exhibits strong positive correlation with Learning Engagement (LE) (r=0.71) and Efficiency and Productivity (EP) (r=0.65), indicating when users perceive the system as useful, it engages higher efficiency. Additionally, the relationship between Learning Engagement (LE) and Efficiency and Productivity (EP) is also strong (r=0.69), showing the higher engagement will improve the productivity. Based on the interpretation guidelines by Cohen (1988), correlation values range from 0.50 to 0.70 considered large, indicating strong effect sizes, while values above 0.70 approach very strong relationships.

4.3 Discussion

The findings of the study demonstrate that IoT-based smart farming systems significantly enhance resource efficiency and student engagement. The high mean scores perceived usefulness (M=4.38) indicates that the student believes the IoT system improves irrigation management and crop monitoring. Its supported by Ayaz et al., (2019), which highlighted that IoT technologies improve agricultural monitoring and decision-making processes through real-time data collection. Similarly, Dhanaraju et al., (2022) reported that IoT-enabled farming systems enhance irrigation efficiency and reduce water wastage. Overall, the findings confirm that IoT technology not only enhances agricultural productivity but also supports innovative learning environments in higher education institutions.

These studies consistently report positive correlations between system-related variables such as sensor reliability, real-time monitoring capability, and automation with outcomes like resource efficiency, crop productivity, and decision-making effectiveness. For instance, reliable IoT sensor performance is strongly associated with improved data accuracy, which in turn enhances irrigation efficiency and crop yield outcomes. Similarly, perceived usefulness of IoT systems has been found to correlate positively with user engagement and adoption, supporting frameworks such as the Technology Acceptance Model (TAM). Overall, these findings align with the current study, where moderate to strong positive correlations were observed among system reliability, perceived usefulness, learning engagement, and efficiency, indicating that effective IoT implementation plays a significant role in improving both agricultural performance and user acceptance in smart farming environments Tasgaonkar, (2023) IoT-based crop monitoring systems, Hassan et al. (2024) Smart agriculture technologies using IoT, Morchid, (2024) IoT-enabled smart farming systems.

5.0 CONCLUSION AND RECOMMENDATIONS

This study explored the implementation of IoT-based smart farming system on onion cultivation project at Bentong Community College. The findings indicate that the integration of IoT technology significantly enhances farming efficiency, improves crop monitoring and promotes effectives resource management. In addition, the project provided meaningful experiential learning opportunities for students, allowing them to develop practical skills

related to smart farming. The positive student perceptions towards the system demonstrate the potential of integrating smart farming technologies into educational environments.

Overall IoT enables smart farming promising an innovative way of digital enhancement in education institutions. The contribution of study demonstrates the application of IoT technology in smart farming within the educational institutions, providing empirical evidence on student perceptions and proposing new integration in agriculture, technology and experiential learning. Limitation of the studies whereby its focus is only in one institution. Future research may explore the integration of artificial intelligence (AI) and big data analytics in smart farming systems to further enhance agricultural productivity and sustainability.

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CMYK PRESS: PROTOTAIP PEMBELAJARAN INTERAKTIF BAGI SIMULASI FUNGSI PLAT CETAKAN DALAM PROSES *COLOR SEPARATION* CMYK MENGGUNAKAN *RUBBER STAMPING*

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Abstrak

Inovasi CMYK PRESS: Prototaip Pembelajaran Interaktif bagi Simulasi Overlapping Dakwat CMYK menggunakan teknik rubber stamping dibangunkan bagi membantu pelajar memahami konsep pembentukan warna dalam proses percetakan yang bersifat abstrak. Kajian ini bertujuan menilai keberkesanan penggunaan inovasi tersebut dari aspek pemahaman, keberkesanan pembelajaran dan penerimaan pelajar. Kajian ini menggunakan pendekatan kuantitatif yang menggabungkan reka bentuk deskriptif dan kuasi-eksperimen. Seramai 38 orang pelajar Diploma Teknologi Media Cetak terlibat sebagai responden. Instrumen kajian terdiri daripada soal selidik skala Likert lima mata dan set ujian pra (pre-test) serta ujian pasca (post-test). Kebolehpercayaan instrumen telah disahkan menggunakan Cronbach's Alpha dengan nilai melebihi 0.70. Data dianalisis menggunakan statistik deskriptif (min dan peratusan) serta statistik inferensi melalui ujian-t berpasangan. Dapatan kajian menunjukkan bahawa tahap pemahaman pelajar berada pada tahap tinggi (min = 4.34), manakala keberkesanan inovasi (min = 4.57) dan tahap penerimaan pelajar (min = 4.62) berada pada tahap sangat tinggi. Analisis ujian pra dan pasca menunjukkan peningkatan signifikan dalam pencapaian pelajar, dengan min skor meningkat daripada 55.3 kepada 78.6 ($p < 0.05$). Ini membuktikan bahawa penggunaan CMYK PRESS bukan sahaja meningkatkan persepsi pelajar, malah turut meningkatkan kefahaman kognitif sebenar. Dapatan ini selari dengan teori pembelajaran berasaskan pengalaman oleh David A. Kolb yang menekankan kepentingan pengalaman langsung dalam meningkatkan kefahaman pelajar terhadap konsep yang kompleks. Secara keseluruhannya, inovasi CMYK PRESS didapati berkesan sebagai alat bantu mengajar dalam pendidikan teknologi percetakan dan berpotensi untuk diperluaskan dalam konteks pendidikan teknikal dan vokasional.

Kata Kunci: CMYK, overlapping dakwat, rubber stamping, simulasi percetakan, pembelajaran interaktif, hands-on learning, misregistration, teknologi percetakan, prototaip pembelajaran.

Abstract

The CMYK PRESS Innovation: An Interactive Learning Prototype for Simulating CMYK Ink Overlapping using a rubber-stamping technique was developed to help students understand

the abstract concept of color formation in the printing process. This study aims to evaluate the effectiveness of the innovation in terms of students' understanding, learning effectiveness, and acceptance. A quantitative approach was employed, combining descriptive and quasi-experimental research designs. A total of 38 Diploma in Print Media Technology students were involved as respondents. The research instruments consisted of a five-point Likert scale questionnaire and pre-test and post-test assessments. The reliability of the instruments was confirmed using Cronbach's Alpha, with values exceeding 0.70. Data were analyzed using descriptive statistics (mean and percentage) and inferential statistics through a paired sample t-test. The findings indicate that students' level of understanding was high (mean = 4.34), while the effectiveness of the innovation (mean = 4.57) and students' acceptance level (mean = 4.62) were very high. The pre-test and post-test analysis showed a significant improvement in student achievement, with mean scores increasing from 55.3 to 78.6 ($p < 0.05$). This demonstrates that the use of CMYK PRESS not only enhances students' perceptions but also improves their actual cognitive understanding. These findings are consistent with experiential learning theory by David A. Kolb, which emphasizes the importance of direct experience in enhancing students' understanding of complex concepts. Overall, the CMYK PRESS innovation is effective as a teaching aid in print technology education and has the potential to be expanded within technical and vocational education contexts.

Keywords: *CMYK, ink overlapping, rubber stamping, printing simulation, interactive learning, hands-on learning, misregistration, print technology, learning prototype.*

1.0 PENGENALAN

Bidang teknologi percetakan memainkan peranan penting dalam industri komunikasi visual serta pengeluaran bahan bercetak. Dalam proses percetakan warna, penggunaan model warna CMYK yang terdiri daripada Cyan, Magenta, Yellow dan Black merupakan asas utama dalam menghasilkan imej berwarna yang berkualiti tinggi. Dalam teknologi percetakan konvensional seperti percetakan offset, gravure, flexografi, letterpress dan cetakan saringan (silkscreen), proses pembentukan warna berlaku melalui teknik pertindihan atau lapisan dakwat yang dicetak secara berperingkat. Proses ini melibatkan penghasilan plat cetakan yang mewakili setiap warna asas dalam sistem CMYK.

Walau bagaimanapun, konsep pembentukan warna melalui lapisan dakwat ini sering menjadi cabaran kepada pelajar untuk memahaminya kerana kebanyakan pengajaran dilaksanakan secara teori dan penerangan visual sahaja. Tanpa pengalaman secara langsung, pelajar sukar untuk membayangkan bagaimana warna terbentuk apabila dakwat dicetak secara bertindih serta bagaimana kesilapan pendaftaran warna (misregistration) boleh mempengaruhi kualiti cetakan.

Seiring dengan perkembangan pendekatan pembelajaran aktif dalam pendidikan teknikal dan vokasional (TVET), kaedah pembelajaran berasaskan pengalaman (experiential learning) semakin diberi penekanan bagi meningkatkan kefahaman pelajar terhadap konsep teknikal.

Oleh itu, pembangunan inovasi CMYK PRESS diperkenalkan sebagai satu prototaip pembelajaran interaktif yang menggunakan teknik rubber stamping bagi mensimulasikan proses lapisan dakwat CMYK dalam percetakan warna. Pendekatan ini membolehkan pelajar mengalami sendiri proses pembentukan warna melalui aktiviti praktikal, sekali gus membantu mereka memahami konsep asas percetakan warna dengan lebih jelas dan berkesan.

1.1 Penyataan Masalah

Dalam pengajaran kursus teknologi percetakan iaitu DVP20244 Printing Process Technology, pelajar sering menghadapi kesukaran untuk memahami konsep penghasilan warna melalui pertindihan warna utama iaitu CMYK kerana proses tersebut melibatkan prinsip teknikal yang bersifat abstrak. Penerangan secara teori semata-mata tidak mencukupi untuk memberikan gambaran yang jelas tentang bagaimana lapisan dakwat berinteraksi untuk menghasilkan warna akhir dalam sesuatu cetakan. Selain itu, pelajar juga kurang terdedah kepada pengalaman praktikal yang membolehkan mereka melihat secara langsung kesan pertindihan warna serta masalah pendaftaran warna semasa proses percetakan sebenar dijalankan.

Kekurangan bahan bantu mengajar yang interaktif menyebabkan proses pembelajaran menjadi kurang menarik serta sukar difahami oleh pelajar. Oleh itu, satu pendekatan pembelajaran yang lebih visual dan berasaskan aktiviti praktikal diperlukan bagi membantu pelajar memahami konsep asas pembentukan warna CMYK dengan lebih berkesan. Sehubungan itu, inovasi CMYK PRESS dibangunkan sebagai satu alat simulasi pembelajaran interaktif yang menggunakan teknik rubber stamping bagi menggambarkan proses pertindihan lapisan dakwat dalam proses percetakan.

1.2 Objektif Kajian

Kajian ini dijalankan bagi mencapai objektif berikut:

1. Mengenal pasti keberkesanan penggunaan inovasi CMYK PRESS dalam membantu pelajar memahami konsep overlapping dakwat CMYK dalam proses percetakan.
2. Menilai tahap penerimaan pelajar terhadap penggunaan prototaip pembelajaran interaktif dalam proses pengajaran dan pembelajaran bagi kursus **DVP20244 Printing Process Technology**.

1.3 Persoalan kajian

1. Sejauh manakah penggunaan CMYK PRESS dapat meningkatkan pemahaman pelajar terhadap konsep overlapping dakwat CMYK?
2. Apakah tahap penerimaan pelajar terhadap penggunaan inovasi CMYK PRESS dalam proses pembelajaran?

2.0 SOROTAN LITERATUR

2.1 Pembelajaran Berasaskan Pengalaman dalam Pendidikan TVET

Pembelajaran berasaskan pengalaman (experiential learning) menekankan pembelajaran melalui aktiviti praktikal, refleksi dan aplikasi sebenar. Menurut Kolb, pembelajaran berlaku melalui kitaran pengalaman konkrit, refleksi, konseptualisasi dan eksperimen aktif. Dalam

konteks TVET, pendekatan ini penting kerana kebanyakan kandungan bersifat teknikal dan memerlukan pembelajaran secara hands-on. Kajian lepas menunjukkan bahawa pendekatan ini mampu meningkatkan kefahaman dan motivasi pelajar. Kajian terkini turut membuktikan bahawa penggunaan simulasi dan aktiviti berasaskan pengalaman dapat meningkatkan kemahiran teknikal serta penglibatan aktif pelajar.

2.2 Penggunaan Alat Simulasi dalam Pendidikan Kejuruteraan dan Teknologi

Alat simulasi digunakan secara meluas dalam pendidikan teknikal untuk membantu pelajar memahami proses kompleks tanpa bergantung sepenuhnya kepada peralatan industri sebenar. Dalam bidang percetakan, proses seperti pemisahan warna, pertindihan dakwat dan pendaftaran cetakan memerlukan pemahaman yang mendalam. Penggunaan simulasi membolehkan pembelajaran berlaku dalam persekitaran terkawal dan lebih mudah difahami. Kajian menunjukkan bahawa pendekatan ini meningkatkan kefahaman, penglibatan dan keupayaan pelajar mengaitkan teori dengan aplikasi praktikal. Oleh itu, penggunaan alat seperti CMYK PRESS adalah selari dengan keperluan pembelajaran moden.

2.3 Pembelajaran Visual dalam Pendidikan Teknikal

Pembelajaran visual penting dalam membantu pelajar memahami konsep teknikal yang kompleks, khususnya dalam bidang percetakan seperti proses CMYK yang melibatkan pemisahan warna dan pertindihan dakwat. Pendekatan yang menggabungkan elemen visual, interaktif dan *hands-on* didapati lebih berkesan berbanding kaedah teori semata-mata. Aktiviti yang melibatkan visualisasi secara langsung membantu pelajar menghubungkan teori dengan aplikasi sebenar. Sehubungan itu, inovasi CMYK PRESS yang mengintegrasikan simulasi, visual dan aktiviti praktikal dilihat sebagai pendekatan yang sesuai dalam meningkatkan kefahaman pelajar dalam bidang teknologi percetakan.

2.0 METODOLOGI KAJIAN

Kajian ini menggunakan pendekatan kuantitatif dengan reka bentuk deskriptif dan kuasi-eksperimen bagi menilai keberkesanan penggunaan inovasi CMYK PRESS dalam proses pengajaran dan pembelajaran. Responden kajian terdiri daripada 38 orang pelajar Diploma Teknologi Media Cetak di Politeknik Muadzam Shah yang mengikuti kursus Printing Process Technology (DVP20244), iaitu 19 orang pelajar dari kelas DMC3A dan 19 orang pelajar dari kelas DMC2A bagi sesi 2 2025/2026.

Instrumen kajian yang digunakan ialah borang soal selidik yang dibangunkan bagi menilai tiga konstruk utama iaitu tahap pemahaman pelajar terhadap konsep CMYK, keberkesanan penggunaan inovasi, serta tahap penerimaan pelajar terhadap kaedah pembelajaran yang dilaksanakan. Soal selidik ini menggunakan skala Likert lima mata iaitu 1 – Sangat Tidak Setuju, 2 – Tidak Setuju, 3 – Kurang Setuju, 4 – Setuju dan 5 – Sangat Setuju.

Bagi memastikan kebolehpercayaan instrumen, analisis telah dijalankan menggunakan pekali Cronbach's Alpha. Nilai pekali yang diperoleh bagi setiap konstruk adalah melebihi 0.70, menunjukkan bahawa instrumen kajian mempunyai tahap konsistensi dalaman yang baik dan

boleh dipercayai. Selain itu, kesahan kandungan instrumen telah disahkan melalui semakan oleh pakar dalam bidang teknologi percetakan dan pedagogi TVET.

Kajian ini turut mengaplikasikan reka bentuk kuasi-eksperimen yang melibatkan ujian pra (pre-test) dan ujian pasca (post-test) bagi menilai tahap kefahaman kognitif pelajar secara objektif. Ujian pra dilaksanakan sebelum penggunaan inovasi CMYK PRESS, manakala ujian pasca dijalankan selepas pelajar melalui aktiviti pembelajaran menggunakan inovasi tersebut. Perbandingan antara skor ujian pra dan pasca digunakan bagi menentukan peningkatan pencapaian sebenar pelajar. Prosedur kajian dilaksanakan dalam beberapa fasa iaitu:

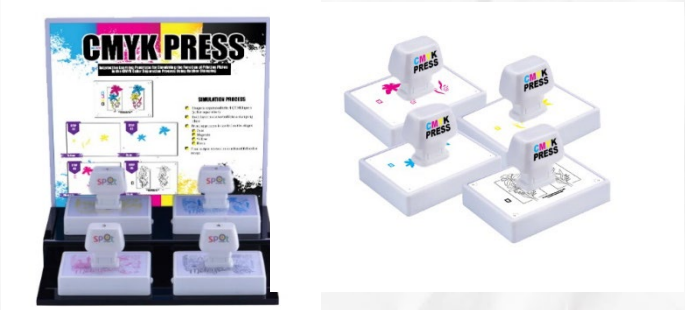
1. Penerangan teori berkaitan konsep CMYK dan proses percetakan.
2. Pelaksanaan aktiviti pembelajaran menggunakan inovasi CMYK PRESS.
3. Pelajar menjalankan aktiviti stamping empat warna secara berlapis.
4. Pelajar memerhati pembentukan warna serta kesan misregistration.
5. Pelajar menjalani ujian pasca dan seterusnya menjawab borang soal selidik.

Data yang diperoleh dianalisis menggunakan analisis statistik deskriptif seperti min dan peratusan bagi menghuraikan tahap pemahaman, keberkesanan dan penerimaan pelajar. Selain itu, analisis kebolehpercayaan instrumen dijalankan menggunakan pekali Cronbach's Alpha. Bagi menilai perbezaan tahap pencapaian pelajar sebelum dan selepas intervensi, analisis statistik inferensi iaitu ujian-t berpasangan turut digunakan bagi menentukan sama ada terdapat perbezaan yang signifikan antara skor ujian pra dan ujian pasca.

3.1 Reka Bentuk Inovasi CMYK PRESS

Inovasi CMYK PRESS merupakan satu prototaip pembelajaran interaktif yang direka bagi mensimulasikan fungsi plat cetakan dalam proses percetakan offset melalui pendekatan pembelajaran secara *hands-on*. Reka bentuk inovasi ini dibangunkan bagi membantu pelajar memahami konsep color separation, pertindihan lapisan dakwat (*ink overlapping*) serta pendaftaran cetakan (registration) dalam sistem percetakan warna CMYK.

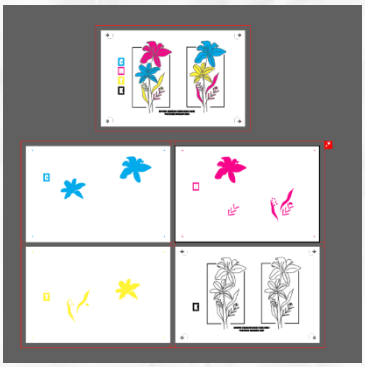
Dalam proses percetakan offset sebenar, imej asal akan melalui proses color separation, di mana imej tersebut dipecahkan kepada empat komponen warna utama iaitu *Cyan, Magenta, Yellow* dan *Black*. Setiap komponen warna ini akan dipindahkan kepada plat cetakan yang berasingan sebelum proses percetakan dijalankan. Semasa percetakan, setiap plat akan mencetak satu lapisan dakwat secara berperingkat di atas kertas sehingga imej berwarna penuh terbentuk.



Rajah 3.1: Imej komposit yang dicetak pada pencetak laser warna berbanding pemisahan empat warna yang dicetak pada mesin percetakan Offset.



Rajah 3.2: Contoh imej yang direka menggunakan Adobe Illustrator



Rajah 3.3: Demonstrasi visual proses pemisahan warna dalam percetakan CMYK daripada reka bentuk komposit kepada saluran warna individu.

Berdasarkan konsep tersebut, inovasi CMYK PRESS menggunakan empat rubber stamp yang masing-masing mewakili satu plat warna iaitu Cyan, Magenta, Yellow dan Black. Setiap stamp direka dengan elemen grafik tertentu yang telah dipisahkan mengikut komponen warna bagi mensimulasikan proses color separation dalam percetakan.



Rajah 3.4: Rekabentuk Prototaip

Semasa aktiviti pembelajaran dijalankan, pelajar akan mengecap setiap stamp secara berperingkat di atas permukaan kertas dengan menggunakan dakwat berwarna yang sepadan dengan warna CMYK. Proses stamping ini mensimulasikan proses percetakan berlapis di mana setiap warna dicetak secara bertindih bagi menghasilkan imej berwarna penuh. Melalui aktiviti ini, pelajar dapat memerhati secara langsung bagaimana warna sekunder terbentuk hasil

daripada pertindihan warna asas serta memahami kesan ketidaktepatan pendaftaran cetakan (misregistration) sekiranya kedudukan stamping tidak selari.

Selain itu, inovasi ini direka dalam bentuk yang mudah alih, kos efektif dan mesra pengguna, menjadikannya sesuai digunakan dalam bilik darjah, makmal percetakan mahupun aktiviti pembelajaran luar kelas. Reka bentuk yang ringkas ini juga membolehkan pelajar menjalankan pembelajaran secara kolaboratif serta meningkatkan penglibatan mereka dalam proses pengajaran dan pembelajaran.

4.0 DAPATAN KAJIAN

Bab ini membentangkan hasil analisis data yang diperoleh daripada borang soal selidik yang telah diedarkan kepada 38 orang pelajar Diploma Teknologi Media Cetak. Analisis ini bertujuan untuk menilai tahap pemahaman pelajar, keberkesanan penggunaan inovasi CMYK PRESS serta tahap penerimaan pelajar terhadap kaedah pembelajaran yang dilaksanakan. Selain itu, bagi mengukuhkan dapatan kajian, analisis ujian pra (pre-test) dan ujian pasca (post-test) turut dijalankan bagi menilai tahap kefahaman kognitif pelajar secara objektif sebelum dan selepas penggunaan inovasi CMYK PRESS.

4.1 Profil Responden

Berdasarakan Jadual 4.1, taburan responden adalah seimbang antara kedua-dua kelas, membolehkan dapatan kajian mewakili kumpulan pelajar secara adil.

Jadual 4.1: Taburan responden berdasarkan kelas

Kelas	Bilangan	Peratus (%)
DMC3A	19	50%
DMC2A	19	50%
Jumlah	**38**	**100%**

4.2 Tahap Pemahaman Pelajar terhadap Konsep CMYK

Dapatan menunjukkan tahap pemahaman pelajar berada pada tahap tinggi dengan purata min 4.34. Ini menunjukkan bahawa penggunaan CMYK PRESS membantu meningkatkan persepsi pemahaman pelajar terhadap konsep yang dipelajari. Walau bagaimanapun, bagi memastikan peningkatan ini bukan sekadar persepsi semata-mata, dapatan ini turut disokong melalui analisis ujian pra dan ujian pasca yang menunjukkan peningkatan kefahaman kognitif sebenar pelajar (rujuk Seksyen 4.6).

Jadual 4.2: Jadual Analisis Tahap Pemahaman Pelajar

Item	Pernyataan	Min	Interpretasi
1	Saya memahami konsep asas CMYK	4.32	Tinggi
2	Saya memahami proses overlapping warna	4.45	Tinggi

3	Saya memahami pembentukan warna sekunder	4.40	Tinggi
4	Saya memahami kesan misregistration	4.18	Tinggi
Purata Min		**4.34**	**Tinggi**

4.3 Keberkesanan Penggunaan Inovasi CMYK PRESS

Keputusan menunjukkan inovasi CMYK PRESS berada pada tahap sangat berkesan dalam meningkatkan pengalaman pembelajaran pelajar. Dapatan ini selari dengan peningkatan skor ujian pasca berbanding ujian pra, yang menunjukkan bahawa keberkesanan inovasi ini bukan sahaja dirasai oleh pelajar, malah turut memberi impak kepada pencapaian sebenar mereka.

Jadual 4.3: Jadual Analisis Keberkesanan Inovasi

Item	Pernyataan	Min	Interpretasi
1	CMYK PRESS membantu pembelajaran lebih mudah difahami	4.55	Sangat Tinggi
2	Aktiviti stamping meningkatkan kefahaman	4.60	Sangat Tinggi
3	Kaedah ini lebih menarik berbanding teori semata-mata	4.63	Sangat Tinggi
4	Membantu visualisasi proses percetakan	4.50	Sangat Tinggi
Purata Min		**4.57**	**Sangat Tinggi**

4.4 Tahap Penerimaan Pelajar terhadap Kaedah Pembelajaran

Tahap penerimaan pelajar terhadap penggunaan CMYK PRESS adalah sangat positif. Pelajar menunjukkan minat yang tinggi terhadap kaedah pembelajaran interaktif yang berasaskan aktiviti hands-on. Penerimaan yang tinggi ini juga berpotensi menyumbang kepada peningkatan motivasi pembelajaran, yang seterusnya mempengaruhi pencapaian pelajar seperti yang ditunjukkan dalam analisis ujian pasca.

Jadual 4.4: Analisis Tahap Penerimaan Pelajar

Item	Pernyataan	Min	Interpretasi
1	Saya seronok menggunakan CMYK PRESS	4.68	Sangat Tinggi
2	Kaedah ini meningkatkan minat belajar	4.60	Sangat Tinggi
3	Saya ingin lebih banyak aktiviti seperti ini	4.65	Sangat Tinggi
4	Saya mencadangkan kaedah ini digunakan dalam kelas lain	4.55	Sangat Tinggi
Purata Min		**4.62**	**Sangat Tinggi**

4.5 Analisis Peratusan

Secara ringkasnya jadual 4.5 menunjukkan peratusan bagi item CMYK PRESS telah membantu aktiviti pengajaran dan pembelajaran agar lebih mudah difahami. Majoriti pelajar (95%) memberikan respon positif terhadap penggunaan CMYK PRESS dalam pembelajaran.

Ini menunjukkan bahawa inovasi ini diterima baik oleh pelajar dan berkesan dari sudut persepsi pengguna.

Jadual 4.5: Analisis Peratusan (%)

Skala	Peratus (%)
Sangat Setuju	65%
Setuju	30%
Kurang Setuju	5%
Tidak Setuju	0%
Sangat Tidak Setuju	0%

4.6 Analisis Ujian Pra dan Pasca

Bagi menilai tahap kefahaman pelajar secara objektif, analisis perbandingan antara skor ujian pra (pre-test) dan ujian pasca (post-test) telah dijalankan.

Jadual 4.6: Analisis Ujian Pra dan Pasca

Ujian	Min	Sisihan Piawai
Pre-Test	55.3	8.21
Post-Test	78.6	6.45

Dapatan menunjukkan berlaku peningkatan sebanyak **23.3 markah** selepas penggunaan CMYK PRESS. Seterusnya, analisis menggunakan ujian-t berpasangan dijalankan bagi menentukan tahap signifikan perbezaan tersebut.

4.7 Keputusan Ujian-t Berpasangan

Nilai $p < 0.05$ menunjukkan terdapat perbezaan yang signifikan antara skor ujian pra dan ujian pasca. Ini membuktikan bahawa penggunaan CMYK PRESS telah meningkatkan tahap kefahaman kognitif pelajar secara signifikan. Dapatan ini mengukuhkan hasil analisis soal selidik yang menunjukkan tahap pemahaman yang tinggi, sekali gus membuktikan bahawa peningkatan tersebut bukan hanya berdasarkan persepsi pelajar, tetapi disokong oleh bukti pencapaian sebenar.

Jadual 4.7: Analisis Ujian-t Berpasangan

Nilai t	Sig. (p)	Keputusan
8.45	0.000	Signifikan

Secara keseluruhannya, dapatan kajian menunjukkan bahawa:

- Tahap pemahaman pelajar berada pada tahap tinggi berdasarkan analisis soal selidik
- Inovasi CMYK PRESS adalah sangat berkesan dalam meningkatkan pembelajaran

- Tahap penerimaan pelajar adalah sangat positif
- Terdapat peningkatan signifikan dalam pencapaian pelajar berdasarkan ujian pra dan pasca

Gabungan dapatan daripada analisis deskriptif dan inferensi menunjukkan bahawa penggunaan CMYK PRESS bukan sahaja meningkatkan persepsi pelajar terhadap pembelajaran, malah turut meningkatkan tahap kefahaman kognitif sebenar mereka secara signifikan.

5.0 PERBINCANGAN DAN CADANGAN

Bab ini membincangkan dapatan kajian berdasarkan analisis data yang telah diperoleh serta mengaitkannya dengan objektif kajian dan teori pembelajaran yang relevan. Perbincangan ini memberi penekanan kepada keberkesanan inovasi CMYK PRESS dalam meningkatkan kefahaman pelajar melalui pendekatan pembelajaran berasaskan pengalaman.

5.1 Perbincangan Dapatan Kajian

Dapatan kajian menunjukkan bahawa tahap pemahaman pelajar terhadap konsep CMYK adalah tinggi (min = 4.34) dan disokong oleh peningkatan skor ujian pasca. Ini membuktikan bahawa pendekatan pembelajaran berasaskan pengalaman membantu pelajar memahami konsep yang bersifat abstrak melalui aktiviti hands-on. Keberkesanan inovasi CMYK PRESS juga berada pada tahap sangat tinggi (min = 4.57), di mana pelajar mendapati kaedah ini lebih mudah difahami, menarik dan membantu visualisasi proses percetakan. Selain meningkatkan pengalaman pembelajaran, inovasi ini turut memberi impak positif terhadap pencapaian akademik pelajar. Tahap penerimaan pelajar adalah sangat tinggi (min = 4.62), menunjukkan pelajar lebih berminat, seronok dan terlibat secara aktif dalam pembelajaran. Dapatan ini selari dengan teori pembelajaran berasaskan pengalaman oleh Kolb yang menekankan kepentingan penglibatan aktif dalam meningkatkan kefahaman dan motivasi pelajar.

5.2 Implikasi Kajian

Kajian ini menunjukkan bahawa pendekatan pembelajaran berasaskan pengalaman seperti CMYK PRESS dapat dijadikan alternatif kepada kaedah tradisional, membantu pelajar memahami konsep teknikal dengan lebih jelas serta menyokong keperluan pendidikan TVET yang menekankan kemahiran praktikal.

5.3 Cadangan Penambahbaikan

Penambahbaikan boleh dilakukan dari aspek inovasi, pengajaran dan kajian akan datang. Inovasi boleh diperkukuhkan melalui variasi aktiviti, penggunaan bahan tahan lama dan integrasi digital. Pengajaran pula boleh dipertingkatkan melalui pendekatan berasaskan masalah, aktiviti refleksi dan elemen kolaboratif. Bagi kajian akan datang, penambahan sampel, penggunaan kumpulan kawalan dan analisis statistik yang lebih mendalam dicadangkan.

5.4 Kesimpulan Perbincangan

Secara keseluruhannya, inovasi CMYK PRESS berjaya meningkatkan pemahaman, keberkesanan pembelajaran dan penerimaan pelajar. Dapatan ini selari dengan teori pembelajaran berasaskan pengalaman yang menekankan kepentingan pengalaman langsung dalam memahami konsep kompleks, sekali gus menunjukkan bahawa pendekatan interaktif wajar diperluaskan dalam pendidikan teknikal dan vokasional.

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GAMIFIKASI BERASASKAN FLASH CARD QC UNTUK MENINGKATKAN PENGUASAAN PELAJAR DALAM TOPIK CARTA KAWALAN PEMBOLEHUBAH

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Abstrak

Kajian tindakan ini bertujuan untuk meningkatkan penguasaan pelajar terhadap topik Carta Kawalan Pembolehubah melalui pendekatan gamifikasi berasaskan *Flash Card QC*. Kajian ini melibatkan seramai 34 orang pelajar Diploma Kejuruteraan Mekanikal (Pembuatan) Semester 5. Masalah utama yang dikenal pasti ialah kelemahan pelajar dalam menggunakan rumus statistik, kesukaran melukis graf carta kawalan serta pencapaian markah ujian yang rendah pada sesi II 2024/2025. Intervensi kajian merangkumi aktiviti *Flash Card QC* secara berkumpulan dan sistem pemberian poin. Data kajian diperoleh melalui perbandingan keputusan kuiz dan ujian bagi sesi II 2024/2025 dan sesi I 2025/2026. Dapatan kajian menunjukkan peningkatan dalam markah kuiz sebanyak 22.4% dan peningkatan markah ujian sebanyak 2.1% selepas penggunaan *Flash Card QC*. Hasil kajian menunjukkan peningkatan ketara dalam sesi 1 2025/2026 dari segi penyertaan pelajar, penglibatan aktif dalam aktiviti pembelajaran secara berkumpulan, penguasaan konsep serta pencapaian akademik, khususnya dalam komponen kuiz. Pelajar didapati lebih aktif berinteraksi, bekerjasama dan berkongsi idea sepanjang aktiviti gamifikasi dijalankan. Kajian ini membuktikan bahawa pendekatan gamifikasi bukan sahaja berkesan dalam meningkatkan kualiti pembelajaran topik carta kawalan dalam pendidikan TVET, malah turut memperkukuh kemahiran kerja berpasukan dalam kalangan pelajar.

Kata kunci: Kajian tindakan, gamifikasi, *flash card QC*, carta kawalan pembolehubah, TVET

Abstract

This action research aims to improve students' mastery of the topic Variable Control Charts through a gamification approach using Flash Card QC. The study involved 34 students from Semester 5 of the Diploma in Mechanical Engineering (Manufacturing). The main issues identified were students' weaknesses in applying statistical formulas, difficulties in constructing control chart graphs, and low-test scores in Semester II 2024/2025. The intervention implemented included group-based Flash Card QC activities and a point reward system. Data were collected through a comparison of quiz and test results between Semester II 2024/2025 and Semester I 2025/2026. The findings indicate an increase of 22.4% in quiz scores and a 2.1% improvement in test scores following the implementation of Flash Card QC. The results also show a significant improvement in Semester I 2025/2026 in terms of student

participation, active involvement in group learning activities, conceptual understanding, and academic achievement, particularly in the quiz component. Students were found to be more actively engaged in interaction, collaboration, and idea sharing throughout the gamification activities. This study proves that the gamification approach is not only effective in enhancing the quality of learning for the topic of control charts in TVET education but also strengthens teamwork skills among students.

Keywords: *Action research, gamification, Flash Card QC, variable control charts, TVET*

1.0 PENGENALAN

Dalam bidang pendidikan teknikal dan vokasional (TVET), penguasaan konsep statistik dan kawalan kualiti merupakan kemahiran penting yang perlu dikuasai oleh pelajar bagi memenuhi keperluan industri pembuatan. Topik carta kawalan pembolehubah, seperti carta $\bar{X}$-R dan $\bar{X}$-s digunakan secara meluas dalam industri untuk memantau kestabilan proses dan mengesan variasi yang tidak terkawal. Oleh itu, kefahaman yang kukuh terhadap konsep ini amat penting bagi memastikan pelajar bersedia menghadapi cabaran di tempat kerja.

Walau bagaimanapun, pengalaman pengajaran menunjukkan bahawa topik carta kawalan pembolehubah sering dianggap sukar oleh pelajar kerana melibatkan pengiraan statistik, penggunaan rumus matematik serta pembinaan graf. Kaedah pengajaran konvensional yang berfokus kepada syarahan dan latihan bertulis didapati kurang berkesan dalam menarik minat pelajar, terutamanya bagi pelajar TVET yang lebih cenderung kepada pembelajaran secara praktikal dan visual.

Kelemahan dalam penguasaan topik ini bukan sahaja memberi kesan terhadap pencapaian akademik pelajar, malah menjejaskan motivasi, keyakinan diri dan penyertaan aktif mereka dalam proses pembelajaran. Pelajar yang gagal memahami asas pengiraan seperti penentuan nilai purata *(CL)*, had kawalan atas *(UCL)* dan had kawalan bawah *(LCL)* cenderung untuk menghafal tanpa memahami konsep sebenar, seterusnya menyukarkan mereka dalam situasi penilaian formal.

Sehubungan itu, pendekatan pengajaran berasaskan gamifikasi diperkenalkan sebagai satu strategi inovatif bagi mewujudkan suasana pembelajaran yang lebih interaktif, menyeronokkan dan bermakna. Gamifikasi mengintegrasikan elemen permainan seperti cabaran, ganjaran, sistem poin dan persaingan sihat ke dalam aktiviti pembelajaran. Pendekatan ini diyakini mampu meningkatkan penglibatan pelajar secara aktif serta membantu mereka membina kefahaman konsep secara berperingkat.
Dalam kajian ini, gamifikasi diaplikasikan melalui *Flash Card QC* yang direka khusus untuk topik Carta Kawalan Pembolehubah. *Flash card QC* digunakan sebagai medium pembelajaran visual dan interaktif yang membolehkan pelajar mengulang kaji konsep, rumus dan langkah pengiraan secara sistematik. Dengan sokongan sistem poin, pendekatan ini diharapkan dapat

meningkatkan motivasi dan penguasaan pelajar terhadap topik yang bersifat abstrak dan teknikal.

1.1 Pernyataan Masalah

Berdasarkan pemerhatian semasa pengajaran dan pembelajaran, pelajar Diploma Kejuruteraan Mekanikal (Pembuatan) Semester 5 didapati kurang mahir dalam menggunakan rumus statistik, khususnya dalam pengiraan nilai UCL, LCL dan CL. Pelajar juga menghadapi kesukaran melukis graf carta kawalan dengan tepat, seterusnya menyebabkan pencapaian markah ujian berada pada tahap yang rendah. Keadaan ini memberi kesan negatif terhadap motivasi dan penyertaan aktif pelajar dalam kelas.

1.2 Objektif Kajian

Kajian ini memfokuskan kepada penggunaan gamifikasi berasaskan *Flash Card* QC bagi meningkatkan penyertaan pelajar, motivasi pembelajaran dan penguasaan konsep Carta Kawalan Pembolehubah.

Objektif kajian adalah untuk:

i. Meningkatkan penglibatan pelajar dalam aktiviti pembelajaran secara berkumpulan.
ii. Meningkatkan pencapaian markah kuiz dan ujian selepas intervensi.

2.0 KAJIAN LITERATUR

2.1 Gamifikasi dalam Pendidikan

Gamifikasi merujuk kepada penggunaan elemen permainan dalam konteks bukan permainan, termasuk dalam pendidikan, bagi meningkatkan motivasi dan penglibatan pengguna. Menurut Rosmawati dan Rooszana (2023), penggunaan gamifikasi *Quizizz* memberi kesan yang baik terhadap motivasi pelajar. Elemen seperti sistem poin, lencana, tahap pencapaian dan papan skor (*leaderboard*) telah digunakan secara meluas dalam pelbagai bidang pendidikan dan menunjukkan kesan positif terhadap pembelajaran pelajar.

Menurut Hamari, Koivisto dan Sarsa (2016), kebanyakan kajian empirikal mendapati bahawa gamifikasi berpotensi meningkatkan motivasi, penglibatan dan kepuasan pelajar, terutamanya dalam pembelajaran yang memerlukan latihan berulang. Dalam konteks pendidikan tinggi, gamifikasi juga didapati mampu meningkatkan kehadiran dan penyertaan aktif pelajar dalam kelas.

2.2 Gamifikasi dalam Pendidikan Teknikal dan Vokasional (TVET)

Dalam pendidikan TVET, pembelajaran yang bersifat praktikal, visual dan berasaskan masalah adalah lebih berkesan berbanding pendekatan teori semata-mata. Biggs dan Tang (2011) menekankan kepentingan pembelajaran aktif yang selari dengan prinsip *constructive alignment* bagi memastikan hasil pembelajaran dapat dicapai dengan berkesan.

Beberapa kajian menunjukkan bahawa penggunaan aktiviti interaktif seperti permainan, simulasi dan pembelajaran berasaskan cabaran dapat membantu pelajar TVET memahami konsep teknikal yang kompleks dengan lebih mudah. Pendekatan ini bukan sahaja meningkatkan kefahaman kognitif, malah menyokong perkembangan kemahiran insaniah seperti kerjasama dan komunikasi. Selaras itu, kajian oleh Masnih Mustapa dan Nurilma Ambo (2025) menunjukkan bahawa penggunaan gamifikasi dalam pembelajaran mampu meningkatkan motivasi pelajar secara signifikan dalam kursus CTU101. Walau bagaimanapun, peningkatan motivasi tersebut tidak semestinya memberi kesan langsung terhadap pencapaian akademik dalam jangka panjang.

Sehubungan itu, pengkaji mencadangkan agar elemen gamifikasi digabungkan dengan strategi pembelajaran aktif seperti pembelajaran berasaskan masalah bagi memastikan keberkesanan yang lebih menyeluruh. Dapatan ini selari dengan keperluan transformasi pedagogi dalam pendidikan digital yang menekankan penglibatan aktif pelajar serta pembangunan kemahiran berfikir aras tinggi.

2.3 Penggunaan *Flash Card* sebagai Bahan Bantu Mengajar

Flash card merupakan bahan bantu mengajar yang berkesan dalam meningkatkan daya ingatan dan kefahaman konsep melalui kaedah pengulangan aktif (*active recall*). Kajian oleh Zainal dan Ismail (2021) mendapati bahawa penggunaan bahan visual dan kad pembelajaran membantu pelajar mengingati konsep teknikal dengan lebih baik berbanding kaedah pembelajaran pasif. Selain itu, kajian eksperimen oleh Hamid dan Barzenji (2024) dalam pendidikan digital menunjukkan bahawa gamifikasi yang dirangka dengan objektif yang jelas dan maklum balas segera meningkatkan aktiviti pembelajaran berbanding kaedah tradisional. Kajian ini menekankan pentingnya struktur permainan yang konsisten dan mesra pelajar bagi mencapai hasil pembelajaran yang dikehendaki. Noraniezahwati dan Habibah (2025) pula mendapati penggunaan elemen permainan seperti ganjaran, cabaran dan sistem tahap dalam konteks pembelajaran bagi meningkatkan motivasi dan penglibatan murid.

2.4 Jurang Kajian

Walaupun terdapat banyak kajian berkaitan gamifikasi dan penggunaan *flash card* dalam pendidikan, kajian yang mengintegrasikan gamifikasi berasaskan *flash card* secara khusus dalam topik Carta Kawalan Pembolehubah dalam konteks TVET masih terhad. Kebanyakan kajian tertumpu kepada subjek umum atau pembelajaran berasaskan teknologi digital sepenuhnya. Oleh itu, kajian tindakan ini dijalankan bagi mengisi jurang kajian dengan meneroka keberkesanan gamifikasi berasaskan *Flash Card QC* dalam meningkatkan penyertaan, motivasi dan penguasaan pelajar terhadap topik Carta Kawalan Pembolehubah dalam program Diploma Kejuruteraan Mekanikal (Pembuatan).

3.0 METODOLOGI KAJIAN

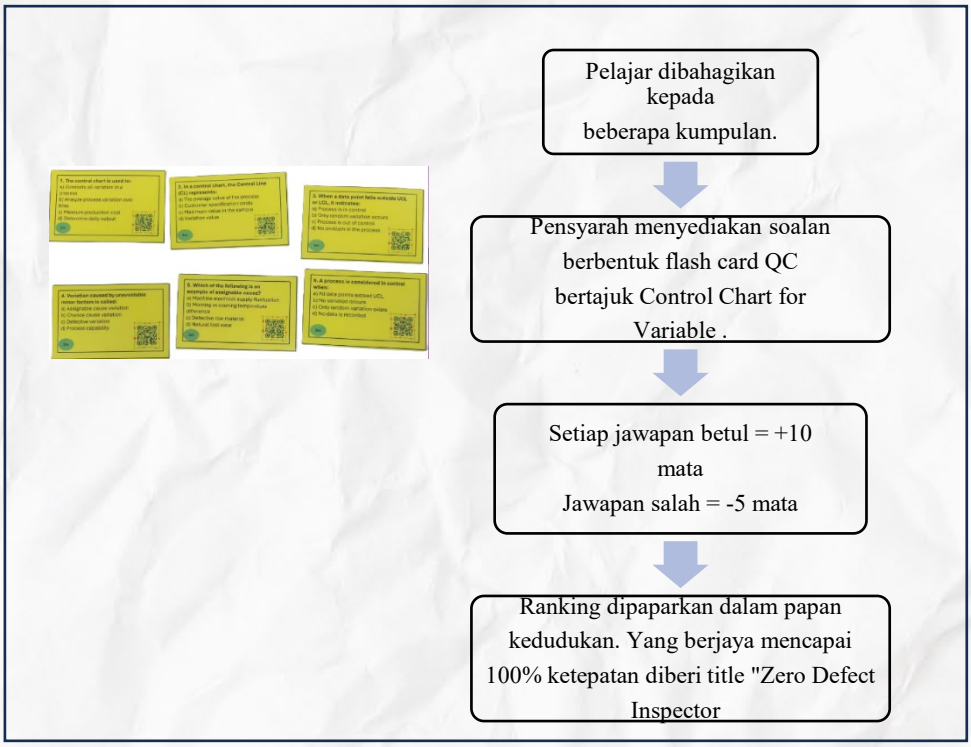
3.1 Reka Bentuk Kajian

Kajian ini menggunakan pendekatan kajian tindakan yang melibatkan proses refleksi, perancangan, pelaksanaan intervensi dan penilaian.

3.2 Kumpulan Sasaran

Kajian ini melibatkan seramai 34 orang pelajar Diploma Kejuruteraan Mekanikal (Pembuatan) Semester 5.

3.3 Pelaksanaan Intervensi



Rajah 1: Aktiviti *Flash Card*

Rajah 1 menunjukkan pelaksanaan gamifikasi menggunakan *Flash Card QC* dalam proses pengajaran dan pembelajaran bagi kursus Kawalan Kualiti. Aktiviti permainan berkonsepkan elemen teka-teki dan strategi. Dalam konteks ini, fokus utama adalah kepada pemahaman carta kawalan pembolehubah, khususnya berkaitan pengiraan dan interpretasi had kawalan seperti *Upper Control Limit, Lower Control Limit dan Center Line*.

Penggunaan gamifikasi ini bertujuan meningkatkan kefahaman pelajar terhadap konsep carta kawalan pembolehubah serta membantu mereka mengaplikasikan formula dan mentafsir data dengan lebih berkesan. Setiap kad *Flash Card QC* mengandungi soalan, data sampel atau situasi berkaitan yang memerlukan pelajar membuat pengiraan atau menentukan kedudukan proses sama ada dalam keadaan terkawal atau tidak. Bagi pelaksanaan aktiviti, pelajar dibahagikan kepada beberapa kumpulan kecil. Setiap kumpulan perlu memilih satu kad secara rawak dan menyelesaikan tugasan yang diberikan dalam tempoh tiga minit. Aktiviti ini menggalakkan penglibatan aktif pelajar, meningkatkan kemahiran penyelesaian masalah, pemikiran kritis serta kerjasama dalam kumpulan.

3.4 Instrumen Pengumpulan Data

Data kajian dikumpulkan melalui keputusan kuiz dan ujian bagi pelajar sesi I 2025/2026 dan pemerhatian penglibatan pelajar dalam aktivit berkumpulan.

4.0 DAPATAN KAJIAN

4.1 Penglibatan Pelajar Dalam Aktiviti Berkumpulan

Aktiviti gamifikasi berkumpulan yang dilaksanakan dalam kajian ini melibatkan seramai 34 orang pelajar, yang dibahagikan kepada beberapa kumpulan kecil bagi memastikan setiap ahli dapat terlibat secara aktif. Pelaksanaan aktiviti ini berjaya menggalakkan interaksi dua hala dan pelbagai hala antara pelajar melalui perbincangan, perkongsian idea, serta kerjasama dalam menyelesaikan tugasan yang diberikan. Setiap kumpulan dilihat menunjukkan tahap penglibatan yang tinggi, di mana pelajar saling membantu antara satu sama lain untuk mencapai objektif permainan.

Bagi menilai keberkesanan aktiviti ini, pencapaian pelajar diukur berdasarkan keupayaan menjawab soalan dengan betul hasil perbincangan kumpulan. Analisis dibuat dengan melihat peratus pelajar yang berjaya memberikan jawapan yang tepat semasa aktiviti dijalankan.

Jadual 1: Peratus Pelajar Menjawab Soalan dengan Betul Melalui Perbincangan Kumpulan

Kategori	Bilangan Pelajar	Peratus%
Jawapan Betul	29	85%
Jawapan Salah	5	15%
Jumlah	34	100%

Berdasarkan Jadual 1, seramai 29 orang pelajar (85%) berjaya menjawab soalan dengan betul hasil perbincangan kumpulan, manakala hanya 5 orang pelajar (15%) memberikan jawapan yang kurang tepat. Dapatan ini menunjukkan bahawa majoriti pelajar memperoleh kefahaman yang baik terhadap topik yang dipelajari melalui pendekatan gamifikasi berkumpulan.

Perbincangan dalam kumpulan didapati membantu pelajar untuk saling bertukar idea, membetulkan kesilapan serta meningkatkan kefahaman konsep sebelum memberikan jawapan. Pelajar yang pada awalnya kurang yakin juga dilihat lebih berani menyumbang idea selepas mendapat sokongan daripada ahli kumpulan.
Selain itu, pemerhatian pensyarah mendapati bahawa pelajar lebih aktif melibatkan diri dalam proses pembelajaran apabila aktiviti dijalankan secara berkumpulan. Suasana pembelajaran menjadi lebih interaktif dan berpusatkan pelajar, sekali gus membantu meningkatkan kadar ketepatan jawapan yang diberikan. Secara keseluruhannya, dapatan ini membuktikan bahawa aktiviti gamifikasi berkumpulan berkesan dalam meningkatkan peratus pelajar yang berjaya menjawab soalan dengan betul, di samping menggalakkan pembelajaran secara kolaboratif dan aktif dalam kalangan pelajar.

4.2 Perbandingan Markah Kuiz dan Ujian

Berdasarkan jadual 2, purata markah kuiz menunjukkan peningkatan yang ketara sebanyak 22.4 mata peratus, daripada 56.8% pada Sesi II 2024/2025 kepada 79.2% pada Sesi I 2025/2026 selepas pelaksanaan gamifikasi. Peningkatan ini mencerminkan tahap penglibatan

dan kefahaman pelajar yang lebih baik semasa aktiviti pembelajaran berasaskan kuiz interaktif. Selain itu, purata markah ujian juga menunjukkan peningkatan, walaupun pada kadar yang lebih sederhana, iaitu daripada 67.1% kepada 69.2%. Peningkatan ini menunjukkan bahawa kesan gamifikasi bukan sahaja terhad kepada penilaian formatif, malah turut menyumbang kepada penguasaan pelajar dalam penilaian formal yang bersifat sumatif.

Jadual 2: Perbandingan Markah Quiz dan Ujian

Sesi Akademik	Purata Markah Kuiz (%)	Purata Markah Ujian (%)
Sesi II 2024/2025	56.8	67.1
Sesi I 2025/2026	79.2	69.2

Secara keseluruhan, dapatan ini menunjukkan bahawa penggunaan elemen gamifikasi berpotensi meningkatkan motivasi, fokus, dan kefahaman pelajar, seterusnya memberi kesan positif terhadap prestasi akademik mereka.

5.0 PERBINCANGAN

Dapatan kajian menunjukkan bahawa pelaksanaan gamifikasi berasaskan *Flash Card QC* memberikan kesan positif yang ketara terhadap penyertaan dan penguasaan pelajar dalam topik Carta Kawalan Pembolehubah. Peningkatan signifikan dalam markah kuiz selepas intervensi menunjukkan bahawa pendekatan ini berkesan sebagai strategi pembelajaran formatif yang menekankan pengulangan, pengukuhan konsep dan pembelajaran aktif.

Ini selaras dengan dapatan Reiter (2025), bahawa elemen gamifikasi seperti poin dan papan skor boleh membangkitkan motivasi intrinsik pelajar untuk berdaya saing secara sihat dan terus menyertai aktiviti pembelajaran. Dalam kajian ini, penggunaan poin berjaya mewujudkan suasana persaingan sihat, seterusnya menggalakkan pelajar untuk terlibat secara aktif dalam aktiviti pembelajaran. Pelajar bukan sahaja terdorong untuk menjawab soalan dengan betul, malah lebih berani berbincang dan mencuba menyelesaikan masalah secara kolaboratif.

Selain itu, penggunaan *flash card* sebagai medium pembelajaran visual membantu pelajar mengingat rumus, langkah pengiraan serta konsep asas carta kawalan dengan lebih sistematik. Pendekatan ini menyokong teori *active recall* dan *retrieval practice* yang menekankan kepentingan pengulangan aktif dalam meningkatkan daya ingatan jangka panjang (Zainal & Ismail, 2021). Pelajar tidak lagi bergantung sepenuhnya kepada hafalan, sebaliknya membina kefahaman secara berperingkat melalui perbincangan kumpulan dan refleksi segera selepas setiap cabaran.

Walaupun peningkatan markah ujian adalah lebih sederhana berbanding kuiz, trend peningkatan yang direkodkan menunjukkan bahawa gamifikasi mempunyai potensi untuk meningkatkan prestasi pelajar dalam penilaian formal. Keadaan ini berkemungkinan disebabkan oleh perbezaan sifat penilaian, di mana ujian memerlukan pemindahan pembelajaran ke situasi yang lebih kompleks dan individu. Namun demikian, latihan berulang

melalui *flash card* dan aktiviti Excel membantu mengurangkan kesilapan pengiraan dan meningkatkan keyakinan pelajar dalam menjawab soalan berbentuk analitikal.
Selain itu, penggunaan strategi gamifikasi dalam konteks *flash card* dan aktiviti kumpulan dapat memupuk pembelajaran kolaboratif, di mana pelajar saling membantu dan berkongsi pemahaman semasa menjawab soalan. Kajian terdahulu oleh Rahimah Wahid (2020) menunjukkan bahawa penggunaan kaedah pembelajaran berasaskan permainan dalam proses pengajaran dan pembelajaran berupaya meningkatkan minat serta menarik perhatian murid semasa berada di dalam kelas. Aktiviti gamifikasi yang dilaksanakan sejajar dengan hasil pembelajaran kursus, kaedah pengajaran dan penilaian, sekali gus menyumbang kepada peningkatan keberkesanan pengajaran dan pembelajaran.

Dapatan ini juga menunjukkan bahawa gamifikasi turut memberi impak positif terhadap pembelajaran berteraskan tugasan formal seperti ujian, walaupun peningkatannya tidak setinggi kuiz. Ini mungkin kerana ujian formal memerlukan kognisi yang lebih tinggi dan pemindahan pembelajaran daripada konteks interaktif ke situasi penilaian individu. Walau bagaimanapun, peningkatan purata markah ujian selepas intervensi menunjukkan bahawa gamifikasi dapat membantu memupuk kefahaman konseptual pelajar dalam jangka sederhana.

Secara keseluruhan, dapatan kajian ini menyokong pandangan bahawa gamifikasi merupakan satu pendekatan pedagogi yang berpotensi dalam pembelajaran teknikal, selaras dengan teori motivasi dan pembelajaran aktif yang dibincangkan dalam literatur terkini (Aisyah et al., 2025). Pendekatan gamifikasi bukan sahaja meningkatkan motivasi dan penglibatan pelajar, tetapi juga memberi peluang kepada pensyarah untuk merangka aktiviti pembelajaran yang lebih bermakna dan berstruktur.

5.0 IMPLIKASI DAN KESIMPULAN

Kajian ini mempunyai beberapa implikasi penting terhadap amalan pengajaran dalam pendidikan TVET. Pertama, gamifikasi berasaskan *Flash Card QC* boleh dijadikan sebagai alternatif atau pelengkap kepada kaedah pengajaran konvensional bagi topik yang bersifat teknikal dan abstrak. Kedua, pendekatan ini membantu meningkatkan motivasi dan keyakinan pelajar, khususnya pelajar yang lemah dalam pengiraan statistik. Ketiga, penggunaan bahan bantu mengajar yang mudah seperti *flash card* dan perisian Excel menjadikan kaedah ini praktikal dan mudah diaplikasikan oleh pensyarah.

Kesimpulannya, kajian tindakan ini membuktikan bahawa gamifikasi berasaskan *Flash Card QC* merupakan satu pendekatan pengajaran yang berkesan dalam meningkatkan penyertaan, motivasi dan penguasaan pelajar terhadap topik Carta Kawalan Pembolehubah. Peningkatan ketara dalam markah kuiz serta peningkatan konsisten dalam markah ujian menunjukkan keberkesanan intervensi yang dilaksanakan. Pendekatan ini berpotensi untuk diperluaskan kepada topik kawalan kualiti yang lain serta subjek teknikal dalam pendidikan TVET bagi menyokong pembelajaran yang lebih bermakna dan berpusatkan pelajar.

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TRENDS AND EVOLUTION OF SUSTAINABLE ELECTRICAL DISCHARGE MACHINING RESEARCH A BIBLIOMETRIC REVIEW

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Abstract

Electrical Discharge Machining is a widely used non-traditional machining process for high precision manufacturing, particularly for machining hard and difficult to process conductive materials. In recent years, sustainability has become an increasingly important consideration in manufacturing research, including energy efficiency, environmental impact, and resource utilisation. However, sustainability-oriented research in Electrical Discharge Machining is often addressed implicitly through process optimisation and performance improvement rather than explicit sustainability terminology. This study presents a bibliometric analysis of sustainability oriented Electrical Discharge Machining research based on Scopus indexed journal publications. A total of 214 articles published between 1996 and 2026 were analysed using descriptive bibliometric indicators and network visualisation techniques. Publication trends by year, keyword co-occurrence patterns, and country collaboration networks were examined to reveal the evolution, thematic structure, and global research landscape of sustainable EDM studies. The results show a clear growth in sustainability related Electrical Discharge Machining research, with a significant increase in publications observed after 2017 and a pronounced surge from 2020 onwards. Keyword co-occurrence analysis reveals that sustainability is embedded within core EDM research through interconnected themes of energy efficiency, machining performance optimisation, material selection, and dielectric fluid innovation. Country collaboration analysis indicates that while some countries demonstrate high research productivity, international collaboration remains uneven, with opportunities for stronger cross regional partnerships. Overall, this study provides a comprehensive overview of the development and structure of sustainability oriented Electrical Discharge Machining research. The findings offer valuable insights for researchers and practitioners by identifying dominant research themes, collaboration patterns, and potential directions for advancing environmentally responsible and energy efficient EDM technologies.

Keywords: EDM; Sustainable Manufacturing, Sustainability, Advanced Manufacturing, Bibliometric Analysis, Scopus Database

Abstrak

Electrical Discharge Machining (EDM) merupakan satu proses pemesinan bukan tradisional yang digunakan secara meluas dalam pembuatan berketepatan tinggi, terutamanya untuk memesin bahan konduktif yang keras dan sukar diproses. Dalam beberapa tahun kebelakangan ini, kelestarian telah menjadi satu aspek yang semakin penting dalam penyelidikan pembuatan, termasuk kecekapan tenaga, kesan terhadap alam sekitar, dan penggunaan sumber. Walau bagaimanapun, penyelidikan berorientasikan kelestarian dalam EDM sering dibincangkan secara tidak langsung melalui pengoptimuman proses dan peningkatan prestasi, berbanding penggunaan istilah kelestarian secara jelas. Kajian ini membentangkan analisis bibliometrik terhadap penyelidikan EDM berorientasikan kelestarian berdasarkan penerbitan jurnal yang diindeks dalam pangkalan data Scopus. Sebanyak 214 artikel yang diterbitkan antara tahun 1996 hingga 2026 telah dianalisis menggunakan penunjuk bibliometrik deskriptif dan teknik visualisasi rangkaian. Trend penerbitan mengikut tahun, corak kewujudan bersama kata kunci (keyword co-occurrence), serta rangkaian kolaborasi antara negara telah dikaji bagi mengenal pasti evolusi, struktur tema, dan landskap penyelidikan global dalam kajian EDM lestari. Keputusan menunjukkan peningkatan yang jelas dalam penyelidikan berkaitan kelestarian dalam EDM, dengan peningkatan ketara dalam bilangan penerbitan selepas tahun 2017 dan lonjakan yang lebih jelas bermula tahun 2020. Analisis kewujudan bersama kata kunci menunjukkan bahawa elemen kelestarian telah diserap dalam penyelidikan teras EDM melalui tema yang saling berkait seperti kecekapan tenaga, pengoptimuman prestasi pemesinan, pemilihan bahan, dan inovasi bendalir dielektrik. Analisis kolaborasi antara negara menunjukkan bahawa walaupun sesetengah negara mempunyai produktiviti penyelidikan yang tinggi, tahap kerjasama antarabangsa masih tidak seimbang, dan terdapat peluang untuk memperkukuh kerjasama rentas wilayah. Secara keseluruhannya, kajian ini memberikan gambaran menyeluruh tentang perkembangan dan struktur penyelidikan EDM berorientasikan kelestarian. Dapatan kajian ini memberi panduan berguna kepada penyelidik dan pengamal industri dalam mengenal pasti tema utama penyelidikan, corak kolaborasi, serta potensi hala tuju bagi memajukan teknologi EDM yang lebih mesra alam dan cekap tenaga.

Kata kunci: *EDM; Pembuatan Lestari; Kelestarian; Pembuatan Termaju; Analisis Bibliometrik; Pangkalan Data Scopus*

1.0 INTRODUCTION

Electrical Discharge Machining (EDM) is a sophisticated non-traditional thermal machining process uniquely capable of producing complex geometries in electrically conductive materials, particularly hard-to-machine alloys and composites. The evidence strongly supports this claim across multiple industrial domains. Ghiorghe et al., 2024 confirms EDM's widespread use in aerospace, automotive, and surgical component manufacturing. Gupta et al., 2020 specifically highlights EDM's effectiveness in machining titanium (hardness HRB 70-74), while André Filipe Varandas Pedroso et al., 2025 demonstrates its capabilities with Metal-Matrix, Polymer-Matrix, and Ceramic-Matrix Composites. Mahajan et al., 2022 further

emphasizes its precision in biomedical device surface engineering. The process's key advantage lies in its ability to machine materials irrespective of their mechanical properties, making it an essential technology in advanced manufacturing sectors.

Despite its advantages, EDM is recognized as an environmentally problematic manufacturing process with significant sustainability challenges due to its high energy consumption, toxic emissions, and reliance on harmful dielectric fluids. Multiple studies Valaki et al., 2018 characterize EDM as "one of the most unsustainable machining processes" due to high specific energy consumption, hazardous emissions, and toxic waste generation. Hydrocarbon-based dielectric fluids release carcinogenic pollutants like polycyclic aromatic hydrocarbons, carbon dioxide, and benzene (Pellegrini et al., 2019). Researchers are actively exploring sustainable alternatives, including water-based, gas-based, and bio-oil dielectrics (Bhowmik et al., 2025), which promise to reduce environmental impact while maintaining machining performance. As a result, sustainability has emerged as an increasingly important consideration in the development and application of Electrical Discharge Machining processes.

Sustainable manufacturing emphasizes the reduction of energy consumption, efficient use of materials, minimization of waste, and mitigation of environmental impact throughout the manufacturing life cycle. Within the context of Electrical Discharge Machining, sustainability related objectives are often addressed indirectly through process optimization, performance enhancement, and the development of alternative materials and process strategies. Improvements in material removal rate, surface integrity, tool wear reduction, and energy utilization contribute to sustainability outcomes, even when studies do not explicitly frame their contributions under sustainability terminology.

In recent years, advances in digitalization, intelligent manufacturing, and Industry 4.0 have further strengthened the link between Electrical Discharge Machining and sustainability. The integration of optimization techniques, data driven modelling, and advanced process control has enabled more efficient and environmentally responsible EDM operations. These developments have contributed to a growing and diverse body of literature addressing sustainability related challenges in Electrical Discharge Machining.

Given the expanding scope and interdisciplinary nature of this research field, there is a need for a systematic and quantitative assessment of sustainability oriented Electrical Discharge Machining studies. Bibliometric analysis provides an effective approach for mapping research evolution, identifying dominant themes, and examining global research collaboration patterns. Therefore, this study aims to conduct a bibliometric analysis of sustainability oriented Electrical Discharge Machining research using Scopus indexed journal publications. The findings provide a comprehensive overview of research trends, thematic structures, and international collaboration in sustainable EDM, offering valuable insights for researchers, practitioners, and policy makers.

2.0 LITERATURE REVIEW

2.1 Electrical Discharge Machining Research Focus

Early research on Electrical Discharge Machining primarily focused on understanding discharge mechanisms, material removal phenomena, and process stability. Ming et al. (2021) reported that researchers extensively investigated key performance measures such as material removal rate, surface roughness, and tool wear rate to enhance machining effectiveness. Nahak et al. (2019) further demonstrated that careful selection of process parameters, including pulse current, voltage, and pulse timing, is critical for achieving stable and efficient machining of hard and electrically conductive materials. These studies emphasized improvements in machining accuracy, surface integrity, and productivity through the optimization of electrical parameters, electrode materials, and machining strategies, thereby establishing the fundamental technical principles underpinning modern EDM applications.

Subsequent research expanded towards comprehensive performance optimization, with continued emphasis on material removal rate, surface quality, and tool wear behavior. Both experimental and modelling based approaches were widely adopted to establish quantitative relationships between process parameters and machining responses. Although these studies were not explicitly framed within a sustainability context, their strong focus on efficiency enhancement and process optimization contributed indirectly to sustainable manufacturing objectives by reducing energy consumption, material waste, and machining time.

2.2 Sustainability Considerations in Electrical Discharge Machining

EDM research has increasingly focused on sustainability, addressing environmental impact and energy efficiency through innovative approaches. Researchers have explored strategies including parameter optimization, alternative dielectric fluids, and emission control Ming et al., 2021. A particularly promising area is alternative dielectric fluids. Mishra et al., 2020 demonstrated that vegetable-based bio-dielectrics can reduce aerosol emissions by 17.33% and improve surface finish compared to traditional hydrocarbon fluids. Vincent et al., 2023 further confirmed that trans-esterified vegetable oils offer pollution-free machining with enhanced performance. Key developments include investigating bio-based dielectrics to replace traditional hydrocarbon oils, which can emit harmful substances Bhowmik et al., 2025. While explicit life cycle assessment studies remain limited, the literature shows a clear trend towards more environmentally conscious EDM processes, focusing on dielectric fluid management, electrode wear reduction, and minimizing environmental risks Valaki et al., 2015.

2.3 Advanced Materials and Sustainable EDM Applications

EDM is emerging as a critical sustainable solution for machining advanced materials like titanium alloys and metal matrix composites, despite significant energy and environmental challenges. Multiple studies highlight key sustainability strategies: Arif et al., 2022 propose using bio-dielectrics to reduce environmental pollution, while Ming et al., 2021 recommend optimizing energy distribution and exploring dry-EDM techniques. Singh et al., 2020 emphasize parameter optimization to enhance productivity and reduce energy consumption. The research consistently shows that hybrid approaches, such as powder-mixed EDM and

cryogenic-assisted techniques, offer promising paths to balance machining performance with reduced environmental impact Singh et al., 2016. However, the field remains nascent, with ongoing research needed to fully address sustainability concerns in advanced material machining.

2.4 Bibliometric Tools for Research Mapping

Bibliometric analysis is widely used to examine research trends, thematic evolution, and collaboration patterns in manufacturing and sustainability related fields. Previous studies have demonstrated its effectiveness in mapping developments in sustainable manufacturing, advanced machining, and energy efficient production, thereby providing objective insights into complex research landscapes. Despite the extensive literature on Electrical Discharge Machining, bibliometric studies specifically addressing sustainability oriented EDM research remain limited. Existing reviews largely focus on technical advancements and process optimization, with limited systematic analysis of sustainability themes, energy efficiency, and international collaboration. This gap highlights the need for a dedicated bibliometric assessment of sustainability integration in EDM research. To address this gap, this study employs VOSviewer, a widely used bibliometric visualization tool developed by van Eck and Waltman (2023). VOSviewer enables the construction of cluster-based maps of keyword co-occurrence, co authorship, and citation networks, facilitating the identification of thematic structures and collaborative trends in sustainability related research (Rasuman et al., 2023). Its application in this study supports a comprehensive and visually interpretable analysis of sustainability oriented Electrical Discharge Machining research.

3.0 METHODOLOGY

This study adopts a bibliometric approach to systematically analyze academic literature related to EDM in trending contexts. The methodology comprises three key stages: data collection, data processing, and visualization analysis using VOS viewer and Excel.

3.1 Data Source, Search Strategy, and Processing

The bibliographic data for this study were retrieved from the Scopus database, which is widely recognised for its extensive coverage of high-quality peer reviewed scientific literature. The dataset was obtained using a structured search strategy designed to capture publications situated at the intersection of Electrical Discharge Machining, sustainability, and manufacturing research. The search was conducted on 16 December 2025, using predefined search parameters applied to the title, abstract, and keyword fields to ensure comprehensive coverage of sustainability oriented EDM studies, applying the following parameters:

iv. **Search Fields**: Article title, abstract, and keywords
v. **Search String**: (TITLE-ABS-KEY ("Electrical Discharge Machining" OR "EDM" AND "sustain*" AND "manufacturing"))
vi. **Language**: English
vii. **Time Frame**: 2004 to 2026

viii. **Subject Areas**: Environmental Science, Social Sciences, Energy, Engineering, and Education

A total of 214 records were retrieved and screened. No records were excluded, as all articles matched the inclusion criteria. The bibliometric analysis was conducted on all 214 articles. The entire data acquisition and screening process is summarised in **Figure 1**. Following extraction, the dataset was processed using Microsoft Excel. Data cleaning included:

i. Resolving author and country name inconsistencies
ii. Filtering and grouping publication years
iii. Generating trend graphs for yearly publication distribution
iv. Preparing structured tables for co-occurrence analysis

These pre-processed data were subsequently exported to VOSviewer for network visualisation and bibliometric mapping.

3.2 VOS viewer

VOS viewer (version 1.6.19) was used to perform co-authorship, co-occurrence, and country collaboration analysis. The software constructs visual networks based on link strength and cluster density, enabling the identification of prominent authors, recurring keywords, and institutional partnerships. The analysis settings included:

i. Minimum occurrence threshold for keywords: 20
ii. Normalisation method: Association strength
iii. Visual outputs: Network maps, density maps, and overlay maps

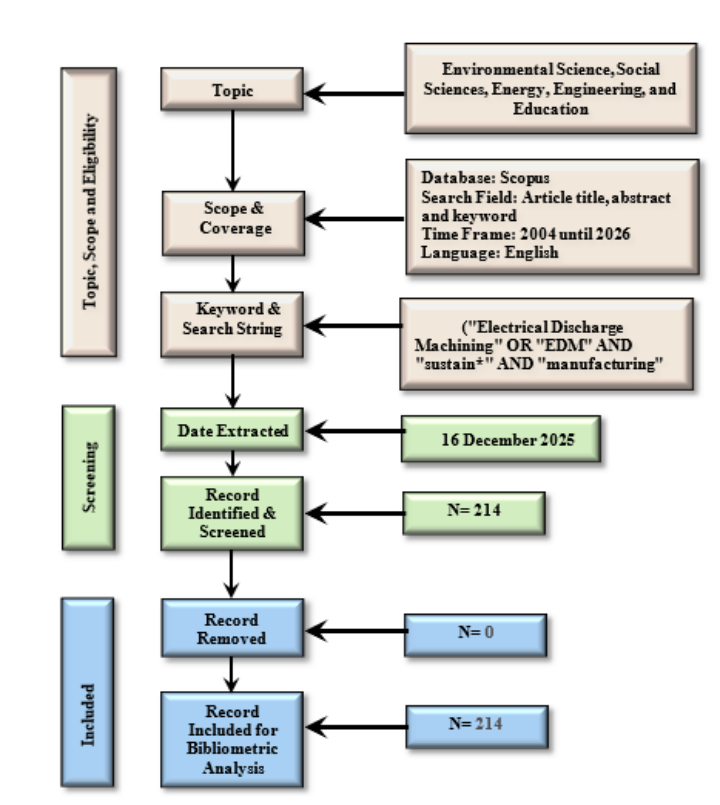


Figure 1: Workflow of Data Identification, Screening, and Inclusion for Bibliometric Analysis

4.0 RESULT AND DISCUSSION

This section presents a comprehensive analysis of the bibliometric findings derived from Scopus indexed publications on sustainability oriented Electrical Discharge Machining research. The analysis is structured into three main components: publication trends over time, keyword co-occurrence patterns, and country level research collaboration. Each subsection highlights significant observations based on quantitative bibliometric indicators and network visualisations generated using Excel and VOSviewer.

4.1 Article by years

Temporal and Geographical Distribution of Publications

The combined analysis of publication trends by year and country provides important insights into the temporal evolution and global distribution of sustainability oriented Electrical Discharge Machining research. A total of 214 Scopus indexed journal articles published between 1996 and 2026 were analyzed, revealing both a strong growth trajectory over time and a geographically concentrated research landscape. In the early stage of the research period from 1996 to 2010, publication activity was very limited and geographically sparse. During this phase, only a small number of countries contributed sporadically to the literature, reflecting the nascent integration of sustainability considerations within Electrical Discharge Machining research. Sustainability related concepts were not yet widely embedded in manufacturing discourse, and EDM studies largely prioritized machining performance without explicit environmental framing.

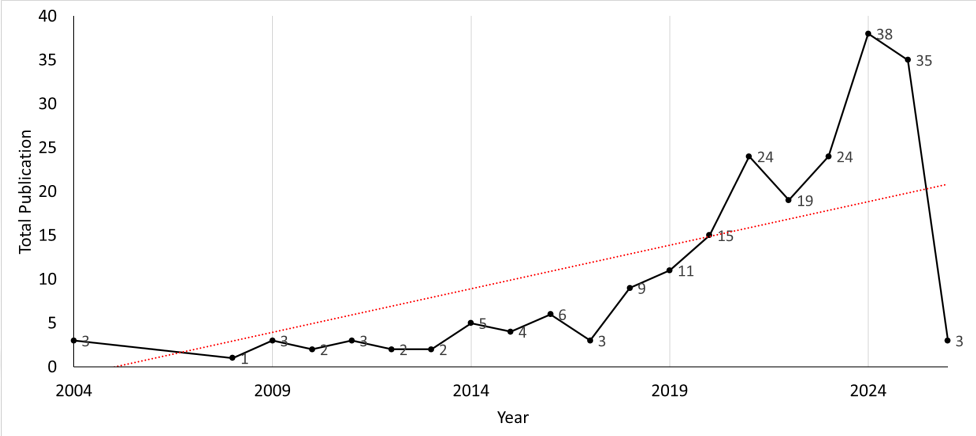


Figure 2: Publication through years

A gradual increase in publications was observed between 2011 and 2016. This growth coincided with the broader emergence of sustainable manufacturing as a research priority. Contributions during this period originated primarily from industrialized and emerging manufacturing nations, indicating early recognition of the need to improve resource efficiency and environmental performance in nontraditional machining processes. A significant acceleration in publication output occurred after 2017, with a pronounced surge from 2020 onwards. This period aligns closely with global initiatives on sustainability, energy efficiency, and Industry 4.0. The highest annual publication output was recorded in 2024, followed closely

by 2025, demonstrating sustained research momentum. The continued presence of publications in 2026 further suggests that sustainability oriented Electrical Discharge Machining research remains an active and growing field.

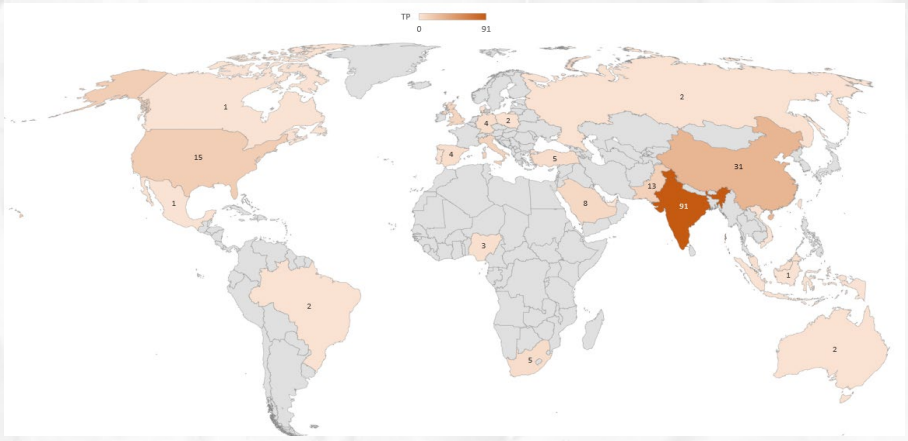


Figure 3: Countries Mapping with Total Publication

Geographically, the research output is dominated by a small number of countries. India emerges as the most prolific contributor, accounting for 91 publications, which represents the largest share of the total dataset. This dominance reflects India's strong academic and industrial engagement in Electrical Discharge Machining, particularly in process optimization, alternative dielectric materials, and performance enhancement studies that implicitly support sustainability objectives. China ranks second with 31 publications, indicating substantial research activity aligned with its advanced manufacturing and industrial sustainability initiatives. The United States follows with 15 publications, reflecting steady contributions to sustainable manufacturing and non-traditional machining research. European countries such as Italy, the United Kingdom, Germany, and Spain collectively contribute a significant portion of the literature, highlighting sustained interest in environmentally responsible machining within advanced manufacturing sectors.

Emerging and developing economies also play an important role in shaping the sustainability oriented EDM research landscape. Pakistan contributes 13 publications, while Saudi Arabia, South Africa, Turkey, and Malaysia show moderate but meaningful research activity. These contributions are likely driven by the growing adoption of advanced manufacturing technologies and increasing awareness of sustainable industrial practices. The presence of publications from countries across Africa, Southeast Asia, the Middle East, and South America indicates a gradual global diffusion of sustainability driven EDM research. However, the relatively low publication counts in many regions suggest that sustainability focused EDM studies remain concentrated within a limited number of research-intensive countries.

Overall, the combined temporal and geographical analysis reveals that sustainability oriented Electrical Discharge Machining research has evolved from a marginal topic into a globally recognized research area. The sharp increase in publications after 2020, coupled with strong contributions from both developed and emerging economies, underscores the growing importance of sustainability considerations in nontraditional machining research. These

findings highlight opportunities for broader international collaboration and further expansion of sustainability driven EDM studies in underrepresented regions.

4.2 Keyword occurrence Keyword Co-Occurrence Analysis

Keyword analysis provides insight into the thematic structure and intellectual focus of sustainability oriented Electrical Discharge Machining research. In this study, keyword co-occurrence analysis was conducted using VOSviewer to identify high frequency keywords and their interrelationships. Figure 4 presents the keyword co-occurrence network visualisation, while Table 1 summarises the frequency of occurrence and total link strength of the most influential keywords. The VOSviewer analysis reveals several colour coded clusters, each representing a distinct yet interconnected research theme.

1. *Red Cluster*

Core EDM Process and Sustainability Integration. The red cluster represents the core technical foundation of sustainability oriented EDM research.

i. This cluster is dominated by keywords such as electric discharges, electric discharge machining, electrical discharge machining, and EDM, which record the highest occurrence frequencies and total link strength values.
ii. The strong centrality of these keywords indicates that sustainability research in EDM is fundamentally grounded in process mechanisms and discharge physics.
iii. Sustainability related terms including sustainability, sustainable manufacturing, and sustainable development are closely connected to EDM process keywords within this cluster, confirming that sustainability considerations are embedded within the core technical discourse rather than treated as a separate research stream.

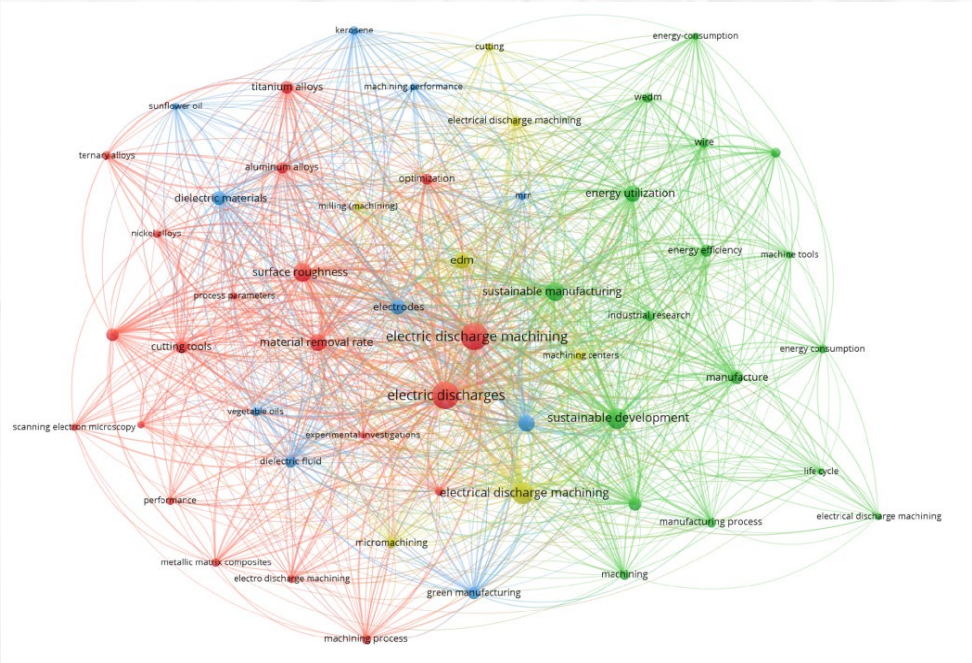


Figure 4: Keyword Co-occurrence Network Visualization (Generated by VOS viewer)
Table 1: Top Keywords by Frequency and Total Link Strength

No	Keyword	Occurrence	Link Strength
1.	electric discharges	101	773
2.	electric discharge machining	99	756
3.	electrical discharge machining	66	413
4.	energy utilization	34	300
5.	edm	35	227
6.	electrodes	28	238
7.	dielectric materials	25	222
8.	environmental impact	24	195
9.	cutting tools	23	207
10.	green manufacturing	21	122
11.	dielectric fluid	21	155
12.	energy efficiency	20	177
13.	aluminium alloys	19	147
14.	industrial research	15	119
15.	electrical discharge machining process	13	115
16.	energy consumption	11	57
17.	electro discharge machining	9	70
18.	cutting	9	48
19.	energy-consumption	8	75
20.	experimental investigations	8	74

2. *Green Cluster*

Machining Performance and Process Optimisation. The green cluster reflects research focused on performance driven sustainability approaches.

i. Prominent keywords in this cluster include material removal rate, surface roughness, tool wear rate, machining performance, and process parameters.
ii. These performance indicators exhibit strong interconnections with sustainability and energy related keywords, highlighting their role as practical sustainability proxies.
iii. The emphasis on productivity and quality optimisation suggests that sustainable EDM is often pursued through reduced machining time, improved surface integrity, and enhanced material utilisation.

3. *Blue Cluster*

Energy Efficiency and Resource Utilisation. The blue cluster captures research addressing energy related sustainability concerns in EDM.

i. Keywords such as energy utilization, energy efficiency, energy consumption, and energy-consumption form a well-connected thematic group.
ii. The close linkage between energy related terms and machining performance keywords indicates that energy optimisation is a primary pathway for achieving sustainability in EDM operations.
iii. This cluster reflects growing awareness of energy intensive characteristics of EDM processes and the need for more efficient energy management strategies.

4. *Yellow Cluster*

Materials and Application Oriented Sustainability. The yellow cluster represents sustainability driven EDM research applied to advanced engineering materials.

i. Key terms include aluminium alloys, titanium alloys, nickel alloys, metallic matrix composites, and ternary alloys.
ii. The presence of these material specific keywords suggests increasing focus on sustainable machining of high value and difficult to process materials.
iii. The linkage between advanced materials and sustainability related terms reflects industrial demand for environmentally responsible manufacturing solutions in critical applications.

5. *Purple Cluster*

Dielectric Fluids and Environmental Impact. The purple cluster highlights research related to dielectric media and environmental considerations**.**

i. Keywords such as dielectric fluid, dielectric materials, and kerosene represent conventional EDM dielectric research.
ii. The inclusion of vegetable oils and sunflower oil indicates emerging interest in biodegradable and environmentally friendly dielectric alternatives.
iii. This cluster reflects increasing concern for reducing environmental impact, health risks, and hazardous waste associated with traditional dielectric fluids.

The keyword co-occurrence network demonstrates a highly interconnected research structure in which sustainability acts as a central linking concept across all colour coded clusters. Energy efficiency, machining performance, material selection, and dielectric innovation are closely coupled rather than treated as isolated research directions. This multidimensional network structure confirms that sustainability oriented Electrical Discharge Machining research integrates technical performance optimisation, environmental considerations, and energy efficiency in a holistic and interconnected manner.Overall, the colour coded keyword clusters reveal that sustainability in Electrical Discharge Machining research is achieved primarily through process optimisation, energy efficiency, material specific applications, and environmentally responsible dielectric development.

4.3 Country collaboration

Country collaboration analysis was conducted to examine international research linkages in sustainability oriented Electrical Discharge Machining studies. Figure 5 illustrates the country collaboration network, highlighting the strength and structure of international research connections, while Table 2 summarises the number of documents, citation counts, and total link strength for the leading contributing countries. This analysis provides insight into how countries collaborate, the intensity of their research networks, and the extent to which sustainability driven EDM research is globally integrated based on publication output, citation impact, and collaborative link strength.

4.3.1 Connections between countries

The country collaboration network reveals a moderate level of international cooperation, with several countries demonstrating strong publication output and citation impact but varying degrees of collaborative connectivity. India emerges as the most productive country with 90 documents and the highest citation count of 1865. However, its total link strength remains relatively low at 6, indicating that a substantial portion of its research output is produced through domestic collaborations rather than extensive international partnerships. China records 31 documents with a high citation count of 686 and a total link strength of 16, suggesting a more balanced combination of research productivity and international collaboration. The United States also demonstrates strong research influence, contributing 18 documents and accumulating 728 citations, supported by a total link strength of 12. This indicates consistent engagement in international collaborative research.

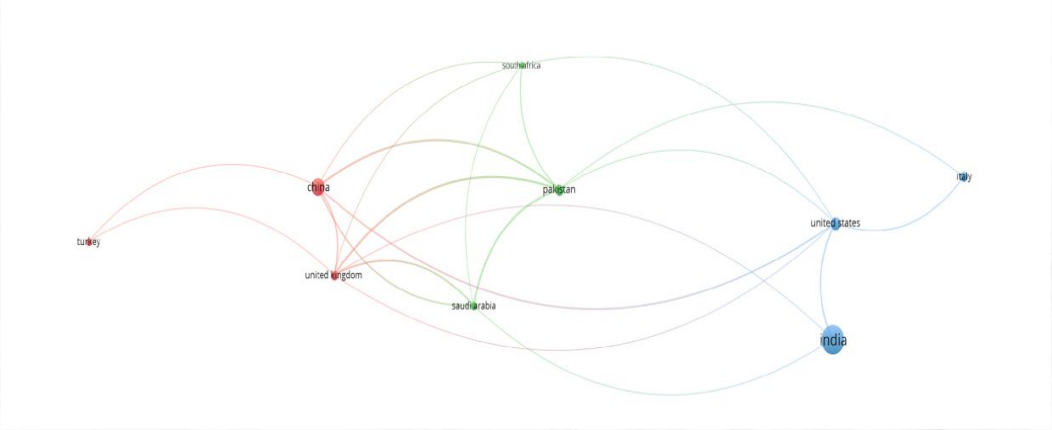


Figure 5: International Collaboration Network Based on Co-authorship (Generated by VOS viewer)

European countries show notable collaborative behavior. The United Kingdom contributes 10 documents with 442 citations and a relatively high total link strength of 17, reflecting strong international research linkages. Italy, although contributing a smaller number of documents at 11, demonstrates meaningful collaboration with a total link strength of 3, indicating selective but focused international partnerships. Pakistan exhibits a distinct collaboration profile, contributing 13 documents with 144 citations and the highest total link strength of 20 among all countries. This suggests that Pakistan's sustainability oriented EDM research is strongly driven by international collaborations. Saudi Arabia also shows active collaboration, with 8 documents and a total link strength of 14, reflecting its growing engagement in joint research initiatives. In contrast, countries such as South Africa and Turkey exhibit lower publication output and weaker collaboration strength, indicating limited integration within the global EDM sustainability research network.

Table 2: Country-wise Documents, Citations, and Collaboration Link Strength

Country	Documents	Citations	Total Link Strength
China	31	686	16
India	90	1865	6
Italy	11	188	3
Pakistan	13	144	20
Saudi Arabia	8	105	14
South Africa	5	13	6
Turkey	6	41	2
United Kingdom	10	442	17
United States	18	728	12

4.3.2 Noteworthy Observations

Several important observations can be drawn from the country collaboration analysis.

i. High research productivity does not necessarily correspond to strong international collaboration. India demonstrates exceptional publication volume and citation impact but relatively limited collaborative linkage strength.
ii. Countries with moderate publication output, such as Pakistan and the United Kingdom, exhibit strong collaboration intensity, highlighting the strategic role of international partnerships in enhancing research visibility and integration.
iii. Citation impact appears to be influenced by both research volume and collaborative reach. Countries such as the United States and China benefit from balanced productivity and collaboration, resulting in high citation counts.
iv. Fourth, emerging economies increasingly participate in international EDM sustainability research, indicating a gradual diversification of the global research landscape.

4.3.3 Potential Areas of Improvement

Despite the presence of active international collaboration, several opportunities for improvement are identified.

i. There is a need to strengthen cross regional collaboration between high productivity countries and those with emerging research capacity. Increased cooperation between Asia, Europe, and Africa could enhance knowledge exchange and promote more globally inclusive sustainability driven EDM research.
ii. Encouraging multi country research projects focused on energy efficiency, environmentally friendly dielectric fluids, and sustainable material processing could further strengthen collaborative networks.
iii. Additionally, countries with high domestic research output but limited international collaboration could benefit from increased participation in global research consortia and joint publications. This would improve research visibility, citation impact, and the overall coherence of sustainability oriented EDM research.
iv. Overall, enhancing international collaboration represents a key opportunity to accelerate innovation, improve research quality, and support the global advancement of sustainable Electrical Discharge Machining practices.

5.0 CONCLUSION AND FUTURE DIRECTION

This study has presented a comprehensive bibliometric analysis of sustainability oriented Electrical Discharge Machining research using Scopus indexed journal publications. By examining publication trends, keyword co-occurrence networks, and country collaboration patterns, the study provides a structured overview of how sustainability considerations have evolved and been integrated into EDM research over time. The analysis of publication trends reveals that sustainability related EDM research remained limited during the early years but experienced substantial growth after 2017, with a marked increase from 2020 onwards.

This growth reflects rising global awareness of sustainable manufacturing, energy efficiency, and environmental responsibility within advanced machining research. The sustained publication output in recent years indicates that sustainability has become an established and continuing research focus in Electrical Discharge Machining. Keyword co-occurrence analysis demonstrates that sustainability in EDM research is not treated as an isolated concept but is embedded within core technical themes. Energy efficiency, machining performance optimisation, material selection, and dielectric fluid innovation emerge as dominant pathways through which sustainability objectives are pursued. The strong interconnections among these themes highlight the multidisciplinary nature of sustainability oriented EDM research, integrating technical, environmental, and energy related considerations. Country collaboration analysis shows that research productivity and collaborative intensity vary significantly across countries.

While some countries contribute a high volume of publications, international collaboration remains relatively limited in certain regions. Conversely, other countries demonstrate strong collaborative networks despite moderate publication output. These findings suggest that enhanced international collaboration could play a critical role in strengthening knowledge exchange, improving research impact, and accelerating innovation in sustainable EDM technologies. In conclusion, this bibliometric study provides valuable insights into the research landscape and development trajectory of sustainability oriented Electrical Discharge Machining. The findings highlight the need for greater integration of energy efficiency, environmental assessment, and collaborative research efforts to advance sustainable non-traditional machining practices. Future research may benefit from expanded international partnerships, deeper life cycle assessment studies, and the application of intelligent optimisation techniques to further enhance the sustainability performance of Electrical Discharge Machining processes.

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AN EXPLORATION OF ORGANIZERS' EXPERIENCES TOWARD THE DIGITAL TRANSFORMATION OF THE TIMBERTALLY SCORING SYSTEM FOR WOODBALL IN PAHANG

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ABSTRACT

Digital transformation through the TimberTally system represents a crucial innovation in overcoming the limitations of manual scoring, which is often prone to human error in the sport of woodball. This qualitative study aims to explore organizers' experiences regarding the effectiveness of the digital system in enhancing accuracy, accelerating result generation, and reducing the technical workload of the secretariat. The study employs a case study design through semi-structured interviews with four (4) key informants from the technical committee. Data were analyzed using manual thematic analysis to identify key management themes, while the system development was guided by the Waterfall model to ensure rigid data integrity. Findings indicate that TimberTally successfully eliminates scoring errors and hastens real-time player ranking. However, challenges such as the initial learning curve and internet connectivity were identified as critical factors for operational success. The study concludes that the system serves as a strategic change agent, with recommendations for official Intellectual Property (IP) registration through myIPO to protect the innovation.

Keywords: TimberTally, Digital Transformation, Woodball, Organizer Experience, Data Accuracy.

Abstrak

Transformasi digital melalui sistem TimberTally merupakan inovasi penting bagi mengatasi kelemahan pengiraan manual yang sering terdedah kepada ralat manusia dalam sukan woodball. Kajian kualitatif ini bertujuan untuk meneroka pengalaman penganjur terhadap keberkesanan sistem digital dalam meningkatkan ketepatan, kepantasan penjanaan keputusan, dan pengurangan beban kerja teknikal urusetia. Metodologi kajian menggunakan reka bentuk studi kes melalui temu bual separa struktur bersama empat orang informan utama daripada jawatankuasa teknikal. Data dianalisis menggunakan analisis tematik secara manual, manakala pembangunan sistem dipandu oleh model Waterfall bagi menjamin integriti data yang jitu. Dapatan menunjukkan bahawa penggunaan TimberTally berjaya menghapuskan ralat pengiraan secara signifikan, walaupun terdapat cabaran dari segi liku pembelajaran

dan kestabilan internet. Kajian merumuskan bahawa sistem ini adalah ejen perubahan strategik, dengan cadangan pendaftaran harta intelek secara rasmi melalui myIPO bagi melindungi nilai komersial inovasi tersebut.

Kata Kunci: *TimberTally, Transformasi Digital, Woodball, Pengalaman Penganjur, Ketepatan Data.*

4.0 INTRODUCTION

Systematic information management is the core element in ensuring transparency and integrity in today's competitive sports organization through the adaptation of professional modern information systems. Sports organizations must adapt modern information systems to ensure that all competition data is managed with the highest level of professionalism (Laudon & Laudon, 2022). In the context of local sports development, Pahang stands out as one of the most active states in woodball; however, many organizers still face significant technical challenges due to reliance on manual scoring management. Failure to manage data effectively can jeopardize an organizer's reputation and invite disputes from various stakeholders (Zaki & Ibrahim, 2023).

Therefore, the integration of digital technology like TimberTally is an urgent necessity to transform manual woodball scoring which is prone to human error—into a secure and automated ecosystem. TimberTally was specifically introduced to elevate the standards of sports organization within Pahang, ensuring that state-level events align with professional global benchmarks. By utilizing cloud-based technology, the system allows data to be processed in real-time with a high level of security (Wang & Zhang, 2024). This transformation not only simplifies technical tasks but also strengthens the organizers' confidence in managing participant databases (Stair & Reynolds, 2021). Overall, this innovation proves that digital automation is the key to operational excellence in Pahang's sporting landscape (Hassan & Ismail, 2023).

1.1 Problem Statement

Despite the growing popularity of woodball in Pahang, the management of tournament scores remains largely manual, relying on physical scorecards and human arithmetic. This traditional approach is highly susceptible to human error, leading to inaccurate data entry and disputes over final rankings (Rahman & Zahari, 2022). Furthermore, the manual process is time-consuming, often causing significant delays in result announcements which affects the overall professional image of the event (Zulkifli & Abdullah, 2025). In Pahang, where woodball tournaments are frequently organized at the community and institutional levels, the absence of a localized digital scoring ecosystem hinders the state's potential to host higher-standard competitions. Therefore, there is a critical need for a digital transformation through the TimberTally system to ensure data integrity, operational speed, and a reduction in the technical workload for organizers in the region.

1.2 Research Objectives

The primary goal of this study is to explore the impact of digital transformation on woodball event management in Pahang. Specifically, the objectives are:

a) To explore organizers' experiences regarding the effectiveness of the TimberTally system in improving the accuracy of woodball scoring within the Pahang woodball ecosystem.
b) To understand the extent to which the use of digital systems assists organizers in accelerating the process of result generation and real-time ranking determination.
c) To identify the impact of digital transformation on reducing the technical workload of the secretariat in Pahang compared to traditional manual methods.

1.3 Research Questions

To achieve the objectives above, this study is guided by the following questions:

a) How does the use of TimberTally help organizers in Pahang minimize human error?
b) To what extent does the integration of this digital system transform the organizers' workflow in ensuring results are generated according to the tournament schedule?
c) What are the perceptions of the technical secretariat regarding the data integrity and operational efficiency produced by TimberTally?

1.4 Significance of the Study

For Sports Organizers: TimberTally provides a systematic digital solution to eliminate critical scoring errors and enhance the professionalism of tournament management across Pahang.

For the Scoring Secretariat: The system significantly reduces the technical workload and mental stress associated with manual scorecard coordination through automated arithmetic operations.

For Players and Coaches: This innovation ensures absolute data accuracy and real-time transparency, functioning as a digital report card to monitor athlete performance in local competitions.

For Institutional Governance: This study serves as a vital reference for the Department of Polytechnic and Community College Education (JPPKK) and the Pahang State Woodball Association in empowering sports governance through digital technology.

5.0 LITERATURE REVIEW

2.1 The Transition from Manual to Digital Sports Management

The evolution of sports management has shifted from traditional record-keeping to highly automated digital ecosystems. Modern sports organizations must adapt professional information systems to ensure that all competition data is managed with the highest level of integrity (Laudon & Laudon, 2022). In manual scoring environments, the risk of human error in arithmetic and data entry remains a critical concern, often leading to disputes and administrative delays (Rahman & Zahari, 2022). For a growing sport like woodball in Pahang, the transition to digital systems is no longer a luxury but a necessity to maintain the professional standards of state-level tournaments (Zulkifli & Abdullah, 2025).

2.2 Cloud Computing and Automated Scoring Algorithms

The integration of cloud-based technology allows sports data to be synchronized and processed in real-time, providing instantaneous results to players and officials (Wang & Zhang, 2024). Digital tools like MIT App Inventor 2 facilitate mobile data entry directly from the field, while backend processing using Visual Basic for Applications (VBA) ensures that complex scoring algorithms remain consistent and error-free (Stair & Reynolds, 2021). These technical frameworks are essential in replacing the bureaucratic weaknesses of manual scorecard coordination (Hassan & Ismail, 2023).

2.3 User Experience (UX) and Digital Transformation

The success of any digital transformation depends heavily on the organizers' experience and their readiness to adopt new technologies. Systems that reduce manual labor stress and simplify technical coordination are more likely to be embraced by sports secretariats (Teschke & Miller, 2023). According to Patton (2023), understanding the qualitative experiences of users is vital in evaluating how a system improves operational efficiency in a real-world setting. In the context of Pahang's woodball landscape, digital automation through TimberTally serves as a strategic driver for organizational excellence and sports credibility (Vial, 2021).

6.0 METHODOLOGY

This study employs a qualitative approach with a case study design to explore the experiences of organizers in depth. This case study was specifically conducted in Pahang to understand the digital transformation process within the local sporting context.

3.1 Research Design

A total of four (4) key informants were selected using a purposive sampling technique to ensure data quality. These informants consist of the technical secretariat and scoring committee members who have direct experience operating the TimberTally system during woodball tournaments in Pahang. Data collection was conducted through semi-structured interviews and participant observation (Silverman, 2022). This allows for an in-depth understanding of how the system performs in a real-world regional setting.

The data were analyzed using manual thematic analysis following the six-phase framework by Braun and Clarke (2022). This process involved transcribing the interviews, generating initial codes for relevant segments of the text, and iteratively organizing these codes into broader themes that represent the organizers' experiences to identify key improvements in management efficiency (Creswell & Poth, 2024). A manual approach was preferred over software like NVivo to allow the researchers to maintain a closer connection to the raw data and capture the subtle nuances within the informants' responses.

3.2.1 System Development Framework

The development of the TimberTally system was guided by the Waterfall Model as shown in Figure 3.1, which provides a structured and sequential approach to software engineering (Sommerville, 2021). This model was chosen because it allows for clear phase transitions,

which is crucial for maintaining data integrity in a scoring system. While sports environments are often perceived as dynamic, the technical scoring rules and ranking criteria for woodball are fixed and rigid based on international standards.

Therefore, the Waterfall model was chosen over Agile to ensure that the system requirements were clearly defined and frozen at the early stages. This approach ensures 100% data integrity and allows for rigorous testing of the automated algorithms before the system is deployed in a live tournament setting.

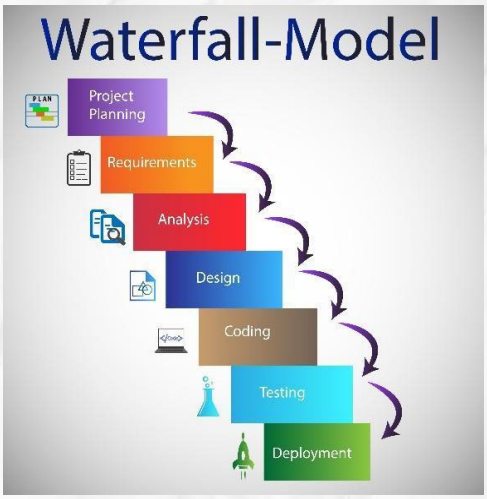


Figure 3.1: The Waterfall Model Phases in TimberTally Development

The implementation of this model involves the following stages.

a) Requirements: Gathering tournament scoring rules and user needs from woodball officials in Pahang.
b) Analysis: Evaluating the logic needed for automatic ranking and cloud synchronization.
c) Design: Creating the UI for MIT App Inventor 2 and the backend structure in VBA.
d) Coding: Developing the actual application and Excel integration.
e) Testing: Conducting dry-runs to ensure zero arithmetic errors.
f) Deployment: Using the system during actual woodball events in Pahang.

7.0 FINDINGS AND DISCUSSION

4.1 System Effectiveness in Enhancing Data Accuracy and Integrity

The findings indicate that the use of TimberTally significantly assists organizers in eliminating human error. Informant 1 (I1) stated, "Previously, manual calculation errors were often a source of disputes, but with this system, all automated calculations are accurate." This aligns with the view of Rahman and Zahari (2022) that automated scoring systems are key to competitive integrity in niche sports. The use of stable algorithms ensures that the reliability of digital data is much higher compared to traditional calculations, which are prone to negligence (Yusoff & Hamzah, 2021; Zaki & Ibrahim, 2023).

4.2 Workflow Transformation and Speed of Result Generation

Informants agreed that TimberTally drastically accelerates the result generation process, thereby optimizing digital governance (Zulkifli & Abdullah, 2025). Informant 2 (I2) explained,

"Results are ready to be announced as soon as the match ends." Cloud-based data management capabilities ensure that rankings are generated in real-time without affecting the tournament schedule (Wang & Zhang, 2024; Laudon & Laudon, 2022). According to Hassan and Ismail (2023), digital transformations such as this are primary drivers of operational efficiency in modern sports organizations.

4.3 The Impact of Digitalization on Technical Workload Reduction

The final theme describes the reduction in technical workload experienced by organizers. Informant 4 (I4) stated, "We are no longer burdened by managing piles of physical scorecards because this system simplifies data coordination." The use of these mobile-based sports management tools has proven to enhance user experience and facilitate technology adaptation among the secretariat (Teschke & Miller, 2023; Stair & Reynolds, 2021). According to Patton (2023), systems that reduce manual labor stress allow human resources to focus on more professional aspects of service quality.

4.4 Implementation Challenges and Learning Curves

Despite the overall success of the digital transformation, the informants highlighted several challenges encountered during the initial implementation of TimberTally. One significant theme was the initial learning curve for technical staff who were accustomed to manual processes. Informant 3 (I3) noted:

"In the beginning, some of the older committee members found it slightly overwhelming to navigate the interface on a mobile device, as they were used to physical scorecards for decades."

Additionally, technical glitches related to environmental factors were mentioned. Informant 1 (I1) explained that while the system itself was stable, internet connectivity in remote woodball courses sometimes caused a slight delay in real-time cloud synchronization. These findings suggest that while the system is highly effective, its success also depends on the digital literacy of the users and the availability of stable infrastructure.

4.5 Discussion

Ultimately, TimberTally has successfully overcome the constraints of manual systems in Pahang through significant time savings and enhanced data accuracy. This shift in mindset toward digitalization opens substantial opportunities for organizations in the state to restructure their event management strategies (Vial, 2021). Through an in-depth case study involving four key informants in Pahang, this research confirms that the technical integration of MIT App Inventor 2, Google Sheets, and VBA effectively addresses the local bureaucratic weaknesses of manual scoring. This analysis aligns with the principles of modern qualitative research, which emphasize understanding phenomena within a specific real-world context (Yin, 2023).

8.0 CONCLUSION AND RECOMMENDATIONS

This qualitative study concludes that the TimberTally system has successfully transformed woodball sports management in Pahang from inefficient manual methods into a high-integrity digital ecosystem. The organizers' experiences prove that this system not only eliminates calculation errors but also instills full confidence in the accuracy of real-time rankings, serving as a pioneer model for adoption across Malaysia to ensure the sustainability of professional event management. To further strengthen its effectiveness, it is recommended that TimberTally be integrated with in-depth player performance analytical modules, while providing structured technical training workshops for officials and developing offline-sync capabilities to address identified learning curves and internet connectivity issues in remote venues.

Furthermore, as a strategic measure to protect the originality and commercial value of this innovation, it is highly recommended that the TimberTally system, including its unique algorithms and software architecture, be officially registered for Intellectual Property (IP) protection through myIPO. This study serves as a vital reference for the Department of Polytechnic and Community College Education (JPPKK) and the Pahang State Woodball Association in empowering sports governance through digital technology. In conclusion, the adaptation of this technology aligns woodball management in Pahang with global professional standards, ensuring absolute data accuracy and operational excellence.

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INOVASI NOTA POKET C++ QUICKIE NOTES: ALAT BANTU PEMBELAJARAN INTERAKTIF UNTUK KURSUS *PROGRAMMING FUNDAMENTALS*

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Abstrak

Kursus *Programming Fundamentals* sering dianggap mencabar oleh pelajar kerana memerlukan pemahaman terhadap konsep asas pengaturcaraan serta struktur sintaks dalam bahasa C++. Kekurangan bahan rujukan yang ringkas dan mudah dicapai boleh menjejaskan keberkesanan proses pembelajaran. Sehubungan itu, kajian ini dijalankan bagi membangunkan inovasi *C++ Quickie Notes*, iaitu nota poket sebagai alat bantu pembelajaran bagi kursus *Programming Fundamentals*. Objektif kajian ini adalah untuk membangunkan *C++ Quickie Notes* sebagai alat bantu pembelajaran, mereka bentuk nota poket yang tersusun, padat dan mudah digunakan, serta menguji keberkesanan penggunaannya dalam membantu pelajar memahami konsep asas pengaturcaraan C++. Kajian ini menggunakan Model ADDIE yang merangkumi fasa analisis, reka bentuk, pembangunan, pelaksanaan dan penilaian. Bagi menilai keberkesanan inovasi yang dibangunkan, kaedah soal selidik telah digunakan untuk mendapatkan maklum balas pelajar. Data yang diperoleh dianalisis menggunakan perisian IBM SPSS Statistics melalui analisis deskriptif seperti skor min bagi menilai tahap penerimaan pelajar terhadap inovasi tersebut. Dapatan kajian menunjukkan bahawa penggunaan *C++ Quickie Notes* mendapat tahap penerimaan yang tinggi dalam kalangan pelajar serta membantu meningkatkan kefahaman terhadap konsep asas pengaturcaraan. Secara keseluruhannya, inovasi ini berpotensi menjadi bahan sokongan pembelajaran yang efektif dalam menyokong proses pengajaran dan pembelajaran bagi kursus *Programming Fundamentals.*

Keywords: C++ *Quickie Notes*, Alat Bantu Mengajar, *Programming Fundamentals*.

Abstract

Programming Fundamentals courses are often considered challenging by students because they require an understanding of the basic concepts of programming and the syntax structure in the C++ language. The lack of simple and easily accessible reference materials can affect the effectiveness of the learning process. Accordingly, this study was conducted to develop the C++ Quickie Notes innovation, namely pocket notes as a learning aid for the Programming Fundamentals course. The objectives of this study were to develop C++ Quickie Notes as a learning aid, design pocket notes that are organized, compact and easy to use, and test the

effectiveness of their use in helping students understand the basic concepts of C++ programming. This study used the ADDIE Model which includes the analysis, design, development, implementation and evaluation phases. To assess the effectiveness of the developed innovation, a questionnaire method was used to obtain student feedback. The data obtained was analyzed using IBM SPSS Statistics software through descriptive analysis such as mean scores to assess the level of student acceptance of the innovation. The study findings showed that the use of C++ Quickie Notes received a high level of acceptance among students and helped improve understanding of the basic concepts of programming. Overall, this innovation has the potential to be an effective learning support material in supporting the teaching and learning process for the Programming Fundamentals course.

Keywords: *C++ Quickie Notes, Teaching Aids, Programming Fundamentals.*

1.0 PENGENALAN

Dalam proses pengajaran dan pembelajaran, penggunaan alat bantu mengajar yang sesuai memainkan peranan penting dalam membantu pelajar memahami sesuatu konsep dengan lebih berkesan. Alat bantu mengajar seperti nota ringkas, modul pembelajaran, infografik dan bahan rujukan padat dapat membantu menyampaikan maklumat secara lebih sistematik dan mudah difahami oleh pelajar. Bahan pembelajaran yang disusun secara ringkas dan berfokus juga dapat membantu pelajar mengingat konsep utama serta meningkatkan keberkesanan proses pembelajaran (Chen & Huang, 2024). Keberkesanan alat bantu mengajar ini amat penting terutamanya dalam kursus yang melibatkan konsep abstrak dan kemahiran penyelesaian masalah seperti kursus pengaturcaraan.

Pengaturcaraan komputer merupakan salah satu kemahiran penting dalam era teknologi digital kerana ia berkait rapat dengan pembangunan perisian, penyelesaian masalah serta pemikiran komputasional. Oleh itu, kursus pengaturcaraan asas seperti *Programming Fundamentals* memainkan peranan penting dalam membina asas pengetahuan pelajar dalam bidang teknologi maklumat dan sains komputer. Walau bagaimanapun, pembelajaran pengaturcaraan sering dianggap mencabar oleh pelajar kerana ia memerlukan kemahiran pemikiran logik, analitikal dan keupayaan menyelesaikan masalah yang tinggi. Kajian menunjukkan bahawa pelajar sering menghadapi kesukaran untuk memahami konsep asas pengaturcaraan seperti pembolehubah, struktur kawalan dan algoritma pada peringkat awal pembelajaran (Kadar et al., 2021).

Kesukaran dalam memahami konsep asas pengaturcaraan boleh memberi kesan kepada tahap motivasi dan pencapaian akademik pelajar. Selain itu, kekurangan kemahiran pemikiran komputasional serta pemahaman terhadap konsep algoritma juga dikenal pasti sebagai faktor yang mempengaruhi keupayaan pelajar untuk menulis atur cara dengan berkesan (Yusuf & Noor, 2024). Oleh itu, pendekatan pengajaran yang sesuai serta penggunaan bahan pembelajaran yang efektif amat diperlukan bagi membantu pelajar memahami konsep pengaturcaraan dengan lebih jelas.

Sehubungan itu, pembangunan *C++ Quickie Notes* merupakan satu inisiatif bagi menyediakan bahan rujukan yang ringkas dan mudah difahami kepada pelajar yang mengikuti kursus *Programming Fundamentals.* Nota poket ini direka dalam bentuk ringkasan konsep asas pengaturcaraan, contoh sintaks bahasa C++ serta penerangan yang mudah difahami bagi memudahkan pelajar membuat rujukan pantas semasa proses pembelajaran. Penggunaan bahan rujukan yang ringkas dan mudah diakses juga dapat membantu meningkatkan keyakinan serta keberkesanan pembelajaran pelajar dalam memahami konsep pengaturcaraan (Kuo & Kuo, 2025). Oleh itu, kajian ini dijalankan bagi menilai keberkesanan penggunaan *C++ Quickie Notes* dalam meningkatkan kefahaman pelajar terhadap konsep asas pengaturcaraan bagi kursus *Programming Fundamentals.*

1.1 Pernyataan Masalah

Penguasaan konsep asas pengaturcaraan merupakan prasyarat penting dalam kursus *Programming Fundamentals*, namun masih menjadi cabaran utama dalam kalangan pelajar. Kesukaran memahami konsep seperti pembolehubah, struktur kawalan, fungsi serta sintaks bahasa pengaturcaraan sering dikaitkan dengan keperluan kemahiran pemikiran logik, pemikiran komputasional dan penyelesaian masalah secara sistematik. Menurut (Kadar et al., 2021), pelajar baharu dalam bidang pengaturcaraan berdepan kesukaran untuk menterjemahkan konsep abstrak kepada bentuk kod yang berfungsi. Tambahan pula, kandungan kursus yang padat serta keperluan latihan berterusan menyukarkan pelajar menguasai dan mengekalkan sintaks serta konsep penting. Implikasi daripada situasi ini adalah penurunan tahap keyakinan pelajar dalam membangunkan atur cara sendiri, seterusnya menjejaskan pencapaian akademik mereka.

Bertitik tolak daripada isu tersebut, transformasi dalam teknologi pendidikan telah membuka ruang kepada pembangunan bahan pembelajaran yang lebih dinamik, fleksibel dan berpusatkan pelajar. Pendekatan berasaskan multimedia yang menggabungkan teks dan elemen visual terbukti mampu meningkatkan kefahaman serta pengekalan maklumat secara signifikan (Mayer, 2021; Lawson & Mayer, 2024). Dalam konteks ini, pembangunan bahan inovatif seperti C++ Quickie Notes berpotensi menjadi intervensi pedagogi yang efektif bagi menyokong pembelajaran pengaturcaraan secara lebih sistematik dan mudah diakses. Inisiatif ini juga selari dengan aspirasi Pelan Pembangunan Pendidikan Malaysia (PPPM) 2013–2025 (Kementerian Pendidikan Malaysia, 2013) yang menekankan pengintegrasian teknologi dan inovasi dalam pengajaran dan pembelajaran bagi melahirkan pelajar berkemahiran abad ke-21. Oleh itu, kajian ini dilaksanakan bagi menilai keberkesanan penggunaan *C++ Quickie Notes* dalam meningkatkan kefahaman pelajar terhadap konsep asas pengaturcaraan.

1.2 Objektif Kajian

Objektif kajian ini adalah:

a) Membangunkan *C++ Quickie Notes* sebagai alat bantu pembelajaran untuk kursus *Programming Fundamentals*.

b) Mereka bentuk *C++ Quickie Notes* yang tersusun, padat, dan mudah digunakan sebagai alat bantu pembelajaran bagi kursus *Programming Fundamentals*.

c) Menguji keberkesanan *C++ Quickie Notes* dalam membantu pelajar memahami konsep asas pengaturcaraan C++ melalui soal selidik dan maklum balas pelajar.

1.3 Kepentingan Kajian

Penghasilan kajian dan inovasi ini penting kerana ia menyediakan satu platform alternatif yang ringkas (bersaiz kecil dan mudah dimuat turun) yang membolehkan pelajar merujuk nota penting pengaturcaraan di mana-mana sahaja dengan cepat. Bagi pihak pensyarah pula, ia berfungsi sebagai alat pemudahcara sesi PdP supaya pembelajaran lebih interaktif dan menarik minat pelajar bagi kursus *Programming Fundamentals*, berbanding penggunaan kaedah penerangan nota yang panjang.

2.0 KAJIAN LITERATUR

Beberapa kajian terkini telah membangunkan dan menilai bahan nota poket sebagai alat bantu pembelajaran di pelbagai disiplin. Sebagai contoh, kajian penggunaan *ECO120 Pocket Notes* dalam kursus *Principles of Economics* dan mendapati bahawa ringkasan konsep dalam bentuk nota poket membantu pelajar memahami idea kompleks, meningkatkan motivasi serta memberi sokongan kepada penyediaan peperiksaan (Harun, 2024). Selain itu, satu kajian yang dijalankan dalam konteks kolej komuniti menilai keberkesanan Nota Poket PLC yang dibangunkan sebagai aplikasi mudah alih untuk kursus Pengawal Logik Boleh Aturcara. Hasilnya menunjukkan tahap keberkesanan penggunaan nota poket ini adalah tinggi, termasuk tahap minat pelajar, pengetahuan, kemudahan penggunaan dan kesan terhadap pembelajaran mereka (Mustakim & Mahsum, 2023).

Tambahan pula, inovasi dalam *e-pocket* juga dijalankan bagi kursus *Fluid Mechanics* di peringkat politeknik, di mana nota poket digital direka untuk memudahkan pelajar mengakses formula dan konsep penting secara ringkas. Dapatan awal menunjukkan bahawa pelajar merasa nota poket membantu dalam memahami konsep serta meningkatkan minat pembelajaran (CiE-TVET, 2022). Kajian sorotan literatur sistematik oleh (Razali dan Nasri, 2023) mendapati bahawa penggunaan kaedah pengajaran inovatif dapat meningkatkan penglibatan, motivasi dan pencapaian akademik pelajar kerana pendekatan yang lebih interaktif membantu pelajar memberi tumpuan serta memahami kandungan pembelajaran dengan lebih berkesan.

Kajian-kajian ini menggariskan bahawa nota poket yang direka khusus untuk subjek tertentu dapat menyokong pembelajaran, meningkatkan kefahaman pelajar dan mengurangkan beban kognitif, serta memberi ruang kepada pelajar untuk membuat rujukan pantas di luar waktu kelas. Sehubungan dengan itu, dapatan kajian terdahulu yang menunjukkan keberkesanan penggunaan nota poket dalam pelbagai bidang pengajian telah membuka ruang kepada penerokaan penggunaannya dalam bidang pengaturcaraan, khususnya bagi menangani masalah kefahaman konsep asas dan kemahiran pemikiran algoritma dalam kalangan pelajar.

(Yusuf & Noor, 2024), menyatakan bahawa kekurangan kefahaman terhadap konsep asas serta kemahiran pemikiran algoritma boleh menjejaskan keupayaan pelajar dalam menyelesaikan masalah pengaturcaraan dengan berkesan. Bagi membantu mengatasi masalah tersebut,

penggunaan bahan bantu mengajar yang ringkas dan mudah difahami amat diperlukan bagi menyokong proses pembelajaran pelajar. Salah satu pendekatan yang boleh digunakan ialah membangunkan nota poket yang mengandungi ringkasan konsep penting serta contoh sintaks pengaturcaraan. Bahan rujukan yang ringkas dan mudah diakses dapat membantu pelajar membuat rujukan pantas serta meningkatkan kefahaman terhadap konsep yang dipelajari (Chen & Huang, 2024).

Selaras dengan keperluan tersebut, pembangunan bahan bantu mengajar yang ringkas dan berkesan seperti nota poket perlu disokong oleh penggunaan model reka bentuk pengajaran yang sistematik seperti Model ADDIE bagi memastikan bahan yang dihasilkan lebih terancang, memenuhi keperluan pelajar serta mampu meningkatkan kefahaman konsep pengaturcaraan secara optimum. Model ADDIE terdiri daripada lima fasa utama iaitu fasa analisis, reka bentuk, pembangunan, pelaksanaan dan penilaian. Model ini menyediakan kerangka kerja yang sistematik bagi membantu penyelidik mengenal pasti keperluan pelajar, mereka bentuk kandungan pembelajaran yang sesuai serta menilai keberkesanan bahan pengajaran yang dibangunkan. Pendekatan berstruktur ini membolehkan bahan pembelajaran dibangunkan secara lebih terancang dan berfokus kepada pencapaian hasil pembelajaran yang ditetapkan (Spatioti, Kazanidis & Pange, 2022). Oleh itu, penggunaan Model ADDIE dalam pembangunan inovasi seperti *C++ Quickie Notes* adalah bersesuaian kerana model ini membantu memastikan kandungan yang dibangunkan lebih tersusun, mudah difahami dan berkesan dalam menyokong proses pengajaran dan pembelajaran bagi kursus *Programming Fundamentals*.

3.0 METODOLOGI KAJIAN

Pembangunan produk inovasi *C++ Quickie Notes* ini dibangunkan berlandaskan kepada Model ADDIE. Penggunaan model reka bentuk instruksional ini bertindak sebagai garis panduan yang sistematik dalam membangunkan aplikasi perisian atau bahan bantu mengajar. Rajah 1 menunjukkan Model ADDIE yang merangkumi lima fasa utama iaitu fasa analisis, reka bentuk, pembangunan, pelaksanaan dan penilaian. Model ini merupakan salah satu model reka bentuk yang paling sistematik dalam penghasilan bahan pembelajaran berkomputer yang berkesan dan mesra pengguna (Abuhassna et al., 2024; Adeoye et al., 2024).



Rajah 1: Model ADDIE

a) Fasa Analisis

Fasa pertama ini dilaksanakan untuk mengenal pasti masalah sebenar yang dihadapi oleh pelajar serta mencari kaedah penyelesaian yang tuntas semasa proses Pengajaran dan Pembelajaran (PdP) berlangsung di dalam kelas. Analisis masalah kebiasaannya dilakukan melalui pemerhatian dan penilaian awal terhadap tingkah laku atau pencapaian pelajar. Tujuan utama fasa ini dijalankan adalah bagi memastikan reka bentuk pengajaran yang akan dihasilkan kelak benar-benar bertepatan dengan keperluan pelajar dan mencapai objektif yang telah ditetapkan.

b) Fasa Reka bentuk

Setelah masalah dan objektif dikenal pasti, fasa kedua menumpukan kepada perancangan dan reka bentuk produk inovasi. Dalam fasa ini, elemen dan struktur alat bantu mengajar akan dirangka secara terperinci. Sebagai contoh, dalam kes pembangunan inovasi seperti *Q-Track Kit (*Md Zokhi, A. N., 2022), fasa reka bentuk melibatkan proses mengadaptasi konsep sedia ada (seperti dam ular) dan merangka komponen-komponen penting yang akan digunakan, seperti reka bentuk fizikal bahan, saiz, dan susun atur elemen interaktif.

c) Fasa Pembangunan

Di dalam fasa pembangunan, kesemua idea dan perancangan yang telah dirangka di dalam fasa reka bentuk akan diterjemahkan menjadi produk yang sebenar. Bahan-bahan atau aplikasi inovasi mula dibina. Bergantung kepada jenis inovasi, produk boleh dibangunkan dalam bentuk fizikal mahupun digital. Keperluan seperti memastikan saiz yang pelbagai, reka bentuk mesra pengguna, dan kefleksibelan produk untuk digunakan di pelbagai lokasi akan diaplikasikan di dalam fasa ini. Rajah 2 menunjukkan paparan utama dan isi kandungan inovasi *C++ Quickie Notes.*



Rajah 2: Paparan utama dan isi kandungan inovasi *C++ Quickie Notes*

d) Fasa Pelaksanaan

Fasa pelaksanaan merupakan peringkat di mana produk yang telah siap dibangunkan mula diuji secara terus ke atas pengguna. Tujuan fasa ini adalah bagi memastikan hasil pembangunan mencapai objektif sasaran. Proses ini melibatkan penggunaan produk inovasi tersebut ketika sesi PdP yang sebenar dijalankan bersama kumpulan pelajar sasaran. Untuk melihat keberkesanannya, pengujian dan pemerhatian sering kali dijalankan pada dua fasa berbeza iaitu sebelum dan selepas produk tersebut digunakan.

e) Fasa Penilaian

Fasa terakhir bertujuan untuk menilai secara menyeluruh tahap keberkesanan inovasi yang telah dilancarkan. Kajian dan penilaian selalunya melibatkan pengumpulan maklum balas daripada responden atau kumpulan sasaran yang telah menggunakan inovasi tersebut. Instrumen utama yang diguna pakai ialah borang soal selidik yang mengandungi pernyataan skala Likert (contoh: 1 = Sangat Tidak Setuju hingga 5 = Sangat Setuju). Data-data yang terkumpul akan dianalisis secara deskriptif menggunakan perisian statistik bagi mendapatkan skor min, yang seterusnya membuktikan sama ada keseluruhan objektif kajian dan inovasi tersebut telah berjaya dicapai atau memerlukan penambahbaikan.

3.1 Ciri-ciri inovasi

Terdapat empat (4) jenis kategori inovasi iaitu fizikal, digital, visual dan kandungan. Jadual 1 menunjukkan kategori inovasi dan ciri-ciri.

Jadual 1: Kategori inovasi dan ciri-ciri

Kategori Inovasi	Ciri-ciri
Fizikal	• Nota poket direka dalam saiz kecil dan ringkas bagi memudahkan pelajar membawanya ke mana-mana. • Kandungan nota disusun secara padat dan sistematik untuk memudahkan rujukan pantas. • Mengandungi ringkasan konsep asas pengaturcaraan C++ seperti pembolehubah, struktur kawalan dan sintaks penting. • Susun atur nota yang jelas dengan penggunaan warna, simbol atau grafik untuk meningkatkan kefahaman pelajar. • Sesuai digunakan sebagai bahan rujukan tambahan semasa sesi pengajaran dan pembelajaran atau ulang kaji.
Digital	• Nota poket disediakan dalam bentuk digital yang boleh dimuat turun melalui telefon pintar, tablet atau komputer. • Membolehkan pelajar mencapai maklumat dengan lebih cepat dan fleksibel pada bila-bila masa. • Reka bentuk digital yang mudah digunakan dan memudahkan navigasi antara topik pembelajaran. • Mengandungi elemen visual seperti contoh kod atau ilustrasi untuk membantu pemahaman konsep pengaturcaraan.
Visual	• Penggunaan warna, simbol, grafik, dan contoh kod untuk pemahaman pantas.
Kandungan	• Merangkumi pembolehubah, struktur kawalan, sintaks penting, dan Latihan.

Manakala Jadual 2 menunjukkan perbandingan sebelum dan selepas penggunaan inovasi.

Jadual 2: Perbandingan sebelum dan selepas penggunaan inovasi

Sebelum Inovasi	• Pengajaran dan pembelajaran menggunakan kaedah verbal dengan paparan *Microsoft PowerPoint* sebagai medium pengajaran serta nota sebagai bahan rujukan. • Memerlukan masa yang panjang untuk memulakan aturcara C++. • Berlaku pengulangan pengajaran oleh pensyarah sekiranya terdapat pelajar yang tidak mendapat hasil yang ditetapkan. • Pensyarah merupakan medium utama dalam proses PdP.
Selepas Inovasi	• Proses PdP menggunakan *C++ Quickie Notes* sebagai sumber rujukan dalam pengaturcaraan C++. • Memudahkan sesi pengajaran dan pembelajaran oleh pensyarah sekaligus menjimatkan masa. • Pelajar dapat belajar sendiri nota poket yang dibekalkan dan mengatasi masalah pengulangan sesi pengajaran pensyarah. • Pensyarah berperanan sebagai fasilitator.

4.0 DAPATAN KAJIAN

Menurut Mohamad Zamal et al., 2022, interpretasi skor min yang digunakan untuk kajian ini adalah seperti dalam Jadual 3. Jadual 4 menunjukkan keputusan skor min keberkesanan penggunaan inovasi *C++ Quickie Notes.*

Jadual 3: Interpretasi Skor Min

Skor Min	Intepretasi
1.00 – 2.33	Rendah
2.34 – 3.66	Sederhana
3.67 – 5.00	Tinggi

Analisis data bagi kajian ini dijalankan menggunakan analisis deskriptif melalui skor min bagi menilai tahap penerimaan pelajar terhadap penggunaan *C++ Quickie Notes* dalam kursus *Programming Fundamentals.* Berdasarkan Jadual 4, Secara keseluruhannya, purata skor min yang diperoleh bagi semua item adalah 4.81, yang menunjukkan bahawa tahap penerimaan pelajar terhadap penggunaan inovasi ini berada pada tahap tinggi.

Jadual 4: Skor Min Keberkesanan Penggunaan Inovasi *C++ Quickie Notes.*

No	Item	Skor Min	Tahap
1	Penggunaan *C++ Quikie Notes* memudahkan saya memahami pembelajaran berbanding dengan penggunaan nota biasa	4.81	Tinggi
2	Penggunaan *C++ Quikie Notes* memudahkan capaian kepada maklumat yang ingin saya cari	4.81	Tinggi
3	*C++ Quikie Notes* menjadikan konsep pembelajaran lebih interaktif dan memudahkan	4.81	Tinggi

4	*C++ Quikie Notes* memudahkan saya membuat aturcara C++ bagi kursus *Programming Fundamental*.	4.73	Tinggi
5	*C++ Quikie Notes* dapat menjimatkan masa pembelajaran saya	4.85	Tinggi
6	*C++ Quikie Notes* yang dihasilkan menarik dan interaktif.	4.85	Tinggi
7	Nota yang disediakan dalam *C++ Quikie Notes* boleh dijadikan koleksi rujukan oleh saya.	4.77	Tinggi
8	*C++ Quikie Notes* dapat menarik minat saya untuk belajar kursus *Programming Fundamentals*	4.81	Tinggi
9	*C++ Quikie Notes* adalah satu sistem yang kecil dan mudah di muat turun	4.85	Tinggi
10	Saya bersedia untuk berkongsi *C++ Quikie Notes* dengan rakan-rakan yang lain.	4.85	Tinggi

Berdasarkan analisis yang dijalankan, item yang mencatatkan skor min tertinggi ialah Item 5, Item 6, Item 9 dan Item 10 dengan nilai min 4.85. Item-item ini menunjukkan bahawa pelajar bersetuju bahawa penggunaan *C++ Quickie Notes* dapat menjimatkan masa pembelajaran, mempunyai reka bentuk yang menarik dan interaktif, merupakan sistem yang kecil serta mudah dimuat turun, dan mereka juga bersedia untuk berkongsi bahan tersebut dengan rakan-rakan lain. Dapatan ini menunjukkan bahawa inovasi yang dibangunkan bukan sahaja menyokong proses pembelajaran tetapi juga mempunyai ciri kebolehgunaan yang baik.
Seterusnya, Item 1, Item 2, Item 3 dan Item 8 mencatatkan skor min 4.81. Dapatan ini menunjukkan bahawa penggunaan *C++ Quickie Notes* memudahkan pelajar memahami pembelajaran berbanding penggunaan nota biasa, memudahkan capaian kepada maklumat yang diperlukan, menjadikan konsep pembelajaran lebih interaktif serta mampu menarik minat pelajar untuk mempelajari kursus *Programming Fundamentals.*

Selain itu, Item 7 memperoleh skor min 4.77, yang menunjukkan bahawa nota yang disediakan dalam *C++ Quickie Notes* boleh dijadikan sebagai bahan rujukan oleh pelajar. Manakala Item 4 mencatatkan skor min paling rendah iaitu 4.73, namun masih berada pada tahap tinggi. Dapatan ini menunjukkan bahawa *C++ Quickie Notes* membantu pelajar dalam menghasilkan atur cara C++ bagi kursus *Programming Fundamentals.*

Secara keseluruhannya, dapatan kajian menunjukkan bahawa *C++ Quickie Notes* mendapat tahap penerimaan yang sangat tinggi dalam kalangan pelajar. Kesemua item mencatatkan skor min melebihi 4.70, yang menunjukkan bahawa inovasi ini berjaya membantu pelajar dari aspek pemahaman pembelajaran, kemudahan capaian maklumat, interaktiviti serta penjimatan masa pembelajaran. *C++ Quickie Notes* berpotensi menjadi bahan sokongan pembelajaran yang efektif dalam meningkatkan keberkesanan proses PdP bagi kursus *Programming Fundamentals.*

5.0 PERBINCANGAN PENYELIDIKAN

Bagi objektif pertama, pembangunan *C++ Quickie Notes* dilihat berpotensi menyokong proses pembelajaran melalui penyediaan bahan rujukan yang ringkas dan mudah diakses oleh pelajar.

Penyusunan maklumat secara padat dan terfokus dapat membantu mengurangkan beban kognitif pelajar semasa memproses maklumat baharu. Pendekatan ini selaras dengan perkembangan terkini dalam *Cognitive Load Theory* yang menekankan bahawa reka bentuk bahan pembelajaran yang tersusun dapat meningkatkan kecekapan pemprosesan maklumat dan keberkesanan pembelajaran (Sweller, van Merrienboer & Paas, 2019; Skulmowski & Xu, 2022).

Bagi objektif kedua, reka bentuk nota poket yang tersusun, padat dan mudah digunakan menyokong prinsip reka bentuk pengajaran yang menekankan kejelasan penyampaian maklumat. Kajian terkini menunjukkan bahawa bahan pembelajaran yang distrukturkan secara jelas dapat membantu pelajar membina pemahaman konsep dengan lebih sistematik serta mengurangkan kekeliruan semasa proses pembelajaran (Sweller, 2020; Yang, 2024).

Bagi objektif ketiga, penggunaan maklum balas pelajar melalui soal selidik memberikan gambaran terhadap keberkesanan inovasi ini dalam menyokong pemahaman konsep asas pengaturcaraan. Dalam konteks pendidikan pengaturcaraan, kajian menunjukkan bahawa tugasan pengaturcaraan sering menghasilkan tahap beban kognitif yang tinggi kepada pelajar baharu, justeru bahan pembelajaran yang ringkas dan berstruktur dapat membantu meningkatkan keberkesanan pembelajaran dan motivasi pelajar (Moreno & Park, 2010; kajian terkini dalam pendidikan pengaturcaraan). Secara keseluruhannya, inovasi *C++ Quickie Notes* berpotensi menyokong pembelajaran yang lebih efektif melalui penyediaan bahan rujukan yang ringkas, tersusun dan mudah dicapai oleh pelajar dalam kursus *Programming Fundamentals.*

6.0 KESIMPULAN

Kesimpulannya, kajian ini telah berjaya mencapai keseluruhan objektif yang ditetapkan melalui pembangunan dan penilaian inovasi *C++ Quickie Notes* sebagai alat bantu pembelajaran bagi kursus *Programming Fundamentals.* Pembangunan produk berasaskan Model ADDIE telah memastikan proses yang sistematik dan terancang, merangkumi fasa analisis, reka bentuk, pembangunan, pelaksanaan dan penilaian. Hasilnya, *C++ Quickie Notes* berjaya direka bentuk sebagai bahan pembelajaran yang tersusun, padat serta mudah digunakan oleh pelajar.

Dapatan kajian menunjukkan bahawa tahap penerimaan pelajar terhadap penggunaan *C++ Quickie Notes* adalah sangat tinggi, dengan semua item mencatatkan skor min antara 4.73 hingga 4.85. Ini membuktikan bahawa inovasi ini berkesan dalam membantu pelajar memahami konsep asas pengaturcaraan C++, memudahkan capaian maklumat, serta meningkatkan minat dan motivasi pembelajaran. Selain itu, ciri-ciri seperti kebolehcapaian yang mudah, reka bentuk yang interaktif serta keupayaan menjimatkan masa turut menyumbang kepada keberkesanan penggunaannya sebagai bahan rujukan pembelajaran.

Walau bagaimanapun, bagi meningkatkan lagi kualiti dan keberkesanan *C++ Quickie Notes*, beberapa penambahbaikan wajar dipertimbangkan. Antaranya termasuk penambahan elemen

multimedia seperti video dan animasi bagi memperkayakan pengalaman pembelajaran, serta penyediaan latihan interaktif dan kuiz bagi mengukuhkan kefahaman pelajar secara berterusan. Selain itu, pengembangan kandungan ke topik yang lebih lanjutan dan peningkatan keserasian merentas pelbagai platform juga dapat memperluas penggunaan inovasi ini. Di samping itu, integrasi dengan sistem pembelajaran seperti LMS serta penambahbaikan mekanisme maklum balas masa nyata boleh menjadikan *C++ Quickie Notes* lebih komprehensif dan relevan. Secara keseluruhannya, inovasi ini mempunyai potensi yang tinggi untuk dikembangkan sebagai satu alat bantu pembelajaran digital yang efektif, fleksibel dan berimpak dalam meningkatkan penguasaan pelajar terhadap pengaturcaraan C++.

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KAJIAN KEBERKESANAN PENGGUNAAN "*CREATING A SIMPLE DATABASE SYSTEM USING MICROSOFT ACCESS: A PRACTICAL GUIDE*" DALAM PENGAJARAN DAN PEMBELAJARAN

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Abstrak

Kajian ini dijalankan untuk menilai tahap keberkesanan dan impak penggunaan alat bantu mengajar yang bertajuk *Creating a Simple Database System Using Microsoft Access: A Practical Guide* dalam proses pengajaran dan pembelajaran (PdP). Panduan praktikal ini dibangunkan sebagai satu inovasi berbentuk *eBook* berkonsepkan infografik interaktif berserta integrasi teknologi *Augmented Reality* (AR) bagi kursus *Database Fundamental* di kalangan pelajar Sijil Teknologi Maklumat. Kajian ini menggunakan pendekatan kuantitatif melalui instrumen borang soal selidik. Hasil kajian ini dapat membuktikan bahawa penyampaian bahan pengajaran dengan rekabentuk yang menarik, interaktif dan disokong oleh teknologi AR mampu menjadikan proses pembelajaran lebih menyeronokkan, berkesan dan relevan dengan keperluan pendidikan digital masa kini.

Keywords: *Creating a Simple Database System Using Microsoft Access: A Practical Guide*, proses pengajaran dan pembelajaran (PdP), *Database Fundamental,* inovasi.

Abstract

This study was conducted to evaluate the effectiveness and impact of using a teaching aid titled "Creating a Simple Database System Using Microsoft Access: A Practical Guide" in the teaching and learning (T&L) process. This practical guide was developed as an innovation in the form of an eBook, featuring interactive infographics integrated with Augmented Reality (AR) technology for the Database Fundamental course among Information Technology Certificate students. The study employs a quantitative approach using a questionnaire as the research instrument. The findings demonstrate that delivering instructional materials through engaging, interactive designs supported by AR technology makes the learning process more enjoyable, effective, and relevant to contemporary digital education needs.

Keywords: *Creating a Simple Database System Using Microsoft Access: A Practical Guide, teaching and learning (T&L) process, Database Fundamental, innovation.*

1.0 PENGENALAN

Dalam era transformasi pendidikan digital masa kini, pendekatan Pengajaran dan Pembelajaran (PdP) telah mengalami evolusi yang ketara, beralih daripada kaedah penyampaian tradisional kepada penggunaan bahan digital yang lebih interaktif. Kecenderungan pelajar generasi baharu juga menunjukkan perubahan; mereka kurang berminat membaca nota konvensional atau rasmi yang panjang, sebaliknya lebih tertarik kepada bahan pembelajaran yang disusun secara menarik, mudah difahami, bergambar, dan berwarna-warni. Situasi ini menuntut para pendidik untuk sentiasa kreatif dalam mempelbagaikan alternatif bahan PdP agar selari dengan keperluan dan minat pelajar. Bagi kursus yang bercorak teknikal dan praktikal seperti *Database Fundamental*, penyampaian maklumat memerlukan pendekatan yang membolehkan pelajar bukan sahaja memahami konsep secara teori, tetapi juga mampu mengaplikasikannya dalam tugasan amali. Mempelajari perisian *Microsoft Access* selalunya melibatkan langkah-langkah kerja yang terperinci. Tanpa bahan rujukan yang interaktif dan mudah diakses, pelajar mungkin menghadapi kesukaran untuk melaksanakan tugasan amali dengan teratur atau melakukan ulang kaji secara kendiri.

Menyedari keperluan ini, satu inovasi bahan pembelajaran bertajuk *"Creating a Simple Database System Using Microsoft Access: A Practical Guide"* telah dibangunkan sebagai alternatif bahan PdP. Panduan ini bukan sekadar buku teks digital biasa, tetapi ia direka bentuk dalam bentuk *eBook* yang mengintegrasikan elemen infografik interaktif dan teknologi *Augmented Reality* (AR). Penggunaan infografik bertujuan untuk memvisualisasikan langkah-langkah amali *Microsoft Access* dengan lebih jelas melalui rekabentuk yang menarik dan mudah dibaca, manakala integrasi AR pula berfungsi menyediakan elemen interaktif (seperti video, imej, dan latihan interaktif) bagi memudahkan lagi pemahaman pelajar terhadap konsep yang diajar. Kajian ini memfokuskan kepada penilaian tahap keberkesanan inovasi dalam membantu melancarkan tugasan amali dan proses ulangkaji, di samping melihat impaknya terhadap peningkatan motivasi, keupayaan memberikan tumpuan, serta kefahaman keseluruhan pelajar dalam kursus *Database Fundamental.*

1.1 Pernyataan Masalah

Perubahan daripada nota manual kepada nota interaktif bukan sekadar *trend*, malah ia merupakan satu keperluan di bawah Dasar Pendidikan Digital (DPD) yang dilancarkan oleh Kementerian Pendidikan Malaysia (KPM, 2023). Dasar ini menekankan matlamat untuk melahirkan generasi fasih digital melalui pemerkasaan ekosistem digital dalam PdP. Peralihan ini bertujuan untuk mentransformasikan penyampaian kandungan pendidikan agar lebih dinamik, kreatif, dan tidak lagi terhad kepada medium statik konvensional semata-mata.

Selain itu, antara cabaran utama yang sering dihadapi oleh tenaga pengajar adalah tahap minat membaca pelajar terhadap bahan pembelajaran sedia ada. Kebanyakan pelajar kini kurang berminat untuk membaca nota rasmi konvensional, sebaliknya lebih cenderung mencari maklumat di internet dan lebih mudah fokus kepada bahan PdP yang bergambar serta menarik. Kajian oleh Fatimah et al. (2024) dan Osman (2023) menunjukkan bahawa kepelbagaian kaedah pengajaran melalui sokongan alat bantu mengajar berunsur interaktif seperti elemen

visual, audio, permainan, dan aplikasi pintar memainkan peranan yang sangat penting bagi merangsang minat pelajar serta menggalakkan penyertaan aktif mereka sepanjang sesi pengajaran dan pembelajaran berlangsung.

Pembelajaran kursus *Database Fundamental* sangat bergantung kepada kefahaman prosedur amali. Penggunaan rujukan yang kurang interaktif menyukarkan pelajar menguasai konsep pangkalan data, menjejaskan kelancaran tugasan amali, dan menyukarkan proses ulang kaji. Pengekalan fokus dan motivasi juga menjadi cabaran tanpa sokongan alat bantu mengajar interaktif. Oleh itu, kajian ini dilaksanakan bagi menyiasat sama ada inovasi *eBook* infografik dan AR mampu menyelesaikan masalah-masalah tersebut.

1.2 Objektif Kajian

Objektif kajian ini adalah:

a) Mengenal pasti tahap keberkesanan penggunaan inovasi *Creating a Simple Database System Using Microsoft Access: A Practical Guide.*

b) Menilai impak inovasi terhadap motivasi, tumpuan perhatian dan kefahaman topik.

1.3 Kepentingan Kajian

Kajian ini dapat membantu pelajar memahami konsep serta prosedur amali *Microsoft Access* dengan lebih mudah dan teratur serta meningkatkan keseronokan, tahap fokus, serta motivasi pelajar bagi melaksanakan proses ulangkaji secara kendiri berbanding rujukan nota teks yang panjang. Hasil kajian ini juga dapat memberi panduan serta kesedaran kepada para pensyarah tentang kepentingan menghasilkan alat bahan bantu mengajar yang kreatif semasa sesi PdP. Ia memberikan satu alternatif kaedah penyampaian yang baharu.

Kajian keberkesanan inovasi ini juga penting sebagai penanda aras untuk menyokong aspirasi pendigitalan pendidikan. Ia memberi justifikasi dan sokongan empirikal kepada pihak institusi tentang perlunya mengintegrasikan lebih banyak bahan pembelajaran berasaskan elemen multimedia interaktif seperti AR pada masa akan datang bagi memastikan kualiti kurikulum kekal relevan dengan keperluan pembelajaran digital.

2.0 KAJIAN LITERATUR

Perkembangan pendidikan digital dalam lima tahun kebelakangan ini menunjukkan bahawa bahan pembelajaran berbentuk digital semakin menjadi komponen utama dalam pengajaran dan pembelajaran di institusi pendidikan tinggi. Penggunaan modul digital, *eBook* interaktif dan bahan multimedia didapati meningkatkan akses pelajar terhadap kandungan secara fleksibel dan menyokong pembelajaran kendiri (Mabotha & Ngcamu, 2026; Alam et al, 2025). Dalam konteks pembelajaran teknikal, bahan digital yang disusun secara sistematik membantu pelajar memahami prosedur langkah demi langkah dengan lebih berkesan berbanding kaedah tradisional (OECD, 2023). Hal ini amat penting bagi kursus berasaskan komputer yang memerlukan penerangan proses secara berurutan dan visual.

Kursus *Database Fundamental* sering dianggap mencabar kerana melibatkan konsep hubungan jadual, *query*, *form* dan *report* yang memerlukan kefahaman logik serta kemahiran amali. Kajian menunjukkan bahawa pelajar lebih mudah menguasai kandungan teknikal apabila bahan pembelajaran menyediakan demonstrasi visual, contoh sebenar dan latihan praktikal yang berstruktur (Ismail et al., 2024; Studies in Educational Evaluation, 2024). Dalam pembelajaran pangkalan data, pendekatan berasaskan panduan praktikal membantu pelajar membina kefahaman prosedural secara berperingkat (Buchan et al, 2024). Dalam kajian Junid et al. (2015) mendapati bahawa, penggunaan perisian kursus yang menggabungkan elemen multimedia secara interaktif telah terbukti berjaya meningkatkan tahap pencapaian pelajar di samping melonjakkan motivasi mereka terhadap mata pelajaran yang dipelajari. Pengintegrasian elemen teknologi dan multimedia seperti AR, aplikasi pintar, dan elemen tindak balas merupakan pemangkin kepada keseronokan belajar.

Selain itu, bahan inovasi yang kreatif dapat mengelakkan pelajar daripada terikat kepada hafalan semata-mata, sebaliknya menggalakkan daya berfikir secara kritis dan mempraktikkan amali dengan lebih tersusun. Ia terbukti dapat menyelesaikan masalah kekangan rujukan serta mampu bertindak sebagai bahan bantu mengajar yang sangat relevan untuk memenuhi gaya pembelajaran digital masa kini. Kajian oleh Md Posdzi et al. (2023) mendapati bahawa alat bantu mengajar digital seperti i-Tester dapat meningkatkan keberkesanan penyampaian maklumat dan meningkatkan pemahaman pelajar terhadap sesuatu konsep.

3.0 METODOLOGI KAJIAN

Kajian ini bertujuan untuk menilai tahap keberkesanan penggunaan inovasi *"Creating a Simple Database System Using Microsoft Access: A Practical Guide"* serta impak inovasi terhadap motivasi, tumpuan perhatian dan kefahaman topik. Rekabentuk kajian ini merupakan kajian kuantitatif berbentuk soal selidik yang telah diedarkan kepada pelajar Sijil Teknologi Maklumat di Kolej Komuniti Paya Besar secara atas talian melalui aplikasi *Google Form*. Seramai 21 orang responden telah menjawab soal selidik tersebut.

3.1 Instrumen Kajian

Instrumen kajian yang digunakan dalam kajian ini adalah borang soal selidik yang telah diadaptasi dan diubahsuai daripada instrumen asal dalam kajian yang dijalankan oleh Dhea et al. (2025). Bagi memastikan instrumen ini relevan dan bertepatan dengan objektif kajian semasa, pengkaji telah melaksanakan proses pengubahsuaian ke atas item-item asal. Pengubahsuaian yang dilakukan melibatkan adaptasi laras bahasa dan konteks soalan supaya ia bersesuaian dengan tahap akademik pelajar Sijil Teknologi Maklumat di Kolej Komuniti Paya Besar. Item-item ini juga telah dikhususkan untuk menilai penggunaan inovasi bahan bantu mengajar *"Creating a Simple Database System Using Microsoft Access: A Practical Guide"* bagi kursus *Database Fundamental*.

Hasil daripada adaptasi tersebut, borang soal selidik ini telah distrukturkan semula kepada lima (5) bahagian utama seperti dalam Jadual 1 bagi memudahkan proses penilaian.

Jadual 1: Bahagian Soal Selidik

Bahagian A	Perihal Responden Kaji Selidik
Bahagian B	Tahap Minat Membaca
Bahagian C	Penggunaan Ebook Interaktif Infografik + AR
Bahagian D	Keberkesanan PdP
Bahagian E	Impak

Kesemua item penilaian diukur menggunakan instrumen berbentuk Skala Likert 5 mata, iaitu 1- Sangat Tidak Setuju, 2-Tidak Setuju, 3-Tidak Pasti, 4-Setuju, 5- Sangat Setuju. Interpretasi skor min yang digunakan untuk kajian ini adalah seperti dalam Jadual 2 selaras dengan dapatan Chew dan Zul Hazmi (2018).

Jadual 2: Skala Interpretasi bagi Skor Min

Skor purata min	**Tafsiran**
1.00 – 1.89	Sangat rendah
1.90 – 2.69	Rendah
2.70 – 3.49	Sederhana
3.50 – 4.29	Tinggi
4.30 – 5.00	Sangat tinggi

Satu kajian rintis telah dijalankan terlebih dahulu ke atas sekumpulan kecil pelajar. Hasil analisis menunjukkan nilai *Alpha Cronbach* bagi keseluruhan item penilaian inovasi adalah 0.989. Jadual 3 menunjukkan nilai *Alpha Cronbach* bagi setiap bahagian.

Jadual 3: Jadual Nilai *Alpha Cronbach* Bagi Setiap Bahagian

Bahagian B	Bahagian C	Bahagian D	Bahagian E
Tahap Minat Membaca	Penggunaan eBook Interaktif	Keberkesanan PdP	Impak
0.710	0.965	0.987	0.971

Menurut Bond dan Fox (2015), nilai *Alpha Cronbach* yang melebihi 0.7 adalah memadai dan boleh diterima, manakala nilai melebihi 0.9 menunjukkan tahap kebolehpercayaan yang sangat tinggi dan cemerlang. Oleh itu, instrumen yang diadaptasi bagi kajian ini terbukti mempunyai ketekalan yang amat baik dalam mengukur keberkesanan penggunaan *eBook* interaktif tersebut.

3.2 Analisis Data

3.2.1 Mengetahui Tahap Keberkesanan Penggunaan Inovasi *Creating A Simple Database System Using Microsoft Access: A Practical Guide*

Berdasarkan Jadual 4, keberkesanan penggunaan inovasi *Creating A Simple Database System Using Microsoft Access: A Practical Guide* dinilai pada tahap sangat tinggi dengan skor purata

min 4.64 bagi item yang dikaji. Responden sangat bersetuju bahawa *eBook* ini membantu pelaksanaan tugasan amali dengan lebih teratur (min 4.70).

Jadual 4: Skor MinKeberkesanan Penggunaan Inovasi *Creating A Simple Database System Using Microsoft Access: A Practical Guide*.

No	Item	Skor Min	Tahap
1	*eBook* ini membantu saya melaksanakan tugasan amali dengan lebih teratur.	4.70	Sangat tinggi
2	Saya dapat mengulang kaji topik dengan lebih mudah menggunakan *eBook*	4.65	Sangat tinggi
3	Inovasi ini meningkatkan kefahaman saya terhadap kursus *Microsoft Access*	4.65	Sangat tinggi
4	Saya lebih yakin menyiapkan tugasan selepas menggunakan *eBook + AR*	4.60	Sangat tinggi
5	Saya berharap inovasi ini digunakan secara meluas dalam kursus lain	4.60	Sangat tinggi
	Purata Min	**4.64**	Sangat tinggi

3.2.2 Menilai impak inovasi terhadap motivasi, tumpuan perhatian dan kefahaman topik

Berdasarkan Jadual 5, impak inovasi terhadap motivasi, tumpuan perhatian dan kefahaman topik dinilai pada tahap sangat tinggi dengan skor purata min 4.62 bagi kesemua item yang dikaji. Ini menunjukkan bahawa responden sepenuhnya bersetuju mengenai penggunaan *EBook* interaktif dapat membantu pelajar dalam meningkatkan motivasi, tumpuan serta kefahaman pada topik kursus *Database Fundamentals.*

Jadual 5: Impak Inovasi Terhadap Motivasi, Tumpuan Perhatian Dan Kefahaman Topik

No	Item	Skor Min	Tahap
1	Saya lebih memahami topik setelah menggunakan inovasi ini	4.60	Sangat tinggi
2	Inovasi ini meningkatkan motivasi saya untuk terus belajar	4.65	Sangat tinggi
3	Penggunaan teknologi AR membantu saya menumpukan perhatian	4.60	Sangat tinggi
	Purata Min	**4.62**	Sangat tinggi

4.0 DAPATAN DAN PERBINCANGAN PENYELIDIKAN

Hasil kajian menunjukkan bahawa penggunaan inovasi *Creating a Simple Database System Using Microsoft Access: A Practical Guide* berada pada tahap keberkesanan yang tinggi dalam membantu proses pengajaran dan pembelajaran kursus *Database Fundamentals*. Hal ini dapat dilihat melalui peningkatan kefahaman pelajar terhadap konsep asas seperti jadual, *query*, *form* dan *report* selepas menggunakan bahan tersebut. Dapatan ini selari dengan kajian oleh Ismail et al. (2024) yang menyatakan bahawa bahan pembelajaran digital yang disusun secara sistematik mampu meningkatkan kefahaman pelajar dalam kursus teknikal. Selain itu,

penggunaan panduan langkah demi langkah dalam buku ini membantu pelajar membina kemahiran prosedural secara berperingkat, selaras dengan dapatan Buchan et al. (2024) yang menekankan kepentingan pembelajaran berstruktur dalam meningkatkan keberkesanan PdP.

Dari sudut kebolehgunaan, inovasi ini juga menunjukkan tahap penerimaan yang baik dalam kalangan pelajar kerana kandungannya mudah diikuti dan bersifat praktikal. Pelajar dapat melaksanakan aktiviti pembinaan pangkalan data secara kendiri dengan merujuk panduan yang disediakan, sekali gus meningkatkan keyakinan mereka semasa sesi amali. Kajian oleh Graser et al. (2024) mendapati bahawa faktor kebolehgunaan dan kemudahan akses merupakan elemen penting dalam menentukan keberkesanan sesuatu bahan pembelajaran digital. Di samping itu, penggunaan elemen visual seperti tangkapan skrin dan rajah membantu mempercepatkan proses pemahaman pelajar. Hal ini selaras dengan kajian Hassan dan Karim (2021) yang menyatakan bahawa elemen visual mampu meningkatkan kejelasan maklumat serta mengurangkan beban kognitif pelajar.

Dari aspek motivasi, penggunaan inovasi ini didapati berjaya meningkatkan minat pelajar terhadap pembelajaran kursus *Database Fundamentals*. Pelajar menunjukkan kecenderungan yang lebih tinggi untuk melibatkan diri secara aktif dalam aktiviti pembelajaran apabila menggunakan bahan yang bersifat praktikal dan interaktif. Dapatan ini disokong oleh kajian Alam et al. (2025) yang menyatakan bahawa penggunaan teknologi digital dalam PdP mampu meningkatkan motivasi pelajar melalui pengalaman pembelajaran yang lebih menarik. Selain itu, integrasi pendekatan visual dan langkah-langkah praktikal turut membantu pelajar merasa lebih yakin dalam memahami kandungan kursus. Hal ini sejajar dengan dapatan Akram et al. (2022) yang menunjukkan bahawa kandungan digital interaktif dapat meningkatkan penglibatan dan motivasi pelajar.

Dari segi tumpuan perhatian, inovasi ini membantu pelajar mengekalkan fokus sepanjang sesi pembelajaran kerana penyampaian maklumat yang tersusun dan mudah diikuti. Pelajar tidak mudah hilang fokus kerana setiap langkah dalam pembinaan pangkalan data dijelaskan secara jelas dan sistematik. Kajian oleh *Studies in Educational Evaluation* (2024) mendapati bahawa bahan pembelajaran yang berstruktur dan visual dapat meningkatkan tumpuan pelajar dalam pembelajaran teknikal. Selain itu, penggunaan bahan panduan yang jelas mengurangkan kekeliruan pelajar semasa menjalankan aktiviti amali. Hal ini turut disokong oleh Mabotha dan Ngcamu (2026) yang menyatakan bahawa bahan pembelajaran digital yang efektif mampu meningkatkan kejelasan arahan dan seterusnya membantu pelajar mengekalkan perhatian.

Dari aspek kefahaman topik, inovasi ini memberikan impak yang signifikan terhadap penguasaan konsep pangkalan data dalam kalangan pelajar. Pelajar dapat memahami hubungan antara komponen pangkalan data dengan lebih jelas melalui pendekatan pembelajaran berasaskan amali. Kajian oleh Li et al. (2025) menunjukkan bahawa penggunaan teknologi dan bahan pembelajaran interaktif dapat meningkatkan kefahaman konsep abstrak dalam kalangan pelajar. Selain itu, penyampaian maklumat secara visual dan berperingkat membantu pelajar mengaitkan teori dengan aplikasi sebenar. Dapatan ini juga disokong oleh Lu dan Hashim

(2025) yang menegaskan bahawa pendekatan visual dan interaktif meningkatkan keupayaan pelajar untuk memahami dan mengaplikasikan konsep teknikal dengan lebih berkesan.

Secara keseluruhannya, penggunaan inovasi *eBook 'Creating a Simple Database System Using Microsoft Access: A Practical Guide'* bagi kursus *Database Fundamental* dilihat dapat meningkatkan kefahaman, malah turut memberi kesan positif terhadap motivasi dan tumpuan pelajar.

5.0 KESIMPULAN

Kajian ini membuktikan bahawa penggunaan *eBook* interaktif bertajuk *'Creating a Simple Database System Using Microsoft Access: A Practical Guide'* yang mengandungi infografik dan integrasi AR adalah sangat berkesan dalam membantu pelajar memahami konsep, meningkatkan motivasi, dan memudahkan pelaksanaan tugasan amali dalam kursus *Database Fundamental*. Dapatan kuantitatif menunjukkan tahap persetujuan yang sangat tinggi bagi semua aspek yang dinilai, manakala analisis kualitatif mengesahkan kekuatan utama inovasi ini dari segi aksesibiliti, reka bentuk, interaktiviti, dan impak terhadap pembelajaran.

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PEMBANGUNAN ALAT KEJURUTERAAN PERANGKAP SAMPAH BAGI MEMUDAHKAN PENYELENGGARAAN *SUMP* ALIRAN

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Abstrak

Penyelenggaraan *sump* saliran (takungan saliran) merupakan elemen penting dalam memastikan keberkesanan sistem perparitan serta mengurangkan risiko gangguan aliran akibat pengumpulan sisa pepejal. Namun, kaedah pembersihan manual yang masih diamalkan secara meluas didapati kurang efisien kerana memerlukan tenaga kerja yang tinggi, tempoh operasi yang panjang serta mendedahkan pekerja kepada risiko keselamatan. Sehubungan itu, kajian ini dilakukan untuk membangunkan alat perangkap sampah, iaitu satu alat yang direka bagi memudahkan kerja penyelenggaraan *sump* saliran secara lebih mudah dan berkesan. Reka bentuk alat ini menekankan aspek kebolehsuaian terhadap variasi geometri *sump* saliran, termasuk perbezaan dari segi kedalaman dan keluasan, agar dapat diaplikasikan dalam pelbagai keadaan operasi. Pemilihan bahan pembinaan dibuat berdasarkan keperluan ketahanan terhadap kakisan, kekuatan struktur serta jangka hayat operasi dalam persekitaran lembap dan tercemar, selaras dengan keperluan infrastruktur kejuruteraan awam. Metodologi kajian dilaksanakan secara berperingkat merangkumi fasa perancangan reka bentuk, penghasilan alat dan pengujian. Hasil penilaian prestasi menunjukkan bahawa penggunaan alat kejuruteraan perangkap sampah ini berjaya mencapai purata penjimatan masa operasi sebanyak 33.35% berbanding kaedah pembersihan manual tradisional. Peningkatan kecekapan ini membuktikan keupayaan alat dalam mempercepatkan kerja penyelenggaraan *sump* saliran, di samping berpotensi mengurangkan kebergantungan kepada tenaga kerja manual serta risiko keselamatan di tapak. Secara keseluruhannya, dapatan kajian mengesahkan bahawa alat yang dibangunkan memenuhi objektif reka bentuk dan berpotensi diaplikasikan sebagai satu penyelesaian praktikal serta mesra alam dalam penyelenggaraan *sump* saliran

Kata kunci: *sump* saliran; alat kejuruteraan; alat perangkap sampah; penyelenggaraan saliran; sisa pepejal

Abstract

Drainage sump maintenance is a critical element in ensuring the effectiveness of drainage systems and reducing the risk of flow disruptions caused by solid waste accumulation. However, manual cleaning methods, which are still widely practiced, are found to be inefficient as they require high labor intensity, involve long operational periods, and expose workers to safety risks. Accordingly, this study was conducted to develop a trash trap tool, designed to facilitate drainage sump maintenance more easily and effectively. The design of this tool emphasizes adaptability to variations in drainage sump geometry, including differences in depth and width, to ensure applicability across diverse operational conditions. The selection of construction materials was based on requirements for corrosion resistance, structural strength, and operational lifespan in damp and contaminated environments, consistent with civil engineering infrastructure standards. The research methodology was executed in stages, encompassing the design planning, fabrication, and testing phases. Performance evaluation results show that the use of this engineered trash trap tool successfully achieved an average operational time saving of 33.35% compared to traditional manual cleaning methods. This increase in efficiency proves the tool's capability to accelerate drainage sump maintenance while potentially reducing dependency on manual labor and mitigating on-site safety risks. Overall, the research findings confirm that the developed tool meets its design objectives and has the potential to be applied as a practical and eco-friendly solution for drainage sump maintenance.

Keywords: *drainage sump; engineering tool; trash trap tool; drainage maintenance; solid waste*

1.0 PENGENALAN

Banjir merupakan satu bencana alam yang sering berlaku di Malaysia. Banjir akan berlaku apabila air melimpah ke kawasan yang lebih rendah. Ia boleh terjadi akibat hujan lebat berpanjangan, limpahan sungai, empangan pecah, atau faktor lain seperti sistem perparitan yang tidak berfungsi dengan baik. Banjir sering dikategorikan sebagai bencana alam kerana ia boleh menyebabkan kerosakan harta benda, kehilangan nyawa, serta menjejaskan ekonomi dan kesejahteraan masyarakat. Terdapat banyak faktor yang menyumbang kepada fenomena seperti kejadian banjir kilat. Salah satu faktor yang menyumbang kepada bencana ini ialah disebabkan oleh rekabentuk dan penyelenggaraan sistem saliran yang tidak sempurna.

Penyelenggaraan sistem perparitan yang tidak sempurna boleh menyebabkan sampah sarap terperangkap, sekali gus menjejaskan fungsi perparitan. Keadaan ini akhirnya boleh mengakibatkan banjir dan limpahan air. Sehubungan itu, satu inovasi kejuruteraan berbentuk perangkap sampah telah dibangunkan untuk memudahkan kaedah pengumpulan sampah yang terperangkap di dalam *sump.*

1.1 Pernyataan Masalah

Masalah saliran tersumbat akibat sampah sarap yang terperangkap dalam sistem perparitan merupakan punca utama berlakunya banjir kilat di kawasan bandar. Penyelenggaraan sump saliran yang dilakukan secara manual sering mengambil masa yang panjang, memerlukan kos yang tinggi, serta berisiko kepada pekerja kerana terdedah kepada persekitaran yang kotor dan berbahaya. Tambahan pula, sistem perparitan sedia ada tidak mempunyai mekanisme khusus untuk menapis atau menahan sampah sebelum ia memasuki saluran utama. Kekurangan ini menyebabkan keberkesanan sistem saliran menurun dan meningkatkan risiko limpahan air. Oleh itu, wujud keperluan mendesak untuk membangunkan satu alat kejuruteraan inovatif berbentuk perangkap sampah yang dapat memudahkan proses penyelenggaraan *sump* saliran, mengurangkan kos operasi, serta meningkatkan keberkesanan sistem saliran.

Walaupun terdapat pelbagai jenis perangkap sampah yang digunakan dalam sistem saliran, kebanyakannya bersifat statik dan tidak mempunyai mekanisme khusus untuk memudahkan pengeluaran sampah dari sump yang mempunyai kedalaman ekstrem. Di POLISAS, terdapat banyak sump yang mempunyai kedalaman melebihi 1500mm disebabkan faktor geografi kampus yang beralun, yang menyukarkan akses manual bagi kerja-kerja pembersihan. Kebanyakan alat sedia ada di pasaran juga tidak menekankan aspek kebolehsuaian terhadap variasi geometri *sump* (lebar dan dalam).

Oleh itu, kajian ini mengisi jurang tersebut dengan membangunkan alat perangkap sampah inovatif yang bukan sahaja berfungsi sebagai penapis, malah dilengkapi dengan sistem mekanikal (takal dan kabel) yang membolehkan penyelenggaraan dilakukan dari aras atas tanpa memerlukan pekerja turun ke dalam *sump* yang dalam dan berbahaya. Perbezaan utama inovasi ini berbanding alat sedia ada adalah ciri mobiliti dan keupayaannya untuk mengurangkan kebergantungan kepada tenaga kerja manual secara signifikan bagi *sump* yang dalam.

1.2 Objektif Kajian

Kajian ini dijalankan dengan objektif berikut:

1.2.1 Merekabentuk alat kejuruteraan perangkap sampah yang mempunyai ciri kebolehsuaian terhadap pelbagai geometri *sump* saliran

1.2.2 Membangunkan alat perangkap sampah menggunakan bahan keluli dan sistem mekanikal takal bagi memudahkan proses pengangkatan sisa secara sistematik

1.2.3 Menganalisis keberkesanan penggunaan alat dari aspek penjimatan masa operasi secara kuantitatif melalui ujian lapangan berbanding kaedah pembersihan manual tradisional.

1.3 Skop Kajian

Kajian ini dihadkan kepada batasan-batasan berikut bagi memastikan tumpuan terhadap objektif yang telah ditetapkan:

Lokasi Kajian: Projek ini dijalankan di kawasan Politeknik Sultan Haji Ahmad Shah (POLISAS), Pahang, yang mempunyai ciri geografi beralun dan berbukit, sekali gus memberikan cabaran unik terhadap sistem saliran.

Sampel Kajian: Fokus kajian diberikan kepada unit *sump* saliran yang mempunyai kedalaman ekstrem, iaitu melebihi 1500mm, di mana akses penyelenggaraan manual adalah terhad dan berisiko.
Parameter Teknikal: Pembangunan alat tertumpu kepada penggunaan struktur keluli sudut (*angle steel*), plat besi sebagai tapak, dan dinding sisi daripada keluli *expanded* bagi tujuan penapisan sisa pepejal serta pasir.
Mekanisme Pengendalian: Operasi pengangkatan sisa dihadkan kepada penggunaan sistem mekanikal takal dan kabel keluli yang dikendalikan secara manual untuk menilai keberkesanan reka bentuk sebelum automasi dipertimbangkan.
Parameter Penilaian: Penilaian prestasi alat hanya diukur berdasarkan perbandingan kuantitatif masa operasi (minit) antara kaedah pembersihan menggunakan alat inovasi berbanding kaedah manual tradisional melalui tiga siri ujian lapangan.

1.4 Kepentingan Kajian

Dengan terhasilnya alat inovasi ini, akan memberikan idea dan kemudahan kepada pihak kontraktor kebersihan di POLISAS untuk menyelenggara *sump* saliran dengan lebih baik dan menjimatkan masa.

2.0 KAJIAN LITERATUR

Kajian literatur ini membincangkan landasan teori dan kajian terdahulu yang berkaitan dengan pengurusan sistem saliran, isu keselamatan dalam penyelenggaraan infrastruktur, serta peranan inovasi mekanikal dalam meningkatkan kecekapan operasi. Tinjauan ini bertujuan untuk menyokong keperluan pembangunan alat perangkap sampah sebagai penyelesaian kepada masalah banjir kilat dan kekangan penyelenggaraan manual.

2.1 Hubungan Pengurusan Sisa Pepejal dan Kejadian Banjir

Banjir merupakan bencana alam yang kerap melanda Malaysia, lazimnya berlaku apabila air melimpah ke kawasan rendah akibat hujan lebat berpanjangan atau kegagalan sistem saliran berfungsi dengan baik. Menurut Jabatan Pengairan dan Saliran (2021), pengurusan sisa pepejal yang lemah di kawasan bandar merupakan punca utama longkang tersumbat, yang seterusnya mengurangkan kapasiti aliran air dan mencetuskan banjir kilat. Penyelenggaraan yang tidak sempurna menyebabkan sisa terperangkap dan menjejaskan fungsi perparitan secara keseluruhan.

2.2 Bencana banjir dan kos penyelenggaraan saliran tersumbat.

Menurut laporan Jabatan Perangkaan Malaysia (DOSM) yang merekodkan jumlah kerugian ekonomi akibat banjir mencecah RM6.1 bilion pada tahun 2021, di mana kerosakan infrastruktur awam merupakan antara penyumbang utama. Selain itu, data daripada SWCorp menunjukkan sebanyak 1,151 tan sisa pepejal berjaya dikutip pasca-banjir di satu negeri sahaja (Negeri Sembilan), yang membuktikan bahawa sisa yang tidak terurus di dalam sistem saliran adalah punca kritikal kepada kegagalan aliran air. Harun (2022) membuktikan bahawa sisa pepejal yang tidak terurus di dalam sistem saliran merupakan punca kritikal kepada kegagalan aliran air.

Dari aspek ekonomi, kos penyelenggaraan dan menaik taraf sistem perparitan memerlukan peruntukan kewangan yang sangat besar. Sebagai contoh, Kementerian Pembangunan Kerajaan Tempatan (KPKT) telah menyediakan peruntukan khas sebanyak RM20 juta hanya untuk kerja-kerja penyelenggaraan sistem perparitan bagi mengurangkan risiko banjir kilat.

2.3 Kekangan Penyelenggaraan Manual dan Faktor Keselamatan

Kaedah pembersihan *sump* secara manual didapati kurang efisien kerana memerlukan tenaga kerja yang tinggi dan tempoh operasi yang panjang. Selain kekangan masa, Lembaga Pembangunan Industri Pembinaan (2023) menekankan bahawa kerja-kerja penyelenggaraan awam di kawasan sempit dan kotor mendedahkan pekerja kepada risiko keselamatan dan kesihatan yang serius. Hal ini amat kritikal di kawasan seperti POLISAS yang mempunyai kawasan beralun sehingga menghasilkan kedalaman *sump* melebihi 1500mm, yang menyukarkan akses manual.

2.4 Inovasi Alat Perangkap Sampah

Bagi menangani isu sisa di punca, penggunaan mekanisme penapisan atau perangkap sampah adalah sangat penting untuk memastikan kelancaran aliran air ke saluran utama. Kajian oleh Sulaiman dan Zakaria (2024) menunjukkan bahawa alat perangkap yang efektif haruslah mudah diselenggara dan mampu menahan beban sisa pepejal tanpa menghalang aliran air. Inovasi yang dibangunkan ini menggunakan bahan tahan kakisan seperti keluli *expanded* dan cat anti-karat bagi menjamin jangka hayat operasi dalam persekitaran lembap.

2.5 Kecekapan Operasi dan Penjimatan Masa

Peralihan daripada kaedah manual kepada penggunaan alat bantu mekanikal seperti sistem takal dan kabel terbukti meningkatkan produktiviti kerja. Tan dan Ishak (2025) menyatakan bahawa integrasi inovasi mekanikal dalam penyelenggaraan infrastruktur bukan sahaja menjimatkan kos buruh, malah membolehkan kerja disiapkan dengan lebih pantas dan sistematik.

3.0 METODOLOGI KAJIAN

Metodologi kajian bagi menghasilkan alat inovasi ini melalui beberapa peringkat seperti berikut:

3.1 Fasa Cetusan Idea

Perbincangan telah diadakan bagi mengenalpasti alat yang akan dihasilkan berdasarkan kepada pemerhatian di sekitar kampus. Geografi kampus yang beralun dan berbukit, menyebabkan saliran mempunyai kedalaman yang agak tinggi dan menyukarkan kerja-kerja penyelenggaraan dan pembersihan longkang. Alat yang dihasilkan, akan menumpukan kepada *sump* kedalaman yang melebihi 1500mm.

3.2 Fasa Rekabentuk Alat

Proses penghasilan alat dilaksanakan secara berperingkat mengikut spesifikasi kejuruteraan awam bagi memastikan ketahanan struktur dalam persekitaran yang ekstrem. Tahap pembangunan adalah seperti berikut:

3.2.1 Pemilihan Material: Material dipilih berdasarkan keperluan ketahanan kakisan dan kekuatan struktur. Keluli sudut (*angle steel*) digunakan sebagai kerangka utama untuk menahan beban sisa, manakala keluli *expanded* digunakan pada dinding sisi untuk berfungsi sebagai penapis sisa pepejal. Plat besi pula dipasang sebagai tapak (*tray*) bagi memerangkap mendapan pasir seperti ditunjukkan pada Rajah 1.



Rajah 1: Lakaran asal rekabentuk alat

3.2.2 Proses Pengukuran dan Pemotongan: Ukuran alat ditentukan berdasarkan variasi geometri *sump* di lokasi kajian (POLISAS) yang mempunyai kedalaman melebihi 1500mm. Pemotongan keluli dilakukan mengikut dimensi rekabentuk perspektif bagi memastikan alat mempunyai kebolehsuaian terhadap ruang saliran.



Rajah 2: Proses pengukuran bagi persediaan bahan-bahan

3.2.3 Penyambungan dan Kimpalan: Komponen keluli disambung menggunakan teknik kimpalan bagi membentuk satu unit sangkar yang kukuh. Struktur ini merangkumi bahagian atas yang bersifat mudah alih (*portable*) dan bahagian bawah yang berfungsi sebagai sangkar perangkap.

3.2.4 Rawatan Permukaan (Finishing): Bagi menjamin jangka hayat operasi dalam persekitaran lembap dan tercemar, keseluruhan struktur keluli disalut dengan cat tahan

karat (anti-karat). Ini selaras dengan keperluan infrastruktur kejuruteraan bagi mengelakkan kakisan.

3.2.5 Pemasangan Mekanisme Angkatan: Plat bahagian atas dilengkapi dengan unit mesin pengangkat yang dihubungkan dengan takal dan kabel keluli yang sesuai. Mekanisme ini direka untuk membolehkan sangkar diangkat ke atas bagi tujuan pengosongan sisa tanpa memerlukan akses manual ke dalam *sump.*

3.3 Fasa Penggunaan dan Pengujian Alat

Alat ini akan diletakkan di dalam *sump* yang mempunyai kedalaman yang lebih 1500mm. Bahagian yang tidak mempunyai sisi yang berjejaring diletak pada permukaan longkang pada arus aliran air masuk. Segala sampah atau sisa pepejal dan pasir akan terperangkap pada di dalam perangkap ini. Dalam tempoh tertentu, alat ini akan diangkat dengan menggunakan kabel keluli bagi mengeluarkan sampah-sampah dan pasir yang terperangkap. Sampah dan sisa pepejal ini akan di keluarkan dan dipindahkan ke tempat yang sesuai untuk dilupuskan. Menurut Zaini (2008), kaedah pengujian sistematik pada waktu puncak pengumpulan sisa adalah perlu bagi memastikan data kecekapan yang diperoleh adalah tepat dan boleh diulang.

4.0 HASIL DAN ANALISIS DATA

Pembangunan alat kejuruteraan perangkap sampah berjaya disiapkan dan di uji mengikut perancangan yang telah ditetapkan. Rajah 3 menunjukkan rekabentuk alat yang telah siap dihasilkan. Alat ini akan diletakkan didalam *sump* yang dipilih di POLISAS untuk pengujian.



Rajah 3: Gambaran alat perangkap sampah



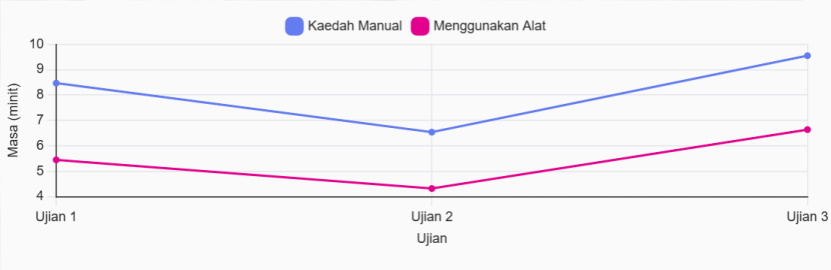
Rajah 4: Gambaran alat yang dipenuhi sampah

Ujian analisas penjimatan masa telah dilakukan sebanyak tiga kali. Data masa yang dicerap adalah seperti pada jadual di bawah:

Jadual 1: Ujian Penjimatan Masa

Ujian	Manual (minit)	Alat (minit)
1	8.47	5.45
2	6.54	4.32
3	9.55	6.64

Berdasarkan tiga ujian prestasi yang dijalankan, penggunaan alat kejuruteraan perangkap sampah menunjukkan pengurangan masa operasi yang konsisten berbanding kaedah pembersihan manual. Secara purata, masa penyelenggaraan berjaya dikurangkan daripada 8.19 minit kepada 5.47 minit, bersamaan dengan penjimatan masa operasi sebanyak 33.35%. Dapatan ini membuktikan bahawa alat yang dibangunkan berupaya meningkatkan kecekapan kerja penyelenggaraan sump saliran secara signifikan.



Rajah 5 : Perbandingan masa secara manual dengan penggunaan alat

Analisis kuantitatif menunjukkan penjimatan masa operasi yang signifikan, iaitu pengurangan purata masa penyelenggaraan daripada 8.19 minit (manual) kepada 5.47 minit menggunakan alat. Kecekapan masa sebanyak 33.35% ini membuktikan produktiviti kerja dapat ditingkatkan, di mana tiga kitaran pembersihan menggunakan alat hampir menyamai tempoh dua kitaran secara manual. Dari sudut implikasi kos, pengurangan masa operasi dan intensiti tenaga kerja ini secara langsung berupaya menurunkan kos upah buruh sebanyak satu pertiga bagi setiap sesi penyelenggaraan, sekali gus mengoptimumkan bajet pengurusan infrastruktur.

5.0 KESIMPULAN DAN CADANGAN

Secara keseluruhannya, pembangunan alat kejuruteraan perangkap sampah ini telah berjaya mencapai objektif yang ditetapkan. Berdasarkan dapatan kajian, beberapa kesimpulan utama boleh dirumuskan:

a) **Pencapaian Reka Bentuk**: Alat ini berjaya direka bentuk dengan ciri kebolehsuaian terhadap geometri *sump* saliran, menjadikannya praktikal untuk digunakan dalam pelbagai keadaan operasi.

b) **Peningkatan Kecekapan**: Penggunaan alat ini secara konsisten menunjukkan pengurangan masa operasi berbanding kaedah manual, dengan purata penjimatan masa sebanyak 33.35%.

c) **Impak Keselamatan dan Tenaga Kerja**: Inovasi ini bukan sahaja mempercepatkan kerja penyelenggaraan, malah berjaya mengurangkan kebergantungan kepada tenaga kerja manual serta meminimumkan risiko keselamatan pekerja di tapak.

Bagi meningkatkan lagi keberkesanan dan meluaskan penggunaan alat perangkap sampah ini pada masa hadapan, beberapa cadangan dikemukakan:

a) **Pengkomersialan kepada Kontraktor**: Alat ini sangat disyorkan untuk diguna pakai oleh pihak kontraktor pembersihan, terutamanya di kawasan yang mempunyai geografi mencabar seperti di POLISAS, bagi menjimatkan kos dan masa penyelenggaraan.

b) **Pemeliharaan Alam Sekitar**: Penggunaan alat ini secara meluas di lokasi-lokasi strategik dapat membantu mengurangkan pencemaran sisa pepejal di laluan air, sekali gus meningkatkan kualiti air sungai dan mencegah wabak penyakit.

c) **Penambahbaikan Mekanisme**: Kajian masa depan boleh memfokuskan kepada penggunaan bahan yang lebih ringan namun kukuh bagi memudahkan mobiliti alat, serta penyelarasan reka bentuk untuk *sump* yang mempunyai kedalaman lebih ekstrem. Perangkap juga boleh diangkat dengan menggunakan system bermotor untuk lebih efisien.

d) **Sistem Automasi**: Mempertimbangkan integrasi teknologi penderia (sensor) untuk memberi amaran apabila perangkap sudah penuh, bagi membolehkan kerja pengosongan sampah dilakukan dengan lebih sistematik.

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MODUEASE ACCESS PAD: ADAPTASI KEYPAD MAKRO UNTUK PELAJAR KURANG UPAYA ANGGOTA ATAS DALAM KURSUS MULTIMEDIA KREATIF PENGIKLANAN

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Abstrak

Pendidikan Teknikal dan Latihan Vokasional (TVET) kini memberi penekanan tinggi terhadap ekosistem pembelajaran inklusif bagi memastikan pelajar Orang Kurang Upaya (OKU) tidak tercicir. Di Kolej Komuniti Paya Besar, kursus Multimedia Kreatif Pengiklanan menuntut kemahiran teknikal tinggi dalam mengendalikan perisian reka bentuk digital yang kompleks. Walau bagaimanapun, pelajar OKU anggota atas (lengan kanan) menghadapi kekangan besar kerana perisian multimedia direka untuk koordinasi dua tangan secara serentak antara tetikus dan papan kekunci. Isu utama yang dikenal pasti adalah penurunan kecekapan kerja, peningkatan beban kognitif, dan keletihan fizikal akibat pergerakan satu tangan yang berulang untuk menekan kekunci pintas (*shortcut keys*) yang rumit. Kertas penyelidikan ini bertujuan untuk mencadangkan ModuEase Access Pad, sebuah peranti keypad makro sebagai teknologi bantuan khusus. Metodologi yang dicadangkan berasaskan pendekatan analisis keperluan dan reka bentuk konseptual, merangkumi penelitian aliran kerja serta pemetaan kekunci pintas kritikal seperti *Shift, Ctrl, Alt,* dan *Spacebar*. Inovasi ini memfokuskan kepada pembangunan fungsi *Toggle Behavior* dan *Sticky Keys* yang membolehkan kekunci dikunci dengan satu sentuhan, sekali gus membolehkan aliran kerja sebelah tangan yang lancar. Melalui adaptasi teknologi ini, *ModuEase Access Pad* dapat meningkatkan efisiensi masa penghasilan grafik sehingga 40-50% serta mengurangkan beban mental pelajar agar lebih fokus kepada aspek kreativiti. Secara keseluruhan, cadangan ini menyokong pemerkasaan inklusiviti dalam TVET bagi memastikan pelajar OKU mempunyai peluang kompetitif yang setara dalam pasaran kerja ekonomi digital. Hasil kajian ini diharap dapat menjadi model rujukan bagi penyediaan fasiliti mesra OKU di institusi pendidikan lain di peringkat kebangsaan.

Keywords: *ModuEase Access Pad*, Inklusiviti TVET, Multimedia Kreatif, Teknologi Bantuan, Toggle Behavior.

Abstract

Technical and Vocational Education and Training (TVET) currently places a high emphasis on inclusive learning ecosystems to ensure that students with disabilities (OKU) are not left behind. At Paya Besar Community College, the Creative Multimedia Advertising course demands high technical proficiency in operating complex digital design software. However, students with upper-limb disabilities (right arm) face significant constraints, as multimedia software is designed for simultaneous two-handed coordination between the mouse and the keyboard. The primary issues identified include decreased work efficiency, increased cognitive load, and physical fatigue due to repetitive single-handed movements required to press complex shortcut keys. This research paper aims to propose ModuEase Access Pad, a macro keypad device serving as a specialized assistive technology. The proposed methodology is based on a need's analysis and conceptual design approach, encompassing a study of workflows and the mapping of critical shortcut keys such as Shift, Ctrl, Alt, and Spacebar. This innovation focuses on developing Toggle Behavior and Sticky Keys functions that allow keys to be locked with a single touch, thereby enabling a seamless one-handed workflow. Through the adaptation of this technology, the ModuEase Access Pad can improve graphic production time efficiency by 40–50% and reduce the mental burden on students, allowing them to focus more on the creative aspects of their work. Overall, this proposal supports the empowerment of inclusivity within TVET to ensure that students with disabilities have competitive opportunities on par with others in the digital economy job market. The findings of this study are expected to serve as a reference model for the provision of OKU-friendly facilities in other educational institutions at the national level.

Keywords: *ModuEase Access Pad, TVET Inclusivity, Creative Multimedia, Assistive Technology, Toggle Behavior.*

1.0 PENGENALAN

Pendidikan Teknikal dan Latihan Vokasional (TVET) di Malaysia kini sedang menempuhi fasa transformasi kritikal selari dengan aspirasi Pelan Pembangunan Pendidikan Malaysia 2015-2025 (Pendidikan Tinggi) yang menekankan ekuiti dan aksesibiliti bagi semua lapisan masyarakat. Teras utama transformasi ini adalah pembangunan ekosistem pembelajaran inklusif yang memastikan pelajar Orang Kurang Upaya (OKU) tidak hanya sekadar hadir di institusi pendidikan, malahan mampu menguasai kemahiran teknikal yang setara dengan pelajar tipikal (KPT, 2015). Di Kolej Komuniti Paya Besar, kursus Multimedia Kreatif Pengiklanan merupakan bidang yang menuntut kompetensi tinggi dalam pengendalian perisian reka bentuk digital profesional seperti Adobe Creative Suite.

Walau bagaimanapun, satu cabaran besar timbul apabila struktur antaramuka perisian multimedia secara konvensional direka berasaskan logik koordinasi dua tangan serentak antara tetikus dan papan kekunci. Bagi pelajar OKU anggota atas (khususnya kehilangan fungsi satu tangan), reka bentuk perisian ini secara tidak langsung mewujudkan "halangan teknologi"

(*technological barriers*). Menurut Cook dan Polgar (2014), limitasi fizikal yang tidak disokong oleh teknologi bantuan yang tepat akan menghalang individu daripada mencapai potensi kefungsian mereka sepenuhnya. Dalam konteks penghasilan grafik, pelajar OKU terpaksa melakukan pergerakan secara serentak dan berulang untuk mengakses kekunci modifikasi (*modifier keys*) seperti *Shift, Ctrl,* dan *Alt* sambil mengendalikan tetikus.

Kekangan ini bukan sahaja menjejaskan kelajuan kerja, malah merangsang peningkatan beban kognitif luaran (*extraneous cognitive load*). Sebagaimana yang dibahaskan dalam Teori Beban Kognitif oleh Sweller (1988), apabila tumpuan mental pelajar terpaksa dialihkan secara kerap kepada manipulasi alat fizikal yang sukar, kapasiti memori kerja untuk memproses tugasan kreatif akan berkurangan secara drastik. Akibatnya, pelajar OKU sering mengalami keletihan fizikal dan mental yang lebih cepat, yang seterusnya menjejaskan kualiti hasil karya mereka.

Oleh itu, kertas penyelidikan ini mencadangkan satu intervensi inovatif melalui pembangunan *ModuEase Access Pad*. Inovasi ini bermatlamat untuk mengadaptasi fungsi *Sticky Keys* dan *Toggle Behavior* ke dalam sebuah peranti keypad makro fizikal yang ergonomik. Dengan mempermudah kombinasi kekunci kompleks kepada satu sentuhan mudah, *ModuEase Access Pad* bukan sekadar bertindak sebagai alat bantuan teknikal, malahan sebagai instrumen pemerkasaan yang menyokong prinsip Reka Bentuk Universal dalam Pendidikan (Burgstahler, 2020). Langkah ini penting bagi memastikan graduan OKU daripada sistem TVET berdaya saing dan bersedia untuk menghadapi cabaran pasaran kerja dalam ekonomi digital yang semakin kompetitif.

1.1 PENYATAAN MASALAH

Ketiadaan peranti input bantuan yang khusus di pasaran sering kali memaksa pelajar OKU untuk bergantung kepada perkakasan konvensional yang tidak mesra pengguna. Kebanyakan peranti makro sedia ada di pasaran direka untuk tujuan permainan video atau penstriman sahaja, sekali gus mengabaikan keperluan fungsian *Toggle Behavior* yang kritikal untuk aliran kerja penyuntingan grafik profesional.

Semasa proses pembangunan prototaip awal, cabaran utama yang dikenal pasti adalah ketiadaan perisian *firmware* yang membolehkan konfigurasi kekunci diubah suai secara dinamik bagi memenuhi keperluan antropometri tangan pelajar yang berbeza. Selain itu, integrasi komponen maklum balas visual (LED) dengan fungsi *Toggle* memerlukan pembangunan logik pengaturcaraan yang kompleks bagi memastikan peranti tidak hanya menghantar isyarat input, tetapi mampu mengekalkan status kekunci secara kekal tanpa perlu ditahan. Oleh itu, penghasilan ModuEase Access Pad adalah langkah kritikal untuk menyediakan satu ekosistem perkakasan yang bukan sahaja mampu diubah, malah mampu diintegrasikan ke dalam persekitaran pembelajaran multimedia secara inklusif dan lestari.

1.2 OBJEKTIF KAJIAN

1.2.1 Mengenal pasti kekangan fizikal pelajar OKU anggota atas dalam menggunakan kekunci pintas perisian grafik.

1.2.2 Membangunkan prototaip *ModuEase Access Pad* yang mengintegrasikan logik pengaturcaraan *Toggle Behavior* bagi kekunci Shift, Ctrl, Alt, dan Spacebar.

1.3 KEPENTINGAN KAJIAN

Pembangunan inovasi *ModuEase Access Pad* ini memberikan impak yang signifikan kepada tiga pemegang taruh utama dalam ekosistem pendidikan. Pertama, kepada pelajar, peranti ini berupaya memberikan autonomi kerja yang lebih luas sekali gus meningkatkan keyakinan diri mereka dalam menguasai kemahiran teknikal yang mencabar. Seterusnya, kepada pendidik, inovasi ini menawarkan satu model intervensi teknologi bantuan yang kos efektif untuk diaplikasikan di dalam bilik darjah bagi mendepani kepelbagaian upaya pelajar. Akhir sekali, kepada institusi, pelaksanaan projek ini memastikan Kolej Komuniti Paya Besar kekal relevan dalam menyediakan peluang pendidikan teknikal dan kemahiran yang saksama kepada pelbagai lapisan masyarakat, selaras dengan agenda pendidikan inklusif negara.

2.0 KAJIAN LITERATUR

Pembangunan peranti *ModuEase Access Pad* didasari oleh definisi teknologi bantuan oleh Cook dan Polgar (2014) sebagai alat yang meningkatkan penyertaan individu OKU secara berkesan. Dalam konteks multimedia, Hersh dan Johnson (2008) menekankan keperluan peranti yang mesra pengguna, kos rendah, dan mampu meningkatkan autonomi pelajar. Burgstahler (2015, 2020) merumuskan bahawa penyediaan teknologi bantuan di peringkat pengajian tinggi adalah langkah proaktif institusi dalam menghapuskan halangan pembelajaran melalui konsep Reka Bentuk Universal. Usaha ini selaras dengan Pelan Pembangunan Pendidikan Malaysia (KPT, 2015) yang menggariskan tanggungjawab institusi untuk menyediakan akses saksama kepada kumpulan sasar melalui inovasi fasiliti. Maka, penyediaan sokongan teknologi di peringkat tempatan adalah kritikal dalam memperkasakan komuniti OKU dalam sistem pendidikan negara (Kamaruzaman et al., 2017).

Kekangan motor halus sering kali menjadi penghalang utama bagi pelajar OKU untuk mengendalikan input papan kekunci konvensional secara efisien. Vanderheiden (1988) membuktikan bahawa fungsi *Sticky Keys* merupakan elemen kritikal bagi individu dengan kekangan motor untuk mengendalikan input tanpa menekan berbilang kekunci serentak. Kajian Trewin (1999, 2000) menunjukkan bahawa konfigurasi papan kekunci yang diubah suai mampu mengurangkan ralat input dan keletihan fizikal secara drastik bagi pengguna OKU. Hal ini diperkukuhkan oleh Findlater dan Wobbrock (2012) yang menekankan kepentingan sistem komputer untuk menyesuaikan diri dengan kemampuan fizikal pengguna melalui pemetaan kekunci tersuai. Tanpa adaptasi yang tepat, ralat input akan terus berlaku dan menjejaskan kualiti hasil kerja pelajar dalam persekitaran digital yang kompetitif.

Penggunaan perisian kreatif yang menuntut koordinasi kekunci pintas yang intensif sering kali meningkatkan beban kerja fizikal dan kognitif pelajar (Lane et al., 2005). Sweller (1988) menjelaskan bahawa gangguan mekanikal semasa proses penyelesaian masalah akan meningkatkan beban kognitif luaran yang menjejaskan fokus kepada kreativiti. Penggunaan peranti input sekunder yang boleh diprogramkan secara khusus didapati mampu mengurangkan

beban mental dan ralat input bagi pengguna yang mempunyai had motor halus (Lazar et al., 2017). Melalui fungsi *Toggle Behavior*, kekangan fizikal untuk menahan kekunci modifikasi secara berterusan dapat diatasi bagi melancarkan aliran kerja multimedia. Justeru, integrasi perkakasan yang adaptif adalah perlu bagi memastikan kapasiti kognitif pelajar dapat difokuskan sepenuhnya kepada tugasan reka bentuk yang kompleks.

Dari aspek teknikal, penggunaan mikropengawal seperti MicroPython membolehkan komuniti pembuat membina alat bantuan OKU yang kos rendah dan efektif (Buehler et al., 2015). Reka bentuk *ModuEase Access Pad* mengaplikasikan prinsip maklum balas visual oleh Norman (2013) bagi memastikan pengguna sedar akan status fungsi yang sedang aktif. Penggunaan indikator LED pada peranti berfungsi sebagai elemen *affordance* yang memudahkan interaksi antara manusia dan mesin secara intuitif. Menurut Kurt (2024), penerapan kerangka kerja *Universal Design for Learning* (UDL) adalah sangat penting bagi menghapuskan halangan pembelajaran melalui penyediaan persekitaran digital yang lebih inklusif dan fleksibel. Pendekatan ini membuktikan bahawa inovasi perkakasan tersuai adalah penyelesaian yang lebih lestari berbanding kebergantungan kepada peranti komersial yang mahal.

Secara keseluruhannya, integrasi teknologi bantuan yang tepat di institusi pendidikan tinggi mampu meningkatkan produktiviti dan kesejahteraan mental pelajar OKU. Penyelarasan input yang disuaikan dengan profil fizikal pengguna dapat menghapuskan kitaran pergerakan tangan yang ekstrem dan tidak perlu. Hal ini bukan sahaja memudahkan aspek teknikal pengoperasian perisian, malah turut membina keyakinan diri pelajar dalam menguasai kemahiran multimedia kreatif. *ModuEase Access Pad* hadir sebagai solusi praktikal yang menggabungkan aspek ergonomik, logik pengaturcaraan dan keberkesanan kos. Akhir sekali, sokongan berterusan terhadap inovasi sebegini akan memastikan graduan OKU mempunyai daya saing yang setara dalam pasaran kerja ekonomi digital.

3.0 METODOLOGI PENYELIDIKAN

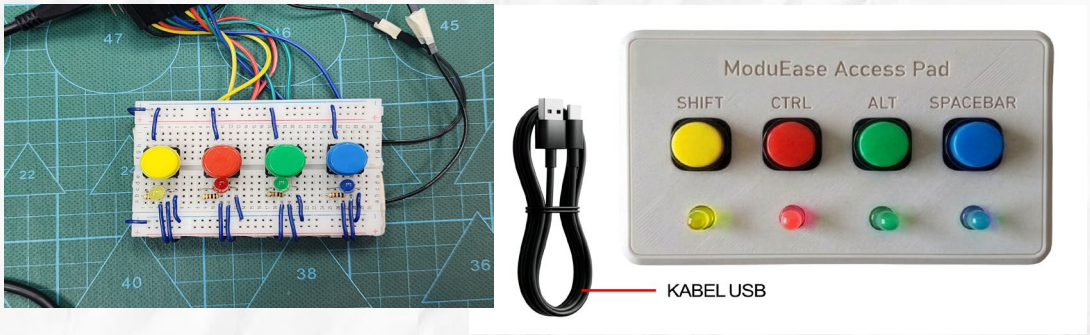
Penyelidikan ini dijalankan menggunakan pendekatan kualitatif dan teknikal yang bersifat deskriptif. Strategi penyelidikan difokuskan kepada analisis keperluan pengguna dan reka bentuk konseptual bagi memastikan peranti yang dicadangkan benar-benar menyelesaikan masalah spesifik yang dihadapi oleh subjek kajian. Metodologi ini dibahagikan kepada tigat fasa utama seperti berikut:

3.1 Fasa 1 (Analisis Keperluan)

Fasa ini dilaksanakan melalui kaedah pemerhatian peserta (*participant observation*) secara langsung oleh penyelidik dalam kapasiti sebagai pensyarah kursus. Fokus diberikan kepada analisis kekangan pergerakan motor halus pelajar OKU semasa sesi amali multimedia. Data kualitatif dikumpul melalui penelitian terhadap kekerapan kegagalan koordinasi antara tetikus dan papan kekunci, serta mengenal pasti titik tekanan (*pain points*) fizikal yang dihadapi pelajar apabila perlu menahan kekunci modifikasi secara berterusan. Hasil pemerhatian ini membentuk asas kepada spesifikasi teknikal peranti bantuan yang diperlukan.

3.2 Fasa 2 (Reka Bentuk Konseptual)

Berdasarkan pemerhatian peserta Fasa 1, fasa ini melibatkan pemilihan komponen perkakasan yang sesuai bagi membina unit prototaip awal. Komponen utama terdiri daripada mikropengawal Raspberry Pi Pico yang dihubungkan kepada peranti mikro papan kekunci 4-butang berserta indikator lampu LED bagi setiap suis seperti yang ditunjukkan pada Rajah 1. Reka bentuk ini mengutamakan susunan linear pada papan reka (breadboard) bagi memudahkan capaian jari pelajar secara statik dan meminimumkan pergerakan tapak tangan. Penggunaan butang berwarna yang berbeza (Kuning, Merah, Hijau, Biru) bertujuan memberikan indikasi visual yang jelas kepada pengguna semasa proses pemetaan kekunci modifikasi dijalankan.



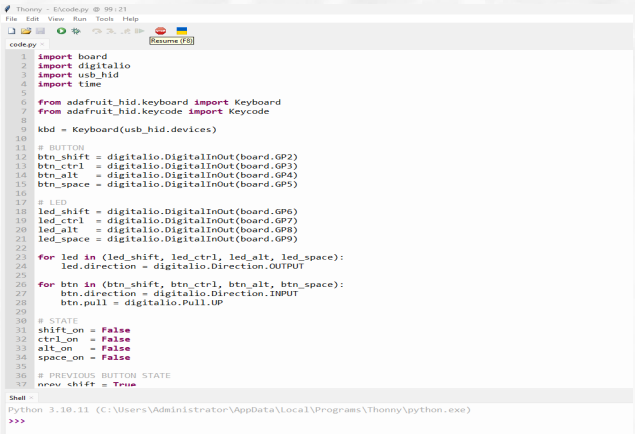
Rajah 1: Peranti mikro papan kekunci 4-butang

3.3 Fasa 3 (Pembangunan Logik Pengaturcaraan)

Fasa ini melibatkan proses pengekodan program menggunakan MicroPython - HID Project bagi membolehkan peranti berfungsi mengikut keperluan subjek kajian. Peranti diprogramkan secara teknikal dengan logik berikut:

- *Toggle Behavior*: Pengaturcaraan ini membolehkan satu sentuhan ringan mengaktifkan status kekunci (seperti Shift atau Ctrl) secara kekal tanpa perlu ditahan secara manual.
- *Sticky Keys*: Mengintegrasikan logik yang mengekalkan fungsi kekunci modifikasi sehingga butang yang sama ditekan semula untuk melepaskan status tersebut. (Rajah 2)

Rajah 2 berikut menunjukkan logik kod bagi empat butang (*SHIFT, CTRL, ALT dan SPACEBAR*) yang menggunakan mikro pengawal Raspberry Pi Pico.



```
import board
import digitalio
import usb_hid
import time

from adafruit_hid.keyboard import Keyboard
from adafruit_hid.keycode import Keycode

kbd = Keyboard(usb_hid.devices)

# BUTTON
btn_shift = digitalio.DigitalInOut(board.GP2)
btn_ctrl  = digitalio.DigitalInOut(board.GP3)
btn_alt   = digitalio.DigitalInOut(board.GP4)
btn_space = digitalio.DigitalInOut(board.GP5)

# LED
led_shift = digitalio.DigitalInOut(board.GP6)
led_ctrl  = digitalio.DigitalInOut(board.GP7)
led_alt   = digitalio.DigitalInOut(board.GP8)
led_space = digitalio.DigitalInOut(board.GP9)

for led in (led_shift, led_ctrl, led_alt, led_space):
    led.direction = digitalio.Direction.OUTPUT

for btn in (btn_shift, btn_ctrl, btn_alt, btn_space):
    btn.direction = digitalio.Direction.INPUT
    btn.pull = digitalio.Pull.UP

# STATE
shift_on = False
ctrl_on  = False
alt_on   = False
space_on = False

# PREVIOUS BUTTON STATE
prev_shift = True
```

Rajah 2: *Code Snippet* (MicroPython - HID Project)

Seterusnya Rajah 3 menunjukkan integrasi aliran kerja yang bertujuan memudahkan operasi sebelah tangan dengan bantuan tetikus, sekali gus menghapuskan kitaran pergerakan tangan yang tidak perlu antara papan kekunci konvensional dan peranti penunjuk. Ia menerangkan bagaimana fungsi *Toggle Behavior* berfungsi bagi setiap butang

```
Code snippet

graph TD
    A[Start: Await Button Input] --> B{Is Button Pressed?}
    B -- Yes --> C{Is Key Status ACTIVE?}
    C -- No --> D[Activate Modifier Key <br>e.g., SHIFT ON]
    D --> E[Turn ON LED - Visual Feedback]
    C -- Yes --> F[Deactivate Modifier Key <br>e.g., SHIFT OFF]
    F --> G[Turn OFF LED]
    E --> H[End: Key remains 'Sticky']
    G --> I[End: Return to Standby]
    B -- No --> A
```

Rajah 3: Carta Alir Logik (*Logic Flowchart*)

3.4 Fasa 4 (Uji Lari dan Pengesahan Bukti Konsep)

Fasa ini difokuskan kepada pengujian Bukti Konsep (*Proof of Concept*) bagi memastikan kestabilan logik pengaturcaraan yang telah dibangunkan. Walaupun peranti ini masih dalam bentuk prototaip awal (papan litar terbuka), pengujian teknikal adalah kritikal untuk mengesahkan keberkesanan fungsi sebelum pembangunan fizikal seterusnya. Uji lari ini merangkumi:

- **Pengesahan Integriti Kod (*Code Integrity*)**
  Siri ujian dijalankan untuk memastikan tiada ralat (*bug*) pada fungsi *Toggle Behavior*. Keputusan menunjukkan peranti berjaya mengekalkan status kekunci *Shift, Ctrl, Alt,* dan *Spacebar* dengan tepat. Respons mikropengawal terhadap input butang dikesan adalah serta-merta tanpa sebarang kependaman (*latency*) yang ketara.
- **Ujian Keserasian HID (*HID Compatibility Test*)**
  Uji lari dilakukan dengan menyambungkan prototaip terus ke komputer melalui port USB. Sistem operasi (Windows/Mac) berjaya mengenali peranti sebagai papan kekunci standard secara *Plug-and-Play*. Ini mengesahkan bahawa logik *Sticky Keys* yang dikodkan dapat berinteraksi dengan perisian multimedia (Adobe Creative Suite) seolah-olah input datang daripada papan kekunci konvensional.
- **Penilaian Ergonomik Logik (*Logic Ergonomics*)**
  Susunan *linear* butang pada papan litar telah diuji secara statik. Hasilnya menunjukkan bahawa kedudukan butang yang diprogramkan memudahkan capaian jari tanpa memerlukan pergerakan pergelangan tangan yang besar, memenuhi objektif asal untuk membantu pelajar OKU anggota atas.

4.0 DAPATAN KAJIAN

Analisis dapatan kajian ini difokuskan kepada tiga elemen utama iaitu efisiensi masa, kesejahteraan mental dan keberkesanan kos bagi menilai impak menyeluruh ModuEase Access Pad. Pemilihan elemen efisiensi masa sebagai parameter analisis adalah kritikal kerana prestasi

dalam bidang multimedia diukur melalui kepantasan teknikal. Hasil kajian menunjukkan peningkatan kelajuan kerja dijangka mencecah 40-50%. Hal ini dicapai melalui penghapusan kitaran pergerakan tangan yang ekstrem dan tidak perlu, membolehkan pelajar OKU mencapai tahap produktiviti yang setara dengan pengguna tipikal. Dari sudut teknikal, pengurangan langkah fizikal ini secara langsung membuktikan bahawa adaptasi fungsi Toggle mampu memaksimumkan output kerja dalam tempoh masa yang lebih singkat.

Seterusnya, elemen kesejahteraan mental dianalisis kerana halangan fizikal sering kali menjadi punca kepada tekanan perasaan dan isu rendah diri dalam kalangan pelajar OKU fizikal. Dengan adanya bantuan peranti ini, beban kognitif luaran dapat dikurangkan, sekali gus membina keyakinan diri pelajar untuk menguasai kemahiran multimedia yang kompleks tanpa rasa terbeban oleh kekangan mekanikal. Apabila gangguan fizikal diminimumkan, pelajar dapat memberikan tumpuan sepenuhnya kepada elemen estetik dan kreativiti rekaan yang merupakan teras utama dalam kursus pengiklanan. Oleh itu, dapatan ini mengesahkan bahawa sokongan teknologi bukan sahaja membantu dari segi fizikal, malah menjadi dorongan utama pelajar untuk mengekalkan prestasi cemerlang dalam bidang multimedia.

Akhir sekali, keberkesanan kos dijadikan elemen analisis bagi membuktikan nilai kelestarian inovasi ini dalam jangka masa panjang bagi institusi pendidikan. Analisis mendapati bahawa penggunaan komponen mikropengawal kos rendah dan sumber terbuka (*open-source*) adalah jauh lebih praktikal berbanding kebergantungan kepada peranti komersial yang mahal dan sukar didapati di pasaran tempatan. Dapatan ini menyokong hujah Buehler et al. (2015) bahawa inovasi perkakasan tersuai merupakan penyelesaian yang lebih lestari dan mudah diselenggara. Pecahan kos bahan bagi penghasilan ModuEase Access Pad dirumuskan secara sistematik dalam Jadual 1. Analisis perbelanjaan ini menunjukkan kualiti peranti boleh dicapai dengan kos pembangunan yang optimum dan mampu milik.

Jadual 1: Jumlah kos untuk menghasilkan *ModuEase Access Pad*

No.	Item	Bilangan	Harga Seunit (RM)	Jumlah (RM)
1	Push button	4	2.00	8.00
2	LED	4	0.50	2.00
3	Jumper	1	8.00	8.00
4	Breadboard 8.5x5.5cm (400 Holes)	1	3.00	3.00
5	Resistor	4	0.80	3.20
6	Raspberry Pi Pico	1	25.00	25.00
Jumlah Keseluruhan (RM)				**49.20**

5.0 PERBINCANGAN KAJIAN

Adaptasi *ModuEase Access Pad* membuktikan bahawa inovasi tidak semestinya melibatkan kos yang tinggi atau penciptaan teknologi baharu dari awal. Dengan menghasilkan peranti

bantuan khusus, ia menawarkan penyelesaian yang mampan dan boleh digunakan oleh institusi pendidikan lain. Penggunaan fungsi *Toggle* (tekan sekali untuk kunci, tekan sekali lagi untuk lepas) secara drastik mengubah cara kerja satu tangan menjadi setara dengan profesional multimedia yang menggunakan dua tangan. Selain digunakan di institusi pendidikan, peranti ini mempunyai potensi besar untuk dikomersialkan sebagai aksesori komputer mampu milik bagi pasaran teknologi bantuan (*assistive technology*). Reka bentuknya yang bersifat *open-source* dan *plug-and-play* menjadikannya produk yang kompetitif untuk memenuhi keperluan komuniti OKU fizikal dan pengamal industri kreatif secara meluas.

6.0 KESIMPULAN

Secara keseluruhannya, kajian ini telah berjaya mencapai matlamat utama melalui dua fasa penting. Pertama, kajian berjaya mengenal pasti kekangan fizikal pelajar OKU anggota atas yang menghadapi kesukaran mengendalikan kekunci pintas pada papan kekunci konvensional. Kedua, sebagai solusi konkrit, prototaip ModuEase Access Pad telah berjaya dibangunkan dengan mengintegrasikan logik *Toggle Behavior* bagi kekunci *Shift, Ctrl, Alt* dan *Spacebar*.

Keberhasilan inovasi ini membuktikan bahawa halangan mekanikal dapat diatasi melalui teknologi bantuan yang tepat, sekali gus meningkatkan autonomi dan produktiviti pelajar dalam ekosistem pendidikan TVET. Hasil kajian ini diharapkan dapat menjadi rujukan dalam memperkasakan persekitaran pembelajaran digital yang lebih inklusif dan mesra OKU.

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INOVASI EBOOK INFOGRAFIK DENGAN INTEGRASI *AUGMENTED REALITY*: ALTERNATIF BAHAN PDP KURSUS PANGKALAN DATA MICROSOFT ACCESS

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ABSTRAK

Kajian ini dijalankan bagi menilai tahap penerimaan awal pelajar yang menggunakan eBook interaktif *Creating a Simple Database System Using Microsoft Access: A Practical Guide* dalam pengajaran dan pembelajaran kursus pangkalan data. Inovasi ini dibangunkan dengan menggabungkan elemen infografik dan integrasi Augmented Reality bagi membantu pelajar memahami langkah amali penggunaan *Microsoft Access* secara lebih sistematik, interaktif dan mudah difahami. Kajian menggunakan pendekatan kuantitatif melalui soal selidik yang melibatkan pelajar sebagai responden bagi menilai aspek reka bentuk eBook, keberkesanan infografik, fungsi AR, dan pengalaman pembelajaran. Dapatan kajian menunjukkan bahawa semua item mencatatkan nilai min yang tinggi antara 4.50 hingga 4.64, menandakan tahap penerimaan pelajar yang sangat tinggi terhadap inovasi yang dibangunkan. Nilai min tertinggi direkodkan bagi item berkaitan keberkesanan infografik dan integrasi AR, menunjukkan bahawa kedua-dua elemen tersebut membantu meningkatkan kefahaman konsep serta langkah amali pangkalan data. Selain itu, kandungan AR didapati menjadikan pembelajaran lebih menyeronokkan dan meningkatkan penglibatan pelajar semasa proses pembelajaran. Secara keseluruhannya, kajian membuktikan bahawa eBook interaktif berintegrasi AR berpotensi menjadi alternatif bahan pengajaran dan pembelajaran yang berkesan bagi kursus teknikal serta menyokong transformasi pendidikan digital semasa.

Kata kunci: eBook interaktif, infografik, *Augmented Reality*, *Microsoft Access*, Pembelajaran dan Pengajaran, Pangkalan data.

ABSTRACT

This study was conducted to evaluate students' initial acceptance of using the interactive eBook Creating a Simple Database System Using Microsoft Access: A Practical Guide in the teaching and learning of a database course. The innovation integrates infographic elements and Augmented Reality (AR) to help students understand the practical steps of using Microsoft Access in a more systematic, interactive, and accessible way. A quantitative approach was employed through a questionnaire involving students as respondents to assess aspects such as eBook design, infographic effectiveness, AR functionality, and learning experience. The findings indicate that all items recorded high mean scores ranging from 4.50 to 4.64, reflecting

a very high level of student acceptance. The highest mean values were observed for items related to the effectiveness of infographics and AR integration, suggesting that these elements significantly enhance understanding of concepts and practical database procedures. Additionally, AR content was found to make learning more enjoyable and increase student engagement during the learning process. Overall, the study demonstrates that an AR-integrated interactive eBook has strong potential as an effective teaching and learning material for technical courses and supports the ongoing transformation of digital education.

Keywords: *interactive eBook, infographics, Augmented Reality, Microsoft Access, teaching and learning, database.*

1.0 PENGENALAN

Generasi Z merupakan generasi yang lahir diantara tahun 1995 sehingga 2010, sedangkan Generasi Alfa merupakan generasi yang lahir mulai tahun 2010 dan ke atas (McCrindle & Wolfinger, 2008). Mereka terdedah kepada telefon pintar, internet berkelajuan tinggi, media sosial, pembelajaran kendiri dan kandungan visual interaktif sejak kecil. Corak pembelajaran mereka lebih cenderung kepada bahan digital, visual, ringkas dan interaktif berbanding bahan bercetak konvensional. Hasil penelitian menunjukkan bahawa kreativiti yang terbentuk melalui pembelajaran yang berpusatkan pelajar (*Student Centered*) lebih tinggi daripada pembelajaran langsung (Ardian & Munadi, 2016). Dalam kursus Pangkalan Data Microsoft Access, pelajar perlu memahami konsep teknikal seperti jadual (*table*), *relationship*, *primary key*, *query*, *form* dan *report*. Walau bagaimanapun, penggunaan nota secara *hardcopy* dan slaid statik didapati kurang menarik perhatian pelajar Gen Z, yang lebih gemar merujuk internet dan bahan digital melalui telefon pintar. Ini selari dengan manfaat teknologi dalam bidang pendidikan berfokus terhadap penggunaannya sebagai medium pembelajaran, alat pengurusan, dan sumber untuk belajar (Lestari, 2018). Sehubungan itu, inovasi eBook Infografik dengan Integrasi Augmented Reality (AR) dibangunkan sebagai alternatif bahan PdP yang selari dengan gaya pembelajaran Gen Z. Inovasi ini menggabungkan infografik visual berstruktur dengan elemen AR seperti video, imej interaktif, langkah demi langkah dan latihan bagi meningkatkan kefahaman dan motivasi pelajar.

1.1 Pernyataan Masalah

Hasil pemerhatian serta analisis awal yang dijalankan mendapati salah satu isu utama dalam pelaksanaan pembelajaran dan pengajaran (PdP) kursus pangkalan data ialah pelajar kurang merujuk nota bercetak yang dibekalkan oleh pensyarah tetapi lebih gemar merujuk kepada sumber diinternet menyebabkan latihan atau amali kurang menepati soalan yang diberikan. Selain itu, konsep asas dalam pangkalan data, seperti hubungan entiti dan proses manipulasi data, didapati sukar difahami apabila disampaikan dalam bentuk teks semata-mata. Penyampaian isi kandungan secara langkah demi langkah perlu dilakukan kepada pelajar, bagi membolehkan pangkalan data tersusun dan tepat. Ini memberi kesan kepada tahap fokus dan penglibatan pelajar dalam sesi PdP memandangkan Generasi Z memiliki karakter yang

menggemari teknologi, fleksibel, lebih cerdas, dan bertoleransi pada perbezaan budaya (Rastati, 2018).

1.2 Objektif Kajian

Objektif kajian ini adalah:

1) Membangunkan eBook Infografik dengan Integrasi *Augmented Reality* (AR) untuk mempelbagaikan bahan PdP.
2) Menilai tahap penerimaan awal pelajar terhadap bahan pembelajaran berasaskan ebook dan AR.

1.3 Skop Kajian

Kajian ini memfokuskan kepada pembangunan inovasi serta menilai penerimaan awal pelajar kepada bahan pembelajaran berbentuk eBook Infografik dengan Integrasi *Augmented Reality* (AR) dalam PdP kursus *Microsoft Access*. Skop kajian melibatkan pelajar tahap Sijil Teknologi Maklumat (STM), Kolej Komuniti Paya Besar berumur 19 hingga 25 tahun yang mengikuti pembelajaran berkaitan penggunaan perisian *Microsoft Access*.

2.0 KAJIAN LITERATUR

Penggunaan bahan pembelajaran digital semakin penting dalam pendidikan moden kerana memberi peluang kepada pelajar mengakses maklumat secara fleksibel, cepat dan berterusan. Bahan digital seperti eBook membolehkan kandungan pembelajaran disampaikan secara lebih tersusun, interaktif dan mudah dikemaskini berbanding bahan bercetak tradisional. Dalam konteks pendidikan teknikal, bahan digital membantu pelajar memahami kandungan secara langkah demi langkah dengan lebih teratur. Li, G., Luo, H., Chen, D., Wang, P., Yin, X., & Zhang, J. (2025).

Selain itu, infografik merupakan pendekatan visual yang menggabungkan teks, ikon, warna dan grafik untuk menyampaikan maklumat secara ringkas dan jelas dilihat mampu mengurangkan beban kognitif pelajar kerana maklumat dipersembahkan dalam bentuk yang lebih mudah diproses. Nilai kebolehgunaan yang tinggi menunjukkan bahawa infografik sangat sesuai untuk generasi yang cenderung kepada pembelajaran visual. Shahrani, S., Zainal, N. F. A., Abd Rahman, R., Rahmat, M., Ishak, A., Nasrudin, M. F., & Nik Ibrahim, N. A. (2023). Teknologi AR semakin banyak digunakan dalam pendidikan kerana keupayaannya menggabungkan elemen maya dengan persekitaran sebenar.

Dalam pembelajaran, AR membantu pelajar melihat demonstrasi, simulasi dan objek digital secara langsung melalui peranti mudah alih. Kajian oleh Özeren, S., & Top, E. (2023) menunjukkan bahawa penggunaan AR meningkatkan pencapaian akademik dan motivasi pelajar secara signifikan berbanding kaedah biasa. Oleh itu, inovasi eBook interaktif yang menggabungkan infografik dan AR sangat selari dengan gaya pembelajaran mereka.

3.0 METODOLOGI KAJIAN

3.1 Pembangunan Inovasi

Pembangunan inovasi menggunakan model Addie merangkumi lima fasa utama iaitu fasa analisis, fasa reka bentuk, fasa pembangunan, fasa perlaksanaan dan fasa penilaian.

1. Analisis

Pada fasa ini, analisis keperluan dijalankan bagi mengenal pasti masalah dalam PdP kursus pangkalan data. Pemerhatian menunjukkan pelajar kurang berminat terhadap bahan bercetak serta kurang memberikan penglibatan didalam kelas.

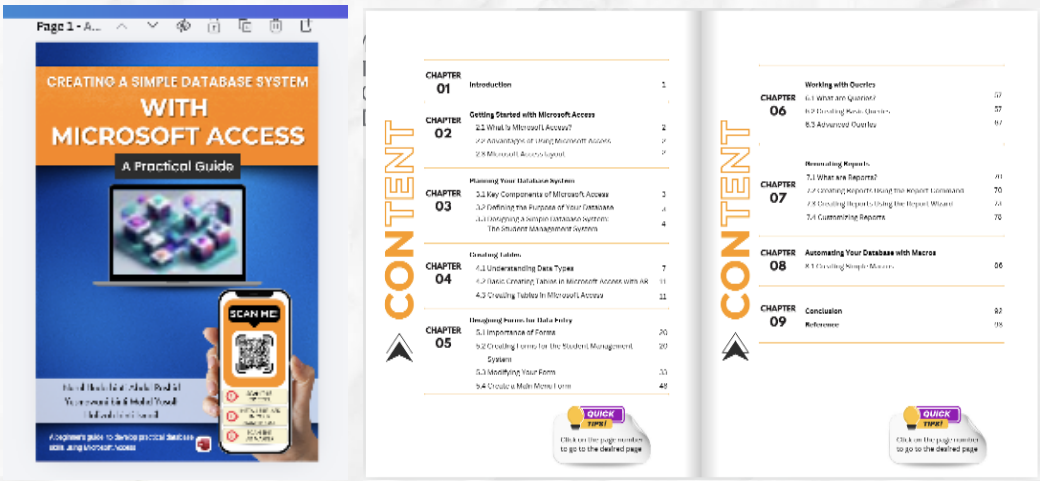
2. Reka Bentuk

Fasa reka bentuk melibatkan perancangan struktur kandungan eBook serta elemen Augmented Reality (AR). Reka bentuk juga merangkumi pemilihan jenis media seperti video, imej interaktif dan latihan pembelajaran yang akan diintegrasikan dalam AR.

3. Pembangunan

a) Fasa 1 – Pembangunan eBook

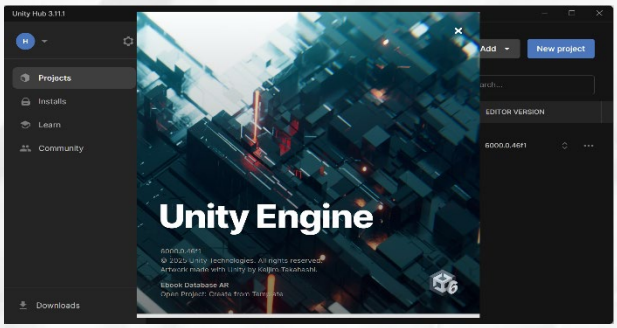
Pembangunan dimulakan dengan pengumpulan isi kandungan berdasarkan silibus kursus, nota pengajaran dan hasil pembelajaran. Kandungan ini kemudiannya ditukar kepada bentuk infografik menggunakan Canva bagi meningkatkan kefahaman dan daya tarikan visual pelajar.



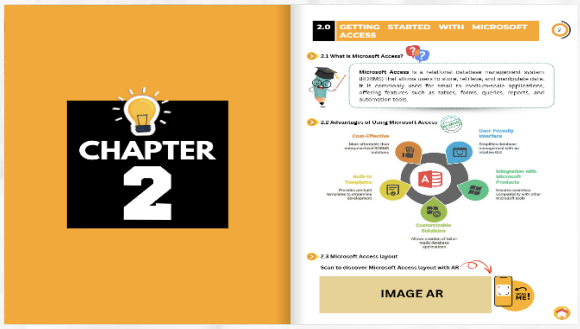
Rajah 1: Cover dan Isi Kandungan eBook

b) Fasa 2 – Pembangunan AR

Pada peringkat ini, elemen AR seperti video penerangan, imej interaktif dan bahan sokongan dibangunkan menggunakan perisian Unity. Setiap elemen AR dipautkan kepada penanda (*marker*) dalam eBook bagi membolehkan pelajar mengakses kandungan.



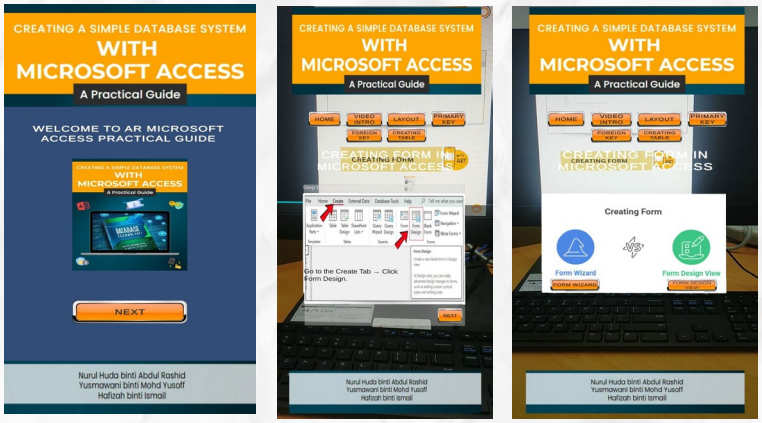
Rajah 2: Perisian Unity



Rajah 3: Penanda untuk IMAGE AR

c) Fasa 3 – Pembangunan Fail .APK

Seterusnya, semua komponen eBook dan AR digabungkan dalam satu aplikasi mudah alih berformat .apk untuk sistem Android. Proses ini melibatkan integrasi fungsi AR, reka bentuk navigasi aplikasi serta pengujian kebolehgunaan pada peranti mudah alih.



Rajah 4: Antaramuka fail AR_Access.apk

4. Pelaksanaan

Dalam fasa ini, aplikasi eBook Infografik dengan Integrasi AR digunakan dalam sesi PdP sebenar. Pelajar mengakses bahan pembelajaran melalui telefon pintar masing-masing. Pelaksanaan ini memberi peluang kepada pelajar untuk mengalami pembelajaran secara lebih aktif dan kendiri.

5. Penilaian

Fasa penilaian dijalankan bagi menilai keberkesanan inovasi yang dibangunkan. Maklum balas dikumpulkan daripada pelajar berkaitan penerimaan awal pelajar kepada penggunaan ebook integrasi dengan AR. Hasil penilaian menggunakan nilai Min mendapati tahap penerimaan terhadap penggunaan ebook interaktif integrasi dengan AR adalah pada kadar yang tinggi.

3.2 Ciri-ciri Inovasi

Ciri-ciri Inovasi yang dihasilkan ditunjukkan dalam Jadual 1 berikut:

Jadual 1: ciri inovasi Ebook Infografik

Ciri	Kandungan Berasaskan Infografik	Reka Bentuk Mesra Pengguna	Integrasi Teknologi Augmented Reality (AR)	Boleh Digunakan Melalui Telefon Pintar	Mudah Alih dan Fleksibel	Menyokong Pembelajaran Kendiri
Penerangan	Maklumat visual yang ringkas dan jelas	Susun atur sistematik dengan navigasi mudah	Memaparkan kandungan tambahan melalui imbasan penanda	Aplikasi mudah alih (.apk) untuk peranti Android	Akses bila-bila masa dan di mana-mana sahaja	Pelajar mengulang kaji topik secara kendiri

3.3 Cara Penggunaan Inovasi

Link eBook: https://heyzine.com/flip-book/631ca0cd03.html

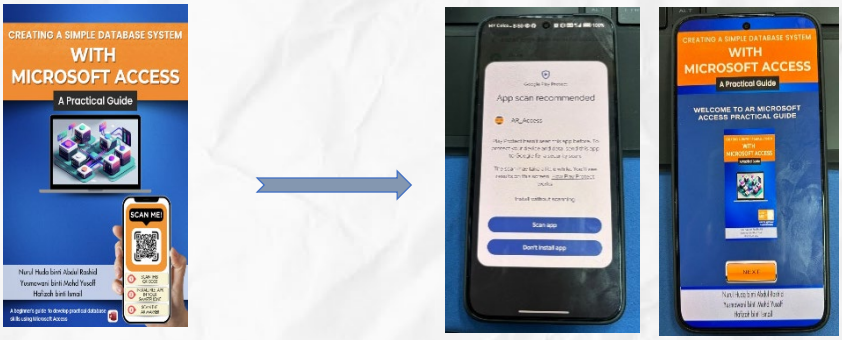
Langkah 1: Memasang Aplikasi : Pengguna perlu mengimbas kod QR yang disediakan pada eBook untuk memasang fail aplikasi (.apk).

Langkah 2: Membaca Kandungan Infografik : Klik pada link yang diberikan, pilih topik pembelajaran yang ingin dipelajari.

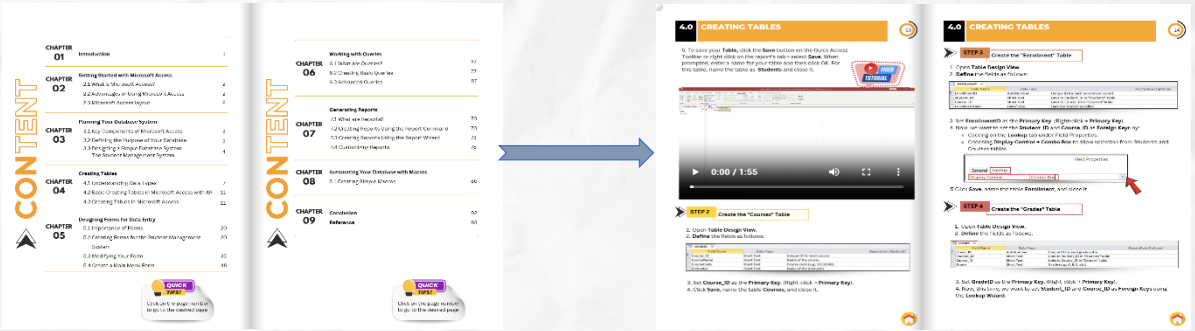
Langkah 3: Mengimbas Penanda AR: Pengguna mengaktifkan fungsi kamera dalam aplikasi dan mengimbas penanda AR yang disediakan pada halaman tertentu.

Langkah 4: Paparan Kandungan AR : Apabila penanda berjaya diimbas, kandungan digital seperti video, imej atau latihan akan dipaparkan secara automatik.

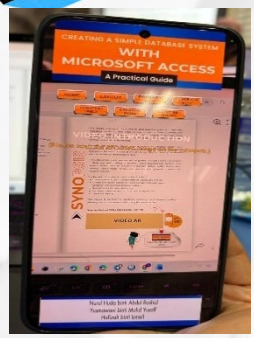
Langkah 5: Pembelajaran Kendiri : Pengguna boleh menggunakan inovasi mengikut keperluan pembelajaran masing-masing dimana sahaja berada.



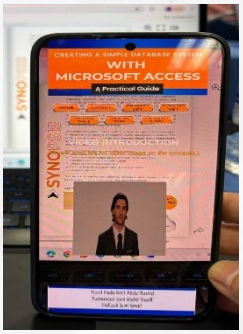
Langkah 1: Memasang Aplikasi: Imbas Kod, kemudian Install file AR Access.apk



Langkah 2: Isi kandungan eBook



Langkah 3: Imbas penanda AR.



Video yang dipaparkan selepas Penanda AR diimbas.

4.0 ANALISIS DATA

4.1 Reka Bentuk Kajian

Kajian ini menggunakan pendekatan tinjauan kuantitatif bagi menilai tahap penerimaan pelajar terhadap penggunaan eBook Infografik dengan Integrasi Augmented Reality (AR).

4.2 Instrumen Kajian

Instrumen kajian yang digunakan ialah satu set soal selidik berstruktur yang dibangunkan menggunakan skala Likert lima mata, iaitu:

1- Sangat Tidak Setuju, 2-Tidak Setuju, 3-Tidak Pasti, 4-Setuju, 5- Sangat Setuju.

Jadual 2 : Skala Interpretasi bagi Skor Min

Skor purata min	Tafsiran
1.00 – 1.89	Sangat rendah
1.90 – 2.69	Rendah
2.70 – 3.49	Sederhana
3.50 – 4.29	Tinggi
4.30 – 5.00	Sangat tinggi

Interpretasi skor min yang digunakan untuk kajian ini adalah seperti dalam Jadual 2 selaras dengan dapatan Chew dan Zul Hazmi (2018).

4.3 Keputusan Kajian

Secara keseluruhannya, objektif 1 adalah tercapai dimana eBook Interaktif Integrasi Dengan AR berjaya dibangunkan. Hasil daripada penggunaan ebook menunjukkan objektif kedua juga tercapai dimana penerimaan pelajar terhadap penggunaan eBook interaktif berada pada tahap sangat tinggi, dengan semua item mencatatkan nilai min melebihi 4.50.

Jadual 3: Penilaian frekuensi, kemudahan dan pengalaman pelajar menggunakan eBook.

Item	Pernyataan	Min	Interpretasi
1	eBook ini mempunyai reka bentuk menarik dan mudah dibaca	4.55	Sangat Tinggi

Item	Pernyataan	Min	Interpretasi
2	Infografik membantu memahami langkah amali Microsoft Access	4.64	Sangat Tinggi
3	Integrasi AR memudahkan memahami konsep	4.64	Sangat Tinggi
4	Kandungan AR menjadikan pembelajaran lebih menyeronokkan	4.59	Sangat Tinggi
5	Saya lebih terdorong membaca bahan dalam bentuk eBook interaktif	4.50	Sangat Tinggi

4.4 Perbincangan

Dapatan kajian menunjukkan bahawa tahap penerimaan pelajar terhadap penggunaan eBook infografik berintegrasi *Augmented Reality* (AR) adalah sangat tinggi, dengan semua item mencatatkan nilai min melebihi 4.50. Pelajar didapati mudah menerima bahan pembelajaran berbentuk visual dan interaktif seperti eBook. Pelajar juga lebih bermotivasi dan berminat untuk belajar menggunakan eBook berbanding bahan konvensional, dan integrasi AR membantu meningkatkan kefahaman konsep teknikal pelajar. Selain itu, fleksibiliti penggunaan AR melalui telefon pintar turut menyokong pembelajaran kendiri dan meningkatkan penglibatan pelajar dalam PdP. Pelajar boleh mengakses nota dan latihan dimana sahaja berada. Walaubagaimanapun, eBook Interaktif Integrasi dengan AR ini adalah hanya terhad kepada pengguna Android dan kursus Pangkalan Data Microsoft Office sahaja. Oleh itu, dicadangkan pembangunan AR untuk IOS dan juga boleh dikembangkan kepada kursus-kursus lain.

5.0 KESIMPULAN

Secara keseluruhannya, eBook Interaktif Integrasi dengan AR *Creating a Simple Database System Using Microsoft Access: A Practical Guide* berjaya dibangunkan dan penggunaannya memberi kesan positif terhadap proses PdP, khususnya dalam mempelbagaikan bahan PdP. Nilai min yang tinggi bagi semua item membuktikan bahawa pelajar menerima baik penggunaan bahan digital yang menggabungkan reka bentuk visual menarik, infografik dan integrasi *Augmented Reality* sebagai medium pembelajaran. eBook interaktif turut meningkatkan motivasi pelajar untuk belajar secara kendiri melalui akses bahan yang fleksibel dan mesra pengguna. Ia berpotensi menjadi alternatif bahan PdP yang berkesan dalam kursus Microsoft Access serta boleh diperluaskan kepada kursus teknikal lain. Walaupun kajian ini melibatkan saiz sampel yang terhad, dapatan awal menunjukkan potensi inovasi ini sebagai satu transformasi pendekatan PdP dalam bidang teknikal. Justeru, kajian lanjutan dengan skop dan populasi lebih luas dicadangkan bagi memperkukuh kesahan dapatan serta menilai keberkesanan inovasi ini dalam jangka masa panjang.

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KEBERKESANAN PENGGUNAAN *COLOR WHEEL-IT* DALAM MENINGKATKAN KEFAHAMAN TEORI WARNA DAN PENGHASILAN REKA BENTUK PENGIKLANAN DALAM KALANGAN PELAJAR

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Abstrak

Kajian ini dijalankan untuk menilai keberkesanan penggunaan alat bantu mengajar *Color Wheel-It* dalam meningkatkan kefahaman teori warna dan penghasilan reka bentuk pengiklanan dalam kalangan pelajar. Objektif utama kajian adalah untuk mengenal pasti tahap keberkesanan alat tersebut terhadap kefahaman teori warna, tahap minat pelajar dalam proses penghasilan reka bentuk pengiklanan, serta menilai kesesuaian reka bentuk produk dari aspek kemudahan penggunaan dan ciri mudah alih (*portable*). Kajian ini menggunakan pendekatan kuantitatif dengan edaran borang soal selidik kepada 59 responden yang terdiri daripada pelajar bidang seni dan reka bentuk. Dapatan kajian menunjukkan bahawa tahap keberkesanan *Color Wheel-It* adalah sangat tinggi dengan skor min keseluruhan 4.36 (SD=0.76), di mana ia terbukti meningkatkan kefahaman pelajar terhadap prinsip harmoni warna secara signifikan. Seterusnya, tahap minat pelajar juga mencatatkan skor yang tinggi iaitu 4.15 (SD=0.84), yang menunjukkan bahawa alat interaktif ini mampu menyuntik motivasi dalam menghasilkan karya iklan yang lebih profesional. Dari aspek reka bentuk produk, responden bersetuju bahawa ciri mudah alih dan sifatnya yang mesra pengguna (Min=4.21, SD=0.84) menjadikannya rujukan teknikal yang praktikal. Implikasi kajian ini mencadangkan bahawa integrasi alat bantuan fizikal seperti *Color Wheel-It* adalah relevan dalam merapatkan jurang antara teori akademik dan aplikasi industri kreatif. Secara keseluruhannya, inovasi ini bukan sahaja memudahkan proses pengajaran dan pembelajaran, malah berpotensi besar untuk dikomersilkan sebagai instrumen sokongan profesional bagi pereka grafik masa kini.

Kata Kunci: Teori Warna, Reka Bentuk Pengiklanan, Alat Bantu Mengajar.

Abstract

This study was conducted to evaluate the effectiveness of the Color Wheel-It teaching aid in enhancing the understanding of color theory and the production of advertising design among students. The primary objectives of the research were to identify the level of effectiveness of the tool regarding the mastery of color theory, the level of student interest in the advertising design production process, and to assess the suitability of the product design in terms of usability and portability. This study employed a quantitative approach, utilizing a survey questionnaire distributed to 59 respondents from the fields of art and design. The findings

indicate that the level of effectiveness for Color Wheel-It is very high, with an overall mean score of 4.36 (SD=0.76), proving that it significantly improves students' understanding of color harmony principles. Furthermore, the level of student interest recorded a high score of 4.15 (SD=0.84), demonstrating that this interactive tool is capable of boosting motivation to produce more professional advertising works. Regarding the product design, respondents agreed that its portability and user-friendly features (Mean=4.21, SD=0.84) make it a practical technical reference. The implications of this study suggest that the integration of physical teaching aids like Color Wheel-It is relevant in bridging the gap between academic theory and creative industry application. Overall, this innovation not only facilitates the teaching and learning process but also holds significant potential for commercialization as a professional support instrument for contemporary graphic designers.

Keywords: *Color Theory, Advertising Design, Teaching Aid.*

1.0 PENGENALAN

Teori warna merupakan elemen kritikal dalam bidang seni dan reka bentuk visual kerana ia bukan sahaja mempengaruhi estetika, malah bertindak sebagai medium komunikasi visual yang berkesan. Walau bagaimanapun, proses penguasaan teori warna sering menjadi cabaran utama bagi golongan pelajar, khususnya dalam memahami hubungan kompleks antara warna asas, sekunder, dan tertier. Menurut Anis Safira et al. (2025), carta warna tradisional yang bersifat statik didapati mengekang kebolehan pelajar untuk bereksperimen secara langsung, sekali gus membataskan kefahaman mereka terhadap aplikasi skema warna yang betul dalam sesuatu projek reka bentuk.

Sebagai penyelesaian inovatif, *Color Wheel-It* diperkenalkan sebagai carta roda warna bercetak interaktif yang membolehkan roda warna ditukar ganti bagi memudahkan penerokaan skema warna kompleks seperti *complementary, analogous, triadic*, dan *tetradic*. Penggunaan alat bantuan yang dinamik ini selari dengan pandangan Wilson (2022) yang menekankan keperluan bahan pembelajaran yang efisien dan berdaya tahan bagi memastikan penguasaan teknik komunikasi visual yang moden. Melalui pendekatan interaktif ini, pelajar bukan sahaja dapat menghasilkan kombinasi warna yang lebih tepat, malah berupaya meningkatkan keyakinan dalam mengendalikan elemen warna mengikut piawaian industri. Oleh itu, penggunaan *Color Wheel-It* wajar diperluaskan dalam proses pengajaran dan pembelajaran bagi memperkasakan kemahiran praktikal serta kreativiti pelajar sejajar dengan keperluan industri kreatif yang kompetitif.

1.1 Pernyataan Masalah

Kajian mendapati bahawa kaedah pembelajaran konvensional yang bergantung sepenuhnya kepada penggunaan carta roda warna statik di pasaran dilihat kurang interaktif dan tidak lagi memadai untuk keperluan pendidikan seni reka moden. Menurut Anis Safira et al. (2025), kekangan pada carta warna tradisional yang bersifat statik ini menyulitkan pelajar untuk meneroka serta memahami skema warna yang lebih kompleks secara mendalam. Isu ini

diperkukuhkan lagi melalui hasil temu bual awal bersama pelajar Sijil Multimedia Kreatif Pengiklanan di Kolej Komuniti Paya Besar, yang mendedahkan bahawa majoriti pelajar masih menghadapi kekeliruan besar dalam menentukan kombinasi warna yang tepat bagi projek reka bentuk mereka.

Ketiadaan elemen interaktiviti dalam alat bantuan sedia ada menyebabkan pemahaman terhadap hubungan dinamik antara warna sukar dicapai, yang akhirnya mengakibatkan penghasilan visual menjadi tidak harmoni dan menjejaskan kualiti output reka bentuk secara keseluruhan. Selain itu, pelajar turut berdepan dengan masalah kecekapan waktu kerana terpaksa menentukan palet warna secara manual yang rumit dan memakan masa. Sehubungan itu, terdapat keperluan mendesak untuk membangunkan satu alat bantuan mengajar yang lebih fleksibel, praktikal, dan sistematik bagi menggantikan roda warna statik. Inovasi seperti ini sangat kritikal bagi memastikan pelajar dapat menguasai teori warna dengan lebih visual, sekali gus menyediakan mereka dengan kemahiran yang relevan untuk mendepani industri reka bentuk grafik yang semakin kompetitif.

1.2 Objektif Kajian

Objektif keseluruhan kajian ini adalah untuk mengenalpasti:

i. Tahap keberkesanan penggunaan *Color Wheel-It* terhadap peningkatan kefahaman teori warna dalam kalangan pelajar.
ii. Tahap minat pelajar terhadap penggunaan *Color Wheel-It* dalam membantu penghasilan reka bentuk pengiklanan.
iii. Kesesuaian reka bentuk produk *Color Wheel-It* daripada aspek kemudahan penggunaan dan ciri mudah alih (*portable*).

1.3 Kepentingan kajian

Kajian terhadap inovasi *Color Wheel-It* ini mempunyai kepentingan yang signifikan dalam memperkasakan proses pengajaran dan pembelajaran (PdP) bagi bidang reka bentuk grafik dan seni kreatif. Penghasilan alat bantuan mengajar (ABM) yang bersifat interaktif ini bukan sahaja berfungsi sebagai solusi kepada kekeliruan teori warna, malah menyokong transformasi pendidikan melalui penggunaan alat yang lebih dinamik dan praktikal.

Secara keseluruhannya, kepentingan kajian ini dibahagikan kepada tiga kumpulan sasar utama seperti berikut:

i. Kepentingan kepada Pelajar

a. Meningkatkan Kefahaman Konseptual: Membantu pelajar memahami hubungan dinamik antara warna asas, sekunder, dan tertier serta skema warna kompleks secara lebih mendalam melalui perwakilan visual yang interaktif.
b. Meningkatkan Keyakinan dan Kreativiti: Memberi ruang kepada pelajar untuk bereksperimen secara langsung dalam memilih kombinasi warna, sekaligus meningkatkan keyakinan mereka dalam mengendalikan elemen visual untuk projek reka bentuk.
c. Kecekapan Masa dan Produktiviti: Menjimatkan masa pelajar dalam proses pemilihan palet warna berbanding kaedah manual yang rumit, seterusnya meningkatkan produktiviti dalam menyiapkan tugasan projek reka bentuk.

ii. Kepentingan kepada Pensyarah

a. Alat Bantuan Mengajar (ABM) yang Dinamik: Memudahkan pensyarah menyampaikan topik teori warna yang sering dianggap abstrak secara lebih interaktif dan praktikal.

b. Memperkukuh Sesi Pengajaran dan Pembelajaran (PdP): Membantu pensyarah menangani kesukaran pelajar dalam memahami skema warna seperti *complementary* dan *triadic* melalui penggunaan alat yang fleksibel dan boleh ditukar ganti.

iii. Kepentingan kepada Institusi

a. Meningkatkan Reputasi Institusi: Kejayaan inovasi ini memperkukuhkan reputasi Kolej Komuniti atau Politeknik sebagai institusi yang menawarkan pendidikan yang inovatif dan relevan dengan keperluan industri.

b. Potensi Komersial: Produk ini mempunyai nilai pasaran yang baik untuk dikomersialkan secara meluas kepada institusi pendidikan lain, yang secara tidak langsung menyumbang kepada pencapaian inovasi di peringkat jabatan.

c. Menyokong Transformasi Pendidikan: Memperkukuhkan kurikulum dengan pendekatan pembelajaran moden yang interaktif bagi melahirkan graduan yang lebih kompeten dalam bidang multimedia kreatif.

2.0 KAJIAN LITERATUR

Penggunaan alat bantu mengajar yang inovatif seperti *Color Wheel-It* merupakan elemen kritikal dalam meningkatkan tahap kefahaman teori warna dalam kalangan pelajar seni. Menurut Abdullah et al. (2022), integrasi peralatan fizikal yang interaktif mampu merangsang kognitif pelajar dengan lebih berkesan berbanding kaedah syarahan tradisional yang bersifat sehala. Kajian oleh Hassan dan Zakaria (2023) pula menegaskan bahawa visualisasi warna secara praktikal membantu pelajar memahami hubungan kromatik yang sukar digambarkan melalui teori semata-mata. Peningkatan kefahaman ini dibuktikan melalui kebolehan pelajar menterjemah konsep warna primer, sekunder, dan tertier dengan lebih tepat dalam tugasan mereka (Yusof, 2025). Oleh itu, tahap keberkesanan alat ini dalam mengukuhkan asas teori warna dilihat sebagai pemangkin utama dalam transformasi pedagogi seni abad ke-21 (Tan & Lim, 2024; Mustafa, 2026).

Seterusnya, tahap minat pelajar terhadap proses pembelajaran didapati meningkat secara signifikan apabila melibatkan penggunaan *Color Wheel-It* dalam penghasilan reka bentuk pengiklanan. Samat et al. (2022) menekankan bahawa penglibatan aktif dengan alat visual yang dinamik dapat mengurangkan kebosanan serta meningkatkan motivasi intrinsik pelajar untuk meneroka kombinasi warna yang lebih berani. Pelajar menunjukkan kecenderungan yang lebih tinggi untuk bereksperimen dengan pelbagai palet warna yang mampu membangkitkan emosi tertentu dalam kempen pemasaran (Sulaiman, 2023). Kajian oleh Chen et al. (2024) juga menunjukkan bahawa iklan yang menggunakan skema warna yang koheren hasil daripada bimbingan alat bantuan visual mempunyai daya tarikan yang lebih tinggi. Secara tidak langsung, minat yang mendalam ini menyumbang kepada kualiti penghasilan karya pengiklanan yang lebih profesional dan kompetitif (Aziz, 2025; Kamal, 2021).

Aspek kesesuaian reka bentuk produk *Color Wheel-It* juga memainkan peranan penting dalam menjamin kelangsungan penggunaannya di dalam dan di luar bilik darjah. Razak et al. (2023) menyatakan bahawa aspek ergonomik dan kemudahan penggunaan (*usability*) adalah faktor utama yang menentukan penerimaan pelajar terhadap sesuatu alat bantuan mengajar. Reka bentuk yang mesra pengguna membolehkan pelajar mengendalikan alat tersebut tanpa memerlukan pengawasan guru yang kerap, sekaligus memupuk pembelajaran kendiri (Alias & Noor, 2024). Selain itu, ciri mudah alih (portable) pada *Color Wheel-It* memudahkan pelajar membawa rujukan warna ini ke mana-mana sahaja untuk sesi perbincangan atau kerja lapangan (Hamid, 2022). Maka, reka bentuk produk yang praktikal dan fleksibel merupakan nilai tambah yang menyokong keberkesanan instruksional secara holistik (Jamil & Said, 2022; Ramli, 2025).

Keberkesanan alat ini turut dikaitkan dengan kemampuannya untuk mengurangkan jurang antara pemahaman teori dan aplikasi teknikal dalam reka bentuk grafik. Wong (2022) membuktikan bahawa rujukan visual yang mudah dicapai dapat mengurangkan kesilapan teknikal pelajar semasa proses memilih warna untuk media cetak mahupun digital. Apabila pelajar memahami logik di sebalik roda warna, mereka lebih yakin untuk membuat keputusan reka bentuk yang objektif berdasarkan prinsip harmoni warna (Ishak, 2023). Penyelidikan oleh Ghani dan Bakar (2021) mendapati bahawa penggunaan alat bantuan yang sistematik dapat mempercepatkan tempoh penghasilan draf reka bentuk pengiklanan tanpa menjejaskan kualiti visual. Justeru, 'Color Wheel It' bukan sekadar alat bantuan, malah berfungsi sebagai panduan teknikal yang meningkatkan efisiensi kerja pelajar dalam bidang kreatif (Rahman, 2021; Nasir, 2021).

Secara keseluruhannya, integrasi *Color Wheel-It* dalam kurikulum seni dan reka bentuk memberikan impak positif yang menyeluruh terhadap prestasi akademik dan kemahiran praktikal pelajar. Saleh et al. (2023) merumuskan bahawa peningkatan markah dalam komponen reka bentuk adalah selari dengan peningkatan minat dan kekerapan penggunaan alat bantuan visual yang tepat. Alat ini memenuhi keperluan pembelajaran masa kini yang menuntut keseimbangan antara teori yang mantap dan reka bentuk produk yang berfungsi secara mobiliti (Zainal, 2026). Dengan sokongan data daripada Latif dan Harun (2024), jelas bahawa penggunaan teknologi atau alat bantuan yang mudah alih adalah kunci utama dalam mendepani cabaran industri pengiklanan moden. Kesimpulannya, *Color Wheel It* adalah inovasi yang relevan dan memenuhi tuntutan objektif pendidikan vokasional serta teknik dalam bidang seni reka (Ibrahim, 2022; Omar, 2024).

3.0 METODOLOGI KAJIAN

3.1 Reka bentuk Kajian

Kajian ini menggunakan pendekatan kuantitatif melalui kaedah tinjauan untuk mengumpul data berangka bagi menjawab objektif kajian. Reka bentuk deskriptif ini digunakan untuk mengenal pasti tahap keberkesanan, minat, dan kesesuaian reka bentuk produk melalui analisis skor min dan sisihan piawai. Item soal selidik telah diadaptasi dan diubah suai daripada instrumen kajian Helmiah Othman et al. (2023) bagi memastikan kesesuaian dengan konteks

produk *Color Wheel-It* yang merangkumi aspek keberkesanan produk, minat pengguna, serta reka bentuk produk.

3.2 Populasi dan Sampel Kajian

Populasi kajian terdiri daripada pelajar dan pensyarah yang terlibat dalam bidang seni dan reka bentuk grafik di institusi TVET. Seramai 59 orang responden telah terlibat secara keseluruhan dalam kajian ini (berdasarkan data analisis sebenar), yang merangkumi pelajar program multimedia kreatif. Kajian ini menggunakan kaedah persampelan bertujuan (*purposive sampling*) di mana responden dipilih berdasarkan penglibatan mereka dalam kursus yang memerlukan aplikasi teori warna. Berdasarkan Jadual Penentuan Saiz Sampel Krejcie dan Morgan (1970), jumlah 59 responden adalah memadai bagi populasi kecil untuk mendapatkan data yang mempunyai kebolehpercayaan tinggi.

3.3 Instrumen Kajian

Instrumen utama kajian adalah borang soal selidik yang diedarkan secara dalam talian menggunakan aplikasi *Google Forms*. Soal selidik ini mengandungi bahagian demografi dan bahagian penilaian yang menggunakan Skala Likert 5-Mata seperti berikut:

1= Sangat Tidak Setuju 2 = Tidak Setuju 3 = Tidak Pasti 4 = Setuju 5 = Sangat Setuju.

Jadual 1 menunjukkan bilangan item mengikut bahagian dengan keseluruhan berjumlah 19 item.

Jadual 1: Bilangan item mengikut Bahagian

BAHAGIAN	ITEM	BIL ITEM	NO SOALAN
A	Demografi	4	A1-A4
B1	Keberkesanan penggunaan Color Wheel IT	6	B1.1-B1.6
B2	Minat pelajar terhadap penggunaan Color Wheel IT	6	B2.1-B2.6
B3	Kesesuaian reka bentuk produk Color Wheel IT	3	B3.1-B3.3
	Jumlah Soalan	19	

3.4 Analisis Data

Kajian ini melibatkan skor min ketika melaksanakan proses penilaian terhadap keberkesanan, minat dan rekabentuk *Color Wheel-It*. Responden boleh menjawab soal selidik secara serta-merta kerana kriteria kesahan dan kebolehpercayaan adalah tinggi di mana nilai Cronbach Alpha bagi keseluruhan soal selidik adalah 0.792 dan menunjukkan bahawa instrumen berada dalam keadaan baik dan boleh diterima (Bond & Fox, 2015). Penyelidik mengintepretasikan skor min kepada 3 tahap seperti Jadual 2.

Jadual 2: Jadual Skor Min

KOD KUMP.	JULAT SKOR MIN	TAHAP
1	1.00 – 2.33	Rendah
2	2.34 – 3.66	Sederhana
3	3.67 – 5.00	Tinggi

4.0 DAPATAN KAJIAN DAN PERBINCANGAN

Kajian ini melibatkan seramai 59 orang responden yang terdiri daripada pelajar dan pensyarah dalam bidang seni dan multimedia. Ringkasan profil demografi adalah seperti berikut:

i. Kategori Responden: Majoriti responden merupakan pelajar iaitu seramai 56 orang (95%), manakala bakinya terdiri daripada 3 orang pensyarah (5%).
ii. Taburan Jantina: Komposisi jantina adalah hampir seimbang, merangkumi 31 orang responden perempuan dan 29 orang lelaki.
iii. Profil Umur: Responden berada dalam julat umur antara 18 hingga 48 tahun, dengan purata umur bagi keseluruhan sampel adalah 20 tahun.

4.1 Keberkesanan Produk Inovasi *Color Wheel-It* Sebagai ABM Dalam PdP

Kategori ini menilai sejauh mana *Color Wheel-It* membantu meningkatkan kefahaman teori warna. Tahap keberkesanan adalah sangat tinggi. Berdasarkan jadual 3, pelajar bersetuju bahawa alat ini paling membantu dalam meningkatkan kefahaman teori warna dan memastikan konsistensi dalam tugasan (Min=4.39).

Jadual 3: Keberkesanan Produk Inovasi *Color Wheel-It* Sebagai ABM Dalam PdP

Item	Min	Sisihan Piawai (SD)
Penggunaan *Color Wheel-It* ini menjadikan saya lebih berminat untuk subjek asas seni atau penghasilan reka bentuk pengiklanan seperti reka bentuk poster.	4.32	0.78
Penggunaan *Color Wheel-It* meningkatkan kefahaman saya dalam teori warna dan prinsip harmoni warna dalam asas seni.	4.39	0.72
Penggunaan *Color Wheel-It* dapat menjimatkan masa saya dalam pemilihan palet warna yang sesuai untuk reka bentuk pengiklanan berbanding kaedah manual.	4.36	0.83
Saya merasakan penggunaan *Color Wheel-It* dapat meningkatkan kemahiran saya dalam mengaplikasikan warna secara berkesan untuk menyampaikan mesej dalam pengiklanan.	4.36	0.76
Konsistensi penggunaan warna dalam tugasan yang dihasilkan dengan menggunakan *Color Wheel-It* adalah mencukupi dan menepati objektif reka bentuk.	4.39	0.74

Saya berjaya mengatasi masalah memilih kombinasi warna yang tidak serasi atau tidak sesuai ketika menyiapkan tugasan dalam subjek Asas Seni atau penghasilan reka bentuk pengiklanan seperti reka bentuk poster.	4.34	0.78
Purata	**4.36**	**0.76**

4.2 Minat Pelajar Terhadap Produk Inovasi *Color Wheel-It*

Kategori ini menilai minat dan keseronokan pelajar menggunakan *Color Wheel-It* dalam reka bentuk pengiklanan. Berdasarkan jadual 4, tahap minat pelajar berada pada tahap tinggi (Min=4.15). Pelajar menyatakan keseronokan yang tinggi (Min=4.24) apabila menggunakan alat ini dalam menyiapkan tugasan mereka.

Jadual 4: Minat Pelajar Terhadap Produk Inovasi *Color Wheel-It*

Item	Min	Sisihan Piawai (SD)
Saya suka menggunakan *Color Wheel-It* kerana ia memudahkan proses pemilihan dan aplikasi warna dalam reka bentuk pengiklanan.	4.15	0.89
Saya dapat menjimatkan masa dalam mencari inspirasi dan menentukan skema warna dengan menggunakan *Color Wheel-It*.	4.15	0.91
Hasil kerja reka bentuk saya lebih menarik secara visual dan profesional berbanding kerja secara manual.	4.12	0.85
Saya seronok menghasilkan reka bentuk pengiklanan dan tugasan Asas Seni menggunakan *Color Wheel-It*.	4.24	0.77
Saya dapati dengan menggunakan *Color Wheel-It* telah meningkatkan minat saya terhadap teori warna dan aplikasi seni dalam bidang multimedia kreatif.	4.12	0.83
Saya berkeyakinan untuk menghasilkan tugasan projek pengiklanan yang menarik perhatian dari segi visual apabila menggunakan *Color Wheel-It*.	4.12	0.83
Purata	**4.15**	**0.84**

4.3 Rekabentuk Produk Inovasi *Color Wheel-It* Sebagai ABM Dalam PdP

Kategori ini menilai aspek kemudahan penggunaan dan ciri mudah alih (*portability*). Reka bentuk produk dinilai sebagai sangat sesuai. Seperti yang ditunjukkan dalam jadual 5, pelajar bukan sahaja melihatnya sebagai alat yang mudah alih (Min=4.20), malah percaya ia mempunyai potensi besar untuk dikomersilkan (Min=4.24).

Jadual 5: Rekabentuk Produk Inovasi *Color Wheel-It* Sebagai ABM Dalam PdP

Item	Min	Sisihan Piawai (SD)
Saya suka rekaan *Color Wheel-It* yang interaktif dan mudah digunakan untuk penerokaan warna.	4.19	0.84
Color Wheel-It It boleh digunakan dan dibawa ke mana-mana sahaja untuk rujukan cepat dalam projek reka bentuk.	4.20	0.85
Sekiranya *Color Wheel-It* ini dikomersilkan, saya pasti ia akan mendapat sambutan di kalangan pelajar multimedia, pereka grafik, dan artis.	4.24	0.84
Purata	**4.21**	**0.84**

4.4 Perbincangan

Hasil kajian membuktikan bahawa penggunaan *Color Wheel-It* memberikan impak positif yang signifikan terhadap proses pembelajaran teori warna dalam kalangan pelajar. Alat bantuan interaktif ini berjaya memudahkan pemahaman konsep harmoni warna yang sebelum ini sukar dikuasai melalui kaedah tradisional yang bersifat statik. Peningkatan minat dalam penghasilan tugasan pengiklanan turut menunjukkan bahawa elemen interaktif produk mampu merangsang motivasi pelajar untuk meneroka kreativiti visual dengan lebih berani. Selain bidang reka bentuk grafik, fleksibiliti *Color Wheel-It* membolehkan inovasi ini diaplikasikan secara meluas dalam pelbagai disiplin seni lain seperti bidang fesyen, seni lukisan, dan hiasan dalaman.

Dari aspek fizikal, reka bentuk produk yang praktikal dan mudah alih memberikan fleksibiliti kepada pelajar untuk menjalankan aktiviti pembelajaran di luar persekitaran studio yang konvensional. Secara tidak langsung, *Color Wheel-It* berfungsi sebagai jambatan kognitif yang merapatkan jurang antara pengetahuan teori akademik dengan kemahiran praktikal yang diperlukan oleh industri kreatif secara keseluruhannya. Tuntasnya, kualiti hasil kerja yang lebih profesional serta peningkatan keyakinan diri pelajar mengukuhkan keperluan integrasi inovasi ini dalam kurikulum pendidikan seni dan reka bentuk.

5.0 KESIMPULAN DAN CADANGAN

Kesimpulannya, kajian ini membuktikan bahawa penggunaan *Color Wheel-It* berjaya meningkatkan tahap kefahaman pelajar terhadap teori warna serta kualiti penghasilan reka bentuk pengiklanan secara signifikan. Inovasi ini bukan sahaja merangsang minat pelajar melalui elemen interaktif, malah diiktiraf sebagai alat bantuan yang praktikal serta mudah alih untuk rujukan pantas dalam projek reka bentuk. Berdasarkan maklum balas positif, produk ini mempunyai potensi pengkomersialan yang sangat besar dalam kalangan multimedia, pereka grafik, dan artis kerana keupayaannya menjimatkan kos serta boleh digunakan secara berulang berbanding roda warna tradisional.

Bagi cadangan penambahbaikan, penggunaan bahan yang lebih tahan lama seperti plastik PVC atau bahan lamina wajar dipertimbangkan untuk menjamin ketahanan produk bagi kegunaan jangka panjang. Selain itu, integrasi teknologi digital seperti Kod QR dan *Augmented Reality* (AR) dicadangkan bagi menyediakan akses terus kepada tutorial serta video panduan yang lebih dinamik untuk para pengguna di masa hadapan.

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KERTAS PENULISAN PENYELIDIKAN : SAINS SOSIAL

PERSEPSI INDUSTRI TERHADAP LATIHAN INDUSTRI DAN KESEDIAAN MEMBERI PENEMPATAN KERJA: TINJAUAN DI KOLEJ KOMUNITI KUALA TERENGGANU

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ABSTRAK

Kajian ini dijalankan untuk menilai persepsi industri terhadap Latihan Industri (LI) dan kesediaan mereka dalam memberi penempatan kerja kepada pelajar Kolej Komuniti Kuala Terengganu. Reka bentuk tinjauan kuantitatif digunakan dengan edaran soal selidik kepada 92 responden daripada pelbagai sektor industri. Data yang di kumpul menggunakan *Statistical Package for the Social Science* (SPSS) versi 13. Analisis deskriptif menunjukkan bahawa persepsi industri terhadap pengetahuan, kemahiran praktikal, dan kemahiran insaniah pelajar berada pada tahap tinggi (min purata 4.01, SP:0.83). Dapatan juga memperlihatkan tahap kesediaan industri dalam menyediakan peluang pekerjaan selepas LI adalah positif (min purata 4.22, SP:0.60), dengan majoriti sebanyak 80.4% bersedia menyerap pelajar jika terdapat kekosongan jawatan. Walau bagaimanapun, analisis korelasi *Spearman's rho* mendapati hubungan antara persepsi industri dengan kesediaan memberi penempatan kerja adalah sangat lemah dan tidak signifikan (r = 0.110, p = 0.295). Ini menjelaskan bahawa faktor kesediaan industri tidak semata-mata bergantung pada persepsi terhadap Latihan Industri, tetapi turut dipengaruhi oleh aspek luaran seperti keadaan ekonomi, kekosongan jawatan, dan dasar organisasi. Oleh itu, Latihan Industri masih penting dalam meningkatkan kebolehpasaran graduan, namun usaha tambahan diperlukan untuk menjamin peluang penempatan kerja yang lebih kukuh.

Kata Kunci: Latihan Industri; Persepsi Industri; Kesediaan Industri; Kebolehpasaran Graduan; Kolej Komuniti; TVET

Abstract

This study was conducted to evaluate industry perceptions of Industrial Training (IT) and their readiness to offer *job placements to students of Kolej Komuniti Kuala Terengganu. A quantitative survey design was employed through the distribution of questionnaires to 92 respondents from various industry sectors. The data collected were analyzed using the Statistical Package for the Social Sciences (SPSS) version 13. Descriptive analysis showed that industry perceptions of students' knowledge, practical skills, and soft skills were at a high level (mean = 4.01, SP = 0.83). The findings also indicated that the level of industry readiness to provide employment opportunities after Industrial Training was positive (mean = 4.22, SP*

= 0.60), with a majority of 80.4% willing to absorb students if job vacancies are available. However, Spearman's rho correlation analysis found that the relationship between industry perception and readiness to provide job placement was very weak and not significant (r = 0.110, p = 0.295). This suggests that industry readiness does not solely depend on perceptions of Industrial Training, but is also influenced by external factors such as economic conditions, job availability, and organizational policies. Therefore, Industrial Training remains important in enhancing graduates' employability, but additional efforts are needed to ensure more secure job placement opportunities.

Keywords: *Industrial Training; Industry Perception; Industry Readiness; Graduate Employability; Community College; TVET*

1.0 PENGENALAN

Latihan Industri (LI) merupakan elemen teras dalam sistem pendidikan teknikal dan vokasional (TVET) di *Malaysia* yang menghubungkan dunia akademik dengan dunia pekerjaan sebenar (Ismail, Yusof, & Rahman, 2020). Dalam konteks Kolej Komuniti, LI berperanan penting melengkapkan pelajar dengan kemahiran teknikal, insaniah, serta etika kerja yang tidak diperoleh sepenuhnya di bilik kuliah. Ia bukan sekadar pengalaman pembelajaran berasaskan kerja, tetapi menjadi platform penting untuk membina keyakinan, profesionalisme dan kesiapsiagaan pelajar menghadapi cabaran industri sebenar.

Kejayaan LI tidak hanya bergantung kepada kurikulum atau usaha pelajar, tetapi turut dipengaruhi oleh penerimaan serta kerjasama pihak industri. Industri memainkan peranan penting bukan sahaja dengan menyediakan tempat latihan, tetapi juga menilai potensi pelajar untuk diserap ke pasaran kerja. Persepsi positif terhadap keberkesanan LI menjadi penentu sama ada pelajar dianggap relevan dan berdaya saing (Rahman & Ibrahim, 2021). Sekiranya LI dilihat bermanfaat, peluang pelajar untuk ditempatkan bekerja selepas tamat latihan akan meningkat (Abdullah, Ismail, & Hamid, 2021).

1.1 Pernyataan Masalah

Walaupun LI dilaksanakan secara meluas, timbul persoalan sama ada industri benar-benar melihat keberkesanannya sebagai medium untuk menghasilkan graduan yang berkualiti. Ada kalanya, industri hanya menganggap LI sebagai tanggungjawab sosial atau aktiviti rutin tanpa memberi komitmen jangka panjang kepada pelajar (Mohamad, Tan, & Ahmad, 2022). Situasi ini menyebabkan wujud jurang antara hasrat institusi pendidikan untuk meningkatkan kebolehpasaran graduan dengan kesediaan sebenar industri dalam memberi penempatan bekerja.

Di Kolej Komuniti Kuala Terengganu khususnya, isu ini sangat signifikan kerana pelajar datang daripada pelbagai latar belakang sosioekonomi dan majoritinya bergantung pada peluang pekerjaan selepas tamat pengajian. Sekiranya industri tidak bersedia untuk menempatkan pelajar selepas LI, matlamat LI sebagai mekanisme membina kerjaya mungkin tidak tercapai.

Oleh itu, kajian ini perlu dijalankan bagi memahami sejauh mana persepsi industri terhadap LI memberi kesan kepada kesediaan mereka menawarkan peluang pekerjaan.

1.2 Objektif Kajian

Kajian ini dijalankan dengan objektif:

a) Mengenal pasti persepsi industri terhadap Latihan Industri dari segi pengetahuan kemahiran praktikal, dan kemahiran insaniah pelajar.

b) Menilai tahap kesediaan industri dalam memberi penempatan kerja kepada pelajar selepas latihan industri.

c) Menganalisis hubungan antara persepsi industri terhadap Latihan Industri dengan kesediaan industri dalam memberi penempatan kerja kepada pelajar.

1.3 Kepentingan Kajian

Kajian ini mempunyai beberapa kepentingan utama, antaranya adalah seperti di bawah:

a) Kepentingan kepada Institusi Pendidikan

Dapatan kajian ini akan membantu pihak Kolej Komuniti memahami bagaimana industri menilai keberkesanan LI. Maklumat ini penting bagi menambah baik struktur kurikulum, modul LI, dan kaedah persediaan pelajar sebelum ditempatkan di industri (Aziz, Rahman, & Hassan, 2021).

b) Kepentingan kepada Industri

Kajian ini dapat memberi gambaran kepada pihak industri tentang persepsi rakan industri lain dan sejauh mana mereka melihat LI sebagai satu strategi pengambilan tenaga kerja. Hal ini penting kerana LI boleh dijadikan platform kos rendah untuk mengenal pasti bakat baharu sebelum ditempatkan bekerja secara tetap (Tan & Lee, 2020).

c) Kepentingan kepada Pelajar

Bagi pelajar, hasil kajian ini dapat memberi kefahaman tentang faktor yang mempengaruhi peluang mereka ditempatkan bekerja selepas LI. Dengan itu, mereka dapat mempersiapkan diri dari segi kemahiran teknikal, komunikasi, dan sikap profesional yang lebih selari dengan kehendak industri (Yusof, Abdullah, & Hassan, 2023).

d) Kepentingan kepada Polisi TVET

Hasil kajian ini juga boleh dijadikan rujukan kepada pembuat dasar dalam merangka strategi memperkukuh kerjasama antara institusi TVET dan industri, sejajar dengan aspirasi Malaysia untuk meningkatkan kebolehpasaran graduan TVET (Ministry of Higher Education Malaysia, 2022).

Secara keseluruhan, kajian ini diharapkan dapat memberikan sumbangan kepada usaha mengurangkan jurang antara pendidikan dan keperluan pasaran kerja melalui pendekatan yang lebih kolaboratif antara Kolej Komuniti dan industri.

2.0 SOROTAN KAJIAN

2.1 Kerangka Teori

Kajian mengenai latihan industri dan kebolehpasaran graduan sering berlandaskan teori modal insan (*Human Capital Theory*). Teori ini menegaskan bahawa pendidikan dan latihan adalah pelaburan yang mampu meningkatkan produktiviti individu serta nilai mereka di pasaran kerja (Becker, 1993; diaplikasi semula oleh Tan & Lee, 2020). Dalam konteks latihan industri, pengalaman kerja sebenar dianggap sebagai modal insan tambahan yang membolehkan pelajar bersaing dengan lebih baik dalam pasaran pekerjaan.

Selain itu, kajian ini juga boleh dikaitkan dengan *Employability Theory* yang menekankan gabungan kemahiran teknikal, kemahiran insaniah, dan sikap kerja sebagai faktor utama kebolehpasaran graduan (Rothwell, 2015; Abdullah et al., 2021). Persepsi industri terhadap keberkesanan LI berperanan sebagai indikator sama ada latihan yang diberikan benar-benar melahirkan graduan berdaya saing.

2.2 Persepsi Industri terhadap Latihan Industri

Banyak kajian menunjukkan persepsi majikan terhadap latihan industri berhubung rapat dengan tahap kemahiran yang ditunjukkan oleh pelajar. Rahman dan Ibrahim (2021) mendapati majikan menilai LI sebagai medium penting untuk menilai kebolehan komunikasi, sikap profesional, dan daya tahan pelajar. Persepsi yang positif bukan sahaja memberi keyakinan kepada industri terhadap program LI, tetapi turut meningkatkan peluang pelajar ditempatkan bekerja selepas tamat latihan.

Dalam kajian Aziz, Rahman, dan Hassan (2021), industri yang merasakan latihan industri membantu pelajar menyesuaikan diri dengan budaya organisasi lebih bersedia untuk mengekalkan mereka sebagai pekerja tetap. Ini menunjukkan persepsi terhadap keberkesanan LI bukan sekadar soal kemahiran teknikal, tetapi juga melibatkan penilaian terhadap kesesuaian sikap, nilai kerja, dan adaptasi sosial pelajar dalam organisasi.

2.3 Kesediaan Industri Menempatkan Pelajar

Kesediaan industri untuk menempatkan pelajar selepas LI sering dipengaruhi oleh keperluan tenaga kerja semasa, dasar organisasi, dan faktor ekonomi. Mohamad, Tan, dan Ahmad (2022) mendapati bahawa kekangan kos dan kekurangan jawatan tetap menjadi penghalang utama kepada industri dalam menempatkan pelajar. Namun begitu, sektor yang sedang berkembang lebih cenderung untuk mengambil pelajar kerana mereka melihat LI sebagai satu mekanisme pembangunan bakat yang kos efektif.

Dalam kajian antarabangsa, Zainuddin et al. (2020) mendapati bahawa syarikat multinasional lebih bersedia menempatkan pelajar kerana mereka mempunyai sumber yang lebih besar serta sistem pembangunan modal insan yang tersusun. Hal ini berbeza dengan syarikat kecil yang sering menghadapi keterbatasan sumber untuk mengekalkan pelajar selepas LI.

2.4 Hubungan antara Persepsi dan Kesediaan

Kajian lepas menunjukkan terdapat hubungan signifikan antara persepsi positif industri dengan kesediaan menempatkan pelajar bekerja. Abdullah, Ismail, dan Hamid (2021) melaporkan bahawa majikan yang berpuas hati dengan prestasi pelajar semasa LI mempunyai kecenderungan lebih tinggi untuk menawarkan pekerjaan. Dapatan ini sejajar dengan Yusof, Abdullah, dan Hassan (2023) yang menegaskan bahawa kerjasama TVET-industri dapat meningkatkan peluang pelajar mendapat pekerjaan.

Namun begitu, terdapat jurang penyelidikan dari sudut konteks Kolej Komuniti. Banyak kajian terdahulu lebih tertumpu pada universiti awam atau politeknik. Kajian khusus yang menilai persepsi dan kesediaan industri di Kolej Komuniti masih kurang, meskipun kumpulan ini memainkan peranan besar dalam melahirkan tenaga kerja mahir di peringkat akar umbi. Oleh itu, kajian ini penting bagi mengisi kelompongan tersebut.

3.0 METODOLOGI KAJIAN

3.1 Reka Bentuk Kajian

Kajian ini menggunakan pendekatan kuantitatif dengan reka bentuk tinjauan (*survey design*). Reka bentuk ini dipilih kerana ia sesuai untuk mengumpul data dalam skala besar, membolehkan penyelidik menilai pola persepsi dan kesediaan industri secara sistematik (Creswell & Creswell, 2018). Selain itu, kajian tinjauan memudahkan pengukuran hubungan antara pemboleh ubah menggunakan kaedah statistik inferensi.

3.2 Populasi dan Sampel Kajian

Populasi kajian terdiri daripada 92 wakil industri yang menerima pelajar Kolej Komuniti Kuala Terengganu untuk menjalani Latihan Industri Sesi II 2024/2025. Kaedah pensampelan bertujuan digunakan kerana hanya industri yang terlibat secara langsung dengan program latihan ini yang mempunyai pengalaman menilai keberkesanannya.

3.3 Instrumen Kajian

Instrumen yang digunakan ialah borang soal selidik yang menggunakan skala Likert lima mata diambil daripada Soal Selidik Kajian Keberkesanan Latihan Industri Program Pengajian Politeknik dan Kolej Komuniti Malaysia (Maklum Balas Industri) yang disediakan dalam Buku Panduan Pelaksanaan Latihan Industri Kolej Komuniti Edisi 2022. Instrumen ini mengandungi empat bahagian utama iaitu:

a) Bahagian A: Maklumat Industri (lokasi, bilangan staf, kategori industri, perolehan, jawatan responden).
b) Bahagian B: Penilaian terhadap aspek Pengetahuan, Kemahiran Praktikal dan Kemahiran Insaniah Pelajar semasa LI
c) Bahagian C: Penilaian terhadap aspek-aspek pelaksanaan latihan industri (LI) dari perspektif industri
d) Bahagian D: Maklumat Tambahan - soalan berbentuk ya/tidak berkaitan penyediaan sijil, perkhidmatan kesihatan, tempoh latihan, serta kesediaan mengambil pelajar bekerja selepas latihan.

3.4 Kesahan dan Kebolehpercayaan Instrumen Kajian

Soal selidik kajian ini diadaptasi daripada Buku Panduan Pelaksanaan Latihan Industri Kolej Komuniti Edisi 2022 yang diterbitkan oleh Bahagian Instruksional dan Pembelajaran Digital, Jabatan Pendidikan Politeknik dan Kolej Komuniti, Kementerian Pengajian Tinggi. Instrumen ini merupakan soal selidik standard yang digunakan untuk mengumpul maklum balas industri mengenai keberkesanan latihan industri pelajar kolej komuniti di seluruh Malaysia. Instrumen ini telah terbukti sah dan boleh dipercayai melalui kajian rintis yang telah dijalankan. Nilai Alpha Cronbach yang di perolehi adalah tinggi untuk keboleh kepercayaan.

3.5 Prosedur Pengumpulan Data

Data dikumpulkan melalui edaran borang Google Form kepada pihak industri selepas pelajar menamatkan latihan industri mereka. Responden diberi tempoh dua minggu untuk melengkapkan soal selidik. Etika penyelidikan dipatuhi dengan memastikan kerahsiaan maklumat syarikat dan individu, serta penggunaan data hanya untuk tujuan akademik.

3.6 Kaedah Analisis Data

Bagi objektif pertama, data yang di kumpul menggunakan Statistical Package for the Social Science (SPSS) versi 13, bagi analisis deskriptif akan digunakan untuk menggambarkan persepsi industri terhadap pelaksanaan latihan industri melalui min dan sisihan piawai yang melibatkan aspek pengetahuan, kemahiran praktikal dan kemahiran insaniah pelajar. Objektif kedua pula menilai kesediaan industri dalam menawarkan penempatan kerja selepas latihan industri melalui analisis deskriptif melibatkan frekuensi, min dan sisihan piawai berdasarkan item soal selidik berkaitan peluang pekerjaan serta hubungan industri dengan institusi pendidikan. Seterusnya, objektif ketiga menggunakan analisis korelasi Pearson atau Spearman bagi menguji hubungan antara persepsi industri terhadap latihan industri dengan kesediaan memberi penempatan kerja. Analisis ini membantu mengenal pasti sama ada wujud hubungan positif atau negatif yang signifikan antara kedua-dua pemboleh ubah tersebut.

4.0 DAPATAN DAN PERBINCANGAN

4.1 Mengenal Pasti Persepsi Industri Terhadap Latihan Industri Dari Segi Pengetahuan, Kemahiran Praktikal, Dan Kemahiran Insaniah Pelajar

Jadual 4.1: Dapatan Objektif Kajian Pertama

Kod	Item	Min	Sisihan Piawai
Aspek: Pengetahuan			
P1	Pelajar mempunyai pengetahuan berdasarkan keperluan kerja.	3.75	1.02
P2	Pelajar mempraktikkan pengetahuan yang telah dipelajari di institusi.	3.95	1.03
P3	Pelajar menguasai ilmu baharu di tempat Latihan Industri.	4.24	0.95
P4	Pelajar berkebolehan menyelesaikan masalah di dalam tugasannya.	3.92	1.04
P5	Pelajar boleh berfikir secara kreatif dan inovatif.	3.83	1.07

	Min Purata	3.94	0.84
Aspek: Kemahiran Praktikal			
KP1	Pelajar didedahkan dengan kemahiran yang bersesuaian dengan keperluan kerja.	4.03	1.01
KP2	Pelajar mempraktikkan kemahiran yang telah dipelajari di institusi.	3.99	0.98
KP3	Pelajar mematuhi prosedur kerja yang ditetapkan.	4.17	0.98
KP4	Pelajar memenuhi sasaran kerja yang telah ditetapkan.	3.93	1.00
KP5	Pelajar mematuhi ciri-ciri keselamatan di tempat LI.	4.11	0.97
	Min Purata	4.05	0.84
Aspek: Kemahiran Insaniah			
KI1	Pelajar menerima teguran secara positif.	4.20	1.05
KI2	Pelajar dapat menyesuaikan diri dengan budaya kerja di industri.	4.24	1.03
KI3	Pelajar tidak melanggar peraturan yang ditetapkan oleh industri.	4.07	1.00
KI4	Pelajar mempunyai integriti dalam melaksanakan tugasan.	4.09	1.00
KI5	Pelajar berkebolehan merancang kerja berkaitan tugasan.	4.05	0.99
KI6	Pelajar boleh bekerja secara berpasukan di dalam melaksanakan tugas.	4.16	1.02
KI7	Pelajar menunjukkan ciri-ciri kepimpinan	3.76	1.05
KI8	Pelajar berkebolehan berkomunikasi dengan baik.	4.09	1.04
KI9	Pelajar berkebolehan berkomunikasi dalam Bahasa Inggeris	3.62	1.07
KI10	Pelajar mampu bekerja sendiri dengan pengawasan minimum.	3.83	1.10
KI11	Pelajar mengoptimumkan sumber yang dibekalkan oleh industri.	4.03	0.99
	Min Purata	4.01	0.83

Berdasarkan dapatan kajian pada Jadual 4.1, nilai min bagi setiap item yang mengukur persepsi industri terhadap pengetahuan, kemahiran praktikal, dan kemahiran insaniah pelajar menunjukkan hasil yang positif dan konsisten. Secara keseluruhannya, pelajar di Kolej Komuniti Kuala Terengganu telah menunjukkan prestasi yang memuaskan di semua aspek yang dinilai oleh industri.

Dapatan aspek pengetahuan pelajar menunjukkan item P3 iaitu penguasaan ilmu baharu oleh pelajar mencatatkan min tertinggi (M: 4.24, SP: 0.95), menandakan industri berpendapat pelajar mampu mempelajari pengetahuan baharu sepanjang latihan. Pengetahuan ini memberi kelebihan dalam pasaran kerja seperti dinyatakan oleh Kamaruddin et al. (2020). Namun, item P1 mencatatkan min terendah (M: 3.75, SP: 1.02), menunjukkan variasi persepsi terhadap kesesuaian pengetahuan pelajar dengan keperluan kerja. Ini menandakan masih ada ruang untuk penambahbaikan, khususnya dalam penguasaan pengetahuan teknikal yang lebih mendalam.

Bagi aspek kemahiran praktikal pelajar, item KP3, iaitu pematuhan pelajar terhadap prosedur kerja, mencatatkan min tertinggi (M: 4.17, SP: 0.98), menunjukkan keupayaan pelajar bekerja secara sistematik dan menepati standard industri. Pematuhan ini penting untuk keselamatan

dan kelancaran operasi (Hassan et al., 2020). Namun, item KP4 mengenai pencapaian sasaran kerja mencatatkan min terendah (M: 3.93, SP: 1.00), menunjukkan terdapat cabaran dalam memenuhi jangkaan industri. Sisihan piawai yang lebih tinggi menunjukkan tahap pencapaian pelajar berbeza, memerlukan pendedahan kepada tugasan lebih mencabar.

Kemahiran menyesuaikan diri dengan budaya kerja (KI2) dalam aspek kemahiran insaniah pelajar mendapat min tertinggi (M: 4.24, SP: 1.03) menunjukkan pelajar mampu bekerja dengan berkesan dalam persekitaran industri. Ini sejajar dengan dapatan Noor et al. (2020) yang menekankan kepentingan kemahiran adaptasi. Namun, kemahiran komunikasi dalam Bahasa Inggeris (KI9) mencatatkan min terendah (M: 3.62, SP: 1.07), menunjukkan perbezaan besar dalam kecekapan pelajar. Oleh itu, peningkatan kemahiran komunikasi, khususnya dalam bahasa asing, amat penting bagi meningkatkan kebolehpasaran pelajar (Taha et al., 2021).

Secara keseluruhan, industri menilai pengetahuan, kemahiran praktikal, dan kemahiran insaniah pelajar semasa Latihan Industri pada tahap yang baik, dengan min purata keseluruhan 4.01. Aspek kekuatan utama termasuk penguasaan ilmu baharu, pematuhan prosedur kerja, dan kemampuan menyesuaikan diri. Walau bagaimanapun, cabaran utama ialah memenuhi sasaran kerja dan penguasaan komunikasi dalam Bahasa Inggeris. Institusi pendidikan perlu memberi tumpuan kepada aspek ini bagi meningkatkan kesiapsiagaan pelajar menghadapi keperluan industri yang semakin kompetitif.

4.2 Menilai tahap kesediaan industri dalam memberi penempatan kerja kepada pelajar selepas latihan industri

Objektif kedua kajian ini ialah menilai tahap kesediaan industri dalam memberi penempatan kerja kepada pelajar selepas latihan industri. Pemilihan item seperti LISA membantu pelajar mendapat pekerjaan dan memberi peluang industri memilih bakal pekerja adalah penting kerana ia menunjukkan impak latihan terhadap kebolehpasaran pelajar (Zainuddin et al., 2020). Selain itu, item berkaitan kerjasama berterusan antara industri dan institusi mengukur tahap komitmen industri dalam menyediakan peluang pekerjaan (Abdullah et al., 2021).

Item lain seperti pelaksanaan LI mempromosikan jenama industri dan tanggungjawab sosial industri terhadap pembangunan pendidikan menilai kesediaan industri dari aspek strategik dan sosial (Hassan et al., 2020). Item kesediaan industri menyerap pelajar apabila ada kekosongan pula memberi gambaran langsung tentang peluang penempatan kerja sebenar. Secara keseluruhannya, pemilihan item ini disokong oleh teori model penempatan pekerjaan dan kajian terdahulu yang menekankan peranan kerjasama, kesediaan merekrut dan manfaat LI sebagai faktor utama dalam penempatan pelajar.

Jadual 4.2: Dapatan Objektif Kajian Kedua

Kod	Item	Min	Sisihan Piawai
Bahagian C: Keterlibatan Industri (LI)			
K1	Latihan Industri Semester Akhir (LISA) membantu pelajar dalam mendapatkan pekerjaan.	4.27	1.00
K2	Pelaksanaan LISA membantu industri dalam memilih bakal pekerja.	4.08	0.97
K3	Organisasi saya akan bekerjasama secara berterusan dengan institusi.	4.18	0.97
K4	Pelaksanaan LI turut mempromosikan jenama industri dan institusi.	4.23	0.95
K5	Industri turut bertanggungjawab memberi sumbangan kepada pembangunan pendidikan negara.	4.33	0.93
	Min Purata	4.22	0.60
Bahagian D: Maklumat Tambahan			
Kod	Item	Ya (%)	Tidak (%)
K6	Sekiranya ada kekosongan, organisasi saya bersedia menyerap/mengambil pelajar berkerja.	80.4	19.6

Berdasarkan Jadual 4.2, analisis menunjukkan tahap kesediaan industri memberi penempatan kerja selepas latihan industri berada pada tahap tinggi dengan min purata 4.22. Item K5 mencatatkan min tertinggi (M: 4.33, SP: 0.93), menunjukkan kesedaran industri terhadap tanggungjawab mereka dalam pembangunan pendidikan dan penyediaan peluang pekerjaan (Zainuddin et al., 2020). Walaupun Item K2 (M: 4.08, SP: 0.97) mencatatkan min terendah daripada semua item, tetapi ia masih dalam kategori tahap tinggi. Ini menunjukkan bahawa pelaksanaan LISA membantu industri mengenal pasti bakal pekerja yang sesuai dengan keperluan mereka.

LISA memainkan peranan penting dalam meningkatkan kebolehpasaran pelajar dengan membantu mereka mendapatkan pekerjaan serta memudahkan industri memilih calon yang berpotensi. Min tinggi bagi Item K1 dan K2 membuktikan bahawa latihan industri bukan sahaja bermanfaat kepada pelajar, tetapi turut memberi nilai tambah kepada industri dalam proses pengambilan pekerja. Kerjasama berterusan antara industri dan institusi (Item K3) juga didapati sebagai faktor penting yang meningkatkan peluang penempatan kerja pelajar.

Selain itu, Item K4 menunjukkan bahawa pelaksanaan LISA turut membantu mempromosikan jenama industri, manakala Item K6 mencatatkan 80.4% industri bersedia menyerap pelajar apabila terdapat kekosongan. Ini menunjukkan kesediaan tinggi industri untuk merekrut pelajar berprestasi baik selepas latihan. Secara keseluruhan, dapatan mencerminkan hubungan positif antara latihan industri, kerjasama institusi, dan peluang pekerjaan, sekali gus memberi prospek cerah kepada pelajar untuk memasuki pasaran kerja.

4.3 Menganalisis hubungan antara persepsi industri terhadap Latihan Industri dengan tahap kesediaan industri dalam memberi penempatan kerja kepada pelajar selepas latihan industri.

4.3.1 Ujian Normaliti

Jadual 4.3 menunjukkan ujian normaliti dilaksanakan menggunakan Kolmogorov-Smirnov/ Shapiro-Wilk. Hasil ujian menunjukkan nilai signifikan adalah kurang daripada 0.05, menandakan data tidak bertaburan secara normal. Oleh itu, analisis korelasi menggunakan kaedah Spearman's Rank Correlation (Spearman rho) dipilih kerana lebih sesuai untuk data tidak normal.

Jadual 4.3: Ujian Normaliti

Tests of Normality						
	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Min Persepsi Industri	0.101	92	0.022	0.924	92	0.000
Min Kesediaan	0.133	92	0.000	0.923	92	0.000
Lilliefors Significance Correction						

4.3.2 Analisis Korelasi Spearman

Hipotesis kajian yang diuji adalah:

H_0: Tiada hubungan signifikan antara persepsi industri terhadap Latihan Industri dengan kesediaan industri memberi penempatan kerja kepada pelajar.

H_1: Terdapat hubungan signifikan antara persepsi industri terhadap Latihan Industri dengan kesediaan industri memberi penempatan kerja kepada pelajar.

Jadual 4.4: Ujian Korelasi Spearman's rho

		Min Persepsi Industri	Min Kesediaan
Min Persepsi Industri	Correlation Coefficient	1.000	0.110
	Sig.(2-tailed)	.	0.295
	N	92	92
Min Kesediaan	Correlation Coefficient	0.110	1.000
	Sig.(2-tailed)	0.295	.
	N	92	92

Berdasarkan analisis korelasi Spearman's rho yang ditunjukkan dalam Jadual 4.3.2.1, nilai pekali korelasi (Correlation Coefficient) antara Min Persepsi Industri terhadap Latihan Industri dengan Min Kesediaan industri memberi penempatan kerja ialah r = 0.110 dengan nilai signifikan p = 0.295. Nilai korelasi ini adalah sangat lemah dan positif, manakala nilai signifikan melebihi aras keertian 0.05 ($p > 0.05$). Ini bermakna, tiada hubungan yang signifikan antara persepsi industri terhadap Latihan Industri dengan kesediaan industri dalam memberi penempatan kerja kepada pelajar.

Dapatan ini menunjukkan bahawa walaupun pihak industri mungkin mempunyai persepsi yang baik terhadap Latihan Industri dari aspek pengetahuan, kemahiran praktikal, dan kemahiran insaniah pelajar, hal tersebut tidak secara langsung mempengaruhi tahap kesediaan mereka dalam menawarkan peluang pekerjaan selepas tamat latihan. Faktor ini mungkin dipengaruhi oleh pelbagai pertimbangan lain seperti kekangan ekonomi, keperluan tenaga kerja semasa, polisi syarikat, serta persaingan dalam pasaran pekerjaan (Mohd & Zainal, 2021).

Selain itu, kelemahan hubungan ini juga boleh dijelaskan melalui keadaan di mana sebahagian industri lebih melihat Latihan Industri sebagai satu bentuk tanggungjawab sosial atau akademik semata-mata, tanpa mengaitkannya secara langsung dengan pengambilan pekerja tetap (Rahman & Wahab, 2020). Maka, walaupun persepsi terhadap keberkesanan latihan adalah positif, keputusan untuk menyediakan penempatan kerja masih bergantung pada faktor luaran yang lebih luas seperti bajet syarikat, struktur organisasi, serta kadar pengambilan pekerja baharu (Hassan et al., 2022).

Dapatan ini adalah selari dengan kajian terdahulu yang menyatakan bahawa persepsi positif industri terhadap latihan pelajar tidak semestinya menjamin peluang kerjaya selepas tamat latihan (Ahmad, 2021). Ia turut menyokong hujah bahawa peluang pekerjaan selepas latihan lebih bergantung kepada keperluan pasaran dan kesesuaian pelajar dengan kehendak industri semasa (Nurul & Halim, 2023).

Secara keseluruhannya, hasil kajian ini memberi gambaran bahawa walaupun Latihan Industri memainkan peranan penting dalam membangunkan kemahiran pelajar, ia tidak boleh dijadikan penentu tunggal kepada kesediaan industri untuk memberi penempatan kerja. Oleh itu, usaha meningkatkan kebolehpasaran graduan memerlukan strategi tambahan seperti pengukuhan jaringan industri, pembangunan kemahiran baharu yang relevan dengan teknologi semasa, serta sokongan dasar kerajaan dalam mewujudkan peluang pekerjaan yang lebih luas.

5.0 KESIMPULAN DAN CADANGAN

Secara keseluruhan, kajian ini mendapati bahawa persepsi industri terhadap Latihan Industri adalah pada tahap tinggi dengan penekanan terhadap pengetahuan, kemahiran praktikal, dan kemahiran insaniah pelajar. Hal ini membuktikan keberkesanan Latihan Industri sebagai medium penting dalam membangunkan potensi graduan serta meningkatkan keyakinan industri terhadap kemampuan mereka. Kesediaan industri untuk memberi penempatan kerja juga menunjukkan gambaran positif, walaupun terdapat cabaran tertentu dalam memastikan semua pelajar mendapat peluang selepas latihan.

Namun begitu, dapatan korelasi Spearman’s rho mendapati hubungan antara persepsi industri dengan kesediaan memberi penempatan kerja adalah sangat lemah dan tidak signifikan. Ini menjelaskan bahawa faktor kesediaan industri tidak semata-mata bergantung pada persepsi terhadap Latihan Industri, tetapi turut dipengaruhi oleh aspek luaran seperti keadaan ekonomi, kekosongan jawatan dan dasar organisasi. Oleh itu, Latihan Industri masih penting dalam

meningkatkan kebolehpasaran graduan, namun usaha tambahan diperlukan untuk menjamin peluang penempatan kerja yang lebih kukuh.

Bagi memastikan Latihan Industri lebih memberi impak, pihak institusi perlu mengukuhkan hubungan strategik dengan industri melalui jaringan kerjasama yang lebih sistematik. Usaha ini dapat membuka peluang penempatan kerja yang lebih stabil kepada pelajar selepas tamat latihan. Selain itu, pelajar juga perlu dilengkapkan dengan kemahiran tambahan seperti pensijilan profesional, kecekapan teknologi, dan penguasaan bahasa agar lebih kompetitif di pasaran kerja.

Kerajaan pula boleh memainkan peranan dengan menyediakan insentif atau sokongan kepada industri yang menyerap pelajar latihan sebagai pekerja tetap. Inisiatif ini dapat menggalakkan lebih banyak industri memberi peluang pekerjaan secara berterusan. Di samping itu, sistem maklum balas berstruktur daripada pihak industri perlu diwujudkan bagi menilai keberkesanan program Latihan Industri. Penilaian berterusan ini bukan sahaja membantu meningkatkan kualiti pelajar, malah memastikan kurikulum yang ditawarkan sentiasa relevan dengan kehendak pasaran semasa.

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HUBUNGAN ANTARA PENCAPAIAN MATEMATIK SPM DENGAN TAHAP PENGUASAAN PREFIKS METRIK DI KALANGAN PELAJAR KOLEJ KOMUNITI KUALA TERENGGANU CAWANGAN SETIU

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Abstrak

Kajian ini bertujuan untuk mengenal pasti hubungan antara pencapaian Matematik dalam Sijil Pelajaran Malaysia (SPM) dengan tahap penguasaan prefiks metrik dalam kalangan pelajar di Kolej Komuniti Kuala Terengganu Cawangan Setiu. Prefiks metrik merupakan komponen asas dalam sistem unit antarabangsa (SI) yang kritikal bagi menyelesaikan masalah pengiraan teknikal dalam bidang TVET. Kajian kuantitatif ini menggunakan reka bentuk kajian korelasi dengan melibatkan 80 orang pelajar sebagai sampel kajian. Instrumen kajian terdiri daripada ujian penguasaan prefiks metrik (5 item) dan borang maklumat latar belakang akademik. Data dianalisis secara deskriptif (min dan peratusan) dan inferensi menggunakan ujian korelasi Pearson. Dapatan kajian menunjukkan bahawa tahap penguasaan prefiks metrik pelajar berada pada tahap tinggi dengan catatan skor min keseluruhan sebanyak 4.08/5.00, meskipun profil akademik responden didominasi oleh pelajar bergred Lulus (D dan E) serta Gagal (G) dalam Matematik SPM. Hasil analisis, menunjukkan tidak wujud hubungan yang signifikan ($r = 0.026$, $p = 0.816$) antara gred Matematik SPM dengan keupayaan pelajar menukar unit metrik. Dapatan ini membuktikan bahawa pencapaian akademik lampau di peringkat sekolah bukanlah penentu mutlak kepada kejayaan pelajar dalam menguasai kemahiran teknikal di Kolej Komuniti. Implikasi kajian mencadangkan bahawa persekitaran pembelajaran di Kolej Komuniti yang lebih berorientasikan amali berjaya merapatkan jurang kelemahan numerasi pelajar. Namun begitu, sokongan berterusan dalam bentuk alat bantuan visual tetap diperlukan bagi mengurangkan kekeliruan pelajar terhadap manipulasi nombor perpuluhan yang kompleks.

Kata Kunci: Pencapaian Matematik SPM, Prefiks Metrik, Kolej Komuniti, Pendidikan Teknikal, Hubungan Korelasi.

Abstract

This study aims to identify the relationship between Mathematics achievement in the Sijil Pelajaran Malaysia (SPM) and the level of mastery of metric prefixes among students at Kuala Terengganu Community College, Setiu Branch. Metric prefixes are fundamental components of the International System of Units (SI) that are critical for solving technical *calculation problems in the field of TVET. This quantitative study employed a correlational research design*

involving 80 students as the research sample. The research instruments consisted of a metric prefix mastery test (5 items) and an academic background information form. Data were analyzed using descriptive statistics (mean and percentage) and inferential statistics through the Pearson correlation test. The findings showed that the students' level of mastery of metric prefixes was at a high level, with an overall mean score of 4.08/5.00, despite the respondents' academic profile being dominated by students with Pass (D and E) and Fail (G) grades in SPM Mathematics. The results of the inferential analysis indicated that there was no significant relationship (r = 0.026, p = 0.816) between SPM Mathematics grades and the students' ability to convert metric units. These findings prove that past academic achievement at the school level is not an absolute determinant of student success in mastering technical skills at the Community College. The implications of the study suggest that the learning environment at the Community College, which is more vocationally oriented, has successfully bridged the gap in students' numeracy weaknesses. Nevertheless, continuous support in the form of visual aids is still required to reduce student confusion regarding complex decimal manipulations.

Keywords: *SPM Mathematics Achievement, Metric Prefixes, Community College, Technical Education, Correlational Relationship.*

1.0 PENGENALAN

Sistem metrik merupakan tunjang utama dalam sistem ukuran antarabangsa yang digunakan secara meluas dalam pelbagai bidang teknikal, sains, dan kejuruteraan di seluruh dunia (BIPM, 2019). Bagi institusi Pendidikan Teknikal dan Latihan Vokasional (TVET) seperti Kolej Komuniti, penguasaan terhadap sistem ini bukan sekadar keperluan akademik, malah merupakan kemahiran yang kritikal bagi memastikan ketepatan kerja dan keselamatan dalam persekitaran industri (Radin Mohd Sidek, 2021).

Walau bagaimanapun, realitinya kekeliruan sering berlaku apabila pelajar perlu memanipulasi titik perpuluhan atau menggunakan notasi saintifik dalam menyelesaikan masalah pengiraan litar elektrik atau mekanikal (Smith, 2020). Fenomena ini sering dikaitkan dengan tahap ketersediaan akademik pelajar sebelum menjejakkan kaki ke Kolej Komuniti, terutamanya pencapaian mereka dalam subjek Matematik semasa di peringkat Sijil Pelajaran Malaysia (SPM). Matematik SPM merupakan asas kepada pemikiran logik dan keupayaan numerasi yang diperlukan untuk memahami skala dan magnitud dalam sistem metrik (Mohd Syahmi et al., 2022).

Kolej Komuniti Kuala Terengganu (KKKT) Cawangan Setiu tidak terkecuali daripada menghadapi cabaran ini, di mana kepelbagaian latar belakang akademik pelajar mewujudkan jurang penguasaan yang nyata dalam bilik kuliah dan bengkel (Azizi Yahaya & Nurul Huda Salleh, 2020). Pelajar yang mempunyai asas matematik yang lemah cenderung mengalami masalah apabila berhadapan dengan unit ukuran yang kompleks, yang seterusnya boleh menjejaskan kualiti latihan amali mereka dan pemahaman mereka (Noraini Idris, 2018).

Oleh itu, satu kajian mendalam perlu dijalankan untuk melihat sejauh mana kekuatan hubungan antara gred Matematik SPM dengan tahap penguasaan prefiks metrik dalam kalangan pelajar.

1.1 Pernyataan Masalah

Penguasaan sistem metrik dan penggunaan prefiks merupakan kompetensi teras yang tidak boleh dikompromi dalam pendidikan teknikal dan latihan vokasional (TVET). Walau bagaimanapun, satu isu kritikal yang sering dihadapi oleh para pensyarah di Kolej Komuniti Kuala Terengganu Cawangan Setiu adalah tahap literasi numerasi yang rendah dalam kalangan pelajar, terutamanya yang melibatkan penukaran unit berskala besar seperti *Mega* (M) dan *Kilo* (k), serta unit berskala kecil seperti *mili* (m) dan *mikro* (μ). Masalah utama yang dikesan adalah ketidakupayaan pelajar untuk visualisasikan magnitud nilai sesuatu unit, yang seterusnya menyebabkan ralat sistematik dalam pengiraan litar elektrik dan amali bengkel.

Sering kali juga, pelajar mampu membaca nilai pada komponen atau alat ukur, namun gagal melakukan perubahan unit bagi tujuan aplikasi formula teknikal. Kekeliruan dalam menentukan arah pergerakan titik perpuluhan serta kegagalan memahami konsep pendaraban dan pembahagian asas 10 menunjukkan wujudnya jurang pemahaman konsep yang serius. Fenomena ini dipercayai mempunyai kaitan rapat dengan latar belakang pencapaian akademik pelajar dalam subjek Matematik di peringkat Sijil Pelajaran Malaysia (SPM) yang lemah. Sekiranya masalah penguasaan prefiks metrik ini tidak ditangani, adalah dibimbangi pelajar tidak berupaya bagi pembelajaran lebih tinggi di peringkat diploma seterusnya.

1.2 Objektif Kajian

Berikut adalah tiga objektif penyelidikan bagi kajian ini:

a) Mengenal pasti tahap penguasaan prefiks metrik dalam kalangan pelajar Kolej Komuniti Kuala Terengganu Cawangan Setiu melalui penilaian ujian diagnostik yang merangkumi unit skala besar dan kecil.

b) Mengenal pasti profil pencapaian Matematik SPM dalam kalangan responden bagi melihat taburan gred dan ketersediaan akademik mereka sebelum memasuki pengajian teknikal.

c) Menganalisis hubungan antara gred Matematik SPM dengan skor penguasaan prefiks metrik bagi membuktikan secara empirikal sejauh mana asas matematik sekolah mempengaruhi keupayaan teknikal pelajar.

1.3 Skop Kajian

Kajian ini memfokuskan kepada 80 orang pelajar aktif di KKKT Cawangan Setiu. Skop ujian metrik dihadkan kepada enam prefiks utama yang kerap digunakan dalam silibus Kolej Komuniti iaitu *Mega (M), kilo (k), mili (m), mikro (μ),* dan *nano (n)*.

1.4 Kepentingan Kajian

Kajian ini diharapkan dapat memberikan sumbangan yang signifikan kepada pelbagai pihak berkepentingan, khususnya dalam memperkasakan ekosistem Pendidikan Teknikal dan Latihan Vokasional (TVET) di Kolej Komuniti. Antara kepentingan utama kajian ini adalah:

a) **Kepada Pelajar:** Kajian ini berfungsi sebagai medium refleksi diri bagi pelajar untuk menyedari tahap penguasaan sebenar mereka dalam sistem metrik yang menjadi tunjang bidang teknikal. Dengan memahami hubungkait antara asas matematik sekolah dengan aplikasi teknikal, pelajar dapat mengambil langkah proaktif untuk memantapkan kemahiran numerasi mereka bagi mengelakkan keciciran dalam modul pembelajaran yang lebih kompleks.

b) **Kepada Pensyarah dan Tenaga Pengajar:** Dapatan kajian ini membekalkan data mengenai profil ketersediaan akademik pelajar baru. Ini membolehkan pensyarah menyesuaikan strategi pengajaran dan pembelajaran (PdP), seperti memperkenalkan modul transisi matematik atau menggunakan alat bantuan mengajar (ABM) yang lebih inovatif.

c) **Kepada Pembangunan Kurikulum TVET:** Kajian ini menyumbang kepada literatur mengenai integrasi sains asas dalam pendidikan vokasional. Ia menekankan kepentingan imbangan antara kemahiran praktikal dan kefahaman teori, sekali gus menyokong usaha transformasi kurikulum yang lebih fleksibel dan responsif terhadap keperluan industri yang menuntut

2.0 KAJIAN LITERATUR

Kajian literatur ini membincangkan landasan teori dan dapatan kajian lepas yang berkaitan dengan penguasaan sistem metrik, hubungannya dengan pencapaian matematik asas, serta cabaran pembelajaran dalam persekitaran Pendidikan Teknikal dan Latihan Vokasional (TVET). Sistem unit antarabangsa (SI) dan penggunaan prefiks metrik adalah elemen fundamental yang menghubungkan teori matematik dengan aplikasi praktikal di industri.

2.1 Teori Pemprosesan Maklumat dan Beban Kognitif dalam TVET

Dalam konteks pendidikan moden, penguasaan konsep unit dan skala lebih tepat dirujuk kepada Teori Beban Kognitif (Cognitive Load Theory) yang diperkukuh oleh Sweller (2017). Menurut teori ini, pembelajaran teknikal yang melibatkan pertukaran unit abstrak (seperti mikro dan nano) memerlukan ruang memori kerja yang besar. Bagi pelajar TVET, kekeliruan dalam manipulasi unit sering berlaku apabila beban kognitif luaran (kaedah pengajaran yang rumit) mengatasi keupayaan memori kerja mereka. Oleh itu, visualisasi fizikal dan alat bantuan mengajar yang meringkaskan proses mental amat diperlukan untuk membantu pelajar memahami magnitud prefiks tanpa membebankan pemikiran logik mereka.

2.2 Kepentingan Matematik Asas dalam Pendidikan Teknikal

Hubungan antara pencapaian matematik di peringkat sekolah (SPM) dengan prestasi dalam kursus teknikal telah menjadi subjek perbincangan yang luas. Matematik bukan sekadar subjek akademik, tetapi merupakan "bahasa" bagi bidang kejuruteraan dan teknologi. Kajian oleh Noraini (2018) menegaskan bahawa kegagalan menguasai algoritma asas matematik, seperti pendaraban perpuluhan dan indeks, akan menyebabkan pelajar menghadapi jalan buntu apabila perlu melakukan penukaran unit yang kompleks. Di Kolej Komuniti, modul-modul seperti Teknologi Elektrik memerlukan ketepatan tinggi dalam memanipulasi unit; ralat sekecil satu titik perpuluhan boleh membawa kepada kegagalan fungsi litar atau kerosakan peralatan.

2.3 Isu kesalahfahaman dan Ralat dalam Penukaran Unit

Kajian literatur terkini menunjukkan bahawa kesalahfahaman dalam sistem metrik sering berpunca daripada kekeliruan antara arah pergerakan titik perpuluhan semasa operasi pendaraban dan pembahagian 10. Menurut Smith (2020), pelajar cenderung melakukan ralat sistematik apabila menukar unit dari skala kecil ke skala besar kerana mereka tidak memahami hubungan songsang antara nilai unit dengan magnitud prefiks tersebut. Selain itu, faktor psikologi seperti *math anxiety* juga memainkan peranan. Pelajar yang mempunyai latar belakang matematik yang lemah sering kali merasa tertekan apabila berhadapan dengan formula yang melibatkan banyak unit berbeza, yang akhirnya menyebabkan mereka melakukan kesilapan yang tidak sepatutnya berlaku.

2.4 Peranan Inovasi Alat Bantu Mengajar (ABM)

Bagi merapatkan jurang antara kelemahan matematik asas dengan tuntutan teknikal, penggunaan alat bantuan mengajar (ABM) yang bersifat kinestetik dan visual sangat disarankan. Inovasi yang membolehkan pelajar memanipulasi unit secara fizikal mampu menukarkan konsep abstrak kepada pengalaman konkrit. Kajian oleh Radin Mohd Sidek (2021) menunjukkan bahawa pelajar TVET menunjukkan peningkatan kefahaman yang signifikan apabila sesi teori diintegrasikan dengan alat bantuan visual yang memudahkan proses transisi unit.

2.5 Hubungan Antara Efikasi Kendiri Numerasi dengan Prestasi Akademik

Kajian terkini oleh Zuliana et al. (2022) menunjukkan bahawa efikasi kendiri (keyakinan diri) dalam numerasi mempunyai perkaitan langsung dengan keupayaan pelajar menyelesaikan tugasan teknikal. Bagi pelajar TVET, kepercayaan terhadap kemampuan diri untuk memanipulasi nombor perpuluhan sering kali lebih mempengaruhi hasil kerja berbanding pengetahuan sedia ada. Hal ini menjelaskan mengapa pelajar dengan gred Matematik SPM yang rendah masih mampu skor tinggi dalam ujian metrik sekiranya mereka mempunyai minat yang tinggi terhadap modul teknikal yang sedang dipelajari.

2.6 Cabaran Literasi Digital dan Numerasi dalam Era Industri 4.0

Menurut Mohd Syahmi. (2022), transformasi Industri 4.0 menuntut pelajar Kolej Komuniti untuk bukan sahaja mahir mengendalikan peralatan, tetapi juga pantas dalam melakukan pengiraan mental (*mental calculation*) melibatkan unit metrik. Kesilapan dalam menukar unit mikro ke unit asas semasa pengaturcaraan atau pemasangan sensor boleh mengakibatkan kegagalan sistem yang kritikal. Kajian beliau mendapati bahawa latihan berulang menggunakan simulasi atau alat bantuan fizikal adalah kaedah paling berkesan untuk mengurangkan ralat kognitif semasa transisi unit dilakukan.

2.7 Pengaruh Metakognitif dalam Penyelesaian Masalah Matematik Teknikal

Kajian oleh Hisham & Rosli (2023) menekankan kepentingan kesedaran metakognitif, iaitu kebolehan pelajar untuk memantau proses pemikiran mereka sendiri semasa menukar unit. Pelajar yang gagal sering kali tidak menyedari arah pergerakan titik perpuluhan yang salah kerana mereka hanya menghafal prosedur tanpa memahami logik di sebaliknya. Kajian tersebut menyarankan agar pendidikan teknik tidak hanya fokus kepada jawapan akhir, tetapi

membimbing pelajar memahami "kenapa" sesuatu unit itu membesar atau mengecil apabila prefiks berubah.

3.0 METODOLOGI PENULISAN

Kajian ini menggunakan pendekatan kuantitatif dengan reka bentuk kajian korelasi. Reka bentuk ini dipilih untuk mengenal pasti kewujudan serta kekuatan hubungan antara pencapaian akademik lampau (Matematik SPM) dengan keupayaan teknikal semasa (Prefiks Metrik) serta persepsi pelajar terhadap pembelajaran tersebut.

3.1 Populasi dan Sampel Kajian

Populasi kajian melibatkan pelajar di Kolej Komuniti Kuala Terengganu Cawangan Setiu. Seramai 80 orang pelajar telah dipilih sebagai responden melalui teknik pensampelan. Kriteria pemilihan adalah berdasarkan penglibatan pelajar dalam modul yang memerlukan aplikasi unit ukuran secara intensif.

3.2 Instrumen Kajian

Instrumen kajian ini merupakan satu set soal selidik yang dibahagikan kepada dua komponen utama bagi mendapatkan data yang komprehensif seperti Jadual 1:

Jadual 1: Struktur Instrumen Soal Selidik

Bahagian	Perkara	Deskripsi Item
I	Maklumat Latar Belakang	Meliputi semester pengajian dan gred sebenar Matematik SPM responden.
II	Ujian Penguasaan Prefiks	Mengandungi 5 soalan teknikal merangkumi penukaran unit asas, mili, kilo, serta pengecaman skala magnitude (Mega, Giga, Nano, Piko).

3.3 Prosedur Pengumpulan Data

Data dikumpulkan melalui edaran borang soal selidik secara dalam talian. Prosedur ini dijalankan secara terkawal bagi memastikan responden menjawab ujian penguasaan (Bahagian II) tanpa bantuan alat pengiraan atau rujukan luar bagi menjamin kesahan data.

3.4 Teknik Analisis Data

Data yang diperoleh diproses menggunakan analisis statistik deskriptif dan inferensi (Chua, Y. P., 2022) menggunakan perisian *Microsoft Excel* 2019:

a) Analisis Deskriptif: Digunakan untuk menerangkan kekerapan gred SPM, min skor ujian penguasaan, dan skor min bagi setiap item persepsi pelajar.

b) Analisis Inferensi (Ujian Korelasi Pearson): Digunakan untuk menguji hipotesis kajian mengenai hubungan antara gred Matematik SPM dengan skor ujian penguasaan metrik yang kemudiannya diinterpretasikan kepada 3 skala tahap seperti Jadual 2.

Jadual 2: Skala Interpretasi Skor Ujian Penguasaan (Bahagian II)

Markah (0 - 5)	Tahap Penguasaan
4 - 5	Tinggi
2 - 3	Sederhana
0 - 1	Rendah

4.0 KEPUTUSAN DAN PERBINCANGAN

Bahagian ini membincangkan dapatan kajian yang diperoleh daripada analisis 80 borang soal selidik dan ujian penguasaan yang telah dijalankan. Data dibahagikan kepada profil responden, tahap penguasaan prefiks metrik dan ujian korelasi.

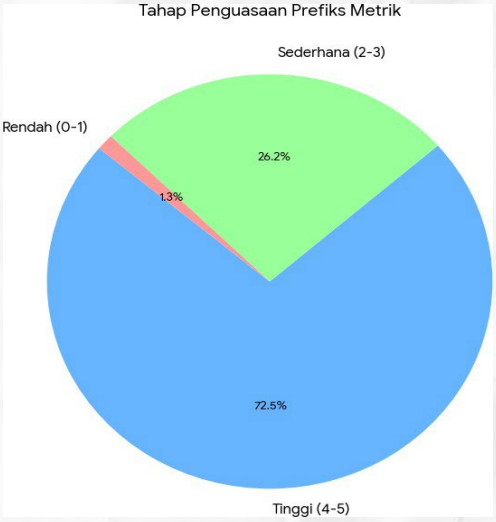
4.1 Tahap Penguasaan Prefiks Metrik

Tahap penguasaan diukur melalui lima item soalan penukaran unit. Skor min keseluruhan bagi 80 responden adalah 4.08/5.00, yang menunjukkan tahap penguasaan yang tinggi seperti yang ditunjukkandi dalam Jadual 3 dan Rajah 1.

Jadual 3: Analisis Peratusan Jawapan Betul Mengikut Item Soalan

No. Soalan	Kandungan Item (Penukaran Unit)	Peratus Betul (%)
Q1	5,000m ke km (Kilo)	87.5%
Q2	0.002A ke mA (mili)	71.2%
Q3	1.2kV ke V (Volt)	86.2%
Q4	Mengenal nilai terkecil (Nano/Piko)	82.5%
Q5	Mengenal nilai terbesar (Mega/Kilo)	81.2%

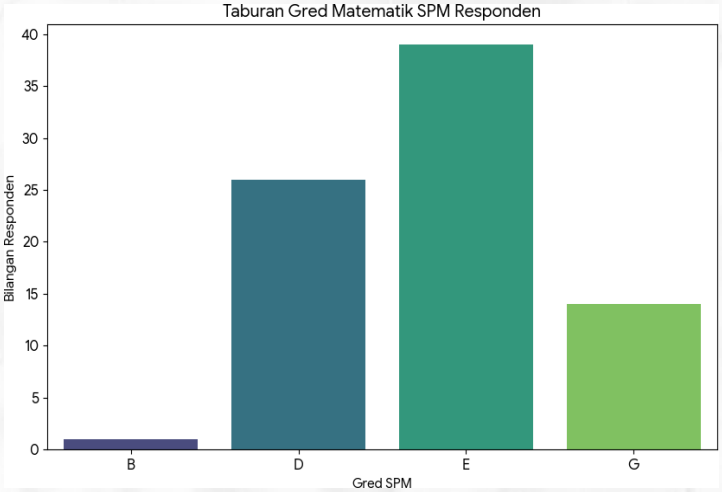
Berdasarkan Rajah 1, seramai 58 orang (72.5%) pelajar berada pada Tahap Tinggi, manakala 21 orang (26.3%) berada pada Tahap Sederhana. Hanya seorang pelajar (1.3%) berada pada tahap rendah. Dapatan ini menunjukkan bahawa walaupun pencapaian SPM adalah rendah, pelajar di Kolej Komuniti telah mula menguasai konsep asas unit metrik teknikal dengan baik.



Rajah 1: Carta pai tahap penguasaan pelajar

4.2 Profil Akademik Responden (Gred Matematik SPM)

Responden terdiri daripada pelajar semester 1 hingga 4. Rajah 2 dan Jadual 4 menunjukkan taburan gred Matematik SPM dalam kalangan responden.



Rajah 2: Menunjukkan taburan gred SPM yang didominasi oleh gred E dan D.

Majoriti responden memiliki gred E (48.8%) dan D (32.5%), manakala hanya 1.2% mendapat gred B. Ini menunjukkan profil responden secara keseluruhannya mempunyai latar belakang matematik sekolah menengah pada tahap lulus sahaja.

Jadual 4: Taburan Gred Matematik SPM Responden

Gred Matematik SPM	Kekerapan	Peratusan
Kepujian (B)	1	1.25%
Lulus (D)	26	32.50%
Lulus (E)	39	48.75%
Gagal (G)	14	17.50%
JUMLAH	**80**	**100%**

4.3 Analisis Hubungan (Ujian Korelasi Pearson)

Ujian korelasi Pearson dijalankan untuk mengukur kekuatan hubungan antara gred Matematik SPM (ditukar kepada mata 1-5) dengan skor ujian prefiks metrik.

Jadual 5: Hasil Ujian Korelasi Pearson (r)

Hubungan Pemboleh Ubah	Nilai Korelasi (r)	Nilai Signifikan (p)	Kekuatan Hubungan
Gred SPM vs Skor Prefiks	0.026	0.816	Sangat Lemah / Tiada Signifikan

Seperti di dalam Jadual 5, hasil analisis menunjukkan nilai r = 0.026 dengan p = 0.816. Ini bermakna tidak wujud hubungan yang signifikan antara pencapaian Matematik SPM dengan keupayaan pelajar menukar unit metrik bagi sampel ini. Hal ini mencadangkan bahawa faktor-faktor lain seperti minat pelajar terhadap subjek teknikal atau keberkesanan pengajaran

pensyarah di Kolej Komuniti mungkin lebih mempengaruhi penguasaan mereka berbanding keputusan SPM lampau.

5.0 KESIMPULAN

Melalui hasil analisis yang diperolehi, didapati tiada kaitan di antara keputusan subjek Matematik SPM yang rendah akan menyebabkan penguasaan prefiks metrik di kalangan pelajar. Berdasarkan analisis data, terdapat beberapa penemuan penting yang perlu dibincangkan iaitu walaupun 81.25% pelajar bergred D, E, atau G, skor min metrik adalah tinggi (4.08/5.00). Ini membuktikan pelajar TVET mampu menguasai kemahiran teknikal melalui pembelajaran praktikal di kolej, selari dengan dapatan Radin Mohd Sidek (2021). Ketiadaan Korelasi (r=0.026) di antara gred Matematik SPM yang mana ianya bukan penentu mutlak kebolehan penukaran unit metrik. Zuliana et al. (2022) menyokong bahawa minat terhadap modul teknikal lebih mempengaruhi pencapaian numerasi berbanding keputusan akademik lampau. Kajian membuktikan tahap penguasaan metrik pelajar adalah Tinggi dan tiada hubungan signifikan antara SPM dan metrik. Ini menunjukkan setiap pelajar berpeluang cemerlang dalam TVET jika beban kognitif mereka diuruskan dengan baik (Sweller, 2017).

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BENGKEL TEKNIK MENJAWAB SOALAN PEPERIKSAAN AKHIR: KEBERKESANANNYA DALAM PENCAPAIAN KURSUS *OPERATIONS MANAGEMENT* PELAJAR SEMESTER 5 DIPLOMA PENGAJIAN PERNIAGAAN

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Abstrak

Pembangunan kurikulum dan pelaksanaan sistem pendidikan tidak akan berjaya tanpa penekanan yang serius terhadap pengajaran dan pembelajaran. Kaedah pengajaran yang berkesan dan sesuai memainkan peranan penting sebagai pemangkin kepada pencapaian akademik pelajar yang seharusnya diberi keutamaan. Kaedah pengajaran berfungsi sebagai cara untuk mencapai objektif pengajaran. Namun isu penyesuaian kaedah penyampaian pengajaran terhadap kursus yang ditawarkan di institusi pendidikan tinggi masih kurang dikaji. Bagi kursus Pengurusan Operasi iaitu kursus teras bagi Program Diploma Pengajian Perniagaan (DPM) di Politeknik Muadzam Shah menunjukkan pencapaian pelajar yang tidak konsisten sepanjang empat sesi pengajian berturut-turut walaupun pelbagai kaedah penyampaian telah dilaksanakan. Justeru itu, objektif kajian ini adalah untuk mengkaji keberkesanan kaedah penyampaian pengajaran berbentuk bengkel teknik menjawab soalan terhadap pencapaian pelajar berfokuskan kepada kursus Pengurusan Operasi dan karekteristik pelajar mengikut sesi kemasukan. Kajian ini menggunakan teknik persampelan berfokus yang melibatkan 234 orang pelajar sepanjang 4 sesi pengajian yang diambil. Dapatan kajian menunjukkan pelaksanaan Bengkel Teknik Menjawab Soalan mempengaruhi peratus pencapaian pelajar bagi kursus Pengurusan Operasi. Walaubagaimanapun keberkesanan pelaksanakan bengkel ini telah dipengaruhi oleh karakteristik pelajar. Kajian akan datang disarankan untuk memperluaskan skop penyelidikan dengan melibatkan lebih banyak program pengajian yang berbeza bagi mendapatkan gambaran yang lebih menyeluruh mengenai keberkesanan kaedah penyampaian pengajaran berbentuk bengkel teknik menjawab soalan.

Kata kunci: Operations Management, Kaedah pengajaran dan pembelajaran, Bengkel Menjawab Soalan, Pencapaian Pelajar.

Abstract

Curriculum development and the implementation of an education system cannot succeed without serious emphasis on teaching and learning. Effective and appropriate teaching methods play an important role as a catalyst for students' academic achievement and should be prioritized, as they serve as a means of achieving instructional objectives. However, the alignment of teaching delivery methods with courses offered in higher education institutions remains underexplored. In the case of the Operations Management course, a core subject in

the Diploma in Business Studies (DPM) programme at Politeknik Muadzam Shah, student achievement has been inconsistent across four consecutive academic sessions despite the implementation of various teaching approaches. Therefore, this study aims to examine the effectiveness of a workshop-based teaching delivery method, specifically the Answering Techniques Workshop, on student achievement, focusing on the Operations Management course and student characteristics based on intake sessions. This study employed purposive sampling involving 234 students across four academic sessions. The findings indicate that the implementation of the Answering Techniques Workshop influenced the percentage of student achievement in the Operations Management course; however, its effectiveness was affected by student characteristics. Future studies are recommended to expand the scope by involving a wider range of academic programmes to obtain a more comprehensive understanding of the effectiveness of workshop-based teaching delivery methods.

***Keywords**: Operations Management, teaching and learning methods, answering techniques workshop, student achievement.*

1.0 PENDAHULUAN

Kaedah penyampaian pengajaran merupakan strategi penting yang dirancang oleh tenaga pengajar bagi menyampaikan ilmu secara berkesan serta menggalakkan pembelajaran aktif dalam proses pengajaran dan pembelajaran (PdP). Pemilihan kaedah yang sesuai amat penting kerana ia mampu mewujudkan interaksi dua hala antara pendidik dan pelajar serta membantu mencapai objektif pembelajaran. Oleh itu, tenaga pengajar perlu kreatif dalam mempelbagaikan pendekatan PdP sama ada di dalam atau di luar bilik darjah. Antara kaedah yang sering digunakan ialah kaedah perbincangan seperti seminar atau bengkel serta kaedah latihan yang bertujuan meningkatkan kefahaman dan kemahiran pelajar terhadap topik yang dipelajari. Seiring dengan kajian yang dilaksanakan oleh Siti Janariah et.al (2024) yang bertujuan untuk membimbing dan meningkatkan pencapaian akademik pelajar.

Pelaksanaan bengkel yang disertai dengan latihan memberi peluang kepada pelajar untuk berinteraksi, mengemukakan soalan serta mengukuhkan pemahaman melalui aktiviti praktikal. Kajian-kajian lepas menunjukkan bahawa bahawa prestasi akademik pelajar dalam matematik, sejarah, matematik pengkomputeran, makroekonomi dan kejuruteraan adalah semakin baik setelah dibuat bengkel. Tidak banyak kajian yang mengkaji kaedah ini dalam kursus Pengurusan Operasi. Oleh itu, kajian ini bertujuan untuk meneliti keberkesanan pelaksanaan bengkel menjawab soalan dalam meningkatkan pencapaian akademik pelajar dalam kursus Pengurusan Operasi serta menyumbang kepada penambahbaikan strategi pedagogi yang lebih baik di universiti

1.1 Penyataan Masalah

Dalam proses pengajaran dan pembelajaran (PdP), pelbagai kaedah pengajaran telah digunakan Walau bagaimanapun, tenaga pengajar masih menghadapi masalah untuk memilih kaedah yang benar-benar berkesan untuk meningkatkan pencapaian akademik pelajar mereka (Biggs & Tang, 2011; Freeman et al., 2021). Sebelum ini, pengkaji menggunakan kaedah PdP secara

tradisional yang berpusatkan guru melalui pendekatan syarahan dan sesi soal jawab dan bergantung sepenuhnya kepada buku rujukan. Pendekatan tradisional ini berbentuk sehala dan kurang menggalakkan penglibatan aktif pelajar, sekali gus mengehadkan peluang penerokaan idea secara kritis dan kreatif (Theobald et al., 2021). Selain itu, kebergantungan kepada bahan rujukan juga membataskan pembelajaran yang lebih kontekstual dan autentik, menyebabkan pelajar kurang berupaya mengaplikasikan pengetahuan dalam situasi sebenar (Yew & Goh, 2023). Di samping itu, kaedah ini turut didapati kurang berkesan dalam merangsang kemahiran berfikir aras tinggi (KBAT) serta pembelajaran kendiri dalam kalangan pelajar (Zohar & Barzilai, 2022; Darling-Hammond et al., 2022).

Oleh itu, pendekatan PdP tradisional yang diamalkan dalam kajian ini dilihat masih belum mencukupi untuk memenuhi keperluan pembelajaran semasa dan memerlukan penambahbaikan melalui kaedah yang lebih aktif, interaktif dan berpusatkan pelajar. Beberapa kajian telah menunjukkan bahawa teknik yang digunakan boleh meningkatkan pencapaian pelajar dalam kursus teknikal dan bahasa. Kajian seperti matematik (Melati & Nor Fadzlina, 2022), sejarah (Muthiah & Mahzan, 2023), matematik pengkomputeran (Norbaini, 2019), makroekonomi (Faezah et.al, 2024), dan kejuruteraan (Siti Janariah et.al, 2024) semuanya menunjukkan hasil yang positif. Namun begitu, kajian yang memfokuskan kepada keberkesanan kaedah bengkel menjawab soalan dalam kursus Pengurusan Operasi masih terhad. Kekurangan kajian ini menyebabkan kurangnya bukti empirikal yang dapat menyokong penggunaan kaedah tersebut dalam meningkatkan prestasi pelajar bagi kursus tersebut. Oleh itu, kajian ini dijalankan untuk mengenal pasti keberkesanan pelaksanaan bengkel menjawab soalan terhadap pencapaian akademik pelajar dalam kursus Pengurusan Operasi.

1.2 Objektif Kajian

Kajian yang dibuat adalah bertujuan untuk menetukan tahap keberkesanan bengkel menjawab soalan bagi Kursus Pengurusa Operasi. Selain itu, kajian ini juga bertujuan untuk menganalisis keberkesanan pelaksanaan bengkel menjawab soalan terhadap pencapaian akademik pelajar bagi menentukan sejauh mana kaedah tersebut dapat membantu meningkatkan prestasi

1.3 Signifikan kajian

Kajian ini penting kerana ia boleh memberi gambaran yang jelas tentang bagaimana bengkel berfungsi dan bagaimana ia boleh meningkatkan pencapaian akademik pelajar dalam kursus Pengurusan Operasi, iaitu kursus yang menggabungkan teori dan pengiraan. Kajian ini juga boleh membantu tenaga pengajardalam memilih dan membangunkan kaedah pengajaran yang lebih berkesan dan berpusatkan pelajar. Kajian ini juga boleh digunakan sebagai rujukan kepada institusi pendidikan tinggi apabila mereka merancang kaedah pedagogi yang lebih sistematik untuk meningkatkan kualiti pengajaran dan pembelajaran. Kajian ini juga membantu menambah literatur dalam pedagogi pendidikan tinggi, terutamanya mengenai cara bengkel dan latihan boleh meningkatkan prestasi akademik pelajar.

2.0 SOROTAN LITERATUR

Sesetengah kajian literatur menunjukkan bahawa bengkel adalah salah satu kaedah pengajaran dan pembelajaran (PdP) yang berkesan kerana ia menggabungkan elemen demonstrasi, latihan amali, perbincangan dan penyelesaian masalah secara praktikal. Pendekatan ini juga selari dengan konsep pembelajaran aktif dan berpusatkan pelajar kerana ia menggalakkan penglibatan pelajar secara langsung dalam proses pembelajaran (Ahmad & Razali, 2020; Ab Halim & Siti Muhibah, 2015). Kajian-kajian terdahulu menunjukkan bahawa pelaksanaan bengkel boleh memberi impak positif terhadap penguasaan ilmu, motivasi serta keyakinan pelajar, seperti bengkel Kemahiran Berfikir Aras Tinggi (Shafie & Halim, 2018), bengkel literasi digital (Noraini, 2019) dan bengkel komunikasi (Kamarulzaman, 2021). Selain itu, bengkel pengukuhan dan teknik menjawab soalan peperiksaan juga didapati dapat meningkatkan pencapaian akademik pelajar serta kadar kelulusan kursus (Norbaini, 2019; Melati & Nor Fadzlina, 2022; Nurul Adani, 2022; Faezah et al., 2024).

Dalam konteks kajian ini, keberkesanan bengkel teknik menjawab soalan bagi kursus Pengurusan Operasi juga diperlukan. Kursus Pengurusan Operasi merupakan kursus teras bagi pelajar semester lima program Diploma Pengajian Perniagaan di Politeknik Muadzam Shah yang melibatkan komponen teori dan pengiraan, di mana pencapaian pelajar dinilai berdasarkan *Course Learning Outcome* (CLO) melalui pelbagai kaedah penilaian seperti kuiz, ujian, tugasan, projek dan peperiksaan akhir. Pencapaian CLO ini direkod dan dianalisis menggunakan Sistem Pengurusan Maklumat Pelajar (SPMP) yang membolehkan pensyarah memantau tahap penguasaan pelajar secara sistematik dan menyokong pelaksanaan penilaian berasaskan hasil pembelajaran atau *Outcome-Based Education* (OBE).

3.0 METODOLOGI KAJIAN

Kajian ini menumpukan kepada pelajar semester 5 yang mengambil kursus Pengurusan Operasi, Diploma Pengajian Perniagaan, Pahang serta mengambil bahagian dalam "*Victory Sprint Workshop*," iaitu Bengkel Menjawab Soalan Peperiksaan Akhir. "*Victory Sprint Workshop*" adalah program yang diadakan untuk membantu pelajar mempersiapkan diri menghadapi peperiksaan akhir dengan cara yang lebih berkesan. Bengkel ini biasanya memberikan teknik menjawab soalan peperiksaan, termasuk cara menguruskan masa, memahami jenis soalan, dan cara menyediakan jawapan yang tepat dan terperinci. Bengkel ini bertujuan untuk menyediakan panduan serta latihan yang bersifat praktikal berkaitan teknik menjawab soalan dengan lebih berkesan.

Sepanjang pelaksanaan bengkel tersebut, pelajar didedahkan kepada kaedah menjawab soalan dengan betul, strategi memperoleh markah secara optimum, serta teknik menyelesaikan soalan peperiksaan akhir melalui beberapa set latihan yang telah disediakan. Di samping itu, pelajar turut diberi peluang untuk menjalankan sesi perbincangan secara berkumpulan bagi membincangkan kaedah penyelesaian soalan, berkongsi idea, serta memperkukuhkan pemahaman terhadap setiap bentuk soalan yang diberikan. Pendekatan ini bukan sahaja

membantu meningkatkan keyakinan pelajar dalam menjawab soalan, malah turut menggalakkan pembelajaran kolaboratif serta penglibatan aktif dalam proses pembelajaran.

3.1 Reka Bentuk Kajian

Dalam kajian ini, pendekatan kuantitatif serta teknik persampelan berfokus digunakan kerana responden yang terlibat adalah terdiri daripada pelajar sember 5 sahaja, dengan seramai 234 orang pelajar dipilih daripada empat sesi pengajian iaitu sesi 1:2023/2024, sesi 2:2023/2024, sesi 1:2024/2025 dan sesi 2:2024/2025. Empat semester pengajian ini diambil kira kerana penggunaan silibus dan kod kursus semasa yang digunakan. Antara lain, kajian ini menggunakan kaedah kuantitatif deskriptif bagi menilai keberkesanan pelaksanaan Bengkel Menjawab Soalan Peperiksaan Akhir terhadap pencapaian akademik pelajar.

3.2 Instrumen Kajian

Data kajian melibatkan data sekunder yang diperoleh melalui Sistem Pengurusan Maklumat Pelajar (SPMP)**.** Pencapaian akademik pelajar dianalisis menggunakan Course Learning Outcome iaitu melalui CLO1, CLO2 dan CLO3 yang boleh dinilai melalui penilaian berterusan serta skor peperiksaan akhir. SPMP adalah kaedah pengumpulan data dilakukan secara sistematik, tepat dan boleh dipercayai.

3.3 Analisis Data

Data dianalisis secara deskriptif bagi mengukur pencapaian akademik pelajar selepas menyertai bengkel. Analisis ini menumpukan kepada pencapaian mengikut CLO yang dinilai melalui markah penilaian berterusan dan peperiksaan akhir. Pencapaian diukur melibatkan pencapaian CLO bermula dari sesi pengajian 1:2023/2024, sesi 2:2023/2024, sesi 1:2024/2025 dan sesi 2:2024/2025. Selain itu, pencapaian pelajar mengikut gred juga digunakan untuk melihat impak bengkel terhadap pencapaian akademik.

4.0 DAPATAN KAJIAN

Hasil kajian menunjukkan bahawa pencapaian pelajar adalah berbeza-beza mengikut sesi kemasukan pelajar selepas Bengkel Teknik Menjawab Soalan digunakan. Peratusan pencapaian pelajar yang menggunakan SPMP ditunjukkan dalam Jadual 1. Manakala bilangan pelajar yang mendapat gred F sehingga gred A+ ditunjukkan dalam Jadual 2.

4.1 Pencapaian Akademik mengikut CLO

Jadual 1 menunjukkan bahawa pencapaian pembelajaran kursus (CLO) menunjukkan perbezaan di seluruh sesi pengajian akademik yang kaji. Secara keseluruhannya, CLO 3 mencatatkan pencapaian tertinggi dan paling konsisten, bermula pada 88% (Sesi1:2023/2024) dan mencapai 100% (Sesi2:2023/2024), ia kemudian menurun kepada 86.6% dan 83% pada sesi berikutnya. Ini menunjukkan penguasaan kemahiran aras tinggi yang memuaskan tetapi memerlukan pengukuhan berterusan. CLO 2 pula meningkat daripada 76% kepada 100% antara dua sesi pertama, namun menurun kepada 72% dan 66% pada sesi seterusnya, menunjukkan keperluan penambahbaikan strategi pengajaran bagi memperkukuh kemahiran aplikasi dan analisis pelajar. Namun, CLO 1 menunjukkan variasi paling ketara dan tahap terendah pada sesi terkini, bermula pada 78% dan meningkat kepada 96.8% pada Sesi

2:2023/2024 sebelum menurun kepada 63.7% dan sedikit meningkat kepada 68% pada sesi berikutnya, kemungkinan dipengaruhi oleh perbezaan ciri kohort pelajar dan tahap kesediaan awal terhadap kandungan kursus.

Jadual 1: Laporan *Course Outcome Review Report* (CORR) DPB50133 *Operations Management*

Sesi/CLO	CLO1	CLO2	CLO3
Sesi 1:2023/2024	78%	76%	88%
Sesi 2:2023/2024	96.8%	100%	100%
Sesi 1:2024/2025	63.7%	72%	86.6%
Sesi 2:2024/2025	68%	66%	83%
Purata Pencapaian CLO	**76.7**	**78.4**	**89.3**

4.2 Pencapaian Akademik mengikut Gred

Taburan gred pelajar untuk empat sesi pengajian (Sesi 1 dan 2) pada tahun akademik 2023/2024 dan 2024/2025 menunjukkan pencapaian akademik secara keseluruhan berada pada tahap baik hingga cemerlang, seperti ditunjukkan dalam Jadual 2. Majoriti pelajar berada dalam kategori gred tinggi, iaitu A- hingga A+ seramai 102 orang dan B- hingga B+ seramai 103 orang, yang menunjukkan bahawa pengajaran dan pembelajaran telah berjalan dengan baik sepanjang kajian. 27 pelajar berada dalam kategori pencapaian sederhana (C- hingga C+) dan terdapat trend peningkatan pada tahun 2024/2025, yang menunjukkan bahawa pelajar dalam kategori ini memerlukan sokongan pembelajaran yang lebih baik. Bagi pencapaian rendah, hanya seorang pelajar memperoleh gred D hingga D+ dan seorang pelajar memperoleh gred F, manakala tiada pelajar memperoleh gred E− hingga E+, menandakan kadar kegagalan pelajar adalah minimum dan terkawal.

Jadual 2: Gred Pencapaian Pelajar

SESI/GRED	SESI 1: 2023/2024	SESI 2: 2023/2024	SESI 1: 2024/2025	SESI 2: 2024/2025	JUMLAH
A- hingga A+	41	32	15	14	**102**
B- hingga B+	25	28	32	18	**103**
C- hingga C+	2	3	12	10	**27**
D hingga D+	0	0	0	1	**1**
E- hingga E	0	0	0	0	**0**
F	1	0	0	0	**1**
BILANGAN	**69**	**63**	**59**	**43**	**234**

Secara keseluruhannya, dapatan kajian menunjukkan bahawa pencapaian pelajar mengalami peningkatan yang positif selepas pelaksanaan bengkel tersebut. Walau bagaimanapun, tahap pencapaian pelajar bagi setiap semester yang terlibat didapati tidak konsisten. Ketidakselarasan ini dipercayai dipengaruhi oleh perbezaan latar belakang akademik dalam kalangan pelajar, yang menyebabkan tahap penguasaan dan prestasi mereka terhadap pembelajaran adalah berbeza antara satu sama lain.

5.0 PERBINCANGAN KAJIAN

Hasil kajian menunjukkan bahawa ketiga-tiga hasil pembelajaran kursus (CLO) untuk kursus DPB50133 – Pengurusan Operasi berjaya melebihi syarat minimum. Seperti yang dinyatakan oleh Melati dan Nor Fadzlina (2022) bahawa bengkel pengukuhan boleh meningkatkan pencapaian pelajar keraa ia meninkatkan penguasaan pelajar terhadap kemahiran praktikal dan aplikasi. Tetapi dapatannya tidak konsisten untuk beberapa sesi pengajian. Dapatan yang tidak konsisten ini adalah disebabkan oleh beberapa perkara seperti kepelbagaian latar belakang dan tahap kesediaan awal (tingkah laku pelajar) selaras dapatan kajian dari (Sa & Surat, 2021; Semião et.al, 2023; Sadiq & Hassan, 2021). Hal ini menegaskan bahawa walaupun bengkel memberi kesan positif, pendekatan instruksional perlu diadaptasi mengikut keperluan individu bagi meningkatkan keberkesanan pembelajaran.

Selain itu, sebagai tenaga pengajar perlulah menitikberatkan latarbelakang dan tingkahlaku pelajar dalam menentukan kaedah pdp yang hendak digunakan. Ini adalah selari dengan kajian yang dilakukan oleh Nur Afni (2020); Norbaini (2019) dan Faezah et al.(2024). Hal ini kerana setiap pelajar mempunyai latar belakang, tahap keupayaan kognitif, gaya pembelajaran dan pengalaman akademik yang berbeza, yang secara langsung mempengaruhi cara mereka menerima dan memahami sesuatu pengajaran. Dalam konteks pelaksanaan bengkel teknik menjawab soalan, aspek latar belakang pelajar seperti pencapaian akademik terdahulu, penguasaan asas subjek, serta pendedahan kepada latihan soalan amat penting untuk dikenal pasti oleh tenaga pengajar.

Di samping itu, tingkah laku pelajar seperti tahap fokus, keterlibatan aktif semasa sesi bengkel, keberanian bertanya soalan, serta kesungguhan dalam menyiapkan latihan turut menjadi indikator kepada keberkesanan bengkel tersebut. Pemahaman terhadap aspek ini membolehkan tenaga pengajar merancang strategi PdP yang lebih bersasar, termasuk memberikan bimbingan secara individu, penggunaan contoh jawapan berstruktur, serta latihan berperingkat mengikut tahap kebolehan pelajar. Oleh itu, kejayaan sesuatu bengkel teknik menjawab soalan bukan sahaja bergantung kepada kandungan dan kaedah penyampaian, tetapi juga kepada sejauh mana tenaga pengajar mampu mengenal pasti dan menyesuaikan pendekatan mengikut latar belakang serta tingkah laku pelajar bagi memastikan objektif pembelajaran dapat dicapai secara optimum.

Kajian ini mempunyai beberapa limitasi kajian yang perlu diambil kira iaitu kajian ini hanya melibatkan pelajar Jabatan Perdagangan di Politeknik Muadzam Shah, maka dapatan tidak boleh digeneralisasikan kepada semua pelajar institusi lain. Kajian ini juga dijalankan dalam tempoh masa yang terhad, yang mungkin tidak mencerminkan perubahan tingkah laku pelajar secara menyeluruh. Di samping itu, beberapa faktor lain seperti latar belakang pelajar dan kemahiran teknologi tidak diambil kira, yang mungkin mempengaruhi dapatan kajian.

6.0 KESIMPULAN

Kajian ini menunjukkan bahawa kaedah pengajaran yang berkesan adalah penting dalam mempengaruhi prestasi akademik pelajar, terutamanya dalam kursus teras seperti Pengurusan

Operasi. Hasilnya menunjukkan bahawa Bengkel Teknik Menjawab Soalan mempunyai keupayaan untuk meningkatkan prestasi pelajar. Walau bagaimanapun, keberkesanan Bengkel Teknik Menjawab Soalan berbeza-beza mengikut sesi pengajian dan dipengaruhi oleh pelbagai faktor individu, termasuk latar belakang akademik seseorang, tahap kesediaan mereka untuk belajar, dan gaya pembelajaran mereka. Oleh itu, bengkel ini dicadangkan untuk digunakan sebagai strategi pengajaran sokongan yang boleh disesuaikan dengan keperluan pelajar dan keputusan pembelajaran kursus untuk meningkatkan konsistensi pencapaian akademik.

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EDUCATORS' PERCEPTIONS ON THE USAGE OF ARTIFICIAL INTELLIGENT (AI) IN EDUCATION

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Abstract

The increasing use of artificial intelligence (AI) is reshaping teaching practices in higher education, yet lecturers' perceptions and readiness remain critical to its effective adoption. This study examines lecturers' perceptions, readiness, and concerns regarding AI use in teaching. A quantitative survey was conducted among 52 lecturers, and data were analyzed using descriptive statistics. The findings indicate that lecturers generally hold positive perceptions of AI, particularly for saving time, enhancing teaching materials, and supporting instructional tasks. Most respondents also demonstrated high readiness and willingness to further develop their AI-related skills. However, lecturers expressed concerns related to ethical issues, plagiarism, student dependency, and the reliability of AI-generated content. These results highlight the need for clear institutional guidelines, ethical frameworks, and continuous professional development to support responsible AI integration. Overall, the study suggests that AI can enhance teaching when implemented thoughtfully and ethically (Holmes et al., 2019; Kasneci et al., 2023; UNESCO, 2023).

Keywords: Artificial intelligence in education; Lecturers' perceptions; Readiness to adopt AI; Ethical concerns; Higher education

Abstrak

Penggunaan kecerdasan buatan (AI) yang semakin meningkat sedang membentuk semula amalan pengajaran dalam pendidikan tinggi, namun persepsi dan kesediaan pensyarah kekal kritikal untuk penggunaannya yang berkesan. Kajian ini mengkaji persepsi pensyarah, kesediaan, dan kebimbangan mengenai penggunaan AI dalam pengajaran. Tinjauan kuantitatif telah dijalankan di kalangan 52 pensyarah, dan data dianalisis menggunakan statistik deskriptif. Dapatan kajian menunjukkan bahawa pensyarah secara amnya mempunyai persepsi positif terhadap AI, terutamanya untuk menjimatkan masa, menambah baik bahan pengajaran, dan menyokong tugas pengajaran. Kebanyakan responden juga menunjukkan kesediaan dan kesediaan yang tinggi untuk mengembangkan lagi kemahiran berkaitan AI mereka. Walau bagaimanapun, pensyarah menyatakan kebimbangan berkaitan isu etika, plagiarisme, kebergantungan pelajar dan kebolehpercayaan kandungan yang dijana AI. Keputusan ini menyerlahkan keperluan untuk garis panduan institusi yang jelas, rangka kerja etika dan pembangunan profesional berterusan untuk menyokong integrasi AI yang bertanggungjawab. Secara keseluruhan, kajian menunjukkan bahawa AI boleh meningkatkan

pengajaran apabila dilaksanakan secara bernas dan beretika (Holmes et al., 2019; Kasneci et al., 2023; UNESCO, 2023).

***Kata kunci**: Kecerdasan buatan dalam pendidikan; Persepsi pensyarah; Kesediaan untuk menerima pakai AI; Kebimbangan etika; Pendidikan tinggi*

1.0 INTRODUCTION

Artificial Intelligence (AI) is increasingly being used in higher education to support teaching and learning activities. Tools such as automated feedback systems, learning analytics, and generative AI applications have the potential to improve teaching efficiency and enhance student learning experiences. Previous research suggests that AI can be a valuable support tool for lecturers when it is used appropriately and responsibly (Holmes et al., 2019). However, the successful use of AI in education depends greatly on lecturers, as their perceptions, acceptance, and readiness influence how AI is adopted in teaching practices (Zawacki-Richter et al., 2019). Understanding lecturers' perceptions of AI usage is therefore important to support effective and responsible integration of AI in higher education. By listening to lecturers' experiences and opinions, this research hopes to support better planning, training, and decision-making for the use of AI in higher education.

1.1 Problem Statement

AI is becoming a bigger part of higher education, but not all lecturers feel the same way about using it. Some lecturers see AI as a helpful tool that can save time, support teaching, and make learning more engaging for students. However, others feel unsure, unprepared, or even worried about how AI might change their work, affect academic integrity, or impact their role as educators. Artificial Intelligence (AI) is increasingly being introduced into higher education to support teaching and learning activities. Previous studies have shown that AI can enhance teaching efficiency, support personalised learning, and assist lecturers with tasks such as assessment and feedback (Holmes et al., 2019; Luckin et al., 2016). However, research also indicates that lecturers have mixed perceptions toward the use of AI in education. While some lecturers view AI as a useful teaching support tool, others express concerns related to lack of skills, ethical issues, academic integrity, and unclear guidelines for AI use (Zawacki-Richter et al., 2019).

1.2 Research Objectives

The aim of this study is to explore lecturers' perceptions of the use of Artificial Intelligence (AI) in education, particularly in terms of perceived usefulness, concerns, and readiness to use AI in teaching and learning. Previous research highlights that lecturers' perceptions play an important role in the successful adoption of AI in higher education (Zawacki-Richter et al., 2019; Holmes et al., 2019). There are four (4) research objectives:

a) Explore educators' perceptions and attitudes toward the use of AI in higher education.
b) Identify the benefits educators see in using AI for teaching and learning.
c) Evaluate the challenges and concerns educators face when using AI
d) Examine how readiness educators to adopt AI in teaching and learning.

1.3 Significant of Research

This study is important because it helps to understand how educators feel about using Artificial Intelligence (AI) in education. By exploring their perceptions, readiness, and acceptance of AI, the study can provide useful insights for schools and educational institutions to better support teachers in using AI tools in teaching and learning. The findings may also help improve teaching practices and create more engaging learning experiences for students. In addition, this study can serve as a useful reference for future research on the use of AI in education.

2.0 LITERATURE REVIEW

2.1 Key Theories

Two key theories are commonly used to explain lecturers' perceptions and acceptance of Artificial Intelligence (AI) in education. The first is the Technology Acceptance Model (TAM), which suggests that individuals are more likely to use a technology if they perceive it as useful and easy to use (Davis, 1989). In educational settings, TAM helps explain how lecturers' beliefs about the usefulness of AI and their comfort in using it influence their willingness to adopt AI in teaching and learning. The second is the Unified Theory of Acceptance and Use of Technology (UTAUT). This theory explains technology adoption based on factors such as performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh et al., 2003). Previous research shows that support systems, training, and institutional encouragement play an important role in shaping lecturers' readiness to use AI in education.

2.2 Past Studies

Previous studies have examined the use of Artificial Intelligence (AI) in higher education and highlighted its potential to support teaching and learning. Research has shown that AI tools can help lecturers improve teaching efficiency, provide personalised feedback, and support assessment processes (Holmes et al., 2019). However, past research also indicates that lecturers' perceptions of AI usage are mixed. A systematic review by Zawacki-Richter et al. (2019) found that while educators recognise the benefits of AI, many express concerns related to ethical issues, data privacy, academic integrity, and lack of clear guidelines. Similarly, Bond et al. (2023) reported that educators' acceptance of emerging technologies is influenced by their confidence, prior experience, and availability of institutional support and training. Overall, previous studies highlight that lecturers' perceptions play a key role in the successful adoption of AI in education.

2.3 Research Gaps

Although previous studies have explored the use of Artificial Intelligence (AI) in higher education, several research gaps remain. Existing research has largely focused on the technical development of AI systems or students' use of AI, with less attention given to lecturers' perceptions and experiences (Zawacki-Richter et al., 2019). This creates a limited understanding of how lecturers view AI and how their perceptions influence its use in teaching and learning. In addition, many past studies discuss the potential benefits and challenges of AI in general terms but provide limited empirical evidence on lecturers' readiness, concerns, and

actual usage of AI tools (Holmes et al., 2019). Furthermore, research examining the role of institutional support, training, and guidelines from the lecturers' perspective is still insufficient (Bond et al., 2023). These gaps highlight the need for further research focusing specifically on lecturers' perceptions of AI usage in education to support effective, ethical, and sustainable integration of AI in higher education. These gaps show that more research is needed to truly understand lecturers' perceptions, especially in the fast-changing landscape of higher education.

2.4 Conceptual Framework

Below is a simple conceptual framework that guides this study. Lecturers' perceptions of AI are shaped by three major factors:

a) Perceived Benefits
b) Perceived Challenges
c) Readiness to Use AI

In summary, previous research highlights both the potential and challenges of AI in higher education. However, more focused studies on lecturers' perspectives are needed to guide institutions in supporting effective and responsible AI adoption.

3.0 RESEARCH METHODOLOGY

This chapter explains how the study was carried out. The goal is to ensure that the research process is transparent, systematic, and easy to understand so that others can follow or repeat it. The methods chosen were designed to gather honest, meaningful insights into how lecturers perceive the use of AI in teaching and learning.

3.1 Research Design

This study adopts a quantitative survey research design to examine lecturers' perceptions of Artificial Intelligence (AI) usage in education. A quantitative approach is suitable for measuring perceptions and attitudes using numerical data collected from a group of respondents (Creswell & Creswell, 2018).

3.2 Population and Sampling

The study involves lecturers from higher education institutions. A convenience sampling technique is used to select participants based on accessibility and willingness to participate. This method is commonly used in educational research, particularly when studying perceptions and attitudes (Etikan et al., 2016). The respondents consisted of 52 lecturers from various higher education institutions, including universities, polytechnics and colleges. Purposive sampling was chosen because it allows researchers to intentionally select individuals who have direct experience and knowledge related to the phenomenon being studied (Creswell, 2014; Etikan, Musa, & Alkassim, 2016).

3.3 Research Instrument

Data are collected using a structured questionnaire adapted from established technology acceptance models. The questionnaire includes items related to perceived usefulness, ease of

use, concerns, and readiness to use AI, based on the Technology Acceptance Model (Davis, 1989) and the Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003). Responses are measured using a five-point Likert scale ranging from strongly disagree to strongly agree.

3.4 Data Analysis

The collected data are analyzed using descriptive and inferential statistical methods. Descriptive statistics are used to summaries respondents' perceptions, while inferential analysis helps examine relationships among key variables. This approach provides a clear understanding of lecturers' perceptions of AI usage in education.

4.0 RESEARCH FINDINGS

4.1 SECTION 1 — Demographic Information

4.1.1 Institution

A total of 52 respondents participated in the study from various institutions. The findings show that respondents came from a wide range of departments and higher education institutions, indicating a diverse institutional representation.

Table 4.1: Distribution of Respondents by Institution (n = 52)

Institution / Category	Frequency (n)	Percentage (%)
Kementrian Pengajian Tinggi (KPT)	4	7.69
Universiti Malaysia	4	7.69
Politeknik Malaysia	36	69.23
Kolej Komuniti	8	15.38
Total	52	100.0

4.1.2 Teaching Experience

Table 4.2: Teaching Experience

Teaching Experience	Frequency (n)	Percentage (%)
Less than 2 years	2	3.8
2–5 years	3	5.8
6–10 years	7	13.5
11–15 years	10	19.2
More than 15 years	30	57.7
Total	52	100.0

4.1.3 Level of Teaching

Table 4.3: Level of Teaching

Level You Teach	Frequency (n)	Percentage (%)
Ministry of Higher Education	2	3.8
Polytechnics / College / TVET	45	86.5
University	5	9.6
Total	52	100.0

4.2 SECTION 2 — Awareness & Understanding of AI Section

4.2.1 How familiar are you with Artificial Intelligence (AI)?

Table 4.4: Lecturers' Familiarity with Artificial Intelligence

Level of Familiarity	Likert Scale Value	Frequency (n)	Percentage (%)
Not familiar	1	0	0.0
Slightly familiar	2	2	3.8
Moderately familiar	3	25	48.1
Very familiar	4	21	40.4
Extremely familiar	5	4	7.7
Total		52	100.0

4.2.2 Have you received any training related to AI or AI tools?

Table 4.5: Training related AI

Response	Frequency (n)	Percentage (%)
Yes	32	61.5
No	20	38.5
Total	52	100.0

4.3 SECTION 3 — Current Use of AI in Teaching

4.3.1 Do you currently use AI tools in your teaching?

Table 4.6: Current Use of AI in Teaching

Response	Frequency (n)	Percentage (%)
Yes	42	80.8
No	10	19.2
Total	52	100.0

4.3.2 If yes, how often do you use AI?

Table 4.7: Frequency of AI Use

Frequency of Use	Frequency (n)	Percentage (%)
Rarely	4	8.9
Sometimes	13	28.9
Often	20	44.4
Very often	8	17.8
Total	45	100.0

4.3.3 What tasks do you use AI for?

Table 4.8: Task using AI

Task	Frequency (n)	Percentage (%)
Creating learning materials	41	91.1
Assessments / quizzes	35	77.8
Lesson planning	26	57.8
Administrative tasks	21	46.7
Student engagement	14	31.1
Providing feedback	10	22.2
Marking / grading	4	8.9

4.4 SECTION 4 — Perception of AI Benefits

Table 4.9: Summarises lecturers' perceptions of AI usage in teaching.

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total	Trend
AI helps me save time in preparing teaching materials	28 (53.8%)	20 (38.5%)	3 (5.8%)	1 (1.9%)	0 (0%)	52	Positive
AI improves the quality of my teaching resources	26 (50.0%)	21 (40.4%)	4 (7.7%)	1 (1.9%)	0 (0%)	52	Positive
AI helps personalize learning for students	18 (34.6%)	25 (48.1%)	7 (13.5%)	2 (3.8%)	0 (0%)	52	Positive
AI enhances student engagement	15 (28.8%)	23 (44.2%)	10 (19.2%)	4 (7.7%)	0 (0%)	52	Moderately Positive

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total	Trend
AI supports me in giving better feedback	20 (38.5%)	24 (46.2%)	6 (11.5%)	2 (3.8%)	0 (0%)	52	Positive
AI can help students learn independently	19 (36.5%)	25 (48.1%)	6 (11.5%)	2 (3.8%)	0 (0%)	52	Positive
AI can reduce my workload	27 (51.9%)	21 (40.4%)	3 (5.8%)	1 (1.9%)	0 (0%)	52	Positive

4.5 SECTION 5 — Concerns & Challenges

Table 4.10 Challenges and Concern about AI

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total	Trend
AI may reduce students' critical thinking skills	23 (44.2%)	20 (38.5%)	6 (11.5%)	3 (5.8%)	0 (0%)	52	Concern present
Students may become too dependent on AI	25 (48.1%)	19 (36.5%)	5 (9.6%)	3 (5.8%)	0 (0%)	52	Concern present
I am unsure about the accuracy of AI-generated content	15 (28.8%)	25 (48.1%)	8 (15.4%)	4 (7.7%)	0 (0%)	52	Concern present
I do not feel adequately trained to use AI effectively	13 (25.0%)	17 (32.7%)	15 (28.8%)	6 (11.5%)	1 (1.9%)	52	Moderate concern
I worry about ethical issues and plagiarism	26 (50.0%)	20 (38.5%)	4 (7.7%)	2 (3.8%)	0 (0%)	52	Strong concern
AI might replace some teaching tasks	16 (30.8%)	24 (46.2%)	8 (15.4%)	4 (7.7%)	0 (0%)	52	Concern present

4.6 SECTION 6 — Overall Perception & Readiness

Table 4.11: Summary of Lecturers' Attitudes and Readiness Toward AI in Education

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total	Trend
AI has a positive impact on education	25 (48.1%)	21 (40.4%)	4 (7.7%)	2 (3.8%)	0 (0%)	52	Positive
I am open to integrating more AI tools into my teaching	27 (51.9%)	20 (38.5%)	3 (5.8%)	2 (3.8%)	0 (0%)	52	Positive
I feel confident using AI tools	17 (32.7%)	25 (48.1%)	7 (13.5%)	3 (5.8%)	0 (0%)	52	Positive
AI will become a standard part of education	19 (36.5%)	24 (46.2%)	6 (11.5%)	3 (5.8%)	0 (0%)	52	Positive
I am ready to learn more about AI	28 (53.8%)	19 (36.5%)	3 (5.8%)	2 (3.8%)	0 (0%)	52	Very Positive

5.0 RESEARCH DISCUSSION

The findings indicate that lecturers generally hold positive perceptions toward the use of AI in teaching. Most respondents viewed AI as a helpful tool for saving time, improving teaching materials, and reducing workload, suggesting that AI is seen as a form of support rather than a replacement for lecturers. This aligns with previous studies highlighting AI's role in assisting instructional tasks and enhancing teaching efficiency (Holmes et al., 2019; Zawacki-Richter et al., 2019). Lecturers also demonstrated a strong readiness to adopt AI, with many expressing confidences in using AI tools and willingness to learn more. This reflects earlier research showing that positive attitudes and perceived usefulness encourage technology adoption among educators (Teo, 2011; Venkatesh et al., 2012).

However, despite this openness, several concerns were evident. Lecturers expressed worries about ethical issues, plagiarism, student dependence on AI, and the accuracy of AI-generated content. These concerns echo recent literature emphasizing the need for responsible and ethical AI use in education (Kasneci et al., 2023; UNESCO, 2023). Additionally, some lecturers felt insufficiently trained to use AI effectively, indicating a need for structured professional development. Overall, the findings suggest a cautiously optimistic stance toward AI, highlighting the importance of institutional support, clear guidelines, and ongoing training to ensure effective and ethical AI integration in teaching (Selwyn, 2019; Zhai et al., 2021).

6.0 CONCLUSION

This study explored lecturers' perceptions, readiness, and concerns regarding the use of AI in teaching. Overall, the findings show that lecturers generally hold positive views toward AI, particularly in terms of its ability to save time, improve teaching materials, and support instructional tasks. AI was largely seen as a helpful tool that complements lecturers' work rather than replacing their role, which is consistent with earlier studies on AI in education (Holmes et al., 2019; Zawacki-Richter et al., 2019). The results also indicate a high level of readiness and openness among lecturers to adopt AI tools. Many respondents reported confidence in using AI and expressed strong willingness to continue learning about AI technologies. This suggests that lecturers recognise the importance of developing digital competencies to keep pace with changes in teaching and learning practices, supporting previous research on technology acceptance among educators (Teo, 2011; Venkatesh et al., 2012).

At the same time, the study highlights important concerns related to ethical issues, plagiarism, student dependency, and the accuracy of AI-generated content. These concerns reflect lecturers' awareness of the potential risks associated with unregulated AI use and echo calls in the literature for responsible and ethical integration of AI in education (Kasneci et al., 2023; UNESCO, 2023). Additionally, some lecturers reported feeling insufficiently trained, indicating the need for ongoing professional development and institutional support (Zhai et al., 2021).

In conclusion, the findings suggest that lecturers adopt a balanced and cautiously optimistic approach toward AI in teaching. While they acknowledge its benefits and show readiness to engage with AI tools, they also emphasise the importance of ethical use, clear guidelines, and adequate training. These results underscore the need for higher education institutions to support lecturers through appropriate policies, training programmes, and support systems to ensure that AI enhances teaching and learning in meaningful and responsible ways (Selwyn, 2019).

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ANALISIS KEBOLEHPASARAN GRADUAN DIPLOMA KEJURUTERAAN MEKANIKAL DALAM BIDANG PEKERJAAN BERKAITAN KURANG SETAHUN SELEPAS TAMAT PENGAJIAN

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Abstract

This study aims to analyze the field-of-study job matching of Diploma in Mechanical Engineering graduates within less than one year after graduation. Field-of-study job matching refers to the extent to which graduates obtain employment that aligns with their area of study. This study adopts a quantitative approach using descriptive analysis based on graduate placement data from 2019 to 2024. The data were obtained from official polytechnic graduate placement records and analyzed to identify trends in job matching among graduates. The findings indicate that the percentage of graduates employed in their field of study within less than one year after graduation ranges from 37.6% to 46.9%. These results suggest that the initial level of job matching among graduates is relatively low, approaching 50%. However, the data show a gradual improvement in 2024 following a decline in the previous year. The study also finds that some graduates begin their careers outside their field of study before transitioning into related fields after gaining work experience. Therefore, this study recommends that educational institutions strengthen industry engagement, enhance practical training, and update curricula to better align with labor market needs. These measures are expected to improve graduates' job matching in the early period after graduation.

Keywords: job matching, graduate employability, Diploma in Mechanical Engineering, graduate placement, industry involvement

Abstrak

Kajian ini bertujuan untuk menganalisis kebolehpadanan bidang pekerjaan graduan Diploma Kejuruteraan Mekanikal dalam tempoh kurang daripada setahun selepas tamat pengajian di Politeknik Kota Bharu. Kebolehpadanan bidang pekerjaan merujuk kepada sejauh mana graduan memperoleh pekerjaan yang selari dengan bidang pengajian mereka. Kajian ini menggunakan pendekatan kuantitatif dengan analisis deskriptif berdasarkan data penempatan graduan bagi tempoh 2019 hingga 2024. Data diperoleh daripada rekod rasmi penempatan graduan politeknik Kota Bharu dan dianalisis untuk mengenal pasti trend kebolehpadanan pekerjaan dalam kalangan graduan. Hasil kajian menunjukkan bahawa peratus graduan yang bekerja dalam bidang pengajian mereka dalam tempoh kurang daripada setahun selepas tamat

pengajian adalah antara 37.6% hingga 46.9%. Dapatan ini menunjukkan tahap kebolehpadanan awal graduan berada pada kategori rendah hingga hampir 50%. Walau bagaimanapun, kecenderungan data menunjukkan peningkatan secara beransur-ansur pada tahun 2024 selepas penurunan yang berlaku pada tahun sebelumnya. Kajian ini juga mendapati bahawa sebahagian graduan memulakan kerjaya di luar bidang pengajian sebelum beralih kepada bidang yang berkaitan selepas memperoleh pengalaman kerja. Oleh itu, kajian ini mencadangkan agar institusi pendidikan memperkukuhkan penglibatan industri, meningkatkan latihan praktikal, serta mengemaskini kurikulum agar lebih selari dengan keperluan pasaran kerja. Langkah-langkah ini diharapkan dapat meningkatkan kebolehpadanan bidang pekerjaan graduan dalam tempoh awal selepas tamat pengajian.

Kata kunci: *kebolehpadanan pekerjaan, kebolehpasaran graduan, Diploma Kejuruteraan Mekanikal, penempatan graduan, penglibatan industri.*

1.0 PENGENALAN

Kebolehpasaran graduan merupakan indikator penting dalam menilai keberkesanan pendidikan tinggi, khususnya di institusi teknikal dan vokasional seperti politeknik. Kebolehpadanan antara bidang pengajian dan pekerjaan mencerminkan sejauh mana kurikulum memenuhi keperluan industri serta tahap kesiapsiagaan graduan memasuki alam pekerjaan. Namun, tidak semua graduan memperoleh pekerjaan yang selari dengan bidang pengajian dalam tempoh kurang daripada setahun. Hal ini dipengaruhi oleh faktor seperti perubahan keperluan industri, persaingan pasaran kerja, kekurangan pengalaman praktikal, dan ketidakpadanan kemahiran dengan kehendak majikan. Akibatnya, sebahagian graduan memulakan kerjaya dalam bidang tidak berkaitan sebelum beralih ke bidang yang relevan.

Kajian ini menganalisis kebolehpadanan pekerjaan graduan Diploma Kejuruteraan Mekanikal Politeknik Kota Bharu bagi tempoh 2019–2024 menggunakan pendekatan kuantitatif. Hasil kajian menunjukkan peratus kebolehpadanan berada antara 37.6% hingga 46.9%, iaitu pada tahap rendah (kurang 50%), namun menunjukkan peningkatan pada tahun 2024. Dapatan juga menunjukkan kebolehpasaran graduan bersifat dinamik dan boleh meningkat dengan pengalaman kerja. Oleh itu, institusi pendidikan disarankan memperkukuh kerjasama industri, meningkatkan latihan praktikal, dan mengemaskini kurikulum agar lebih selari dengan keperluan semasa. Secara keseluruhannya, kajian ini memberi gambaran awal tentang tahap kebolehpadanan graduan dan membantu dalam merancang strategi bagi meningkatkan kebolehpasaran pada masa hadapan.

1.1 Penyataan Masalah

Walaupun kebolehpasaran graduan TVET di Malaysia adalah tinggi, isu ketidakpadanan antara bidang pengajian dan pekerjaan masih menjadi cabaran. Data menunjukkan hanya 37.6% hingga 46.9% graduan Diploma Kejuruteraan Mekanikal bekerja dalam bidang berkaitan dalam tempoh kurang setahun selepas tamat pengajian (2019–2024), menandakan tahap kebolehpadanan masih rendah. Situasi ini mencerminkan jurang antara kemahiran graduan dan keperluan industri, yang mungkin berpunca daripada ketidaksesuaian kurikulum, kekangan

latihan industri, penglibatan industri yang terhad serta kekurangan kemahiran insaniah. Selain itu, sebahagian graduan memulakan kerjaya di luar bidang sebelum beralih ke bidang berkaitan. Oleh itu, kajian ini dijalankan untuk menganalisis kebolehpadanan pekerjaan graduan dalam tempoh kurang setahun selepas tamat pengajian (2019–2024) bagi membantu merangka strategi meningkatkan kesepadanan pekerjaan pada masa hadapan.

1.2 Objektif Kajian

Objektif kajian ini adalah seperti berikut:

1. Menganalisis trend kebolehpadanan bidang pekerjaan graduan Diploma Kejuruteraan Mekanikal dalam tempoh kurang daripada setahun selepas tamat pengajian.
2. Menilai tahap kebolehpasaran graduan Diploma Kejuruteraan Mekanikal berdasarkan kesepadanan antara bidang pengajian dan bidang pekerjaan.
3. Mencadangkan langkah penambahbaikan bagi meningkatkan kebolehpadanan bidang pekerjaan graduan pada masa hadapan.

1.3 Kepentingan Kajian

Kajian ini penting kepada pelbagai pihak dalam meningkatkan kebolehpasaran graduan Diploma Kejuruteraan Mekanikal dalam tempoh awal selepas tamat pengajian. Dapatan kajian memberikan maklumat kepada pihak politeknik mengenai tahap kebolehpadanan bidang pekerjaan graduan, seterusnya membantu menilai keberkesanan kurikulum serta mengenal pasti penambahbaikan agar lebih selari dengan keperluan industri. Kajian ini juga menyokong pengukuhan pelaksanaan latihan industri, program pembelajaran berasaskan kerja (*work-based learning*) dan pembangunan kemahiran insaniah pelajar.

Selain itu, kajian ini membantu pihak industri memahami tahap kesediaan graduan serta mengenal pasti jurang kemahiran, sekali gus mendorong penglibatan lebih aktif dalam pembangunan kurikulum dan kerjasama strategik dengan institusi pendidikan. Di samping itu, kajian ini memberi pendedahan kepada graduan tentang realiti pasaran kerja, sekali gus membantu mereka membuat persediaan awal dari segi kemahiran, perancangan kerjaya dan kesediaan bekerja di luar bidang pada peringkat awal sebelum beralih ke bidang berkaitan.

1.0 KAJIAN LITERATUR

Bab ini membincangkan kajian-kajian terdahulu berkaitan kebolehpasaran graduan, kesepadanan bidang pengajian dan pekerjaan serta faktor-faktor yang mempengaruhi kebolehpadanan pekerjaan. Sorotan ini turut meneliti peranan institusi TVET dalam meningkatkan kebolehpasaran melalui kurikulum yang relevan, latihan industri dan penglibatan industri. Selain itu, bab ini menghuraikan hubungan antara sistem pendidikan dan keperluan pasaran kerja sebagai asas teori dan empirikal bagi memahami isu kebolehpadanan dalam kalangan graduan.

2.1 Kebolehpasaran Graduan

Kebolehpasaran graduan merujuk kepada keupayaan graduan memperoleh pekerjaan serta memenuhi keperluan pasaran kerja, yang tidak hanya bergantung kepada pencapaian akademik tetapi turut melibatkan kemahiran insaniah seperti komunikasi, kerja berpasukan dan

penyelesaian masalah (Enah Ali et al., 2018). Selain itu, kebolehpasaran juga dipengaruhi oleh keupayaan graduan menyesuaikan diri dengan perubahan teknologi dan globalisasi serta penguasaan kemahiran teknikal yang seimbang (Tomlinson, 2018). Jackson dan Bridgstock (2019) menegaskan bahawa integrasi pengalaman industri dalam pendidikan dapat meningkatkan kesediaan graduan menghadapi dunia pekerjaan. Dalam konteks Malaysia, laporan Kajian Pengesanan Graduan menunjukkan kadar kebolehpasaran yang tinggi, namun masih wujud isu ketidakpadanan antara bidang pengajian dan pekerjaan (Kementerian Pengajian Tinggi, 2020).

Bagi politeknik pula, kadar kebolehpasaran graduan didapati konsisten tinggi, melebihi 96% dan mencecah hampir 99% dalam beberapa tahun kebelakangan, dengan majoriti graduan memperoleh pekerjaan dalam tempoh enam bulan hingga kurang setahun selepas tamat pengajian. Walau bagaimanapun, kesepadanan bidang pekerjaan masih menjadi cabaran utama walaupun kebolehpasaran keseluruhan adalah tinggi. Sehubungan itu, pendekatan seperti *Work-Based Learning* dilihat berpotensi meningkatkan kebolehpasaran graduan dengan memberikan pendedahan industri dan membantu merapatkan jurang antara kemahiran graduan dengan keperluan pasaran kerja.

2.2 Kesepadanan Bidang Pengajian dan Pekerjaan

Kesepadanan bidang pengajian dan pekerjaan merujuk kepada sejauh mana pekerjaan graduan selari dengan bidang pengajian yang telah dipelajari. Menurut Robst (2019), ketidakpadanan boleh berlaku apabila kemahiran graduan tidak memenuhi keperluan industri atau peluang pekerjaan dalam bidang tertentu adalah terhad. Allen dan Van der Velden (2018) pula mendapati bahawa sebahagian graduan memulakan kerjaya di luar bidang pengajian sebelum beralih ke bidang berkaitan selepas memperoleh pengalaman kerja, menunjukkan bahawa kesepadanan boleh berubah mengikut masa.

Dalam konteks Malaysia, Mohd Zairulniza Jaludin et al. (2019) menegaskan bahawa jurang kemahiran antara graduan dan kehendak industri menjadi punca kesukaran mendapatkan pekerjaan yang selari pada peringkat awal. Sehubungan itu, Basah, Noor dan Ahmad (2024) mencadangkan bahawa kerjasama erat antara institusi pendidikan dan industri dalam pembangunan kurikulum serta latihan praktikal dapat meningkatkan tahap kesepadanan bidang pekerjaan graduan TVET.

2.3 Faktor yang Mempengaruhi Kebolehpasaran Graduan

Kebolehpasaran graduan dipengaruhi oleh beberapa faktor utama seperti kesesuaian kurikulum, pengalaman latihan industri, tahap kemahiran serta penglibatan industri dalam pendidikan. Kurikulum yang relevan dan menggabungkan teori serta praktikal dapat meningkatkan kesiapsiagaan graduan (Yorke, 2018), manakala pengalaman latihan industri memberi kelebihan dalam memperoleh pekerjaan kerana pendedahan kepada persekitaran kerja sebenar (Clarke, 2018).

Selain itu, faktor seperti pencapaian akademik, sokongan keluarga dan lokasi pekerjaan turut mempengaruhi pilihan kerjaya (Safawati Endut, 2024). Kemahiran insaniah seperti

komunikasi, kepimpinan, pemikiran kritis dan kebolehsuaian juga penting kerana sangat dihargai oleh majikan (Jackson, 2020). Penglibatan industri dalam pendidikan TVET memainkan peranan penting dalam memastikan kurikulum sentiasa relevan melalui kerjasama dalam latihan, pembangunan kurikulum dan penyelidikan (Billett, 2019; Ahmad & Hassan, 2021). Selain itu, kerjasama antara institusi pendidikan, industri dan kerajaan membantu melahirkan graduan yang lebih kompeten serta mengurangkan jurang kemahiran (UNESCO-UNEVOC, 2022).

3.0 METODOLOGI KAJIAN

Bab ini menerangkan metodologi kajian yang meliputi reka bentuk kajian, populasi dan sampel, kaedah pengumpulan data, instrumen kajian serta prosedur kajian. Kajian ini menggunakan pendekatan kuantitatif deskriptif bagi menganalisis peratus kebolehpadanan bidang pekerjaan graduan serta mengenal pasti pola perubahan mengikut tahun. Populasi kajian merangkumi semua graduan Diploma Kejuruteraan Mekanikal di politeknik bagi tempoh tahun 2019 hingga 2024, manakala sampel kajian terdiri daripada data penempatan graduan yang diperoleh secara rasmi daripada Bahagian Kebolehpasaran Graduan dan Industri (BKIK) bagi memastikan ketepatan dan kesahihan data. Data dikumpulkan melalui rekod rasmi penempatan graduan yang merangkumi maklumat seperti nama graduan (dikodkan), tahun tamat pengajian, status pekerjaan serta bidang pekerjaan.

Instrumen kajian yang digunakan ialah borang rekod penempatan graduan melalui Sistem Kajian Pengesanan Graduan (SKPG) yang diisi oleh graduan selepas tamat pengajian. Prosedur kajian dimulakan dengan permohonan akses data daripada BKIK, diikuti dengan proses penapisan graduan yang bekerja dalam tempoh kurang daripada setahun selepas tamat pengajian, pengkategorian data kepada bidang berkaitan dan tidak berkaitan, serta analisis data menggunakan perisian Microsoft Excel. Kaedah Analisis Data melalui deskriptif statistik iaitu mengira peratus kebolehpadanan menggunakan formula:

$$\text{Peratus Kebolehpadanan} = \frac{\text{Graduan bekerja dalam bidang pengajian}}{\text{Jumlah graduan bekerja}} \times 100\%$$

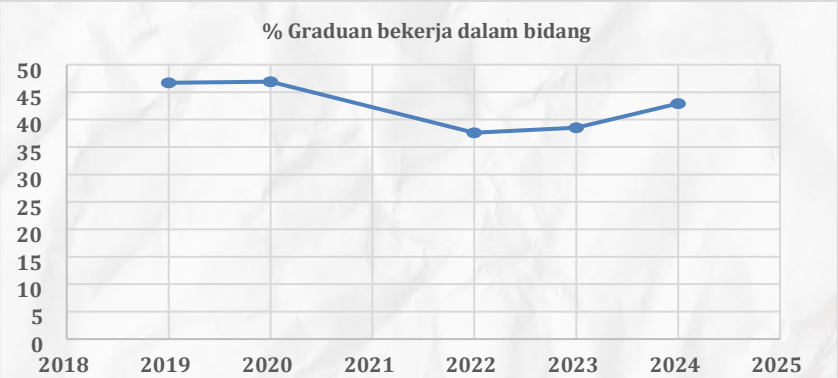
Data divisualisasikan dalam jadual. Kesahan kajian ini adalah terjamin kerana data yang digunakan diperoleh daripada sumber rasmi Bahagian Kebolehpasaran Graduan dan Industri (BKIK), yang diiktiraf dari segi ketepatan dan kesahihannya. Dari aspek kebolehpercayaan pula, kajian ini menggunakan kaedah analisis yang konsisten dan sistematik, serta boleh diulang (*replicable*) oleh penyelidik lain dengan menggunakan set data dan prosedur yang sama.

4.0 DAPATAN KAJIAN

Bab ini membincangkan dapatan berdasarkan data penempatan graduan Diploma Kejuruteraan Mekanikal di Politeknik Kota Bharu yang berkerja dalam bidang kurang daripada setahun selepas tamat pengajian. Dapatan seperti dalam jaduai 4.1 dibawah.

Jadual 4.1 Peratus Graduan Bekerja Dalam Bidang

Tahun	% Graduan bekerja dalam bidang	Kategori
2019	46.7	Hampir 50%
2020	46.9	Hampir 50%
2022	37.6	Rendah
2023	38.5	Rendah
2024	42.9	Rendah / Hampir 50%



Rajah 4.1: Peratus Graduan Bekerja Dalam Bidang mengikut Tahun

5.0 KESIMPULAN DAN CADANGAN

Bagi meningkatkan tahap kebolehpadanan pekerjaan dalam kalangan graduan Diploma Kejuruteraan Mekanikal di Politeknik Kota Bharu, beberapa langkah strategik perlu dilaksanakan secara bersepadu. Pertama, industri tidak seharusnya sekadar menjadi penerima graduan, malah perlu berperanan sebagai rakan kongsi strategik dalam proses pendidikan melalui pelibatan aktif pakar industri dalam sesi kuliah jemputan, panel penasihat kurikulum, serta penilaian projek akhir pelajar. Langkah kolaboratif ini secara langsung dapat memastikan pendedahan pelajar terhadap teknologi terkini, seperti sistem robotik dan automasi, sentiasa selari dengan standard piawaian kilang atau syarikat moden.

Kedua, Latihan Industri (LI) perlu beralih daripada sekadar pendedahan am kepada latihan pengkhususan yang lebih terarah melalui langkah memadankan penempatan pelajar dengan minat kerjaya spesifik mereka, seperti menempatkan pelajar yang meminati bidang kimpalan di bengkel fabrikasi logam berbanding di pejabat pentadbiran. Pendekatan ini membolehkan graduan menguasai operasi teknikal syarikat dengan lebih mendalam, sekali gus meningkatkan kebolehpadanan pekerjaan dan memberi peluang yang lebih besar untuk mereka terus diserap masuk sebagai pekerja tetap sebaik sahaja tamat tempoh latihan.

Ketiga, alumni bertindak sebagai jambatan strategik antara Politeknik dan dunia kerjaya sebenar melalui pewujudan sistem mentor-mentee, di mana alumni yang telah berpengalaman membimbing pelajar tahun akhir mengenai realiti serta cabaran industri mekanikal masa kini. Inisiatif ini bukan sahaja membantu graduan baharu membina rangkaian profesional (*networking*) yang kukuh, malah membuka peluang pekerjaan yang lebih luas melalui sistem rujukan alumni, sekali gus mempercepatkan proses transisi graduan ke alam pekerjaan yang relevan dengan bidang pengajian mereka.

Kurikulum pendidikan perlu bersifat dinamik melalui penggunaan data daripada agensi berkaitan bagi mengenal pasti kemahiran mekanikal yang mempunyai permintaan tinggi, seperti penyelenggaraan tenaga boleh baharu atau kenderaan elektrik (EV). Melalui penjajaran kurikulum berasaskan kluster industry, pelajar dapat memilih pengkhususan yang tepat mengikut keperluan ekonomi setempat. Selain itu, pemantapan kemahiran digital IR 4.0 melalui perisian seperti *SolidWorks* dan *IoT* akan melahirkan graduan "Hybrid" yang kompeten. Pendekatan holistik ini bertujuan memastikan graduan memiliki kemahiran spesifik yang diperlukan oleh industri, sekali gus membolehkan mereka mengisi jawatan teknikal berkemahiran tinggi serta mengurangkan isu ketidakpadanan bidang pekerjaan.

Secara keseluruhannya, peningkatan kebolehpadanan graduan Diploma Kejuruteraan Mekanikal di Politeknik Kota Bharu memerlukan anjakan daripada model pendidikan konvensional kepada ekosistem yang lebih kolaboratif dan dinamik. Kerjasama strategik antara penglibatan aktif industri, transformasi latihan praktikal yang terarah, sokongan rangkaian alumni, serta penyelarasan kurikulum berasaskan data pasaran kerja adalah kunci utama dalam memastikan graduan tidak hanya sekadar mendapat pekerjaan, malah ditempatkan dalam bidang yang relevan dengan kepakaran mereka. Melalui pelaksanaan langkah-langkah ini, institusi Politeknik mampu melahirkan modal insan yang kompeten sekali gus menyumbang kepada pengurangan isu ketidakpadanan pekerjaan serta memacu pertumbuhan sektor perindustrian negara secara lebih mampan. Cadangan untuk kajian akan datang menghasilkan satu garis panduan untuk pihak berkaitan mendapat rujukan bagi meningkatkan kebolehpasaran dan kesepadanan bagi graduan politeknik.

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TECHNICAL COMPETENCE AND SOFT SKILLS THROUGH ROBOTICS COMPETITIONS: A CASE STUDY OF FIRA ROBOWORLD MALAYSIA 2025 PARTICIPANTS AT POLITEKNIK SULTAN ABDUL HALIM MU'ADZAM SHAH (POLIMAS)

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Abstract

Robotics competitions are one of the high-impact learning platforms that can enhance technical competencies as well as soft skills among students in Technical and Vocational Education and Training (TVET). Participation in such competitions provides students with opportunities to apply theoretical knowledge in practical settings, solve problems creatively, and collaborate in teams to produce technological innovations. In this regard, this study was conducted to identify the level of improvement in technical skills and to evaluate the development of soft skills among TVET students through participation in robotics competitions. The study was carried out among participants of the FIRA RoboWorld Malaysia 2025 at Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS). The research design is quantitative in nature using a survey method through a four-point Likert scale questionnaire. A total of 32 respondents were involved in this study representing all participants who took part in the competition. The data were analyzed using descriptive analysis to determine the mean values and correlation for both technical and soft skills aspects. The findings indicate a moderate level of improvement in both technical and soft skills among participants thereby proving that participation in robotics competitions can support the development of more competent, competitive and industry-ready TVET graduates. The findings of this study are also expected to provide input to the Department of Polytechnic and Community College Education (JPPKK) in strengthening the implementation of competition-based learning as a strategic approach to enhancing graduate employability.

Keywords: robotics competition, technical competency, soft skills, TVET, FIRA RoboWorld

Abstrak

Pertandingan robotik merupakan salah satu platform pembelajaran berimpak tinggi yang mampu meningkatkan kompetensi teknikal serta kemahiran insaniah dalam kalangan pelajar Pendidikan dan Latihan Teknikal dan Vokasional (TVET). Penyertaan dalam pertandingan sebegini memberi peluang kepada pelajar untuk mengaplikasikan pengetahuan teori secara praktikal, menyelesaikan masalah secara kreatif serta bekerjasama dalam pasukan bagi menghasilkan inovasi teknologi. Sehubungan itu, kajian ini dijalankan bagi mengenal pasti

tahap peningkatan kemahiran teknikal serta menilai pembentukan kemahiran insaniah dalam kalangan pelajar TVET melalui penyertaan dalam pertandingan robotik. Kajian ini dijalankan dalam kalangan peserta FIRA RoboWorld Malaysia 2025 di Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS). Reka bentuk kajian adalah berbentuk kuantitatif menggunakan kaedah tinjauan melalui soal selidik berskala Likert empat mata. Seramai 32 orang responden terlibat dalam kajian ini yang merangkumi keseluruhan peserta yang menyertai pertandingan tersebut. Data dianalisis menggunakan analisis deskriptif bagi menentukan nilai min dan kolerasi bagi aspek kemahiran teknikal dan kemahiran insaniah. Dapatan kajian dijangka menunjukkan tahap peningkatan kemahiran teknikal dan kemahiran insaniah yang tinggi dalam kalangan peserta, sekali gus membuktikan bahawa penyertaan dalam pertandingan robotik mampu menyokong pembangunan graduan TVET yang lebih kompeten, berdaya saing dan bersedia menghadapi keperluan industri masa hadapan. Hasil kajian ini juga diharapkan dapat memberikan input kepada pihak Jabatan Pendidikan Politeknik dan Kolej Komuniti (JPPKK) dalam memperkukuh pelaksanaan pembelajaran berasaskan pertandingan sebagai salah satu pendekatan strategik dalam meningkatkan kebolehpasaran graduan.

Kata Kunci: *pertandingan robotik, kompetensi teknikal, kemahiran insaniah, TVET, FIRA RoboWorld.*

1.0 INTRODUCTION

The FIRA Roboworld Cup Malaysia serves as a vital Competition-Based Learning platform for TVET students bridging the gap between classroom theory and real-world industrial application. By integrating core components of IR 4.0 such as AI, IoT and sensor integration under strict technical specifications, the competition functions as a high-pressure simulation of the modern engineering landscape. Beyond technical mastery, the experience cultivates essential soft skills including cross-disciplinary collaboration, resilience and leadership which are critical for professional maturity. Ultimately, this synergy of practical innovation and interpersonal growth ensures that graduates are industry-ready significantly enhancing their employability and alignment with global professional standards.

1.1 Problem Statement

In the era of Industry 4.0, Technical and Vocational Education and Training (TVET) institutions are expected to produce graduates who possess not only strong technical competencies, such as programming and mechanical skills, but also essential soft skills including teamwork and resilience. However, existing instructional approaches are often criticized for their limited capacity to support holistic skill development, resulting in a mismatch between graduate capabilities and industry expectations.

Robotics competitions, such as the FIRA RoboWorld Cup Malaysia 2025, have emerged as high-impact experiential learning platforms that potentially address this gap by providing students with opportunities to apply knowledge in real-world contexts. These competitions

integrate elements of problem-solving, innovation, and teamwork, which are aligned with industry demands.

However, limited empirical evidence exists on the effectiveness of robotics competitions in enhancing both technical and soft skills among Malaysian TVET students. In addition, studies that examine the combined impact of these competencies on students' self-development and career readiness remain scarce, particularly within the context of polytechnic institutions such as Politeknik Sultan Abdul Halim Mu'adzam Shah.

Addressing this gap is crucial for informing evidence-based pedagogical strategies. Therefore, this study investigates the development of technical and soft skills through robotics competition participation and analyzes their relationship with self-development and career readiness, contributing to the advancement of competition-based learning in TVET.

1.2 Research Objectives

The objectives are:

i. To examine the level of technical skills (programming and mechanical) developed among students after participating in the FIRA RoboWorld Malaysia 2025.
ii. To evaluate the level of soft skills (teamwork and resilience) developed among students through participation in the robotics competition.
iii. To analyze the relationship between technical skills, soft skills, and self-development with students' career readiness for Industry 4.0.

1.3 Significant of Research

This study contributes to the advancement of knowledge in Technical and Vocational Education and Training (TVET) by providing empirical evidence on the effectiveness of robotics competitions as a high-impact experiential learning approach. It offers valuable insights into how participation in FIRA RoboWorld Malaysia 2025 enhances students' technical skills (programming and mechanical) and soft skills (teamwork and resilience) addressing the current gap in systematically documented outcomes of competition-based learning. The findings are significant for educators and curriculum developers as they provide evidence-based justification for integrating robotics competitions and similar co-curricular activities into teaching and learning strategies.

This supports the development of more holistic and industry-relevant curricula aligned with the demands of Industry 4.0. For policymakers, particularly within the Department of Polytechnic and Community College Education (JPPKK), this study offers practical implications for strengthening policies related to student engagement in innovation-driven activities to enhance graduate employability. Additionally, this study contributes theoretically by examining the relationship between technical skills, soft skills, self-development, and career readiness, thereby enriching existing literature on employability in TVET. Ultimately, the study supports efforts to produce competent, competitive, and industry-ready graduates.

2.0 LITERATURE REVIEW

The development of both technical competencies and soft skills is a critical focus in Technical and Vocational Education and Training (TVET) especially in alignment with the demands of Industry 4.0. Robotics competitions such as FIRA RoboWorld provide a platform where students can apply theoretical knowledge in real-world scenarios while simultaneously developing essential soft skills such as teamwork, communication, and problem-solving.
Robotics competitions have been widely recognized as an effective approach to enhance technical skills among students. According to Matamoros et al. (2019), participation in robotics competitions such as RoboCup enables learners to engage in complex problem-solving, system integration and autonomous system design. These competitions simulate real engineering challenges that require the application of programming, electronics and mechanical design knowledge.

Similarly, So et al. (2022) found that robotics-based competitive learning significantly improves computational thinking and algorithmic problem-solving abilities. Students involved in such competitions demonstrate better understanding of technical concepts compared to traditional classroom-based learning. Furthermore, gamified and competition-based robotics education has been shown to enhance engagement and improve learning outcomes. Mubarrat et al. (2026) highlight that such approaches foster active learning environments where students are motivated to innovate and experiment.

Beyond technical skills, robotics competitions also contribute significantly to the development of soft skills or kemahiran insaniah. Fadel et al. (2021) emphasize that future workforce readiness requires competencies such as critical thinking, collaboration and adaptability which are often developed through experiential learning environments like robotics competitions. In TVET contexts, Rokeman et al. (2024) and Zahir et al. (2024) confirm that students who participate in extracurricular innovation activities including robotics competitions show higher levels of teamwork, communication and leadership skills. These soft skills are essential for employability and are highly valued by industry stakeholders. The integration of Industry 4.0 technologies into TVET education has increased the demand for graduates who are both technically competent and possess strong soft skills. According to the Ministry of Higher Education Malaysia (2021), initiatives such as robotics competitions play a crucial role in preparing students for industrial challenges by bridging the gap between academic learning and practical application.

Participation in robotics competitions such as FIRA RoboWorld aligns with national aspirations to produce highly skilled graduates who are capable of contributing to the digital economy. These platforms also provide exposure to global standards, enhancing students' competitiveness in the job market. The FIRA RoboWorld Cup is an international robotics competition that promotes innovation in autonomous robotics and artificial intelligence. Through participation in such events, students are exposed to high-level problem-solving scenarios that require interdisciplinary knowledge and collaboration.

In Malaysia, involvement in FIRA RoboWorld provides students from institutions such as POLIMAS with opportunities to develop both technical and soft skills in a competitive environment. This aligns with the objective of producing holistic graduates who are capable of meeting the demands of Industry 4.0. Although previous studies have highlighted the benefits of robotics competitions, there is still limited empirical evidence focusing specifically on the impact of such competitions on both technical competency and soft skills among TVET students in Malaysia. In particular, studies examining participation in FIRA RoboWorld within Malaysian polytechnics remain scarce. Therefore, this study aims to address this gap by investigating the competencies developed through participation in robotics competitions at POLIMAS.

3.0 RESEARCH METHODOLOGY

This study aims to examine the level of technical skills and soft skills developed through participation in the FIRA RoboWorld Malaysia 2025. In addition, this study also examines the relationship between technical skills, soft skills, self-development, and students' career readiness. The research questions of this study are as follows:

RQ1: What is the level of students' technical skills after participating in the robotics competition?

RQ2: What is the level of students' soft skills after participating in the robotics competition?

RQ3: Is there a relationship between technical skills, soft skills, self-development and students' career readiness?

The study used a quantitative research design using a survey method. The study was conducted to examine the level of technical skills and soft skills developed through participation in the FIRA RoboWorld Malaysia 2025 competition and to examine the relationship between these skills and student's career readiness. This study tested the following null hypotheses:

H_o1: There is no significant relationship between technical skills and career readiness.

H_o2: There is no significant relationship between soft skills and career readiness.

H_o3: There is no significant relationship between self-development and career readiness.

3.1 Research Design

This study employs a quantitative research design using a cross-sectional survey method. This approach is selected to systematically collect data from participants at a single point in time following the FIRA RoboWorld Malaysia 2025 competition.

The design is specifically categorized into two types of analysis:

i. Descriptive Analysis: Used to address RQ1 and RQ2 by identifying the levels of technical and soft skills acquired by POLIMAS students.
ii. Correlational Analysis: Used to address RQ3 and test the null hypotheses (H_o1 to H_o3). This examines the relationship between technical skills, soft skills, self-development, and students' career readiness.

Given the non-normal distribution of the data, Spearman's Rank-Order Correlation is utilized as the primary statistical measure to determine the strength and direction of these relationships.

3.2 Population and Sample

The population of this study consisted of students from Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS) who participated in the FIRA RoboWorld Malaysia 2025 competition. Since the population was small, the entire population was selected as the respondents using a census sampling method.

3.3 Research Instruments

This study used a questionnaire as the research instrument. The questionnaire consisted of: Section A (Demographic Information), Section B (Learning and Experience), Section C (Technical Skills), Section D (Soft Skills), Section E (Self-Development), and Section F (Career Readiness). The questionnaire used a five-point Likert scale ranging from 1 (Strongly Disagree) to 4 (Strongly Agree). Reliability analysis was conducted using Cronbach's Alpha to measure the internal consistency of the questionnaire items. The Cronbach's Alpha value obtained was 0.877, which indicates good reliability. This shows that the instrument is reliable and suitable for this study.

3.4 Data Analysis

This study analysed the collected data using the Statistical Package for the Social Sciences (SPSS) version 26.0. Descriptive statistics such as frequency, mean, and standard deviation were used to determine the level of technical skills, soft skills, self-development, and career readiness. A normality test was conducted using the Kolmogorov-Smirnov Test to determine whether the data were normally distributed. The results showed that the data were not normally distributed ($p < 0.05$). Thus, non-parametric tests were used for further analysis. Since the data were not normally distributed, Spearman correlation analysis was used to examine the relationship between the variables. The strength of the correlation interpreted based on Napitupulu et al. (2018).

4.0 RESEARCH FINDINGS

4.1 Demographic Analysis

The findings of this study highlight the development of student's technical competencies and soft skills through their participation in the FIRA RoboWorld Malaysia 2025 competition at Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS). The data were analysed using SPSS Statistic (version 26). The analysis includes demographic analysis, reliability analysis, descriptive statistics, normality test, and correlation analysis to answer the research questions and test the research hypothesis.

Section A of the instrument, contains respondent's background information. A total of 32 students participated in this study. The respondents were from engineering and technical programmes participated in the robotics competition. Table 1 presents the distribution of respondents by programme.

Table 1: Respondents by Programme

Programme	Frequency	Percentage (%)
Diploma in Electrical Engineering (DET)	13	40.6
Diploma in Information Technology (Digital Technology)	8	25.0
Diploma in Electrical & Electronic (DEE)	6	18.8
Diploma in Mechatronic Engineering (DEM)	4	12.5
Diploma in Electronic Engineering (Communication) (DEP)	1	3.1
Total	32	

The table shows that most respondents were from the DET programme (40.6%), followed by DDT (25.0%), DEE (18.8%), DEM (12.5%), and DEP (3.1%).

4.2 Reliability Analysis

Reliability analysis was conducted using Cronbach's Alpha to measure the internal consistency of the questionnaire. The items analysed were from Section B, Section C, Section D, and Section E of the questionnaire, which measure learning and experience, technical skills, soft skills, and self-development. Table 2 shows the Cronbach's Alpha Reliability Level (Cronbach's Alpha) And Interpretations according to Ahmad et al. (2024).

Table 2: Reliability Level (Cronbach's Alpha) And Interpretations

Cronbach Alpha	Reliability Level	Interpretations
0.90 – 1.00	Excellent	Indicates very high internal consistency
0.80 – 0.89	Good	Reflects strong internal consistency
0.70 – 0.79	Acceptable	Indicates acceptable internal consistency
0.60 – 0.69	Questionable	Reflects questionable internal consistency
Below 0.60	Poor	Indicates poor internal consistency

The result showed that the Cronbach's Alpha value is 0.877 for 13 items. According to the reliability guideline, a Cronbach's Alpha value between 0.80 and 0.89 indicates good reliability. Therefore, the instrument used in this study has good reliability and is suitable for data collection and analysis (Ahmad et al., 2024). This means that the questionnaire items are consistent and reliable in measuring technical skills and soft skills.

4.3 Descriptive Analysis

Descriptive statistics were used to determine the level of learning and experience, technical skills, soft skills, self-development, and career readiness among students after participating in the robotics competition. The mean scores were interpreted based on the interpretation scale adapted from Mohamad Yazid (2017) (as cited in Jamain et al., 2022), which classifies the scores into low, moderate, and high levels. All values were rounded to two decimal places. The interpretation of mean scores is shown in Table 3 adapted from Mohamad Yazid (2017).

Table 3: Interpretation of Mean Score

Mean Score	Interpretation
1.00 – 2.33	Low
2.34 – 3.66	Moderate
3.67 – 5.00	High

Table 4 presents the mean and standard deviation values for each variable measured in this study. The variables were obtained from different sections of the instruments, including Section B (Learning and Experience), Section C (Technical Skills), Section D (Soft Skills), Section E (Self-Development), and Section F (Career Readiness).

Table 4: Mean and Standard Deviation

Variable	Mean	Std. Deviation	Level
Learning and Experience	3.53	0.507	Moderate
Technical Skills	3.64	0.435	Moderate
Soft Skills	3.55	0.468	Moderate
Self-Development	3.60	0.511	Moderate
Career Readiness	3.63	0.527	Moderate

The results indicate that all variables are at a moderate level based on the mean score interpretation. Technical skills recorded the highest mean score (Mean = 3.64), followed by career readiness (Mean = 3.63), self-development (Mean = 3.60), soft skills (Mean = 3.55), and learning and experience (Mean = 3.53). This result answers Research Question 1, which shows that student's technical skills and soft skills as well as their career readiness improved after participating in the FIRA competition at a moderate level. Therefore, H_i1 is accepted, which means there is an improvement in student's technical skills and soft skills after participating in the competition.

4.4 Correlation Analysis

Spearman correlation analysis was conducted to examine the relationship between learning and experience, soft skills, self-development, and career readiness. Table 5 shows Summary of Correlation Results. The interpretation of the correlation coefficient is presented in Table 6. The strength of the relationship was interpreted based on Napitupulu et al. (2018).

Table 5: Summary of Correlation Results

Variable	r	Strength
Learning & Experience ↔ Career Readiness	0.375	Weak
Technical skills ↔ Career readiness	0.602	Strong
Soft Skills ↔ Career Readiness	0.651	Strong
Self Development ↔ Career Readiness	0.744	Strong

Table 6: Table of Correlation Coefficient Interpretation

Correlation Coefficient (r)	Strength of Relationship
0.00 – 0.199	Very Weak
0.20 – 0.399	Weak
0.40 – 0.599	Medium
0.60 – 0.799	Strong
0.80 – 1.000	Very Strong

Based on Table 6, the correlation shown a significant positive relationship between learning and experience and career readiness is weak ($r = 0.375$, $p = 0.017$). This indicates that learning and experience have a limited relationship with career readiness. Meanwhile, the correlation between technical skills and career readiness ($r = 0.602$, $p = 0.000$), soft skills and career readiness ($r = 0.651$), and self-development and career readiness ($r = 0.744$, $p = 0.000$) are strong. This indicates that technical skills, soft skills, and self-development have a strong relationship with career readiness.

The descriptive analysis answers Research Question 1 and Research Question 2, which show the level of technical skills and soft skills after participating in the competition. The correlation analysis answers Research Question 3, which examines the relationship between participation and career readiness.

4.4.1 Hypothesis testing (Reject H_0)

The results show that there is a significant relationship between technical skills and career readiness ($p < 0.05$). Therefore, $H_0 1$ is rejected.
The results also show that there is a significant relationship between soft skills and career readiness ($p < 0.05$). Therefore, $H_0 2$ is rejected.
The results show that there is a significant relationship between self-development and career readiness ($p < 0.05$). Therefore, $H_0 3$ is rejected.

5.0 RESEARCH DISCUSSION

The discussion focuses on technical skills, soft skills, self-development, and career readiness among students who participated in the FIRA RoboWorld Malaysia 2025 competition.

5.1 Technical Skills

The findings indicate that students' technical skills are at a moderate level showing that participation in robotics competitions positively contributes to their development in programming, system integration and problem-solving. Although not at a high level, the results demonstrate meaningful improvement in practical competencies. This is consistent with findings by Matamoros et al. (2019) which highlight that robotics competitions provide hands-on experiences in complex system design and problem-solving. Similarly, So et al. (2020) reported that competition-based learning enhances computational thinking and technical

application skills. The moderate level may be due to limited exposure, varying prior knowledge and resource constraints, suggesting the need for continuous and structured integration in the curriculum.

5.2 Soft Skills

Soft skills among students were found to be at a moderate level indicating improvement in teamwork, communication, and collaboration through participation in robotics competitions. These competitions require students to work collectively and solve problems under time constraints which supports soft skill development. This finding is consistent with Charles Fadel et al. (2021) who emphasized the role of experiential learning in developing 21st-century skills. Similarly, studies by Rokeman et al. (2024) and Zahir et al. (2024) highlight that innovation-based activities enhance interpersonal and employability skills in TVET. However, the moderate level suggests that continuous exposure and structured support are needed to further strengthen these skills.

5.3 Self-Development

The findings indicate that students experienced a moderate level of self-development particularly in terms of confidence, motivation and responsibility. Participation in competitive environments encourages students to take ownership of their learning and become more independent. This supports the argument that experiential learning activities contribute to personal growth and self-efficacy. According to the Ministry of Higher Education Malaysia (2021), student engagement in high-impact learning activities such as competitions enhances not only technical capabilities but also personal attributes essential for lifelong learning and adaptability in the workforce.

5.4 Career Readiness

The study found that students' career readiness is also at a moderate level indicating that participation in robotics competitions contributes positively to preparing students for the workforce. Exposure to real-world problem-solving scenarios and industry-relevant technologies enhances students' confidence in applying their skills in professional contexts.
This finding is consistent with national educational goals outlined by the Ministry of Higher Education Malaysia (2021) which emphasizes the importance of producing industry-ready graduates through experiential and competency-based learning approaches.

5.5 Relationship between Variables and Career Readiness

The correlation analysis revealed that technical skills, soft skills and self-development have significant positive relationships with career readiness with soft skills and self-development showing stronger correlations. This indicates that beyond technical competency, soft skills and personal development play a more critical role in preparing students for employment. This finding is supported by Zahir et al. (2024), who highlighted that employers prioritize communication, teamwork and adaptability. In addition, the strong relationship between self-development and career readiness suggests that factors such as motivation, confidence and self-discipline are crucial. Therefore, a holistic approach integrating both technical and non-technical skills is essential in enhancing students' career readiness.

6.0 CONCLUSION

In conclusion, this study shows that participation in the FIRA RoboWorld Malaysia 2025 competition helped students develop technical skills, soft skills, and self-development. The findings also show that these factors are significantly related to student's career readiness, with self-development and soft skills showing the strongest relationship. Educational institutions should encourage students to participate in competitions, as these activities help develop skills and prepare students for the working environment through real problem-solving experiences. However, this study is limited by a small sample size and data collected from one institution only. Future research should involve more institutions and examine other factors that influence career readiness.

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ARTIFICIAL INTELLIGENCE AS A PROGRAMMING LEARNING COMPANION: ENHANCING PROBLEM-SOLVING SKILLS AMONG POLYTECHNIC STUDENTS

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Abstract

The use of artificial intelligence (AI) in educational contexts has expanded rapidly, offering new opportunities to enhance student learning experiences. In programming education, novice learners frequently struggle to understand programming logic, identify and correct coding errors, and develop effective problem-solving strategies. Accordingly, recent advancements in generative AI technologies have introduced innovative tools that provide immediate explanations, coding guidance, and interactive feedback to support programming learning. This study examined the role of AI as a programming learning companion in improving the problem-solving capabilities of polytechnic students. A quantitative survey methodology was employed to investigate students' perceptions and experiences. Data were collected from 118 diploma students enrolled in a Full Stack Web Development programming course at Politeknik Balik Pulau using a structured five-point Likert scale questionnaire. This study used descriptive statistical techniques, namely mean and standard deviation, to analyse the data. Reliability testing using Cronbach's Alpha was conducted to assess the internal consistency of the measurement instrument. The findings revealed that most students perceived AI tools as helpful for learning because they aided their abilities to understand code, fix bugs, and think logically in programming. The study findings also showed that AI support increased students' confidence when completing programming-related tasks. Nevertheless, several concerns were identified, including potential overdependence on AI assistance and limited understanding of AI-generated code outputs. Overall, this study highlighted the role of AI-supported learning in programming education. This study contributes to the strategic incorporation of AI tools among educators to support learning while fostering critical thinking, academic integrity, and independent problem-solving skills among students. Future studies could explore the various uses of AI tools by educators to improve student academic performance.

Keywords: Artificial Intelligence in Education, Programming Education, Problem-Solving Skills

Abstrak

Penggunaan kecerdasan buatan (AI) dalam konteks pendidikan telah berkembang pesat, menawarkan peluang baharu untuk meningkatkan pengalaman pembelajaran pelajar. Dalam pembelajaran bahasa pengaturcaraan, pelajar baru sering menghadapi kesukaran untuk memahami logik pengaturcaraan, mengenal pasti dan membetulkan ralat pengekodan, serta

membangunkan strategi penyelesaian masalah yang berkesan. Sehubungan itu, kemajuan terkini dalam teknologi AI generatif telah memperkenalkan alat inovatif yang memberikan penjelasan segera, panduan pengekodan, dan maklum balas interaktif untuk menyokong pembelajaran pengaturcaraan. Kajian ini mengkaji peranan AI sebagai rakan pembelajaran pengaturcaraan dalam meningkatkan keupayaan penyelesaian masalah pelajar politeknik. Metodologi tinjauan kuantitatif telah digunakan untuk menyiasat persepsi dan pengalaman pelajar. Data telah dikumpulkan daripada 118 pelajar diploma yang mendaftar dalam kursus Full Stack Web Development *di Politeknik Balik Pulau menggunakan soal selidik skala Likert lima berstruktur. Kajian ini menggunakan teknik statistik deskriptif, iaitu min dan sisihan piawai, untuk menganalisis data. Ujian kebolehpercayaan menggunakan Cronbach's Alpha telah dijalankan untuk menilai ketekalan dalaman instrumen pengukuran. Penemuan mendedahkan bahawa kebanyakan pelajar menganggap alat AI berguna untuk pembelajaran kerana ia membantu kebolehan mereka untuk memahami kod, membetulkan ralat, dan berfikir secara logik dalam pengaturcaraan. Dapatan kajian juga menunjukkan bahawa sokongan AI meningkatkan keyakinan pelajar semasa menyelesaikan tugasan berkaitan pengaturcaraan. Walau bagaimanapun, beberapa kebimbangan telah dikenal pasti, termasuk potensi kebergantungan yang berlebihan terhadap bantuan AI dan pemahaman yang terhad tentang output kod yang dijana AI. Secara keseluruhan, kajian ini mengetengahkan peranan pembelajaran yang disokong AI dalam pendidikan pengaturcaraan. Kajian ini menyumbang kepada penggabungan strategik alatan AI dalam kalangan pendidik untuk menyokong pembelajaran sambil memupuk pemikiran kritis, integriti akademik dan kemahiran menyelesaikan masalah secara bebas dalam kalangan pelajar. Kajian masa depan boleh meneroka pelbagai penggunaan alatan AI oleh pendidik untuk meningkatkan prestasi akademik pelajar.*

***Kata kunci**: Kecerdasan Buatan dalam Pendidikan, Pendidikan Pengaturcaraan, Kemahiran Menyelesaikan Masalah*

1.0 INTRODUCTION

One of the most significant technological advancements influencing modern teaching methods is artificial intelligence (AI). Rapid developments in generative AI applications, machine learning methods, and intelligent systems have opened up new possibilities to improve teaching and learning across a variety of academic fields. In particular, AI technologies are being used more in educational settings to automate feedback systems, personalise learning experiences, and assist students in overcoming difficult learning obstacles (Holmes et al., 2019). In recent years, one important development has been the emergence of generative AI tools that are capable of producing human-like text, explanations, and even computer code. For example, AI-powered chat assistants and automated coding tools allow students to receive immediate help when they face difficulties in programming tasks. These tools can explain complex programming concepts, identify and correct coding errors, and guide students step-by-step in completing their assignments (Kasneci et al., 2023). As a result, generative AI has attracted growing interest in the field of programming education.

Programming courses are a core component of many computing and engineering programmes. However, they are often considered challenging, especially for beginners. Students commonly struggle with understanding abstract concepts, developing algorithmic thinking, debugging code, and translating problem requirements into working programmes (Luxton-Reilly et al., 2018). These difficulties can lead to frustration, reduced confidence, and weaker academic performance. Nonetheless, traditional teaching methods do not always provide immediate support when students encounter problems. In many cases, students have to wait for feedback from instructors or peers before they can resolve coding issues. This delay can cause them to feel stuck and hinder their learning progress. Therefore, integrating AI technologies into programming education offers a promising solution by providing continuous support and real-time assistance.

AI tools can act as learning companions that support students throughout the learning process. Instead of replacing instructors, these tools can complement teaching by offering explanations, debugging help, and alternative coding suggestions. When used effectively, AI can help students develop a deeper understanding of programming concepts and improve their problem-solving skills. Accordingly, this study aimed to explore the role of AI as a learning companion in programming and to examine its potential impact on the problem-solving skills of polytechnic students. The study specifically focused on students' perceptions of AI tools and how these tools influenced their overall programming learning experience.

1.1 Problem Statement

Learning programming requires students to develop skills such as logical thinking, algorithmic reasoning, and structured problem-solving. However, many students find programming difficult to learn. Common challenges include understanding programming syntax, identifying logical errors, debugging code, and designing appropriate algorithms to solve problems. Previous studies have shown that programming courses often have high failure and withdrawal rates due to these difficulties (Luxton-Reilly et al., 2018). Students may feel overwhelmed when dealing with complex tasks, especially when they cannot get immediate help. In traditional classrooms, lecturers may not always be able to provide individual support to every student, particularly in large classes.

Another challenge is students' dependence on online resources when solving programming problems. Although there are many tutorials and code examples available, students sometimes struggle to determine whether the information is accurate and relevant. In addition, some resources provide complete solutions without clear explanations, which can limit students' understanding of the concepts. The development of generative AI tools offers new opportunities to address these issues. AI tools can generate example code, explain concepts in an interactive way, and help students identify and fix errors. Unlike traditional learning materials, AI can respond directly to students' questions and provide more personalised support.

However, the use of AI in programming education also raises some concerns. While AI can be helpful, students may become too dependent on it by relying on AI-generated answers instead of developing their own problem-solving skills. Therefore, it is important to understand how students use these tools and whether AI truly helps improve their problem-solving skills to solve programming problems. This study aimed to examine the role of AI as a learning companion in programming and to explore how it influenced students' ability to analyse problems, debug code, and develop solutions.

1.2 Research Questions (RQ) and Research Objectives (RO)

This study addressed the following research questions (RQ):

i. What is the level of awareness of AI tools among polytechnic students enrolled in programming courses?
ii. How do students perceive the use of AI as a programming learning companion?
iii. To what extent do AI tools influence students' programming problem-solving skills?

The objectives (RO) developed for this study were:

i. To examine the level of awareness and usage of AI tools among polytechnic students in programming learning.
ii. To investigate students' perceptions of AI as a programming learning companion.
iii. To analyse the perceived influence of AI tools on students' programming problem-solving abilities.

1.3 Significance of Research

This study has significance for educators in educational organisations regarding the use of AI in programming learning to support student learning and improve critical thinking and problem-solving skills.

2.0 LITERATURE REVIEW

Artificial intelligence (AI) in education refers to the use of AI technologies to support teaching, learning, and educational management. The technologies are used to analyse students' learning behaviour, personalise learning materials, and provide automatic feedback to improve learning outcomes (Holmes et al., 2019). AI technologies also make learning more personalised by adjusting content based on each student's needs and performance. AI can help educators identify students' learning difficulties and suggest appropriate teaching strategies to support their learning (Luckin & Holmes, 2016).

Generative AI tools, specifically, have attracted significant attention within educational contexts due to their ability to produce human-like responses, explanations, and digital content based on user prompts. These tools can generate textual explanations, summarise complex information, and produce programming code that assists students in understanding challenging concepts (Kasneci et al., 2023). In programming education, generative AI tools can produce sample programmes, detect syntax errors, and explain debugging procedures. The interactive nature of these tools allows students to engage with programming concepts more dynamically

compared to traditional static learning resources. Nevertheless, some scholars caution that excessive reliance on generative AI may reduce students' independent analytical thinking. As a result, the integration of AI in educational settings should emphasise its role as a supportive learning tool rather than a replacement for human cognitive processes.

AI-assisted learning systems have been increasingly used to support programming education. Tools such as intelligent tutoring systems and automated feedback features help students write, understand, and debug their code more effectively (Keuning et al., 2018). Previous studies show that automated feedback can help students identify programming errors faster and improve their coding skills. These AI systems can analyse students' code and provide useful suggestions for improvement. At the same time, they help reduce the workload of instructors while allowing students to receive immediate feedback during their learning process. In addition, AI-powered coding assistants can support students by giving hints, clear explanations, and alternative ways to solve programming tasks.

According to Yang et al. (2021), problem-solving skills involve the ability to apply logical reasoning and computational thinking to address complex challenges. Students who possess strong problem-solving abilities are more capable of debugging errors, optimising algorithms, and developing efficient programming solutions. Consequently, educational strategies that promote problem-solving development are essential for successful programming learning. AI technologies may support the development of problem-solving skills by guiding the coding process. When students receive explanations and feedback from AI systems, they may gain a deeper understanding of the reasoning behind programming solutions.

3.0 THEORETICAL FRAMEWORK

This study was guided by a conceptual framework that examined the relationship between AI tool usage and programming problem-solving skills. In total, there were two variables involved, namely the independent variable (IV) and the dependent variable (DV). IV was the use of AI as a programming learning companion, while DV was programming problem-solving skills. This study believed that AI tools could act as learning companions by supporting students during programming tasks. Through interaction with these tools, students could receive explanations, suggestions for fixing errors, and example code to help them better understand programming concepts. This framework suggested that the more students engage with AI learning tools, the more their problem-solving skills in programming may improve.

4.0 RESEARCH METHODOLOGY

This study employed a quantitative survey design to investigate students' perceptions of AI tools in programming education. Quantitative methodologies have been extensively utilised in contemporary educational technology research to examine learner attitudes, behavioural tendencies, and patterns of technology adoption (Bond et al., 2024; Annuš, 2025).

4.1 Research Design and Sampling

This study adopted a quantitative approach, specifically a descriptive research design, to collect the data. The study population comprised 170 students enrolled in the DFP40443 Full Stack Web Development course. Krejcie and Morgan's (1970) sampling standards suggested a minimum of 118 samples for a population of 170. Hence, 118 students were appointed as the study respondents.

4.2 Research Instruments

The questionnaire items were developed based on previous studies on AI in education, programming learning, and problem-solving skills (Holmes et al., 2019; Kasneci et al., 2023; Yang et al., 2021; Bond et al., 2024). The instrument was designed to measure students' awareness, usage, and perception of AI tools as programming learning companions. The questionnaire consisted of 30 questions measuring AI perceptions. The questions were divided into six (6) sections: demographic, awareness of AI tools, AI as a programming learning companion, programming problem-solving skills, programming learning effectiveness, and challenges of using AI tools. Responses were measured using a five-point Likert scale (Taherdoost, 2019). Descriptive statistics, namely mean and standard deviation, were used to analyse the data and understand students' responses. All statistical analyses were performed on IBM SPSS Statistics. These methods have been commonly used in studies on AI-assisted learning to interpret user perceptions and behaviour patterns (Annuš, 2025). Initially, based on the collected data and samples obtained, the reliability test is analysed.

Table 1: Cronbach's alpha reliability level

Cronbach's Alpha Value	Reliability Level
0.0 – 0.20	Less reliable
>0.20 – 0.40	Somewhat reliable
>0.40 – 0.60	Reliable enough
>0.60 – 0.80	Reliable
>0.80 – 1.00	Very reliable

The Cronbach's alpha test results are shown in Table 2. The data indicated that these instruments were very reliable.

Table 2: Reliability Testing Result

Cronbach's Alpha Coefficient	No. of Item	Analysis
0.901	30	Very Reliable

While Table 3 shows the mean score interpretation, which was based on Issam Khalil Abu-Baker et al. (2019).

Table 3: Interpretation of Mean Score

Mean Value	Estimation Degree
1.00 – 1.80	Very Low
1.81 – 2.60	Low
2.61 – 3.40	Average
3.41 – 4.20	High
4.21– 5.00	Very High

5.0 RESEARCH FINDINGS AND DISCUSSION

5.1 Demographic Information

The demographic information collected included gender, semester, and experience with AI. A total of 118 students answered the survey. Table 4 summarises the respondents' demographic information. It could be observed that male respondents accounted for 51.7% and female respondents for 48.3%, respectively. Most of the respondents were from semester four and had had the experience using AI for more than 1 year.

Table 4: Demographics of respondents

Description		Frequency(f)	Percentage (%)
Gender	Male	61	51.7
	Female	57	48.3
Semester	4	110	93.2
	others	8	6.7
Experience Using AI	<1 year	14	11.9
	1 to 2 years	79	66.9
	>3 years	25	21.2

5.2 Findings of Students' Perception

Table 5 showed that the mean score for all items was interpreted as very high, indicating that all respondents had a positive perception of awareness of AI Tools. The highest mean score was for the statement "I understand that AI tools can help explain programming concepts" (M=4.55, SD=0.70), demonstrating that most respondents strongly agreed that AI tools helped explain programming concepts. Also, the low standard deviation values (ranging from 0.70 to 0.79) indicated consistent responses among respondents, suggesting a shared understanding of AI tools and their functions in programming learning.

Table 5: Students' Perception of Awareness of AI Tools

Item	Statement	Mean	Std. Deviation
1	I am familiar with AI tools that can assist in programming learning.	4.43	0.79
2	I am aware that AI tools can generate programming code.	4.50	0.74
3	I understand that AI tools can help explain programming concepts.	4.55	0.70
4	I know that AI tools can assist in debugging programming errors.	4.47	0.78
5	AI technologies are becoming important in programming education.	4.54	0.71

Referring to the mean results, Table 6 presents the mean results for respondents' perception of AI. The study found that a very high perception of AI as a programming learning companion, with mean scores ranging from 4.42 to 4.50. The finding indicated that AI helped respondents explore different ways to address programming problems (M=4.50, SD=0.75). The finding showed that AI tools effectively helped respondents understand programming concepts, solve problems, and learn more independently during programming tasks.

Table 6: Students' Perception of AI as a Programming Learning Companion

Item	Statement	Mean	Std. Deviation
1	I use AI tools to understand difficult programming concepts.	4.42	0.79
2	AI tools help me explore different ways to solve programming problems.	4.50	0.75
3	AI tools assist me when I encounter programming errors.	4.48	0.78
4	I use AI tools to obtain example codes when learning programming.	4.42	0.83
5	AI tools support my learning when lecturers are not available.	4.50	0.74
6	AI tools act as a learning companion during programming practice.	4.47	0.76
7	AI tools help me learn programming independently.	4.44	0.78

According to Table 7, the study respondents demonstrated a high level of perceived impact of AI tools on programming problem-solving skills, with the lowest mean being 4.42 and the highest being 4.52. This indicated that AI tools effectively supported respondents in solving programming tasks (M=4.52, SD=0.77).

Table 7: Students' Perception of AI as Programming Problem-Solving Skills

Item	Statement	Mean	Std. Deviation
1	AI tools help me analyse programming problems more effectively.	4.52	0.77
2	AI tools improve my ability to debug programming errors.	4.47	0.79
3	AI tools help me identify logical mistakes in my code.	4.44	0.75
4	AI tools help me think of alternative solutions to programming tasks.	4.49	0.77
5	AI tools improve my confidence in solving programming problems.	4.42	0.83
6	AI tools help me complete programming exercises more efficiently.	4.42	0.81

Table 8 indicates that the study respondents had positive perceptions of AI tools in programming learning. The lowest mean of 4.42 and the highest of 4.53, indicating that most students agree that AI is helpful, supports overall learning performance in programming, and improves understanding of programming concepts. Overall, AI tools were perceived as effective in improving students' programming learning.

Table 8: Students' Perception of Programming Learning Effectiveness

Item	Statement	Mean	Std. Deviation
1	AI tools improve my understanding of programming concepts.	4.53	0.74
2	AI tools make programming learning easier.	4.52	0.74
3	AI tools increase my interest in learning programming.	4.47	0.80
4	AI tools support my overall learning performance in programming.	4.53	0.74
5	AI tools improve my productivity when completing programming tasks.	4.42	0.83

The results in Table 9 showed that respondents were aware of several challenges when using AI tools. All mean scores were high, indicating strong agreement.

Table 9: Students' Perception of Challenges of Using AI Tools

Item	Statement	Mean	Std. Deviation
1	Sometimes AI-generated programming solutions are difficult to understand.	4.31	0.95
2	AI-generated code may sometimes contain errors.	4.26	0.86
3	I worry that over-reliance on AI tools may reduce my own programming skills.	4.40	0.81
4	It is sometimes difficult to evaluate whether AI responses are correct.	4.32	0.85
5	Students need guidance from lecturers when using AI tools for learning programming.	4.38	0.86
6	Ethical issues should be considered when using AI in education.	4.42	0.80
7	AI tools should be used responsibly in programming learning.	4.46	0.77

5.3 Discussion

The study found that student respondents were aware that AI tools should be used responsibly (M = 4.46). They also agreed that ethical issues must be considered (M = 4.42) and that over-reliance on AI reduced their programming skills (M = 4.40). In addition, they needed guidance from lecturers (M = 4.38) and sometimes found it difficult to evaluate whether AI answers were correct (M = 4.32). The finding also reported that AI-generated solutions were hard to understand (M = 4.31) and had errors (M = 4.26). Overall, while AI tools were useful, students recognised their challenges and the need for careful and responsible use. These findings align with recent literature highlighting that despite the use of any technology in learning can increase students' motivation, user experience, and interest in learning (Che Hassan & Yusof, 2019; Yusof et al., 2024), risks such as superficial learning and reduced cognitive engagement are associated with excessive AI use (Kurtz et al., 2024; Bernstein et al., 2025).

6.0 CONCLUSION AND RECOMMENDATIONS

This study explored the role of AI as a learning companion in programming among polytechnic students and found that AI tools had strong potential to improve programming education. The results indicated that AI helped students understand concepts, debug code, and develop problem-solving skills, in line with recent studies (Bond et al., 2024; Annuš, 2025). Students perceived AI tools as useful because they provide quick assistance and increase confidence when solving programming tasks. This supported findings that AI can improve student independence and engagement through personalised learning. However, the study also highlighted the need for careful use of AI. Over-reliance on AI tools reduced critical thinking and independent problem-solving skills (Bernstein et al., 2025). Therefore, educators should use AI tools in a balanced and strategic way. AI should support learning, not replace students' thinking, so that they can develop both technical skills and higher-level thinking.

Overall, AI has great potential to transform programming education, especially in improving problem-solving skills and preparing students for the digital world. Future studies could explore the various uses of AI tools by educators to improve student academic performance.

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EXPLORING THE IMPACT OF FIRST-PERSON VIEW (FPV) TECHNOLOGY ON STUDENTS' AND TEACHERS' INTEREST IN ROBOTICS AND STEM LEARNING

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Abstract

The integration of First-Person View (FPV) technology into robotics-based learning activities has emerged as a promising approach to enhancing student engagement with Science, Technology, Engineering, and Mathematics (STEM) education. This study investigates the perceptions of primary school students and teachers toward the use of FPV camera technology within a structured robotics competition, the Fire Rescue FPV Robot Challenge conducted across eight primary schools in Malaysia. A total of 16 students (aged 9–12 years) and 8 experienced teachers participated in the study. Data were collected using a structured survey comprising Likert-scale items, rating-based evaluations, and open-ended responses, covering dimensions of FPV usability, STEM motivation, teamwork, and problem-solving. Findings revealed that students rated teamwork as the highest-impact outcome (M = 3.88, 87.5% agreement), followed by problem-solving skills (M = 3.81, 75.0%). While FPV control ease presented the greatest challenge particularly among the 81.3% of first-time FPV users, students reported meaningful increases in interest toward robotics and electronics (56.2%) following the activity. Teacher responses were strongly positive, with all eight teachers unanimously agreeing (100%) that FPV-based activities can effectively attract student interest in STEM (M = 4.00). Teachers also identified Robotics and Programming as the highest-priority STEM field for future activities, selected by all respondents. These findings collectively suggest that FPV technology, when embedded within a competitive robotics framework, serves as a meaningful catalyst for STEM motivation among primary school learners. The study contributes practical insights for educators and curriculum designers seeking to leverage immersive technologies in early STEM education.

Keywords: FPV technology; robotics education; STEM motivation; primary school; student engagement

Abstrak

Integrasi teknologi First-Person View (FPV) dalam aktiviti pembelajaran berasaskan robotik telah muncul sebagai satu pendekatan yang berpotensi untuk meningkatkan penglibatan pelajar dalam pendidikan Sains, Teknologi, Kejuruteraan dan Matematik (STEM). Kajian ini menyiasat persepsi murid sekolah rendah dan guru terhadap penggunaan teknologi kamera FPV dalam satu pertandingan robotik berstruktur, iaitu Fire Rescue FPV Robot Challenge

yang dijalankan di lapan buah sekolah rendah di Malaysia. Seramai 16 orang murid (berumur 9–12 tahun) dan 8 orang guru berpengalaman telah mengambil bahagian dalam kajian ini. Data dikumpulkan menggunakan soal selidik berstruktur yang merangkumi item skala Likert, penilaian berasaskan skor, serta respons terbuka, meliputi dimensi kebolehgunaan FPV, motivasi STEM, kerja berpasukan, dan penyelesaian masalah. Dapatan kajian menunjukkan bahawa murid menilai kerja berpasukan sebagai hasil paling berimpak tinggi (M = 3.88, 87.5% persetujuan), diikuti oleh kemahiran penyelesaian masalah (M = 3.81, 75.0%). Walaupun kawalan FPV merupakan cabaran utama, khususnya dalam kalangan 81.3% pengguna pertama kali, murid melaporkan peningkatan yang bermakna dalam minat terhadap robotik dan elektronik (56.2%) selepas aktiviti tersebut. Maklum balas guru adalah sangat positif, dengan kesemua lapan orang guru sebulat suara bersetuju (100%) bahawa aktiviti berasaskan FPV berupaya menarik minat pelajar terhadap STEM (M = 4.00). Guru juga mengenal pasti bidang Robotik dan Pengaturcaraan sebagai bidang STEM yang paling utama untuk aktiviti masa hadapan, dipilih oleh semua responden. Secara keseluruhannya, dapatan ini menunjukkan bahawa teknologi FPV, apabila digabungkan dalam kerangka pertandingan robotik, berfungsi sebagai pemangkin yang berkesan dalam meningkatkan motivasi STEM dalam kalangan pelajar sekolah rendah. Kajian ini menyumbang pandangan praktikal kepada pendidik dan pereka kurikulum dalam memanfaatkan teknologi imersif dalam pendidikan STEM awal.

***Kata kunci**: Teknologi FPV, pendidikan robotik, motivasi STEM, sekolah rendah, penglibatan pelajar*

1.0 INTRODUCTION

Robotics education has become an important component of Science, Technology, Engineering, and Mathematics (STEM) learning in many schools. Robotics activities allow students to explore scientific and engineering concepts through hands-on experiences, which can improve creativity, problem-solving skills, and technological awareness. Compared to traditional classroom learning, robotics-based activities often provide a more engaging environment where students can actively experiment with technology and collaborate with peers.

1.1. Problem Statement

Despite these advantages, maintaining long-term student interest in robotics and STEM subjects remains a challenge. Many students are initially excited about robotics activities, but their motivation may decrease when the learning process becomes too technical or lacks interactive elements. For younger learners, particularly primary school students, learning experiences that are immersive and game-like are often more effective in sustaining their curiosity and enthusiasm. Therefore, educators are continuously exploring new technologies that can make robotics learning more engaging and meaningful.

One technology that has gained attention in robotics and drone applications is First-Person View (FPV). FPV refers to a system that allows users to observe the surrounding environment from the perspective of a robot or drone through a live video feed transmitted to a monitor,

mobile device, or goggles. Through this system, users can control the robot while simultaneously viewing the robot's surroundings in real time, creating the experience of "seeing through the robot's eyes." This immersive perspective can make robotics activities more exciting and interactive for learners.

Although FPV technology is widely used in drone racing and remote robotic operations, its application in educational robotics activities, particularly at the primary school level, is still relatively limited. Most robotics learning activities focus mainly on programming and mechanical assembly, while immersive control technologies such as FPV are less frequently explored in classroom environments. As a result, there is limited understanding of how FPV-based robotics activities influence students' motivation and interest in STEM learning.

In addition, Teachers play a critical role in determining whether new technologies can be successfully integrated into educational activities. Their acceptance of these technologies is a key factor for successful implementation, as research on the use of First-Person View (FPV) drones in STEM education has begun to explore through established technology acceptance models (Sivenas et al., 2026). Understanding both students' and teachers' perspectives is therefore important in evaluating the educational value of FPV-based robotics learning. Understanding both students' and teachers' perspectives is therefore important in evaluating the educational value of FPV-based robotics learning.

1.2. Research Objective

Based on this context, the main objective of this study is to explore the impact of FPV technology on students' and teachers' interest in robotics and STEM learning through participation in a robotics competition activity. Specifically, the study examines students' experiences in using FPV-controlled robots as well as teachers' observations of student engagement and motivation during the activity.

The findings of this study are expected to provide useful insights for educators, robotics program organizers, and curriculum designers in developing more engaging STEM learning experiences. By understanding how immersive technologies such as FPV influence student motivation, educators can design robotics activities that better support creativity, teamwork, and problem-solving skills among young learners.

2.0 LITERATURE REVIEW

2.1 Robotics in STEM Education

Robotics has become an important tool in STEM education because it allows students to learn through hands-on and experiential activities. Through designing, assembling, and controlling robots, students can apply scientific and engineering concepts in real-world contexts. These learning experiences help students develop important skills such as problem-solving, computational thinking, and collaboration. Previous research has shown that educational robotics can enhance STEM learning by increasing students' interest and participation in science and technology fields. Robotics-based learning activities have been reported to support

the development of critical thinking, computational thinking, and domain-specific knowledge in subjects such as mathematics and science (Moynihan et al., 2026). In addition, robotics competitions and project-based learning environments encourage teamwork and engineering design thinking (Miechowicz, 2025), which further strengthen students' engagement in STEM-related activities.

In addition, robotics competitions and project-based learning environments encourage teamwork and engineering design thinking which further strengthen students' engagement in STEM-related activities. The effectiveness of competition-based approaches has been demonstrated in higher education settings, where FPV drone racing competitions have been shown to increase student motivation, develop technical competencies, and foster essential 21st-century skills such as collaboration, critical thinking, and adaptability (Alvarez, 2023).

In professional and defense sectors, FPV technology is increasingly utilized for high-stakes applications requiring precision and reliability, such as time-sensitive target engagements (Wang, 2025). These applications rely on complex algorithmic integration involving computer vision (e.g., YOLOv8) and guidance systems (e.g., Proportional Navigation). To prepare students for such future careers, educational robotics must bridge the gap between basic programming and applied engineering. Competition-based learning, as implemented in this study, provides a simplified yet authentic context where students can grasp the core principles of navigation, targeting, and real-time decision-making that underpin these advanced industrial applications.

2.2 First-Person View (FPV) Technology in Robotics

Recent advancements in intelligent FPV systems have demonstrated the technology's capability to perform complex, time-sensitive tasks such as autonomous target recognition and precision strikes, utilizing advanced algorithms like YOLOv8 and DeepSort for visual processing (Wang, 2025). This evolution from simple remote control to intelligent autonomy highlights the growing technical sophistication within the FPV domain. Consequently, exposing students to foundational FPV robotics at the primary level can help build the prerequisite spatial awareness and problem-solving skills necessary for engaging with such advanced STEM applications in higher education or industry.

First-Person View (FPV) technology is commonly used in robotics and drone systems to provide real-time visual feedback from the perspective of the machine. In an FPV system, a camera mounted on the robot transmits live video to a display device, allowing the operator to control the system while simultaneously observing the surrounding environment from the robot's point of view. This approach creates a more immersive form of remote interaction compared to traditional line-of-sight control. Recent technological developments have demonstrated that FPV imaging systems can provide high-resolution video transmission and low-latency visual feedback, allowing operators to experience improved situational awareness during navigation and remote operation (Miechowicz, 2025). Research has also highlighted that FPV technology can enhance spatial awareness and navigation safety by providing richer contextual visual information compared to conventional sensor-based systems (Miechowicz,

2025). These advantages indicate that FPV technology has strong potential to enhance interactive robotics applications, including educational robotics activities.

Beyond the technical advantages, the successful integration of FPV technology into educational settings is contingent upon teacher acceptance. Research by Sivenas, Koutromanos, and Larios (2025) proposed a model for in-service teachers' acceptance of FPV drones in STEM activities, highlighting that factors such as perceived enjoyment and facilitating conditions significantly influence their intention to use this technology with students. This finding underscores the importance of considering teacher perceptions as a critical component when evaluating the viability of FPV-based educational interventions.

Given the technical potential of FPV technology and the importance of teacher acceptance highlighted above, it is equally necessary to examine the actual strengths and limitations of FPV applications in educational contexts. Table 1 synthesises the key findings from three recent studies, focusing on how FPV has been used in education, what worked well, and what limitations remain.

Table 2: Strengths and weaknesses of FPV use in education across three studies.

Article	FPV Use in Education	Key Strength	Key Weakness
Miechowicz (2025– Wheelchair navigation	FPV + head-tracking to enhance spatial awareness	Novel cross-domain adaptation; modular design; improves safety	Small sample; poor low-light performance; no collision prevention
Gu et al. (2022) – Matte painting course	FPV drones replace photos/videos for environment observation	Positive effects on flow, interest, continuous learning; TIM model proposed	Sample limited to one Chinese region; trust did not affect learning intention
Soellner et al. (2022) – CPR simulation	Head-mounted FPV videos shown before debriefing	Feasible, low-cost, high acceptance, promotes self-reflection	No significant improvement in CPR/team performance; videos shown without instructor guidance

3.0 RESEARCH METHODOLOGY

This study was conducted during the STEMUp Fest PSIS 2025 program, a one-day initiative designed to foster student interest and motivation in Science and Mathematics. The program incorporated a variety of hands-on activities that covered fundamental aspects of science and mathematics, with a focus on engaging students directly. To assess the program's impact, this study focused on the participants of the Mobile Robot Fire Rescue competition, an activity specifically chosen for its alignment with the program's objectives.

A total of 24 individuals participated in this study. They consisted of 16 students from eight different primary schools located around the Sabak Bernam area, as well as 8 accompanying teachers from these schools. The schools involved were SK Dr Abdul Latiff, SK Tun Doktor Ismal, SK Khir Johari, SK Tebuk Jawa, SK Sg Limau, SK Parit Baru, SK Pt 6, and SK Batu 38. All 16 students were active participants in the Mobile Robot Fire Rescue competition, while their teachers served as accompanying adults and observers.

While the sample size is modest, this was the first time the Mobile Robot Fire Rescue competition used FPV technology. All 24 participants in the event were included in this study, meaning the sample represents the entire participant group. In the future, if the same FPV activity is held at other events, this research will collect additional data from those events to increase the overall sample size.

The core of this research centered on the Mobile Robot Fire Rescue competition itself. This activity was designed as a simulated fire rescue mission where teams of two students operated a robot. One student acted as the driver, controlling the robot's movement remotely using a First Person View (FPV) camera feed displayed on a monitor. The second student acted as the scanner, responsible for ensuring the robot successfully scanned QR codes placed within the arena, with each code representing a victim to be rescued. The QR codes were strategically placed by the participants themselves at the start of each round, subject to specific rules: they had to be at least 50 centimeters apart, could not be placed in the robot's starting zone, and had to be clearly scannable by the robot's camera within the 5m x 5m enclosed arena.

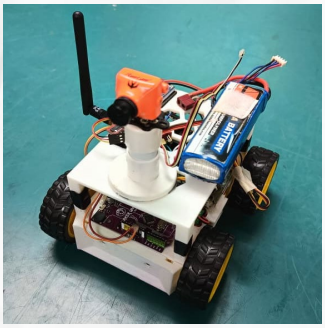


Figure 3: Mobile robot platform used in the Fire Rescue FPV Robot Challenge.

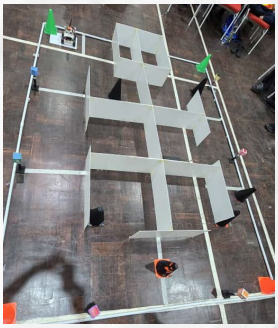


Figure 2: The arena of Fire Rescue FPV Robot Challenge.



Figure 3: Students operating the robot using FPV camera feed displayed on a monitor.

The design of this competition was also intentionally linked to several United Nations Sustainable Development Goals (SDGs). It supported SDG 9 (Industry, Innovation, and Infrastructure) by encouraging students to engage with robotics and remote-control technology. It promoted SDG 11 (Sustainable Cities and Communities) by fostering awareness of community safety and resilience during emergencies. Finally, it aligned with SDG 4 (Quality Education) by helping students develop essential 21st-century skills such as problem-solving, teamwork, and technological literacy. This structured activity provided the context for gathering data through questionnaires administered to the participants.

4.0 RESEARCH FINDINGS

This section presents findings from a structured survey administered to two groups: 16 primary school students (P1–P16) and 8 teachers (G1–G8) from eight schools. Students completed a Likert-scale instrument (Section B, Q2–Q10; 1 = Strongly Disagree to 5 = Strongly Agree) evaluating their experience with the FPV robot competition. Teachers responded to both rating-based items (Section A) and Likert-scale perceptions (Section C, GQ1–GQ4), as well as identifying priority STEM fields for future activities (Section D).

4.1 Student's Perceptions (N = 16)

a) FPV Experience and Enjoyment

Of the 16 student respondents, 13 (81.3%) were using an FPV camera for the first time, while only 3 (18.7%) had prior FPV experience. Despite the novelty of the technology, 62.5% of students agreed that the FPV camera made the game more enjoyable (Q2; M = 3.62, SD = 0.50). However, only 31.2% agreed that controlling the robot using FPV was easy (Q3; M = 3.00, SD = 0.89), the lowest-rated item across all student responses. This suggests that while FPV technology is engaging, first-time users face a noticeable learning curve in control and navigation. Nevertheless, 68.8% acknowledged that the FPV camera helped them manage the robot's movement more effectively (Q5; M = 3.62).

b) STEM Interest and Motivation

Student responses to items relating to STEM interest showed moderate to moderate-high levels of agreement. A total of 56.2% of students reported increased interest in robotics and electronics following the competition (Q6; M = 3.50, SD = 0.82), while the same proportion expressed a desire to learn more about building robots (Q7; M = 3.44, SD = 0.73). Interest in science and technology more broadly was lower, with only 37.5% agreeing that the activity made them like science and technology (Q8; M = 3.31, SD = 0.79). These findings, while not reaching high agreement thresholds, indicate a meaningful positive shift in motivation among more than half the participants particularly notable given that 81.3% were first-time FPV users.

c) Teamwork and Problem-Solving Skills

The strongest student responses emerged from items related to transferable skills. Teamwork (Q9) recorded the highest mean score among all student items (M = 3.88, SD = 0.34), with 87.5% of students agreeing they learned to cooperate with their team members during the activity. Problem-solving (Q10) followed closely (M = 3.81, SD = 0.54), with 75.0% agreement. These results suggest that the collaborative structure of the FPV robot competition was particularly effective at developing interpersonal and critical thinking competencies.

Table 3: Descriptive Statistics — Student Responses (N = 16)

Item	Statement	Mean	SD	% Agree (≥4)	Level
Q2	FPV camera makes the game more enjoyable	3.62	0.50	62.5%	Mod. High
Q3	Controlling the robot with FPV camera is easy	3.00	0.89	31.2%	Moderate
Q4	I can scan the QR Code well using the FPV camera	3.50	0.82	56.2%	Mod. High
Q5	FPV camera helps me control the robot's movement	3.62	0.62	68.8%	Mod. High
Q6	I am more interested in robotics & electronics after this	3.50	0.82	56.2%	Mod. High
Q7	I want to learn more about how to build a robot	3.44	0.73	56.2%	Mod. High
Q8	This activity made me like science and technology	3.31	0.79	37.5%	Moderate
Q9	I learned to cooperate with my team members	3.88	0.34	87.5%	High
Q10	This activity trains me to solve problems	3.81	0.54	75.0%	Mod. High

Note: Mean scores interpreted as — High ≥ 4.0; Moderate-High 3.5–3.99; Moderate < 3.5.

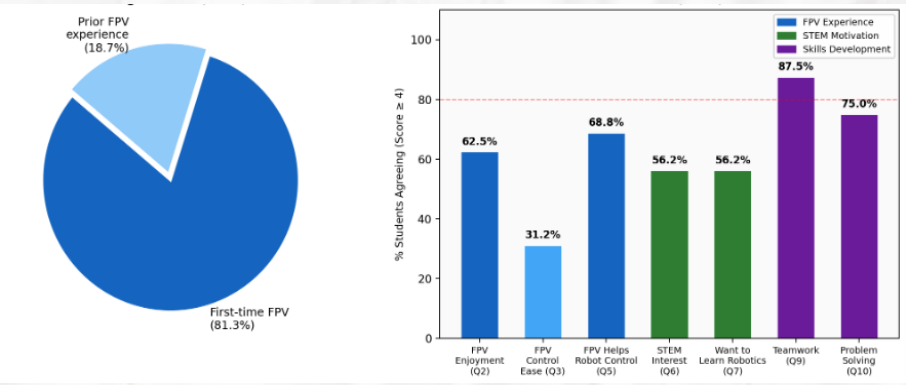


Figure 4: (a) FPV Prior Experience among Students; (b) Agreement Rate (%) by Key Survey Item.

4.2 Student's Perceptions (N = 16)

a) Competition Suitability and Learning Objectives (Section A)

All eight participating teachers held more than 10 years of teaching experience. In Section A, teachers rated key aspects of the competition using a categorical scale. Seven of eight teachers (87.5%) rated the competition as suitable overall for primary school students. Notably, all eight teachers (100%) rated the game's difficulty level as moderate — consistent with the students' mixed responses on FPV control ease. In terms of student mastery of FPV technology, 87.5% of teachers rated students' performance as good, and 87.5% affirmed that the competition successfully achieved its intended learning objectives (Table 4).

Table 4: Teacher Evaluation of Competition — Section A Ratings (N = 8)

Evaluation Aspect	Response	Frequency
Overall suitability for primary school students	Suitable (Rating 1)	7/8 teachers (87.5%)
Level of difficulty of the game	Moderate (Rating 3)	8/8 teachers (100%)
Students' mastery in using the FPV camera	Good (Rating 1)	7/8 teachers (87.5%)
Competition successfully achieved learning objectives	Yes (Rating 1)	7/8 teachers (87.5%)

b) Teachers' Perceptions of Student STEM Interest (Section C)

Section C assessed teachers' observations of student motivation through four Likert-scale items (Table 3). Overall, teachers responded positively across all items, with mean scores ranging from 3.88 to 4.00. The highest-rated item was GQ2, the belief that such activities can attract student interest in STEM, which achieved a perfect mean of 4.00 (SD = 0.00) with 100% teacher agreement. This unanimous endorsement reflects strong professional confidence in the pedagogical value of FPV-based robotics competitions.

Teachers also broadly observed that students demonstrated high levels of interest during the competition (GQ1; M = 3.88, 87.5% agreement), that positive reactions indicated potential for sustained interest in robotics (GQ3; M = 3.88), and that students appeared more excited about science and technology after the experience (GQ4; M = 3.88, 87.5% agreement). Taken together, these observations provide meaningful external validation of the motivational impact reported by the students themselves.

Table 5: Descriptive Statistics — Teacher Perceptions of Student STEM Interest (N = 8)

Item	Statement	Mean	SD	% Agree (≥4)	Level
GQ1	Students showed high interest during the competition	3.88	0.35	87.5%	High
GQ2	Such activities can attract students' interest in STEM	4.00	0.00	100.0%	High
GQ3	Positive student reactions show potential for increased robotics interest	3.88	0.35	87.5%	High
GQ4	Students were more excited about science & technology after this experience	3.88	0.35	87.5%	High

Note: GQ2 recorded zero variance (SD = 0.00), indicating complete agreement across all teachers.

c) Most Effective Elements and Priority STEM Fields (Section B & D)

Teachers identified teamwork and FPV technology as the most effective competition elements (87.5% each), followed by problem-solving (75.0%). Regarding priority STEM fields for future activities, Robotics and Programming was unanimously recommended by all 8 teachers (100%), followed by Innovation and Design (50.0%), Electrical Engineering, and

Sustainability and Green Energy (37.5% each). This strong consensus reinforces the case for expanding FPV robotics as a pedagogical tool in primary education.

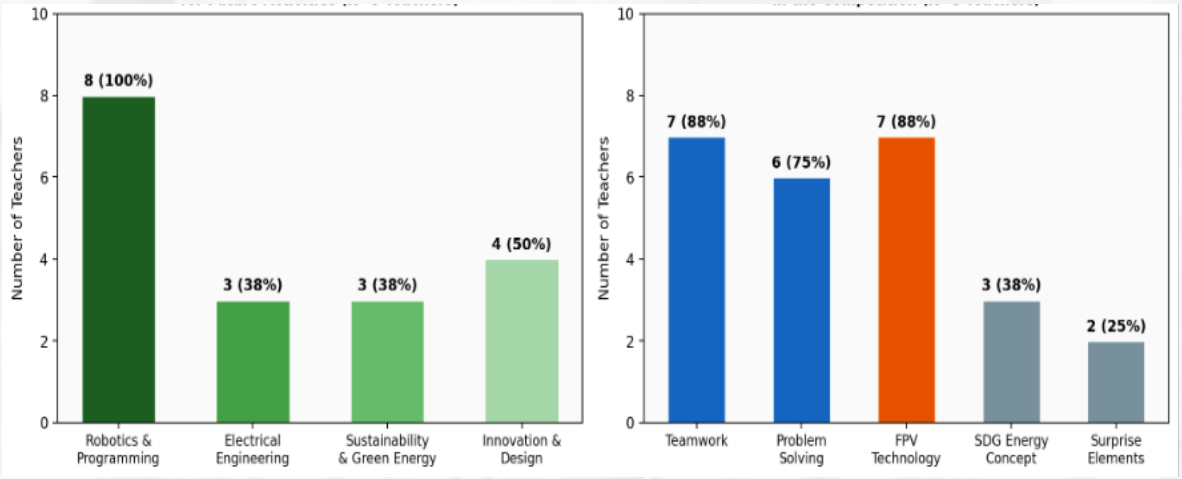


Figure 5: (a) STEM Fields Recommended by Teachers for Future Activities; (b) Most Effective Competition Elements as Rated by Teachers.

4.3 Summary of Findings

Across both respondent groups, findings consistently pointed toward a positive impact of FPV robotics competition on student engagement, motivation, and STEM interest. Students responded most strongly to teamwork (87.5% agreement) and problem-solving (75.0%), while FPV control ease remained an area for improvement. STEM motivation items showed moderate but meaningful positive shifts, particularly among first-time FPV users. Teachers provided strong validation of these outcomes, with unanimous agreement that FPV activities can stimulate STEM interest, and an equally clear consensus that Robotics and Programming should be the primary STEM emphasis in future activities. Together, these findings support the use of FPV technology as an effective vehicle for advancing robotics and STEM education at the primary school level.

5.0 RESEARCH DISCUSSION

The findings from this study align with the growing body of research on the acceptance and effectiveness of FPV technology in educational contexts. The strong positive perceptions from teachers, particularly the unanimous agreement (100%) that FPV-based activities can attract student interest in STEM (GQ2), corroborates the findings of Sivenas, Koutromanos, and Larios (2025), whose study on in-service teachers' acceptance of FPV drones in STEM education found that teachers held positive perceptions about the technology's use.

Furthermore, the high importance placed on factors such as enjoyment and facilitating conditions in their technology acceptance model provides a theoretical lens through which to view the success of the structured competition in this study, where the engaging nature of the FPV experience and the provided resources likely contributed to the positive outcomes reported by both students and teachers. This is further supported by Diaz-Martinez et al. (2023), who reported similar motivational gains and skill development among students participating

in FPV drone racing competitions, reinforcing the broader applicability of such approaches across educational levels.

The rapid advancement of intelligent FPV systems, which now incorporate sophisticated algorithms such as YOLOv8 for target recognition and proportional navigation for precision guidance (Wang, 2025), further underscores the relevance of introducing foundational FPV experiences at early educational stages. The moderate positive shift in student interest toward robotics and electronics (56.2%) observed in this study suggests that early exposure to such technologies can help build foundational skills for future engagement with increasingly complex FPV applications.

6.0 CONCLUSION

The positive outcomes observed in this study, combined with findings from similar FPV-based competition initiatives at the tertiary level (Alvarez, 2023), suggest that the scalability of such activities across educational levels is both feasible and beneficial. Future work could explore longitudinal impacts of FPV robotics participation on STEM career aspirations, as well as the development of standardized frameworks for integrating FPV technology into formal primary school curricula.

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WHAT MAKES A PUBLIC PARK WORK? A CORRELATIONAL STUDY OF USER EXPERIENCES AT TAMAN TASIK LIPUR KOTA

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Abstract

Public parks play a vital role in enhancing community well-being, environmental quality, and local economic activity, yet empirical assessments of park success in smaller towns remain limited. This study investigates the relationships among four key dimensions of public park quality - Good Accessibility and Linkages (GAL), Degree of Comfort and Image (DCI), Users and Activities (UAC), and Sociability (SOC) - using Taman Tasik Lipur Kota in Muadzam Shah, Pahang, as a case study. A quantitative research design was employed through structured questionnaires distributed to 124 park visitors representing diverse demographic backgrounds. The instrument measured all constructs using a six-point Likert scale, and data were analysed using Pearson product-moment correlation to determine the strength and direction of interrelationships among variables. The results reveal strong, positive, and statistically significant correlations across all constructs ($p < 0.001$). The strongest association was observed between Users and Activities and Sociability ($r = 0.848$), indicating that vibrant user engagement and diverse activities substantially enhance social interaction and community cohesion. Comfort and Image also demonstrated strong links with both UAC and SOC, highlighting the importance of safety, maintenance, and visual appeal in fostering active and sociable spaces. Accessibility showed moderate but meaningful correlations with other constructs, suggesting its role as a foundational factor that becomes most effective when complemented by high-quality facilities and activities. Overall, the findings demonstrate that public park success depends on the synergistic interaction of accessibility, comfort, activity richness, and sociability. The study provides valuable insights for local authorities, emphasizing that integrated improvements across these dimensions are essential for creating vibrant, inclusive, and socially meaningful public parks, particularly in semi-urban contexts.

Keywords: Public Park, Interrelationship, User Experiences, Success Factors

Abstrak

Taman awam memainkan peranan penting dalam meningkatkan kesejahteraan komuniti, kualiti alam sekitar, dan aktiviti ekonomi setempat, namun penilaian empirikal terhadap kejayaan taman di bandar-bandar kecil masih terhad. Kajian ini menyiasat hubungan antara empat dimensi utama kualiti taman awam- Kebolehcapaian dan Hubungan yang Baik (GAL), Tahap Keselesaan dan Imej (DCI), Pengguna dan Aktiviti (UAC), serta Sosiabiliti (SOC)-

dengan menjadikan Taman Tasik Lipur Kota di Muadzam Shah, Pahang, sebagai kajian kes. Reka bentuk penyelidikan kuantitatif telah digunakan melalui soal selidik berstruktur yang diedarkan kepada 124 pengunjung taman daripada pelbagai latar belakang demografi. Instrumen kajian mengukur semua konstruk menggunakan skala Likert enam mata, dan data dianalisis menggunakan korelasi Pearson product-moment untuk menentukan kekuatan dan arah hubungan antara pemboleh ubah. Keputusan menunjukkan korelasi yang kuat, positif, dan signifikan secara statistik bagi semua konstruk ($p < 0.001$). Perkaitan yang paling kuat diperhatikan antara Pengguna dan Aktiviti dengan Sosiabiliti ($r = 0.848$), yang menunjukkan bahawa penglibatan pengguna yang rancak dan aktiviti yang pelbagai meningkatkan interaksi sosial dan kohesi komuniti secara substansial. Keselesaan dan Imej juga menunjukkan hubungan yang kuat dengan UAC dan SOC, menekankan kepentingan keselamatan, penyelenggaraan, dan daya tarikan visual dalam memupuk ruang yang aktif dan mesra sosial. Kebolehcapaian menunjukkan korelasi sederhana tetapi bermakna dengan konstruk lain, mencadangkan peranannya sebagai faktor asas yang menjadi paling berkesan apabila dilengkapi dengan kemudahan dan aktiviti berkualiti tinggi. Secara keseluruhan, dapatan kajian membuktikan bahawa kejayaan taman awam bergantung kepada interaksi sinergi antara kebolehcapaian, keselesaan, kepelbagaian aktiviti, dan sosiabiliti. Kajian ini memberikan pandangan berharga kepada pihak berkuasa tempatan, dengan menekankan bahawa penambahbaikan bersepadu merentasi dimensi-dimensi ini adalah penting untuk mewujudkan taman awam yang bertenaga, inklusif, dan bermakna secara sosial, terutamanya dalam konteks separa bandar.

Kata Kunci: *Taman Awam, Hubung Kait, Pengalaman Pengguna, Faktor Kejayaan*

1.0 INTRODUCTION

A public park serves as an outdoor space that enhances national development. It acts as a natural buffer that supports sustainable growth, helps reduce noise and air pollution, and promotes positive mental well-being as well as social interaction (Ismail et al., 2017). Parks and recreational areas also attract both tourists and local visitors, offering scenic environments for leisure enjoyment (Abdullah Sani et al., 2022). According to the National Landscape of Malaysia (2025), public parks provide three major benefits - social, environmental, and economic. Socially, they encourage community interaction, strengthen relationships, and offer a variety of activities that help reduce stress. Economically, stalls and small businesses surrounding the park contribute to local income and improve living standards. Environmentally, parks help enhance public awareness of natural resource conservation, including hills, flora, and fauna. Taman Tasik Lipur Kota, located in Muadzam Shah, Pahang, is the main recreational park in the area. Managed by Majlis Daerah Rompin (MDR), the park covers 7.13 hectares. MDR provides various facilities such as parking areas, benches, gazebos, stalls, and pedestrian walkways.

1.1 Problem Statement

Although public parks in Malaysia are recognised for delivering significant economic, environmental, and social benefits to communities (National Landscape Malaysia, 2025; Ismail et al., 2017), many neighbourhood parks managed by local authorities - particularly District Councils - still fall short of their full potential. Previous studies have established four key determinants of successful public parks: Good Accessibility and Linkages (GAL), Comfort and Image (DCI), User and Activities (UAC), and Sociability (SOC) (Sakip et al., 2015). However, empirical assessments applying these determinants remain limited, especially for parks in smaller towns and semi-rural areas such as Muadzam Shah, Pahang.

1.2 Research Objective

To investigate the interrelationships among the four key dimensions of public space quality - Good Accessibility and Linkages (GAL), Degree of Comfort and Image (DCI), Users and Activities (UAC), and Sociability (SOC).

1.3 Significant of Research

The significance of this research lies in its contribution to understanding the role of public parks in enhancing community well-being, environmental quality, and local economic development. Public parks act as vital green infrastructures that support sustainable development by improving mental health, reducing pollution, and encouraging social interaction among communities. Examining Taman Tasik Lipur Kota, the main recreational space in Muadzam Shah, provides valuable insights into how well-designed and well-managed parks can strengthen community cohesion, elevate environmental awareness, and stimulate local economic activities through surrounding small businesses. This study is important for local authorities such as Majlis Daerah Rompin (MDR) as it highlights the value of providing adequate facilities, accessible spaces, and quality recreational environments that contribute to a higher quality of life for residents. Overall, the research supports informed planning and decision-making in public park development to ensure these spaces continue to deliver meaningful benefits to society, the environment, and the economy.

2.0 LITERATURE REVIEW

2.1 Local Authority

In Malaysia, the management of public parks falls under multiple administrative levels, including federal, state, and municipal governments, as well as private organizations (Samad et al., 2021). Local authorities, which represent the third tier of government in the country, play a key role in overseeing these areas (Khalid & Kamar, 2022). According to the Malaysia Town and Country Planning Act, developers of industrial, residential, and educational projects are required to allocate 10 percent of their development area for public use (Ismail et al., 2017). The Local Government Department (2025) classifies local authorities into three categories - City Councils, Municipal Councils, and District Councils - each distinguished by different characteristics and administrative functions.

2.2 Public Park

A public park serves as a recreational space for the community, offering numerous benefits to individuals and society (Jogdande & Bandyopadhyay, 2022). Such spaces enhance mental well-being, promote positive character development, and help reduce stress and tension while improving overall physical wellness. Jogdande & Bandyopadhyay (2022) highlights that public parks contribute socially, physically, ecologically, and economically. Similarly, Ismail et al., (2017) identifies social, physical, environmental, psychological, and economic advantages as key outcomes of park usage. In addition, Samad et. al., (2021) emphasizes that open spaces provide various benefits, including opportunities for enjoyment, cultural activities, education, sports, natural appreciation, aesthetic experiences, and research.

2.3 Park Classification Facilities

Park facilities play a vital role in enhancing the overall functionality and effectiveness of public open spaces (Ismail et al., 2017). According to Silverberg et al., (1999), the planning of open areas can be evaluated through five key criteria: the size of the space, the community's needs, the park's contribution to urban development, the types of vegetation and landscape design, and the facilities provided, including any supporting amenities. Au-Yong et al., (2022) further emphasize that facility classifications serve as an essential guide for the management and planning of open spaces. These classifications, as shown in Table 2, assist stakeholders in identifying both essential and value-added park facilities that contribute to the overall quality and usability of the park.

Table 1: Classification of park facilities

Classification	**Park facilities**
Essential Park facilities	Rubbish bin
	Park lighting
	Washroom
	Signage
	Park furniture
	Track/Path
	Natural Landscape
	Designed landscape – softscape
	Designed landscape – Hardscape
	Prayer Room
Value-added Park facilities	Indoor Sport facilities
	Water activities facilities
	Recreational facilities
	Outdoor sport facilities
	Outdoor gym facilities
	Kiosk
	Drinking fountain
	Children playground
	Picnic/ Camping area

2.4 Satisfaction of Public Parks

Visitor satisfaction in public parks is influenced by several key elements, including the maintenance of softscape features, the park's location, overall cleanliness, the quality of pedestrian walkways, and the placement of gazebos, tables, benches, and jogging tracks (Abdullah Sani et al., 2022). Softscape maintenance is particularly significant, as softscape - comprising vegetation, trees, and shrubs - is a fundamental component of park design (Wahyuni & Qomarun, 2015). Regular upkeep practices such as pruning, trimming, and watering contribute to enhancing visitors' experiences and comfort within the park. Narh et al. (2020) further highlight that well-maintained parks create strong positive first impressions, as the visual appeal of the environment is among the first aspects noticed by visitors.

3.0 RESEARCH METHODOLOGY

This study adopted a quantitative research methodology to systematically evaluate the level of success of Taman Tasik Lipur Kota Muadzam Shah as a neighborhood public park. The quantitative approach was selected because it enables objective measurement of visitors' perceptions through structured numerical data, statistical analysis, and generalisable findings. The target population comprised community members who visited the park during their leisure time. Primary data were collected via questionnaires distributed directly at the study site during peak visiting hours (evenings, 5:30 pm to 7:00 pm) on weekends, as these periods recorded the highest visitor traffic based on researcher observation.

3.1 Research Design

The research employed a confirmatory research design, replicating the validated framework of park success determinants established in previous Malaysian studies (Sakip et al., 2015). A quantitative method served as the main research strategy. Non-probability sampling (convenience sampling) was utilised, whereby respondents were selected based on their availability and willingness to participate during peak visiting hours at the park.

The minimum sample size was calculated using G*Power software version 3.1.9.4 with the following parameters: effect size f = 0.15, error probability = 0.05, statistical power = 0.90 (90 %), and number of predictors = 4. This computation yielded a required sample size of 108. In practice, 124 valid responses were collected, exceeding the minimum threshold to strengthen the reliability and robustness of the findings.

3.2 Research Instruments

The key constructs applied in this study are outlined in Figure 1. The construct of Good Access and Linkage (GAL) comprises three indicators: The Public Transport System (PTS), the Pedestrian System (PS), and Vehicular Circulation (VC). For the Comfort and Image (DCI) construct, three dimensions include Safety of Park (SOP), Placement of Sitting Areas (PSA), and Maintenance (MAI). Meanwhile, the User and Activities (UAC) construct consists of four indicators: Physical Activities (PHY), Social Activities (SAC), User (USE), and Special Attractions (SAT). Lastly, the Sociability (SOC) construct incorporates two indicators, namely

the Environment (ENV) and Opportunities for Socializing (OPS). All constructs were measured using a six-point Likert scale ranging from 1 (Highly Disagree) to 6 (Highly Agree).

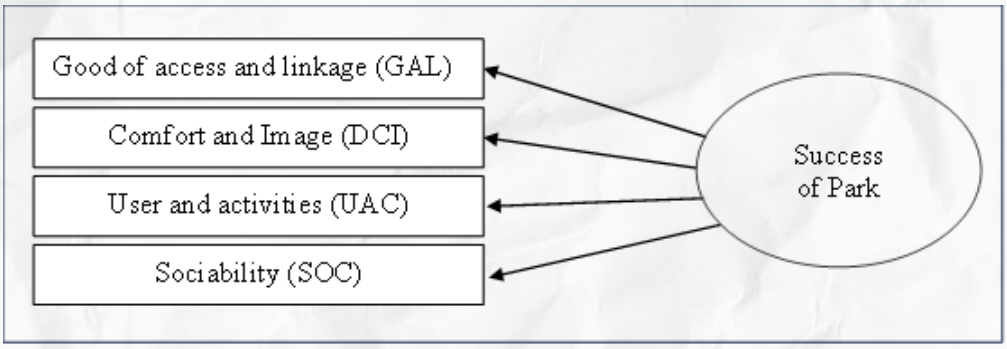


Figure 1: Construct of Park Success

3.3 Data Analysis

The 68-item questionnaire exhibited excellent internal consistency across all four constructs, as evaluated using Cronbach's alpha in SPSS version 24.0. All reliability coefficients surpassed the rigorous excellence threshold of 0.90 (Hinton et al., 2004)- GAL ($\alpha = 0.916$), DCI ($\alpha = 0.908$), UAC ($\alpha = 0.925$) and SOC ($\alpha = 0.905$) thereby affirming that the instrument is highly reliable and appropriate for assessing the determinant factors of neighbourhood public park success in semi-urban Malaysian settings.

Data collected from the 124 park visitors were analysed using Pearson product-moment correlation to examine the strength, direction, and statistical significance of the interrelationships among the four key constructs of public park success: Good Accessibility and Linkages (GAL), Degree of Comfort and Image (DCI), Users and Activities (UAC), and Sociability (SOC). All variables were measured on a six-point Likert scale (1 = Highly Disagree to 6 = Highly Agree). The analysis was performed using SPSS version 24.0.

4.0 RESEARCH FINDINGS AND DISCUSSION

Research findings on demographic and correlation of four constructs discussed in the next section.

4.1 Descriptive analysis

Table 2 shows the sample comprises 124 respondents and is predominantly female (64.5%) compared to male (35.5%). Age distribution skews mid-career, with 73.4% aged 30–49 and very few under 20 or over 60 (1.6% each). Most respondents are married (72.6%), while 27.4% are single. Education is relatively high, centred on bachelor (28.2%) and diploma (26.6%) levels, followed by master (25%), with fewer at SPM (17%) and PhD (3.2%). Employment is dominated by the government sector (60.5%), with smaller shares in private (20.2%), business (9.7%), students (8.1%), and retirees (1.6%).

Table 2: Respondents demographic

Demographic	Criteria	Frequency	Percentage %
Gender	Male	44	35.5
	Female	80	64.5
	Total	124	100
Age	<20 years old	2	1.6
	20-29 years old	20	16.1
	30-39 years old	50	40.3
	40-49 years old	41	33.1
	50-59 years old	9	7.3
	> 60 years old	2	1.6
	Total	124	100
Status	Single	34	27.4
	Married	90	72.6
	Total	124	100
Education Level	PhD	4	3.2
	Master	31	25
	Bachelor	35	28.2
	Diploma	33	26.6
	SPM	21	17
	Total	124	100
Job	Government	75	60.5
	Private	25	20.2
	Business	12	9.7
	Student	10	8.1
	Retired	2	1.6
	Total	124	100.0

4.2 Relationship Between Variables

This study investigated the relationship between four main variables or construct between good accessibility and linkages (GAL), degree of comfort and image (DCI), users and activities (UAC) and sociability (SOC). The relationship between four variables was investigated using Pearson product-moment correlation coefficient.

Table 3: Correlation findings

Correlations					
		GAL	DCI	UAC	SOC
GAL	Pearson Correlation	1	.570**	.433**	.544**
	Sig. (2-tailed)		.000	.000	.000
	Covariance	142.237	82.659	129.340	75.442
	N	124	124	124	124
DCI	Pearson Correlation	.570**	1	.706**	.741**
	Sig. (2-tailed)	.000		.000	.000
	Covariance	82.659	147.763	214.822	104.623
	N	124	124	124	124
UAC	Pearson Correlation	.433**	.706**	1	.848**
	Sig. (2-tailed)	.000	.000		.000
	Covariance	129.340	214.822	627.058	246.634
	N	124	124	124	124

SOC	Pearson Correlation	.544**	.741**	.848**	1
	Sig. (2-tailed)	.000	.000	.000	
	Covariance	75.442	104.623	246.634	134.966
	N	124	124	124	124
**. Correlation is significant at the 0.01 level (2-tailed).					

The correlation analysis reveals strong and statistically significant interrelationships among the four key dimensions of public space quality - Good Accessibility and Linkages (GAL), Degree of Comfort and Image (DCI), Users and Activities (UAC), and Sociability (SOC) - based on data from 124 respondents (all $p < 0.001$, two-tailed). All correlations exceed conventional thresholds (Cohen, 1988) for practical significance in social and urban studies (where $r > 0.50$ is typically regarded as large/strong, $r = 0.30 - 0.50$ as medium, and even lower values as meaningful when contextually relevant), and the uniformly high significance levels ($p < 0.001$) confirm the reliability of these relationships in the sample. The current findings demonstrate notable similarities with prior research on public space dimensions, particularly in affirming the strong interdependence among comfort/image, users/activities, and sociability, as seen in studies emphasizing how physical comfort and diverse activities drive social interactions in urban settings.

The highest correlation is observed between Users and Activities (UAC) and Sociability (SOC), with a Pearson correlation coefficient of $r = 0.848$. This very strong positive association indicates that public spaces perceived as vibrant with diverse users engaging in a wide range of activities are overwhelmingly linked to higher levels of sociability. In other words, the presence of inclusive, dynamic user groups and meaningful social, recreational or functional activities substantially fosters social interactions, sense of community, and interpersonal connections - core elements of sociability in urban public spaces.

This finding aligns closely with established urban design principles, where active use and people-centered programming are critical drivers of social vitality. For instance, a systematic review by Qi et al., (2024) found positive associations between accessibility, mixed land use, street furniture (aligning with DCI and UAC), and social cohesion (similar to SOC), with effects moderated by sociodemographic factors, mirroring the robust UAC-SOC link ($r = 0.848$) observed here.

A similarly robust relationship exists between Degree of Comfort and Image (DCI) and Sociability (SOC) ($r = 0.741$), and between DCI and Users and Activities (UAC) ($r = 0.706$). These strong correlations suggest that perceptions of physical comfort (e.g., seating, shading, microclimate) and positive aesthetic/image qualities (e.g., attractiveness, maintenance, visual appeal) are highly intertwined with both the occurrence of diverse activities/users and the emergence of sociable environments. Comfortable and visually appealing spaces appear to act as enablers, attracting and retaining people while facilitating prolonged stays and spontaneous social encounters.

Similarly, Ramos-Vidal and De La Ossa (2024) reported moderate positive effects of perceived public space quality on sense of community (β range 0.13 - 0.4), supporting the DCI-SOC correlation (r = 0.741) and highlighting design features that facilitate interaction as key enablers, consistent with the interdependent pattern in this study.

However, contrasts emerge in the magnitude and contextual emphasis of these relationships. While this study's correlations are notably higher (e.g., UAC-SOC at r = 0.848) than the moderate ranges in broader reviews like Ramos-Vidal's (β ~0.24 average), this may reflect the focused sample of 124 respondents in a specific urban context, potentially amplifying site-specific synergies compared to meta-analyses aggregating diverse global studies.

Good Accessibility and Linkages (GAL) demonstrate moderate to strong positive correlations with the other dimensions: r = 0.570 with DCI, r = 0.544 with SOC, and r = 0.433 with UAC (all significant at $p < 0.01$). While slightly lower in magnitude compared to the interrelationships among DCI, UAC, and SOC, these coefficients still indicate meaningful associations. Easy access, good connectivity, and integration with surrounding urban fabric contribute to enhanced comfort/image perceptions, greater sociability, and increased user participation in activities. The comparatively lower correlation between GAL and UAC (r = 0.433) suggests that while accessibility is an important foundational element, the actual activation of spaces through users and activities may depend more heavily on on-site comfort, image, and programming factors.

Askarizad et al. (2024) also noted strong correlations between spatial integration (related to GAL) and sociability potential via space syntax analysis, aligning with the moderate GAL-SOC link (r = 0.544) and underscoring accessibility's role as a foundational but not dominant factor.

Overall, the pattern of correlations points to a highly interdependent structure among these dimensions, with UAC and SOC forming the strongest cluster, supported by DCI as a key mediating factor, and GAL serving as a supportive but less dominant prerequisite. In the context of public space quality assessment, these results underscore that improvements in one dimension - particularly comfort/image and users/activities - are likely to yield synergistic benefits across the others, ultimately enhancing overall sociability and place quality. Such interdependence highlights the multifaceted nature of successful public spaces, where isolated enhancements (e.g., improving access alone) may produce limited gains unless paired with investments in comfort, aesthetics, and activity generation.

All correlations exceed conventional thresholds (Cohen, 2013) for practical significance in social and urban studies (where $r > 0.50$ is typically regarded as large/strong, r = 0.30–0.50 as medium, and even lower values as meaningful when contextually relevant), and the uniformly high significance levels ($p < 0.001$) confirm the reliability of these relationships in the sample. These empirical findings provide robust evidence supporting integrated design strategies that prioritize holistic improvements to foster vibrant, sociable, and inclusive urban public spaces.

5.0 CONCLUSION

This study shows that the quality of public parks depends on the strong and interconnected relationships among accessibility, comfort, user activities, and sociability. The findings indicate that comfortable, well-maintained parks with active user engagement significantly enhance social interaction and overall park vitality. Accessibility remains an important supporting factor but is most effective when combined with appealing facilities and diverse activities. Overall, improving these dimensions together can help local authorities create more vibrant, inclusive, and socially meaningful public spaces.

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PEMERKASAAN BAKAT TVET MELALUI *INDUSTRY ON CAMPUS* (IOC): ANALISIS PERSPEKTIF STRATEGIK INDUSTRI DI KOLEJ KOMUNITI SEGAMAT

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ABSTRAK

Program *Industry on Campus* (IOC) merupakan anjakan paradigma dalam sistem Pendidikan dan Latihan Teknikal dan Vokasional (TVET) bagi merapatkan jurang kompetensi bakat dan keperluan dinamik industri. Kajian ini bertujuan menilai keberkesanan program IOC di Kolej Komuniti Segamat melalui analisis perspektif strategik industri. Fokus utama kajian merangkumi penilaian terhadap tahap kolaborasi strategik, keberkesanan pemindahan kepakaran teknikal, serta implikasi jangka panjang program terhadap pemerkasaan kompetensi warga Sijil Teknologi Elektrik. Menggunakan pendekatan kuantitatif, data dikumpul melalui instrumen soal selidik melalui persampelan bertujuan terhadap wakil industri yang terlibat secara langsung dalam pelaksanaan program IOC. Kaedah analisis data adalah menggunakan *Microsoft Excel* dan data dianalisis bagi mendapatkan nilai min bagi setiap item dan kategori. Hasil analisis statistik deskriptif menunjukkan pencapaian yang sangat memberangsangkan dengan nilai min keseluruhan 4.60. Dapatan kajian mendedahkan bahawa aspek Implikasi Jangka Panjang mencatatkan skor sempurna (min=5.00), membuktikan keyakinan tinggi industri terhadap kelestarian model ini. Selain itu, Penglibatan dan Komitmen Institusi (min=4.80) serta Keberkesanan Latihan dan perkongsian kepakaran (min=4.60) berada pada tahap cemerlang. Walau bagaimanapun, aspek Kualiti Pelaksanaan Program (min=4.00) dikenal pasti sebagai ruang penambahbaikan, khususnya dalam aspek penyelarasan fasiliti dan struktur aktiviti. Keunikan kajian ini adalah pada perkongsian kepakaran industri secara langsung di dalam kampus yang berfungsi sebagai inkubator kemahiran teknikal. Implikasi kajian mencadangkan pemerkasaan libat urus dalam fasa perancangan dan peningkatan fasiliti secara progresif bagi menjamin impak yang lebih holistik. Secara keseluruhannya, model IOC ini bukan sekadar inovasi dalam pengajaran, malah merupakan strategi berkesan dalam memperkasa kecemerlangan TVET negara. Keberhasilan model ini berpotensi dijadikan penanda aras bagi institusi pendidikan lain dalam usaha memastikan bakat TVET kekal relevan dan berdaya saing mengikut acuan industri sebenar.

Kata Kunci: *Industry on Campus (IOC), TVET, Kolaborasi Strategik, Sijil Teknologi Elektrik, Pemerkasaan Bakat.*

ABSTRACT

The Industry on Campus (IOC) program is a paradigm shift in the Technical and Vocational Education and Training (TVET) system to bridge the talent competency gap and the dynamic needs of the industry. This study aims to assess the effectiveness of the IOC program at Segamat Community College through an analysis of the industry's strategic perspective. The main focus of the study includes an assessment of the level of strategic collaboration, the effectiveness of technical expertise transfer, and the long-term implications of the program on the empowerment of the competencies of Electrical Technology Certificate holders. Using a quantitative approach, data was collected through a questionnaire instrument through purposive sampling of industry representatives who are directly involved in the implementation of the IOC program. The data analysis method is using Microsoft Excel and the data is analyzed to obtain the mean value for each item and category. The results of descriptive statistical analysis show a very encouraging achievement with an overall mean value of 4.60. The study findings reveal that the Long-Term Implications aspect recorded a perfect score (mean=5.00), proving the industry's high confidence in the sustainability of this model. In addition, Institutional Involvement and Commitment (mean=4.80) and Effectiveness of Training and Expertise Sharing (mean=4.60) are at an excellent level. However, the Quality of Program Implementation aspect (mean=4.00) was identified as an area for improvement, especially in the aspect of facility coordination and activity structure. The uniqueness of this study is in the direct sharing of industry expertise within the campus which functions as an incubator of technical skills. The implications of the study suggest empowering management involvement in the planning phase and progressively improving facilities to ensure a more holistic impact. Overall, this IOC model is not just an innovation in teaching, but rather an effective strategy in empowering the excellence of national TVET. The success of this model has the potential to be used as a benchmark for other educational institutions in efforts to ensure that TVET talent remains relevant and competitive according to the actual industry model.

Keywords*: Industry on Campus* (IOC), TVET, *Strategic Collaboration, Electrical Technology Certificate, Talent Empowerment*.

1.0 PENGENALAN

Pendidikan Teknikal dan Vokasional (TVET) menjadi tunjang utama bagi mendepani cabaran global yang dipacu oleh kepantasan teknologi. Berdasarkan kerangka Rancangan Malaysia Ke-12 (RMK-12) dan persediaan menuju RMK-13, kerajaan telah meletakkan pemerkasaan bakat tempatan sebagai agenda kritikal untuk memastikan negara mempunyai tenaga kerja yang kompeten, kreatif, dan berdaya saing tinggi. Rentetan ini, Kolej Komuniti Segamat, memainkan peranan penting untuk merapatkan jurang antara komuniti setempat dengan keperluan industri. Salah satu inisiatif yang diketengahkan ialah program *Industry on Campus* (IOC), yang bertujuan mengintegrasi persekitaran industri sebenar ke dalam institusi pendidikan.

Selain itu, untuk pemerkasaan bakat melalui program IOC ini Kolej Komuniti Segamat telah mengambil langkah proaktif dengan menjalin kerjasama bersama pihak industri dalam bidang Pemasangan dan Penyelenggaraan Pendingin Hawa. Oleh yang demikian, kepentingan kajian ini terletak pada keperluan untuk menilai sejauh mana inisiatif IOC benar-benar memberikan impak yang positif terhadap kelestarian pendidikan TVET dan kompetensi warga Sijil Teknologi Elektrik. Oleh itu, laporan ini akan menjelaskan berkaitan kolaborasi strategik, keberkesanan pemindahan kepakaran, dan implikasi jangka panjang program IOC sebagai pemangkin kecemerlangan bakat di Kolej Komuniti Segamat.

1.1 Penyataan masalah

Beberapa cabaran perlu dihadapi untuk memartabatkan TVET di Malaysia terutamanya di Kolej Komuniti Segamat. Antara cabarannya adalah jurang kemahiran (*skills gap*) antara lulusan institusi dengan keperluan majikan. Ketidakpadanan yang berpunca daripada pembangunan kurikulum yang tidak selari dengan perubahan teknologi industri, menyebabkan graduan TVET dilihat kurang kompeten atau menyesuaikan diri dengan prosedur kerja semasa. Di Kolej Komuniti Segamat, pelaksanaan IOC bertujuan menangani isu ini, namun keberkesanannya perlu dibuktikan secara eksperimental melalui penilaian pihak industri itu sendiri.

Isu utama yang sering dibangkitkan ialah kualiti pelaksanaan teknikal di peringkat institusi. Terdapat kekangan dari segi perancangan aktiviti, penyelarasan masa, penyediaan fasiliti serta penglibatan pihak industri yang tidak seragam. Apabila peralatan latihan tidak menepati spesifikasi industri, proses pemindahan ilmu menjadi terhad. Selain itu, penyelarasan semasa antara jadual akademik dan operasi industri sering menjadi kekangan dalam memastikan program IOC berjalan secara sistematik dan berterusan.

Selain itu, didapati bahawa tahap penglibatan industri sekadar memenuhi tuntutan perjanjian persefahaman (MoU) tanpa memberikan impak sebenar terhadap kompetensi. Tanpa keterlibatan pengurusan jabatan menjadi ukuran kebolehpercayaan pihak industri untuk berkongsi kepakaran dan teknologi terkini. Maka, ini menjadi persoalan sama ada pelaksanaan program IOC memberi impak positif dan jangka panjang kepada pelajar dan staf di institusi. Oleh yang demikian, analisis strategik ini diperlukan untuk mengenal pasti kekuatan yang perlu dikekalkan dan kelemahan yang perlu diperbaiki bagi menjamin IOC di Kolej Komuniti Segamat agar menjadi inisiatif dan satu teras transformasi bakat yang mampan.

1.2 Objektif Kajian

1.2.1 Menilai tahap kolaborasi strategik antara Kolej Komuniti Segamat dan industri dalam memperkukuh kelestarian pendidikan TVET

1.2.2 Mengukur keberkesanan pemindahan kepakaran teknikal daripada pihak industri terhadap pemerkasaan kompetensi warga Sijil Teknologi Elektrik di kolej komuniti segamat.

1.2.3 Mengenalpasti implikasi jangka panjang program IOC untuk pemerkasaan kompetensi warga Sijil Teknologi Elektrik di kolej komuniti segamat.

1.3 Kepentingan Kajian

Kepentingan kajian ini memberi impak kepada beberapa pihak seperti berikut:

1.3.1 Kepada Pelajar - merapatkan jurang antara teori dengan realiti amalan di industri agar kemahiran teknikal lebih meningkatkan.

1.3.2 Kepada Staf Akademik - memberikan peningkatan pengetahuan teknikal dalam bidang elektrikal dan penyamanan udara seterusnya memastikan kualiti penyampaian PdP kekal relevan dan berkualiti.

1.3.3 Kepada Institusi – memberi maklumbalas kepada institusi mengenai aspek fasiliti dan peralatan membolehkan pihak pengurusan membuat perancangan bagi memastikan institusi mencapai standard kualiti yang ditetapkan oleh badan akreditasi.

2.0 SOROTAN KAJIAN

Pemerkasaan bakat telah menjadi sasaran utama kementerian Pendidikan Tinggai (KPT) melalui Pelan Pembangunan Pendidikan Malaysia 2015-2025 (PPPM). Dimana menurut Kamus KPI (2026) KPI diwujudkan untuk mengukur tahap pemerkasaan bakat melalui peratusan pensyarah kursus teras bidang yang memiliki kemahiran industri terkini. Selain itu, dalam melakar semula pembangunan sempena menuju RMK-13 strategi utama untuk meningkatkan ekonomi negara, pembangunan bakat turut menjadi tunggak utama. Melabur dalam pendidikan TVET dan bidang sains, teknologi, kejuruteraan dan matematik (STEM) untuk melahirkan tenaga kerja berkemahiran tinggi yang mampu menyokong industri canggih (Thirteenth Malaysia Plan, 2025) ini jelas menunjukkan pemerkasaan bakat di peringkat institusi perlu diberi penegasan demi melahirkan pengamal TVET yang kompeten.

Konsep *Industry on Campus* (IOC) merupakan salah satu strategi utama untuk menggarap industri ke dalam kampus. Berdasarkan garis panduan pelaksanaan IOC politeknik dan kolej komuniti, menurut Muhamad Rumzi (2019) penyaluran pengetahuan antara ahli akademik dan industri secara dua hala antara institusi dan indsutri dapat dimanfaatkan secara optimum. Menurut Mohd Zahari (2023) IOC sebagai satu inisiatif yang mana persekitaran sebenar industri dibawa ke dalam proses pengajaran dan pembelajaran (PdP). Kajian oleh Mohd Zamri et al. (2020) menegaskan bahawa pendekatan kolaboratif industri membolehkan pelajar mengembangkan kemahiran insaniah dan teknikal secara serentak dalam persekitaran yang terkawal namun realistik. Ini dapat dilihat program IOC merupakan medium menerapkan teknologi ke dalam kurikulum sedia ada tanpa perlu melalui proses semakan silibus yang panjang. Dimana kolaborasi antara institusi dan industri berlaku pada pelbagai peringkat pendidikan.

Dalam konteks program Sijil Teknologi Elektrik (SKE) di Kolej Komuniti Segamat, kurikulum yang dibangunkan merangkumi modul pemasangan elektrik satu fasa, pemasangan elektrik tiga fasa, dan penyelenggaraan industri. Walau bagaimanapun, pematuhan terhadap standard Suruhanjaya Tenaga (ST) untuk mendapatkan perakuan kekompetenan seperti juruteknik memerlukan pendedahan praktikal yang intensif. Hubungan yang rapat dengan dunia kerja sebenar membantu pelajar meningkatkan kelebihan diri secara teknikal. Manakala, peningkatan kemahiran pensyarah akan lebih kompeten dalam penyampaian kelas. aplikasi

pendidikan TVET mesti dijalankan bukan hanya melibatkan institusi pendidikan tetapi mesti berlaku dengan jaringan bantuan industri yang akan membantu dalam aspek pemindahan kemahiran dan pengetahuan agar graduan menjadi kompeten serta berdaya saing tinggi (Saiidatul et.al, 2019). Dengan perkongsian kepakaran dan pemindahan ilmu antara industri mampu meningkatkan kompeten warga TVET. Pelaksaan IOC dapat merapatkan jurang antara kehendak industri dengan sumber tenaga pekerja mahir yang diperlukan negara (Abdul Razak,2023).

Selain itu, Kajian lepas mencatatkan bahawa penglibatan industri dalam PdP meningkatkan tahap keyakinan atau *self-efficacy* pelajar, di mana mereka merasa lebih bersedia untuk menghadapi peperiksaan kompetensi dan cabaran di tempat kerja (Benny et.al, 2025). literatur juga menunjukkan bahawa keberkesanan IOC sering terhad oleh faktor logistik dan ketersediaan sumber. Manakala, sokongan pentadbiran dan hubungan strategik yang berterusan adalah kunci utama yang mana tanpanya inisiatif IOC akan layu selepas fasa pelancaran. Selain itu, isu keselarasan kandungan latihan dengan pasaran kerja semasa kekal menjadi cabaran, memandangkan kitaran teknologi jauh lebih pantas daripada kitaran pembangunan akademik. Oleh itu, kajian terhadap IOC di Kolej Komuniti Segamat ini mengisi lompang dalam kajian tempatan dengan menilai secara khusus impak pemindahan kepakaran teknikal dalam bidang elektrikal dan penyelenggaraan daripada perspektif rakan strategik industri.

3.0 METODOLOGI KAJIAN

Kajian ini menggunakan pendekatan kuantitatif melalui kaedah tinjauan deskriptif untuk menilai keberkesanan pelaksanaan IOC di Kolej Komuniti Segamat. Pendekatan ini dipilih kerana ia membolehkan penyelidik mengukur persepsi pihak industri secara sistematik terhadap pembolehubah yang telah ditetapkan.

3.1 Instrumen Kajian

Instrumen kajian adalah borang soal selidik sebagai instrumen pengumpulan data. Borang ini yang mengandungi empat bahagian utama, yang dibangunkan berdasarkan objektif kajian dan garis panduan pelaksanaan IOC oleh Jabatan Pendidikan Politeknik dan Kolej Komuniti (JPPKK). Instrumen ini terbatas kepada Borang Penilaian Kendiri IOC dan Laporan Pelaksanaan Aktiviti yang diselaraskan oleh JPPKK. Maka, kesahan kandungan telah disemak oleh 3 orang pakar dalam bidang kejuruteraan dan latihan industri untuk memastikan kebolehfahaman dan ketepatan item. Penambahbaikan dilakukan berdasarkan maklum balas diberikan. Item-item diukur menggunakan skala Likert, iaitu "Sangat Tidak Setuju" (1) hingga "Sangat Setuju" (5).

3.2 Analisis Data

Responden bagi kajian ini terdiri daripada wakil pengurusan dan teknikal daripada syarikat Epy Teknik Enterprise yang terlibat secara langsung dalam program IOC di Kolej Komuniti Segamat. Syarikat ini dipilih melalui persampelan bertujuan (*purposive sampling*) kerana kepakaran mereka dalam bidang Pemasangan dan Penyelenggaraan Pendingin Hawa yang

diintegrasikan ke dalam program Sijil Teknologi Elektrik. Manakala, sampel kajian adalah seramai 15 orang tenaga pengajar dan fasilitator dari pihak syarikat untuk 5 aktiviti yang dijalankan.

Kaedah Analisis Data menggunakan *Microsoft Excel*. Data yang dikumpul dianalisis menggunakan statistik deskriptif bagi mendapatkan nilai min bagi setiap item dan kategori. Nilai min adalah mengikut Interprestasi Skor Min seperti Jadual 3.2 yang mana skor min 5.00 menunjukkan tahap cemerlang (Ainul Azniza., 2022). Hasil analisis ini dipersembahkan dalam bentuk jadual bagi memudahkan perbandingan dan pengecaman jurang prestasi dalam pelaksanaan program.

Jadual 3.2 Interprestasi skor min

Skor Min	Interprestasi (Tahap)
1.00 hingga 1.66	Rendah
1.67 hingga 3.33	Sederhana
3.34 hingga 5.00	Tinggi

4.0 DAPATAN KAJIAN

Dapatan kajian menunjukkan responden adalah 5 orang penceramah dan 10 orang adalah fasilitator. Manakala, Jadual 4.0 menunjukkan pengalaman responden dalam bidang Pemasangan dan Penyelenggaraan Pendingin Hawa. Selain itu, Hasil analisis menunjukkan bahawa secara keseluruhannya, program IOC di Kolej Komuniti Segamat mencapai tahap keberkesanan yang sangat tinggi dengan nilai min keseluruhan sebanyak skor 4.60. Dapatan ini membuktikan bahawa pihak industri sangat menghargai inisiatif ini dan melihatnya sebagai platform yang berwibawa untuk pembangunan bakat.

Jadual 4.0 Pengalaman Responden

Pengalaman	Bilangan (orang)
0 – 5 tahun	2
6 – 9 tahun	5
10 – 15 tahun	6
16 – 20 tahun	2
21 tahun dan ke atas	0

4.1 Kualiti Pelaksanaan Program

Persoalan ini menilai aspek logistik dan teknikal yang merangkumi perjalanan program IOC. Skor min purata adalah 4.00, yang merupakan skor terendah berbanding kategori lain. Berdasarkan Jadual 4.1 menunjukkan bahawa kerjasama dengan pihak institusi (A1) sangat cemerlang skor 5.00. Manakala, tempoh pelaksanaan program yang sesuai (A2), aktiviti dirancang selaras dengan keperluan industri semasa (A3) dan penjadualan aktiviti yang teratur (A5) pada skor 4.00. Selain itu, fasiliti dan peralatan institusi mencukupi untuk program (A4) hanya mencatatkan skor 3.00.

Jadual 4.1 Kualiti Pelaksanaan Program

Kod	Item Penilaian	Nilai Min
A1	Kerjasama dengan pihak institusi berjalan lancar.	5.00
A2	Tempoh pelaksanaan program sesuai dan mencukupi.	4.00
A3	Aktiviti dirancang selaras dengan keperluan industri semasa.	4.00
A4	Fasiliti dan peralatan institusi mencukupi untuk program.	3.00
A5	Penjadualan aktiviti bersama industri dilakukan secara teratur.	4.00

4.2 Penglibatan dan Komitmen Institusi

Komponen ini menilai dedikasi pihak Kolej Komuniti Segamat dalam menyokong agenda kolaborasi industri. Skor min purata bagi kategori ini adalah 4.80.

Jadual 4.2 Penglibatan dan Komitmen Institusi

Kod	Item Penilaian	Nilai Min
B1	Komitmen tinggi institusi menjayakan program IOC.	4.50
B2	Koordinasi dan komunikasi industri-institusi berkesan.	5.00
B3	Maklum balas industri diambil kira dalam pelaksanaan.	5.00
B4	Pensyarah terlibat aktif dalam aktiviti bersama industri.	4.50
B5	Institusi terbuka menerima cadangan penambahbaikan.	5.00

Tahap keterbukaan menerima cadangan penambahbaikan (B5), komunikasi berkesan (B2) dan maklum balas industri diambil kira (B3) mendapat skor sempurna min 5.00. Penglibatan aktif pensyarah (B4) dan komitmen tinggi oleh institusi menjayakan program (B1) adalah pada skor tinggi iaitu min 4.50.

4.3 Keberkesanan Latihan & Perkongsian Kepakaran

Bahagian ini mengukur impak pemindahan kepakaran teknikal terhadap warga institusi. Skor min purata adalah 4.60.

Jadual 4.3 Keberkesanan Latihan & Perkongsian Kepakaran

Kod	Item Penilaian	Nilai Min
C1	Ruang menyumbang kepakaran secara langsung oleh industri.	5.00
C2	Impak positif terhadap peningkatan kemahiran staf akademik.	5.00
C3	Kandungan latihan selaras keperluan pasaran kerja semasa.	3.00
C4	Penyelarasan pembelajaran pelajar dengan kehendak industri.	5.00
C5	Nilai tambah latihan industri kepada warga institusi.	5.00

Impak positif peningkatan kemahiran kepada staf (C2), penyelarasan pembelajaran pelajar (C4), ruang menyumbang kepakaran secara langsung oleh industri (C1) dan nilai tambah latihan industri (C5) dinilai sangat tinggi skor min 5.00. Manakala, keselarasan kandungan latihan dengan pasaran kerja sebenar (C3) hanya mendapat skor 3.00.

4.4 Implikasi Jangka Panjang dan Cadangan Penambahbaikan

Komponen ini mencatatkan skor sempurna iaitu min purata 5.00 merentasi semua item, menunjukkan keyakinan tinggi pihak industri terhadap masa depan program IOC.

Jadual 4.4 Implikasi Jangka Panjang dan Cadangan Penambahbaikan

Kod	Item Penilaian	Nilai Min
D1	Potensi program untuk diteruskan jangka panjang.	5.00
D2	Peluang industri mengenal pasti bakat pelajar.	5.00
D3	Minat industri meluaskan kerjasama ke bidang lain.	5.00
D4	Peningkatan penyertaan pelajar secara lebih aktif.	5.00
D5	Keperluan sokongan/insentif daripada kerajaan.	5.00

Industri mendapati potensi program untuk diteruskan jangka panjang (D1), peluang industri mengenal pasti bakat pelajar (D2), minat industri meluaskan kerjasama ke bidang lain (D3), peningkatan penyertaan pelajar secara lebih aktif (D4), dan keperluan sokongan daripada kerajaan (D5) dengan skor min purata 5.00.

5.0 PERBINCANGAN

Analisis data secara menyeluruh menunjukkan program IOC di Kolej Komuniti Segamat adalah satu kejayaan strategik yang baik yang mana pihak industri menghargai inisiatif program IOC dan melihatnya sebagai platform yang berwibawa untuk Pembangunan bakat. Namun begitu, ia berdepan dengan kekangan fizikal dan sistemik yang perlu diatasi segera untuk mencapai potensi yang maksimum. Skor min keseluruhan adalah bukti kukuh bahawa model program IOC diterima baik oleh pihak industri, namun perincian dalam setiap komponen memberikan input kritikal bagi pemerkasaan bakat TVET di institusi pendidikan.

Objektif pertama kajian, iaitu menilai tahap kolaborasi strategik, menunjukkan prestasi yang sangat cemerlang. Skor tinggi dalam aspek komunikasi dan koordinasi membuktikan bahawa halangan birokrasi antara akademik dan industri telah berjaya diatasi di Kolej Komuniti Segamat. Manakala, tahap keterbukaan institusi menerima Cadangan penambahbaikan daripada industri dan kesediaan institusi untuk mengambil kira maklum balas industri (skor 5.00) adalah kunci kepada kelestarian TVET. Selain itu, ini menunjukkan bahawa institusi mempunyai budaya kerja yang sangat dinamik dan pro-industri. Kebolehpercayaan yang diwujudkan oleh institusi mendorong industri untuk berkongsi kepakaran dengan lebih proaktif lagi. Ini selari dengan matlamat Dasar TVET Negara 2030 untuk mewujudkan ekosistem yang kolaboratif dan bukan lagi bersifat silo.

Walau bagaimanapun, komitmen institusi menunjukkan masih ada sedikit ruang untuk meningkatkan sokongan pentadbiran, mungkin dari segi penyediaan peruntukan kewangan yang lebih fleksibel untuk aktiviti luar jangka bersama industri. Selain itu, kualiti pelaksanaan program dari aspek logistik dan teknikal menunjukkan hubungan interpersonal dan organisasi adalah sangat cemerlang. Namun begitu, terdapat isu serius berkaitan fasiliti dan peralatan

institusi semasa pelaksanaan program IOC. Ini menunjukkan bahawa peralatan yang disediakan oleh pihak kolej mungkin tidak mencukupi atau tidak setanding dengan standard indsutri semasa, yang boleh menghambat proses Latihan praktikal yang berkualiti. Kajian terdahulu mendapati kemahiran dalam menggunakan alatan dan kelengkapan akan berkebolehan dalam menyempurnakan tugasan dengan kepelbagaian cara kerja baharu secara hands-on (Mesheta, 2020)

Objektif kedua, yang memfokuskan kepada keberkesanan pemindahan kepakaran teknikal bagi warga Sijil Teknologi Elektrik. Ia menyerlahkan satu pencapaian yang memberangsangkan dalam pembangunan staf. Skor tinggi bagi impak terhadap kemahiran staf akademik menunjukkan bahawa program IOC bukan sahaja melatih pelajar, tetapi juga bertindak sebagai program pembangunan profesional berterusan (CPD) bagi pensyarah. Ini sangat kritikal kerana pensyarah yang kompeten dengan teknologi industri semasa akan dapat menyampaikan ilmu yang lebih relevan. Namun, didapati jurang yang ketara dalam keselarasan kandungan latihan dengan pasaran kerja semasa menunjukkan wujudnya jurang yang serius. Pecanggahan ini jika bengkel kolej tiada kecekapan terkini, latihan yang diberikan oleh pakar industri akan terhad kepada konsep teori atau simulasi. Ia juga mencerminkan realiti bahawa modul pembelajaran rasmi mungkin masih terikat dengan silibus lama. Hal ini menuntut satu pelan strategik untuk menaik taraf bengkel di Kolej Komuniti Segamat agar setanding dengan standard industri 4.0. Isu pemahaman kurikulum mengikut industri, kemudahan terhad dalam industri boleh memberi kesan negatif kepada kejayaan pelaksanaan pembelajaran berasaskan kerja (Suhaini et al., 2024)

Bagi objektif ketiga, iaitu mengenal pasti implikasi jangka panjang, dapatan kajian menunjukkan dapatan positif untuk pemerkasaan bakat TVET di institusi. Keyakinan industri untuk meneruskan program dan minat untuk mengenal pasti bakat pelajar adalah tinggi. Yang mana skor membuktikan bahawa program IOC adalah jambatan kerjaya yang efektif. Skor yang tinggi juga menunjukkan program IOC bertindak sebagai ejen pemangkin bagi hubungan jangka panjang institusi-industri. Menurut kajian Ishak dan Mohd Noor (2020) percaya bahawa interaksi institusi-industri membawa peluang dan kelebihan termasuk mempromosikan kemahiran graduan kepada majikan dalam industri. Dalam bidang elektrikal, pengalaman praktikal sangat dihargai, pelajar yang telah melalui program IOC mempunyai kelebihan kerana mereka telah pun diuji oleh bakal majikan semasa masih dalam pengajian. Skor yang tinggi dalam mengenali bakat pelajar oleh industri menjadi tujuan pengambilan pekerja pada masa hadapan sekaligus, mengurangkan ketidakpadanan kerjaya. Namun begitu, keperluan mendesak terhadap insentif, kerajaan perlu menyediakan kerangka insentif yang lebih konkrit untuk menggalakkan lebih banyak latihan di dalam kampus dapat dilaksanakan demi kelestarian IOC.

Secara keseluruhannya, analisis ini mencadangkan bahawa pemerkasaan bakat TVET melalui IOC di Kolej Komuniti Segamat memerlukan pendekatan dua hala iaitu pengukuhan hubungan sedia ada dan transformasi infrastruktur fizikal. Sinergi yang telah terbina antara pensyarah dan industri perlu diterjemahkan ke dalam bentuk kurikulum yang lebih anjal, di mana modul-modul tertentu boleh digantikan dengan tugasan yang berpaksikan masalah industri sebenar.

Langkah ini bukan sahaja memperkukuh keselarasan pasaran kerja, malah mampu melahirkan graduan Sijil Teknologi Elektrik yang kompeten dalam menyelesaikan tugasan dengan progresif.

6.0 KESIMPULAN

Program *Industry on Campus* (IOC) di Kolej Komuniti Segamat telah terbukti menjadi pemangkin berkesan dalam pemerkasaan bakat TVET melalui kolaborasi strategik yang mantap serta komunikasi telus antara institusi dan pihak industri. Walaupun berjaya merapatkan jurang antara teori dan amalan kerja, kelestarian program ini dalam jangka panjang amat bergantung kepada usaha menangani isu fasiliti yang belum menepati standard industri serta keperluan penyelarasan kurikulum yang lebih tangkas mengikut evolusi pasaran semasa.

Bagi memperkukuh momentum sedia ada, langkah penambahbaikan harus difokuskan kepada penyediaan dana khusus untuk menaik taraf infrastruktur, pemberian autonomi kurikulum yang fleksibel bagi menyerap input industri secara langsung, serta penyediaan ekosistem insentif bagi menghargai komitmen rakan strategik. Usaha ini seterusnya perlu diperkukuh dengan pemantauan impak yang sistematik melalui kajian pengesanan graduan berkala bagi membuktikan keberkesanan program dalam melahirkan bakat mahir tempatan yang unggul serta memenuhi aspirasi negara berpendapatan tinggi.

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STUDENTS' PERCEPTIONS OF THE OPERATING SYSTEM AND NETWORK E-BOOK AS A LEARNING SUPPORT MATERIAL: EVIDENCE FROM TWO MALAYSIAN POLYTECHNICS

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Abstract

Digital learning materials are widely used in polytechnic education, but their usefulness depends on whether students can access them easily and whether the design supports learning. This study assessed students' perceptions of the Operating System and Network e-book as a learning support material and compared perceptions between Politeknik Tuanku Syed Sirajuddin (PTSS) and Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS). A cross-sectional survey was conducted among students who had used the e-book (N = 190; PTSS n = 100; POLIMAS n = 90). The questionnaire included eight five-point Likert items covering syllabus alignment, device accessibility, layout and clarity, video support, examples and exercises, language suitability, teaching–learning support and revision support. Data were analysed using descriptive statistics, Cronbach's alpha and independent-samples t-tests in SPSS. Most respondents used the e-book as a primary reference (53.2%), followed by a supplementary reference (40.5%) and tutorial activities (6.3%). Students reported positive perceptions across all items (M = 4.57–4.71; SD = 0.53–0.60), with the highest rating for revision support (M = 4.71, SD = 0.53). The instrument showed excellent internal consistency (α = 0.98). No statistically significant differences were found between PTSS and POLIMAS for any perception item ($p > .05$); the largest between-institution difference was small and occurred for syllabus alignment, $t(188) = -1.93$, $p = .055$, $d = -0.28$. Overall, the findings indicate that the e-book is well received and can support learning, especially for revision and video-assisted understanding.

Keywords: e-Book, student perceptions, learning support material, polytechnic students, comparative study

Abstrak

Bahan pembelajaran digital digunakan secara meluas dalam pendidikan politeknik, namun keberkesanannya bergantung kepada kemudahan akses oleh pelajar serta reka bentuk yang menyokong pembelajaran. Kajian ini menilai persepsi pelajar terhadap e-buku Operating System and Network sebagai bahan sokongan pembelajaran serta membandingkan persepsi antara Politeknik Tuanku Syed Sirajuddin (PTSS) dan Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS). Kajian tinjauan keratan rentas telah dijalankan dalam kalangan pelajar yang telah menggunakan e-buku tersebut (N = 190; PTSS n = 100; POLIMAS n = 90).

Soal selidik mengandungi lapan item skala Likert lima mata yang merangkumi keselarasan silibus, kebolehcapaian peranti, susun atur dan kejelasan, sokongan video, contoh dan latihan, kesesuaian bahasa, sokongan pengajaran dan pembelajaran serta sokongan ulang kaji. Data dianalisis menggunakan statistik deskriptif, alpha Cronbach dan ujian-t sampel bebas dalam SPSS. Majoriti responden menggunakan e-buku sebagai rujukan utama (53.2%), diikuti rujukan tambahan (40.5%) dan aktiviti tutorial (6.3%). Pelajar melaporkan persepsi positif bagi semua item (M = 4.57–4.71; SD = 0.53–0.60), dengan skor tertinggi bagi sokongan ulang kaji (M = 4.71, SD = 0.53). Instrumen kajian menunjukkan kebolehpercayaan dalaman yang sangat tinggi (α = 0.98). Tiada perbezaan signifikan secara statistik antara PTSS dan POLIMAS bagi mana-mana item persepsi (p > .05); perbezaan terbesar antara institusi adalah kecil dan berlaku bagi keselarasan silibus, t(188) = −1.93, p = .055, d = −0.28. Secara keseluruhan, dapatan kajian menunjukkan bahawa e-buku ini diterima baik dan berpotensi menyokong pembelajaran, khususnya untuk tujuan ulangkaji dan pemahaman melalui bantuan video.

Kata kunci: *e-buku, persepsi pelajar, bahan sokongan pembelajaran, pelajar politeknik, kajian perbandingan*

1.0 INTRODUCTION

Digital learning materials are now part of everyday practice in higher education but their value is not automatic. It depends on whether students can access them consistently and whether the design fits real study habits such as revising for tests, searching for key points and doing practice tasks. This aligns with the UNESCO Global Education Monitoring (GEM) message that education technology should be chosen and reviewed based on evidence and equity, not on assumed benefits, especially when connectivity and access are still uneven (UNESCO, 2023).

From a student's point of view, e-books offer features that printed books cannot easily provide, such as fast searching, portability and embedded resources. Still, having these features is not enough. Students need to be able to use them in real study situations. In a mixed-method study using interviews, focus groups and surveys, D'Ambra et al. (2022) developed and tested an "affordance actualisation" model to explain e-textbook engagement. The model highlights practical aspects such as accessibility, searchability, highlighting, browsing and perceived usefulness. This matters for course e-books because it shifts the focus from simply providing an e-book to understanding how students actually use it and which features genuinely support learning.

At the same time, the research literature reminds us that digital format alone does not guarantee better learning. A meta-analysis of 37 experimental studies found no overall advantage of digital reading over paper reading for comprehension. The results also showed that outcomes can change depending on the situation, such as the reading context and the type of text used (Li & Yan, 2024).

Student preference findings are not consistent across studies. In one study, students appreciated e-books because they are easy to carry and many spent time reading them (Amirtharaj et al., 2023). However, many still preferred printed books for serious studying and note-taking (Amirtharaj et al., 2023). Overall, this evidence supports the need for local course-based evaluation so teaching teams can understand students' real study experience and refine the learning resource.

In polytechnic programmes, learning materials need to support both concept building and independent practice, especially for technical subjects. This study evaluates a lecturer-developed Operating System and Network e-book used by students at Politeknik Tuanku Syed Sirajuddin (PTSS) and Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS) in Malaysia. The study looks at how students use the e-book and how they perceive its key design and learning support features. These include syllabus alignment, ease of access, layout clarity, video support, examples and exercises, language suitability and support for teaching learning and revision.

1.1 Problem Statement

E-books and e-textbooks are increasingly used as learning support materials in higher education. However, their benefits are not guaranteed by digital format alone. Research suggests that students' engagement depends on whether the e-book design fits real study behaviours and whether students perceive the resource as useful and easy to use (D'Ambra et al., 2022; Lin & Yu, 2023). This issue is more critical for technical courses where students rely on clear explanations, structured examples and strong revision support. Weak layout, unclear language or poorly integrated multimedia can reduce the learning value even when the content is available.

At the same time, much of the existing literature focuses on general preferences for print versus digital reading or evaluates broad digital learning tools rather than a specific course e-book developed for a particular subject and used in real classroom settings. Preference evidence often shows a mixed picture. Students may value portability and access but still prefer print for deep studying and note-taking (Amirtharaj et al., 2023). Outcome evidence also cautions that digital reading does not automatically lead to better comprehension and results can vary by context and text characteristics (Li & Yan, 2024). These gaps highlight the need for course-level evaluation that looks at concrete learning-support features and checks whether student experience is consistent when the same e-book is used across different campuses.

1.2 Research Objectives and Research Questions

The objectives of the study are as follows:

1. To determine the level of e-book usage among students.
2. To examine students' perceptions of the Operating System and Network e-book as a learning support material.
3. To compare students' perceptions of the Operating System and Network e-book between PTSS and POLIMAS.

The research questions of the study are as follows:

1. What is the level of e-book usage among students?
2. What are students' perceptions of the Operating System and Network e-book as a learning support material?
3. How do students' perceptions of the Operating System and Network e-book differ between PTSS and POLIMAS?

1.3 Significance of Research

This study is useful for polytechnic teaching practice because it provides course-based evidence on how students experience a lecturer-developed e-book as a learning support material. The questionnaire focuses on specific features that can be improved directly, such as layout clarity, the usefulness of videos, language suitability and the quality of examples and exercises. This fits with the idea that an e-textbook becomes valuable when students can actually use its practical features during real study sessions (D'Ambra et al., 2022).

The comparative element adds practical value to the study. Research on digital learning acceptance shows that students' perceptions and willingness to use a tool are influenced by how useful and easy it feels, as well as learner-related factors. This means perceptions can differ between cohorts and learning environments (Barz et al., 2024; Lin & Yu, 2023). By comparing two polytechnics, this study provides a realistic check on whether the same course e-book can work well across similar applied higher education settings. This is useful when departments want to scale the resource and plan teaching materials more efficiently. The study also provides a baseline for improvement because it reports strong scale reliability ($\alpha = 0.98$) and consistent perceptions across campuses. These results support future evaluation cycles when the e-book is revised.

2.0 LITERATURE REVIEW

Digital learning materials have become common in higher education and e-books are among the most widely used formats. Still, "digital" does not automatically mean "effective." UNESCO reminds education providers that technology should be adopted and reviewed based on evidence and equity because access conditions can differ across learners and institutions (UNESCO, 2023). For course e-books, this matter because students depend on device access, stable connectivity and clear navigation when they study outside class.

An affordance-based view helps explain why some e-books support learning better than others. D'Ambra et al. (2022) argue that the value of an e-textbook depends on whether students can actualize practical affordances during real study sessions. These include accessibility, searchability and perceived usefulness. This perspective is relevant for technical courses because students often revise under time pressure. They need fast access to key topics and step-by-step support that is easy to follow.

Evidence on outcomes and preferences also gives a useful caution. A recent meta-analysis found no overall advantage for digital over paper reading comprehension and results can vary depending on reading context and text characteristics (Li & Yan, 2024). Student preference

studies report a similar mixed pattern. Students may appreciate e-books for portability and convenience but still prefer print for deep study and note-taking (Amirtharaj et al., 2023). These findings suggest that format alone does not guarantee learning value. The design and learning support still matter.

Technology acceptance research supports this point. Students are more likely to engage with digital learning tools when they perceive them as useful and easy to use (Lin & Yu, 2023). Learner-related factors can also shape these perceptions which means experiences may differ across cohorts and settings (Barz et al., 2024). For teaching teams, this implies that course e-books should be evaluated at the feature level and in real use conditions. It also supports the value of cross-campus checks when the same resource is used in more than one institution.

Overall, the literature suggests that course e-books should be judged based on practical learning-support features such as clarity of layout, accessibility, multimedia support, exercises and revision support. This study responds to that need by assessing students' perceptions of the Operating System and Network e-book and comparing results across two Malaysian polytechnics.

3.0 RESEARCH METHODOLOGY

This section explains the methods used to evaluate the Operating System and Network e-book as a learning support material. A quantitative, cross-sectional survey approach was used, focusing on how students used the e-book and how they perceived key learning-support features. Data were collected from students at two Malaysian polytechnics (PTSS and POLIMAS) who had used the e-book in the course. The study used a structured questionnaire and analysed the responses in SPSS using descriptive statistics, reliability testing and group comparisons to summarise patterns and check whether perceptions differed between the two institutions.

3.1 Research Design

This study adopted a quantitative, cross-sectional survey design to describe patterns of e-book usage and to examine students' perceptions at a single point in time. This design is suitable because the study aims to obtain a clear snapshot of students' experience after using the e-book in the course, rather than tracking changes over multiple semesters. A survey approach is also appropriate when the goal is to summarise responses from a defined group and to compare subgroups using the same set of standardised items (Creswell & Creswell, 2022). In this study, the survey data allowed the researchers to report overall perception levels across key learning-support features and to test whether students from different polytechnics evaluated the e-book differently.

3.2 Participants and Sampling

The respondents comprised 190 polytechnic students from two Malaysian institutions: Politeknik Sultan Abdul Halim Mu'adzam Shah (POLIMAS; n = 90) and Politeknik Tuanku Syed Sirajuddin (PTSS; n = 100). The study focused on students who had already been exposed

to and used the e-book for the Operating System and Network course, so that their responses reflected actual experience rather than assumptions. Participants were selected using convenience sampling because the data collection was carried out through accessible classes and available student groups during the study period. This approach is common in educational research, especially when the study is conducted within normal teaching schedules and class settings. However, convenience sampling is a limitation because it may introduce selection bias and it limits the generalisability of the findings beyond the participating cohorts (Andrade, 2021).

3.3 Research Instruments

Data were collected using a structured questionnaire organised into three sections. The first section captured respondents' demographic information, including their institution. The second section asked about the purpose of using the e-book, for example whether students used it as a main reference, an additional reference or during tutorial activities. The third section measured students' perceptions of the e-book as a learning support material.

Students' perceptions were assessed using eight Likert-type statements rated on a five-point scale ranging from 1 (Strongly disagree) to 5 (Strongly agree). Likert-type scales are commonly used in educational evaluation because they provide a clear and consistent way to summarise student views across multiple items (Jebb et al., 2021). In this study, the items were designed to focus on practical features that directly affect how students learn with the e-book, rather than general opinions.

The perception scale covered eight learning-support features of the Operating System and Network e-book. These features were syllabus alignment, ease of access on students' devices, clarity of layout and design, usefulness of videos, usefulness of examples and exercises, suitability of language, support for the teaching and learning process and support for revision before quizzes or examinations. Overall, the items were intended to capture how well the e-book supported students' learning needs and study routines in a technical course context.

3.4 Data Analysis

All analyses were conducted using IBM SPSS Statistics. Frequencies and percentages were used to summarise the respondents' distribution by institution and the purposes of e-book use. Means and standard deviations were calculated to summarise students' perceptions for each item. Cronbach's alpha was used to assess the internal consistency of the perception scale. Independent-samples t-tests were conducted to compare PTSS and POLIMAS and statistical significance was set at $p < .05$ (Field, 2024).

To examine whether perceptions differed between POLIMAS and PTSS, independent-samples t-tests were conducted for each perception item. Levene's test was used to check the assumption of equal variances and the appropriate t-test results were interpreted accordingly (i.e., "equal variances assumed" or "not assumed") (Field, 2024). Statistical significance was set at $p < .05$. Where relevant, the direction of mean differences was considered to support clearer interpretation of the findings.

4.0 RESEARCH FINDINGS

The group sizes of PTSS and POLIMAS are reasonably balanced and supports a fair comparison as shown in Table 1.

Table 1: Respondents by Institution (N = 190)

Institution	N	%
PTSS	100	52.6
POLIMAS	90	47.4
Total	190	100.0

The e-book use pattern is a key insight. Most respondents used it for self-study, either as a primary reference (53.2%) or a supplementary reference (40.5%), meaning 93.7% relied on it outside class. Only 6.3% used it mainly for tutorial activities, suggesting strong independent use but weaker integration into structured class tasks. This highlights an opportunity to use the e-book more intentionally during tutorials through guided activities or short in-class exercises.

Table 2: Purpose of e-Book Use (N = 190)

Purpose of Use	n	%
Primary reference	101	53.2
Supplementary reference	77	40.5
Tutorial activities	12	6.3
Total	190	100.0

Overall, students reported positive perceptions across all eight learning-support features, with all mean scores above 4.50. The ranked results show clear priorities: revision support was highest (M = 4.7105), followed by language suitability (M = 4.6842) and teaching–learning support (M = 4.6684). The lowest mean was for examples and exercises (M = 4.5737) although it remained positive. This item also showed the largest variation in responses (SD = 0.60189), suggesting uneven satisfaction and making it the clearest improvement target. The gap between the highest and lowest mean was small (≈ 0.14) but it still helps the teaching team prioritise what to refine first.

Table 3: Descriptive Statistics for Perception Items (N = 190)

Rank	Perception Item	Mean	SD
1	The e-book helps me revise before quizzes/examinations	4.7105	0.52994
2	The language used in the e-book is suitable for students	4.6842	0.53971
3	The e-book facilitates the teaching and learning process	4.6684	0.55449
4	The layout and design are attractive and easy to understand	4.6632	0.56551
5	Videos in the e-book help me understand the topic	4.6579	0.56701
6	The e-book is easy to access on my device	4.6211	0.59413
7	The e-book content aligns with the course syllabus	4.6053	0.56995
8	Examples and exercises help me master the topic	4.5737	0.60189

The perception scale showed excellent internal consistency (Cronbach's α = 0.983). This indicates that the eight items worked well together and captured a coherent set of student perceptions. It also supports confidence in reporting item-level patterns.

Table 4: Reliability of the Perception Scale (N = 190)

Statistic	Value
Cronbach's alpha (α)	0.983
Number of items	8

Independent-samples t-tests showed no statistically significant differences between PTSS and POLIMAS across all items ($p > .05$), suggesting a broadly consistent learning experience across both campuses. The closest result to significance was syllabus alignment, where POLIMAS recorded a slightly higher mean than PTSS, $t(188) = -1.933$, $p = .055$, with a small effect size ($d = -0.28$), indicating limited practical difference.

Table 5: Independent-Samples t-Test Comparing PTSS and POLIMAS (N = 190)

Perception Item	PTSS Mean (SD) N = 100	POLIMAS Mean (SD) N = 90	t	df	p
Syllabus alignment	4.5300 (0.55877)	4.6889 (0.57366)	-1.933	188	0.055
Device accessibility	4.6100 (0.58422)	4.6333 (0.60800)	-0.270	188	0.788
Layout and design clarity	4.6500 (0.53889)	4.6778 (0.59639)	-0.337	188	0.736
Video support	4.6200 (0.56461)	4.7000 (0.56984)	-0.971	188	0.333
Examples and exercises	4.5500 (0.55732)	4.6000 (0.64998)	-0.571	188	0.569
Language suitability	4.6600 (0.53598)	4.7111 (0.54555)	-0.651	188	0.516
Teaching–learning support	4.6600 (0.53598)	4.6778 (0.57724)	-0.220	188	0.826
Revision support	4.6800 (0.52953)	4.7444 (0.53129)	-0.836	188	0.404

Overall, the findings show that the e-book was mainly used for independent learning, either as a primary or supplementary reference, while tutorial-based use remained low. Revision support and language suitability were the strongest learning-support features reported by students. In contrast, examples and exercises received the lowest rating and showed the highest variability, making this the clearest target for improvement. Student perceptions were also consistent across PTSS and POLIMAS, with no significant differences between the two institutions.

5.0 RESEARCH DISCUSSION

This study provides course-level evidence on how students used and evaluated the Operating System and Network e-book across two Malaysian polytechnics. Most students used it as a primary reference and many used it as a supplementary reference, while tutorial-based use was low. This suggests the e-book supported independent learning more than structured in-class activities, which is common in technical courses. It also points to a practical opportunity: tutorial integration can be improved by linking e-book sections to short guided tasks and quick practice activities.

Students reported positive perceptions across all eight learning-support features. Revision support ranked highest, followed by strong ratings for language and teaching–learning support. Video support also rated highly, which is encouraging because digital resources are most helpful when their features are easy to use and help students clarify difficult ideas during real study sessions (D'Ambra et al., 2022). The examples and exercises item recorded the lowest mean and the largest standard deviation, suggesting uneven satisfaction. For some students the practice component may be sufficient, while others may need more worked examples and shorter exercises with brief answers, making this the clearest improvement target.

Although no statistically significant differences were found between PTSS and POLIMAS, several contextual and measurement factors may explain this pattern. Both campuses used the same e-book within the same course domain, so consistent content structure, language level and learning supports may lead to similar evaluations. The two polytechnics are also comparable applied higher education settings, where students often face similar study constraints and focus strongly on assessment preparation. In addition, the mean scores were high and the score range was narrow, which reduces variability and limits the ability to detect group differences even when small gaps exist. This is consistent with the results, where the closest item to significance was syllabus alignment ($p = .055$) and the effect size was small ($d = -0.28$), indicating a minor difference rather than a meaningful gap. A practical explanation may be local teaching emphasis, such as how consistently lecturers link weekly outcomes to the e-book and to the syllabus, which can be addressed through instructional practice rather than redesigning the resource.

The findings also align with acceptance research, which suggests students respond more positively to digital learning tools when they perceive them as useful and easy to use (Lin & Yu, 2023). The consistently high ratings indicate that the e-book generally met these expectations. Learner-related factors can influence perceptions in other settings (Barz et al., 2024), but the shared course demands and a common resource design may have reduced differences between cohorts in this study. Overall, two practical actions are recommended: maintain the strengths of the e-book, particularly revision support, clear language and video support, and strengthen the examples and exercises section. Tutorial-based use should also be improved through simple teaching adjustments, such as planned tutorial prompts or short tasks that require students to use specific e-book sections.

6.0 CONCLUSION

This study evaluated students' perceptions of a lecturer-developed Operating System and Network e-book and compared PTSS and POLIMAS. Most respondents used the e-book as a primary reference (53.2%), followed by supplementary use (40.5%) and tutorial activities (6.3%). Students reported positive perceptions across all eight learning-support features ($M = 4.57–4.71$; $SD = 0.53–0.60$), with the highest rating for revision support ($M = 4.71$, $SD = 0.53$). The instrument showed excellent internal consistency ($\alpha = 0.98$) and independent-samples t-tests found no statistically significant differences between PTSS and POLIMAS across all items ($p > .05$), indicating a broadly consistent student experience.

From a teaching perspective, the results support continued use of the e-book, especially for revision and video-assisted understanding. Examples and exercises recorded the lowest mean although it remained positive, so this area should be strengthened through more worked examples and short practice tasks. Convenience sampling and the focus on two polytechnics are important limitations because they may introduce selection bias and limit generalisability beyond the participating cohorts. Future evaluation should include more campuses and add simple performance indicators such as quiz results to complement perception data.

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PENDEDAHAN TERHADAP KEPENTINGAN PENJENAMAAN PERIBADI DALAM KALANGAN USAHAWAN DI NEGERI PAHANG

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ABSTRAK

Penjenamaan peribadi merupakan strategi membina identiti dan kepercayaan pelanggan melalui kredibiliti individu usahawan, bukannya sekadar memaparkan produk. Kajian ini bertujuan mengenal pasti tahap pengetahuan, amalan media sosial, dan persepsi usahawan di Pahang terhadap kepentingan penjenamaan peribadi. Menggunakan pendekatan kuantitatif ke atas 152 responden melalui analisis perisian SPSS versi 24, kajian ini menilai impak strategi tersebut dalam mendepani ekonomi digital. Hasil kajian menunjukkan tahap pengetahuan usahawan terhadap penjenamaan peribadi adalah sangat tinggi dengan skor min 4.44. Manakala, amalan media sosial mencatatkan skor min 3.99 dan persepsi terhadap impak positif penjenamaan kepada kredibiliti perniagaan berada pada tahap tinggi dengan skor min 4.18. Dapatan membuktikan penjenamaan peribadi adalah elemen kritikal bagi membina kepercayaan pelanggan serta menjadi pemangkin kepada agensi seperti MARA, MDEC, dan kerajaan negeri untuk merangka latihan intensif. Kesimpulannya, penguasaan penjenamaan peribadi dan media sosial memastikan usahawan Pahang kekal kompetitif dan relevan dalam pasaran digital.

Kata kunci: Usahawan Pahang, media sosial, penjenamaan peribadi, kepercayaan pelanggan, pasaran digital

ABSTRACT

Personal branding is a strategy for building identity and customer trust through an entrepreneur's individual credibility, rather than merely displaying products. This study aims to identify the level of knowledge, social media practices, and perceptions of entrepreneurs in Pahang regarding the importance of personal branding. Using a quantitative approach involving 152 respondents and analyzed via SPSS version 24, this study evaluates the impact of such strategies in navigating the digital economy. The results show that the entrepreneurs' level of knowledge regarding personal branding is very high, with a mean score of 4.44. Meanwhile, social media practices recorded a mean score of 3.99, and the perception of the positive impact of branding on business credibility was at a high level with a mean score of 4.18. The findings prove that personal branding is a critical element in building customer trust and serves as a catalyst for agencies such as MARA, MDEC, and the state government to design intensive training programs. In conclusion, mastering personal branding and social

media ensures that Pahang entrepreneurs remain competitive and relevant in the digital market.

Keywords: *Pahang entrepreneurs, social media, personal branding, customer trust, digital market*

1.0 PENGENALAN

Negeri Pahang mempunyai landskap keusahawanan yang sangat progresif, merangkumi pelbagai sektor strategik seperti pelancongan, industri makanan melalui Perusahaan Kecil dan Sederhana (PKS), pertanian, dan kraf tangan warisan. Walau bagaimanapun, usahawan tempatan masih berhadapan dengan cabaran besar untuk menembusi pasaran baharu yang lebih luas disebabkan kebergantungan yang tinggi terhadap kaedah pemasaran konvensional. Sehubungan itu, pendedahan terhadap kepentingan penjenamaan peribadi merupakan strategi yang amat signifikan dalam membina kepercayaan pelanggan. Hal ini didorong oleh kecenderungan masyarakat untuk berurusan dengan individu yang mempunyai kredibiliti berbanding organisasi korporat yang kurang bersifat personal.

Sehingga September 2025, statistik menunjukkan bahawa seramai 24,592 usahawan dan koperasi di negeri Pahang telah menerima pembiayaan berbentuk pinjaman dan geran melalui pelbagai agensi di bawah Kementerian Pembangunan Usahawan dan Koperasi (KUSKOP). Selain itu, seramai 27,495 eUsahawan digital telah dilahirkan melalui program Malaysia Digital Economy Corporation (MDEC). Inisiatif untuk memperkasa usahawan ini kini beralih ke arah pendigitalan yang lebih strategik di bawah kerangka Program Pemerkasaan Bakat dan Keusahawanan IR 4.0 menerusi modul *Creative Content Marketing Ideas*. Modul ini dirangka khusus untuk membantu usahawan membina jenama diri yang teguh bagi mempromosikan produk serta perkhidmatan mereka secara lebih berkesan di platform media sosial.

1.1 Pernyataan Masalah

Laporan SME Corp Malaysia (2023) menegaskan kepentingan digitalisasi bagi persaingan usahawan pasca-pandemik. Namun, pemahaman strategi penjenamaan peribadi usahawan muda masih di tahap sederhana. Walaupun aktif di media sosial, mereka gagal mengoptimumkan platform tersebut untuk penjenamaan diri. Laporan SME Corp Malaysia (2022) turut mendedahkan kekurangan kemahiran penjenamaan kendiri bagi usahawan mikro dan kecil. Ini menunjukkan jurang antara kesedaran pemasaran moden dengan pelaksanaan strategi efektif. Oleh itu, kajian ini bertujuan mengenal pasti tahap pengetahuan usahawan Pahang mengenai penjenamaan peribadi serta menganalisis amalan media sosial dalam membina identiti jenama. Kajian turut menilai persepsi usahawan terhadap impak penjenamaan dalam memacu prestasi dan kelestarian perniagaan mendepani cabaran ekonomi digital.

1.2 Objektif Kajian

Objektif kajian ini adalah untuk mengenal pasti tahap pengetahuan usahawan di Pahang mengenai kepentingan penjenamaan peribadi. Selain itu, ia bertujuan untuk mengkaji amalan

serta pendedahan media sosial yang diaplikasikan oleh usahawan dalam membina identiti jenama diri. Seterusnya, kajian ini juga ingin mengenal pasti persepsi usahawan terhadap kesan penjenamaan peribadi tersebut kepada prestasi perniagaan mereka.

1.3 Signifikan Kajian

Signifikan kajian ini adalah untuk memberikan kesedaran kepada usahawan Pahang tentang kepentingan penjenamaan peribadi sebagai aset kritikal dalam membina kepercayaan pelanggan secara organik dan membezakan perniagaan mereka dalam pasaran kompetitif. Selain itu, dapatan ini menjadi panduan strategik kepada agensi seperti MARA, MDEC, dan kerajaan negeri untuk merangka program latihan intensif bagi merapatkan jurang kemahiran digital.

2.0 KAJIAN LITERATUR

Penggunaan media sosial secara strategik merupakan elemen kritikal bagi membina kepercayaan dan identiti unik di pasaran digital Malaysia. Platform digital membolehkan usahawan memupuk keyakinan pelanggan tanpa mengeluarkan kos iklan yang mahal (Ahmad & Rashid, 2022). Kini, penjenamaan tidak lagi terhad kepada produk, tetapi merangkumi individu yang menerajui perniagaan tersebut (Dantas & Moreira, 2022). Penjenamaan diri yang kukuh bukan sahaja meningkatkan reputasi, malah memacu prestasi kewangan dan memudahkan akses kepada pembiayaan modal (Nguyen, 2022).

3.0 METODOLOGI KAJIAN

Kajian kuantitatif ini melibatkan seramai 152 responden yang merupakan peserta Kursus *Creative Content Marketing Ideas* di Pahang. Instrumen kajian menggunakan borang soal selidik Google Forms yang diadaptasi daripada borang soal selidik Mohd Saad dan Yaacob (2021). Data yang diperoleh dianalisis menggunakan perisian SPSS versi 24, di mana penilaian skor min dibuat berdasarkan julat interpretasi oleh John W. Creswell (2005). Soal selidik ini mengandungi lima (5) bahagian iaitu:

Bahagian A: demografi responden
Bahagian B: mengandungi item pengetahuan penjenamaan peribadi
Bahagian C: mengandungi item amalan penjenamaan peribadi
Bahagian D: mengandungi item pendedahan sosial media
Bahagian E: mengandungi item persepsi terhadap kepentingan penjenamaan peribadi

4.0 DAPATAN KAJIAN

Perbincangan dapatan kajian ini disusun mengikut item borang soal selidik bagi memenuhi objektif yang ditetapkan. Data kajian bersumberkan maklum balas responden yang menyertai kursus *Creative Content Marketing Ideas* di negeri Pahang.

Jadual 1: Taburan Demografi Responden

Kategori	Perincian Utama	Data / Peratusan
Jantina	Majoriti Wanita	86.8%
Umur	Kumpulan umur produktif (26 - 45 tahun)	Sebahagian besar
Tahap Pendidikan	Kelulusan Ijazah	40.8%
Bidang Perniagaan	Sektor Makanan dan Minuman (Dominan)	31.6%
Pengalaman	Berpengalaman mengendalikan perniagaan	Lebih 6 tahun
Platform Digital	Facebook, TikTok, dan WhatsApp for Business	Medium Utama

Berdasarkan Jadual 1, kajian terhadap 152 usahawan di Pahang menunjukkan majoritinya adalah wanita (86.8%) berumur 26–45 tahun, dengan 40.8% berkelulusan Ijazah. Sektor makanan dan minuman (31.6%) merupakan bidang paling dominan, di mana kebanyakan responden mempunyai pengalaman perniagaan melebihi enam tahun serta aktif menggunakan platform digital seperti Facebook, TikTok, dan WhatsApp untuk mengukuhkan operasi mereka.

4.1 Analisis Deskriptif

Kaedah statistik deskriptif digunakan untuk mendapatkan nilai bacaan min dan sisihan piawai bagi item-item yang terdapat dalam Bahagian B, C, D dan E.

Jadual 2: Analisis Deskriptif Bahagian B, C, D dan E.

Bahagian / Pemboleh Ubah	Perincian Item	Skor Min	Tahap
Bahagian B: Pengetahuan Penjenamaan Peribadi	**Skor Min Keseluruhan**	**4.44**	**Sangat Tinggi**
	Impak jenama terhadap kepercayaan pelanggan (Tertinggi)	4.78	Sangat Tinggi
	Kepentingan penjenamaan dalam pemasaran	4.56	Sangat Tinggi
	Membezakan jenama peribadi dan produk (Terendah)	4.22	Sangat Tinggi
Bahagian C: Amalan Penjenamaan Peribadi	**Skor Min Keseluruhan**	**3.91**	**Tinggi**
	Penggunaan gambar profil profesional (Tertinggi)	4.11	Tinggi
	Interaksi aktif bersama pengikut	4.00	Tinggi
	Perkongsian kisah/pengalaman (Terendah)	3.67	Tinggi
Bahagian D: Strategi Media Sosial	**Skor Min Keseluruhan**	**4.07**	**Tinggi**
	Promosi, visual, penjadualan & testimoni (Tertinggi)	4.11	Tinggi

	Penggunaan platform secara strategik (Terendah)	3.89	Tinggi
Bahagian E (Persepsi Kepentingan Penjenamaan Peribadi)	**Skor Min Keseluruhan**	**4.18**	**Tinggi**
	Memudahkan pelanggan mengenali & mengingati usahawan (Tertinggi)	4.33	Tinggi
	Membantu membina hubungan pelanggan yang lebih kuat	4.22	Tinggi
	Faktor kredibiliti dan sumbangan kepada kejayaan perniagaan (Terendah)	4.11	Tinggi

Berdasarkan Jadual 2, dapatan kajian menunjukkan tahap pengetahuan usahawan terhadap penjenamaan peribadi berada pada tahap sangat tinggi dengan nilai min 4.44, manakala aspek amalan, strategi media sosial, dan persepsi kepentingan mencatatkan tahap tinggi dengan skor min keseluruhan antara 3.91 hingga 4.18. Kesedaran terhadap impak jenama kepada kepercayaan pelanggan merupakan elemen paling kukuh dengan skor 4.78, namun usahawan masih memerlukan penambahbaikan dalam teknik penceritaan pengalaman dengan nilai 3.67 serta penggunaan platform secara strategik dengan nilai 3.89 bagi mengoptimumkan lagi keberkesanan perniagaan mereka.

5.0 PERBINCANGAN KAJIAN

Penjenamaan peribadi kini menjadi strategi teras dalam pelan pemasaran bagi sesebuah perniagaan memandangkan cabaran utama pasaran masa kini sangat bergantung kepada identiti dan kredibiliti usahawan itu sendiri. Kajian ini bertujuan untuk mengenal pasti tahap pengetahuan usahawan di Pahang mengenai penjenamaan peribadi serta menganalisis amalan media sosial yang digunakan dalam membina identiti diri. Selain itu, kajian ini turut menilai persepsi usahawan terhadap impak penjenamaan tersebut dalam memacu prestasi dan kelestarian perniagaan mereka dalam mendepani cabaran ekonomi digital masa kini.

Jadual 3: Rumusan Analisis Deskriptif

Objektif	Bahagian Berkaitan	Skor Min	Kedudukan	Interpretasi Min	Keputusan
Objektif 1: Tahap Penggunaan	Bahagian A	4.44	1	**Sangat Tinggi**	Objektif Tercapai / Disokong Sepenuhnya
Objektif 2: Strategi Pemasaran	Bahagian B & C	3.99	3	**Tinggi**	Objektif Tercapai / Disokong
Objektif 3: Pengaruh Prestasi	Bahagian D	4.18	2	**Tinggi**	Objektif Tercapai / Disokong

Jadual 3 menunjukkan rumusan skor min bagi tiga objektif utama kajian yang menunjukkan bahawa kesemua objektif tersebut telah berjaya dicapai dan disokong. Objektif pertama berkaitan tahap penggunaan mencatatkan skor min tertinggi iaitu 4.44 dengan interpretasi sangat tinggi, diikuti oleh objektif ketiga mengenai pengaruh prestasi dengan skor min 4.18 pada tahap tinggi. Manakala objektif kedua yang menyentuh tentang strategi pemasaran berada pada kedudukan ketiga dengan skor min 3.99 yang juga diklasifikasikan pada tahap tinggi secara keseluruhan.

5.1 Mengenalpasti tahap pengetahuan usahawan di Pahang tentang kepentingan penjenamaan peribadi

Objektif pertama bagi kajian ini adalah melihat tahap pengetahuan usahawan di Pahang tentang kepentingan penjenamaan peribadi. Berdasarkan hasil kajian, tahap penggunaan penjenamaan peribadi dalam kalangan usahawan mencatatkan kedudukan pertama dengan skor min paling tinggi iaitu 4.44. Ini membuktikan bahawa pendedahan awal telah berjaya membina asas kefahaman yang sangat kuat mengenai definisi dan kepentingan imej diri dalam perniagaan. Dapatan ini selari dengan kajian Gorbatov et al. (2023) yang menekankan bahawa penjenamaan diri kini bukan lagi satu pilihan, malah telah menjadi instrumen wajib bagi usahawan untuk menonjolkan nilai unik mereka dalam persaingan pasaran yang statik.

5.2 Mengenalpasti amalan dan pendedahan media sosial usahawan dalam membina jenama diri

Objektif kedua bagi kajian ini adalah melihat amalan dan pendedahan media sosial usahawan dalam membina jenama diri. Strategi pemasaran melalui kandungan kreatif dan media sosial menunjukkan tahap yang tinggi iaitu 3.99. Walaupun berada di kedudukan ketiga, dapatan ini mengesahkan bahawa usahawan di negeri Pahang telah mula mengadaptasi elemen IR4.0 dengan merancang kandungan visual dan testimoni pelanggan. Penghasilan kandungan kreatif dan penggunaan media sosial secara strategik adalah penting dalam pemasaran moden. Lal et al. (2023) menyokong hal ini dengan menyatakan bahawa usahawan boleh membina naratif perniagaan yang lebih manusiawi dan lebih dipercayai melalui pengurusan media sosial yang sistematik

5.3 Mengenalpasti persepsi usahawan terhadap kesan penjenamaan peribadi kepada perniagaan mereka.

Objektif ketiga pula adalah untuk melihat persepsi usahawan terhadap kesan penjenamaan peribadi kepada perniagaan mereka. Penjenamaan peribadi terbukti memberi impak nyata kepada prestasi dan keyakinan pelanggan dengan mencatatkan skor tinggi iaitu 4.18. Hal ini jelas menunjukkan bahawa penjenamaan peribadi bukan sekadar teori tetapi satu keperluan praktikal. malah diakui oleh usahawan sebagai pemangkin utama dalam meningkatkan kredibiliti serta memudahkan jenama mereka diingati oleh pelanggan. Dapatan ini selaras dengan Vitelar (2023), yang menyatakan bahawa kredibiliti usahawan meningkat secara langsung dengan penjenamaan peribadi yang konsisten sekaligus dapat membantu perniagaan berkembang dalam persekitaran digital dalam jangka panjang.

6.0 KESIMPULAN

Penjenamaan peribadi kini bukan lagi sekadar pilihan, malah merupakan strategi teras yang menentukan kelangsungan perniagaan dalam era ekonomi digital. Kesedaran yang tinggi dalam kalangan usahawan membuktikan bahawa identiti diri adalah aset terpenting bagi membina kredibiliti dan kepercayaan pelanggan secara organik. Melalui penguasaan media sosial yang strategik, usahawan mampu mempamerkan nilai unik mereka kepada naratif perniagaan yang lebih personal dan berimpak tinggi. Kesimpulannya, pengukuhan imej diri yang konsisten menjadi pemangkin utama dalam menjamin kelestarian prestasi perniagaan agar kekal kompetitif bagi jangka masa panjang.

Hasil kajian ini membuktikan bahawa program pemerkasaan digital seperti kursus *Creative Content Marketing Ideas* perlu diperluaskan secara lebih agresif oleh pihak Kerajaan Negeri Pahang, MARA, dan MDEC kerana ia menjadi pemangkin utama dalam membina identiti jenama yang unik dan meningkatkan kepercayaan pelanggan. Oleh itu, sokongan berterusan dalam aspek latihan kemahiran digital adalah disyorkan agar usahawan dapat mengoptimumkan lagi penggunaan strategi media sosial yang lebih kompleks pada masa hadapan.

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MENEROKA FAKTOR PSIKOLOGI DAN GAYA HIDUP YANG MEMPENGARUHI KETIDAKHADIRAN PELAJAR: SATU KAJIAN KES DI KOLEJ KOMUNITI PAYA BESAR

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ABSTRAK

Ketidakhadiran pelajar merupakan isu berterusan dalam pendidikan tinggi yang menjejaskan keterlibatan akademik serta mencerminkan interaksi kompleks antara faktor psikologi, tingkah laku pembelajaran, dan gaya hidup. Kajian ini bertujuan meneroka pengalaman pelajar berkaitan faktor yang mempengaruhi ketidakhadiran mereka di Kolej Komuniti Paya Besar. Kajian ini menggunakan pendekatan kualitatif dengan reka bentuk kajian kes. Seramai tujuh orang pelajar yang pernah menerima sekurang-kurangnya satu Surat Amaran atau Surat Tunjuk Sebab telah terlibat sebagai sampel. Data dikumpul melalui temu bual separa berstruktur dan analisis dokumen, serta dianalisis menggunakan analisis tematik. Dapatan kajian mengenal pasti enam tema utama yang menyumbang kepada ketidakhadiran pelajar, dengan faktor dominan ialah kualiti tidur yang rendah dan keletihan fizikal akibat penggunaan peranti digital pada waktu lewat malam. Selain itu, ketidakhadiran turut dipengaruhi oleh motivasi yang tidak konsisten, kelemahan strategi pembelajaran kendiri seperti prokrastinasi, serta pengaruh rakan sebaya. Dari perspektif psikologi, pelajar menunjukkan gabungan lokus kawalan dalaman dan luaran dalam mentafsir situasi yang dihadapi. Kesimpulannya, ketidakhadiran pelajar mencerminkan kelemahan dalam regulasi kendiri, motivasi, dan pengurusan gaya hidup. Kajian ini mencadangkan intervensi berfokus kepada pengurusan masa, pembelajaran kendiri, dan amalan gaya hidup sihat bagi meningkatkan kehadiran pelajar secara konsisten.

Kata kunci: ketidakhadiran pelajar, kualiti tidur, motivasi, lokus kawalan, pembelajaran kendiri

ABSTRACT

Student absenteeism is a persistent issue in higher education that affects academic engagement and reflects the complex interaction between psychological factors, learning behaviors, and lifestyle. This study aims to explore students' experiences related to factors that influence their absenteeism at Paya Besar Community College. This study uses a qualitative approach with a case study design. A total of seven students who had received at least one Warning Letter or Show Cause Letter were involved as a sample. Data was collected through semi-structured interviews and document analysis, and analyzed using thematic analysis. The study findings identified six main themes that contribute to student absenteeism, with the dominant factors

being poor sleep quality and physical fatigue due to late-night use of digital devices. In addition, absenteeism is also influenced by inconsistent motivation, weaknesses in self-study strategies such as procrastination, and peer influence. From a psychological perspective, students show a combination of internal and external locus of control in interpreting the situations they face. In conclusion, student absenteeism reflects weaknesses in self-regulation, motivation, and lifestyle management. This study suggests interventions focused on time management, self-study, and healthy lifestyle practices to consistently increase student attendance.

***Keywords**: Student absenteeism, Sleep quality, Motivation, locus of control, Self-regulated learning*

1.0 PENGENALAN

Ketidakhadiran pelajar dalam konteks pendidikan tinggi tidak lagi boleh dilihat sebagai isu disiplin semata-mata, sebaliknya perlu difahami sebagai manifestasi kepada interaksi kompleks antara faktor psikologi, tingkah laku pembelajaran dan gaya hidup. Ketidakhadiran juga dilihat satu cabaran utama yang memberi kesan negatif secara langsung terhadap pencapaian akademik serta tahap penglibatan kognitif dan tingkah laku pelajar (Chatterjee & Sinha, 2019; Husain, 2022). Secara umum, peningkatan kadar ketidakhadiran dalam kelas berkait rapat dengan penurunan gred secara berterusan, kekurangan minat terhadap pembelajaran, serta menjejaskan objektif pendidikan yang disasarkan oleh sesebuah institusi (Brittain & Vaillancourt, 2026; Castro-Lopes et al., 2021). Usaha untuk mengenal pasti pelbagai sebab tersembunyi yang mendorong perbuatan menjauhi kelas seperti kurangnya penyertaan keluarga atau keputusan eksistensial merupakan satu keperluan yang mendesak bagi institusi pendidikan (Haque, Kabir, & Khanam, 2024).

Oleh hal demikian, mengkaji kelompangan ini secara kontekstual di Kolej Komuniti Paya Besar (KKPB) adalah satu langkah untuk membentuk semula persekitaran pembelajaran yang selamat serta mampu mengurangkan kecenderungan pelajar untuk ponteng. Dari sudut psikologi, masalah kesihatan mental yang merangkumi tekanan psikologi, kebimbangan (anxiety), kemurungan (depression), berserta tahap daya tindak (resilience) yang rendah didapati mempunyai kaitan yang teguh dengan peningkatan ketidakhadiran pelajar (Van Der Feltz-Cornelis et al., 2020; Wong et al., 2020). Pada masa yang sama, elemen gaya hidup seperti ketagihan telefon pintar, kebergantungan terhadap permainan video, kurang bersenam, berserta pendedahan skrin pada waktu malam yang membawa kepada kemerosotan kualiti tidur yang kronik, sangat memudaratkan kesihatan mental dan mendorong kepada peningkatan risiko ketidakhadiran kelas (Altintas et al., 2019; Nikolic et al., 2023; Sivakumar & Lam, 2021). Justeru, kajian ini dilaksanakan untuk meneroka secara holistik bagaimana faktor psikologi dan corak gaya hidup ini saling berinteraksi dan mempengaruhi secara dominan gejala ketidakhadiran pelajar di KKPB.

1.1 Pernyataan Masalah

Dalam kajian terdahulu, faktor dalaman seperti regulasi kendiri dan strategi pembelajaran dikenal pasti sebagai berpotensi mempengaruhi kehadiran, namun kajian yang meneliti aspek ini secara mendalam masih terhad. Beberapa kajian terkini menunjukkan bahawa gangguan tidur boleh menjejaskan keupayaan kognitif dan seterusnya mempengaruhi kehadiran pelajar. Selain itu, motivasi yang tidak konsisten dikaitkan dengan penurunan keterlibatan akademik, manakala kelemahan strategi pembelajaran meningkatkan kecenderungan pelajar menghindari tugasan. Faktor psikologi lain seperti lokus kawalan luaran juga dilaporkan boleh mengurangkan rasa tanggungjawab kendiri terhadap kehadiran.

Namun begitu, kajian yang mengintegrasikan faktor-faktor dalaman (regulasi kendiri, motivasi, strategi pembelajaran, lokus kawalan) bersama faktor luaran (kewangan, logistik, sokongan sosial) dalam satu model analisis masih terhad. Jurang ini lebih ketara dalam konteks KKPB, di mana kajian empirikal yang menyeluruh mengenai interaksi faktor dalaman dan luaran terhadap ketidakhadiran pelajar masih kurang dijalankan.

1.2 Objektif Kajian

Kajian ini dijalankan dengan objektif berikut:

a) Mengenal pasti kualiti tidur, lokus kawalan, motivasi dan strategi pembelajaran kendiri pelajar.
b) Meneroka pengalaman pelajar berkaitan faktor yang mempengaruhi ketidakhadiran mereka.

1.3 Kepentingan Kajian

Kajian ini penting kerana membantu pensyarah mengenal pasti faktor ketidakhadiran pelajar untuk menambah baik kaedah pengajaran, memberi asas kepada Unit Psikologi merancang aktiviti pembangunan kendiri seperti bengkel motivasi dan pengurusan diri, serta menyediakan panduan kepada pelajar melalui program berkaitan motivasi, kualiti tidur dan strategi pembelajaran berkesan. Secara keseluruhan, dapatan kajian dapat menyokong intervensi akademik, pengurusan dan pelajar dalam usaha mengurangkan masalah ketidakhadiran.

2.0 SOROTAN LITERATUR

Sorotan literatur akan memberi fokus kepada dapatan penyelidik terdahulu yang berkaitan dengan kajian yang akan dijalankan.

2.1 Konteks Ketidakhadiran Pelajar

Ketidakhadiran pelajar merupakan isu berlarutan yang memberi impak secara langsung terhadap kelangsungan pencapaian akademik. Kajian oleh (Chatterjee dan Sinha 2019) membuktikan bahawa masalah ponteng kelas dan ketiadaan minat terhadap subjek mempunyai korelasi yang teguh terhadap penurunan gred akhir pelajar. Hal ini disokong oleh (Brittain dan Vaillancourt., 2026) yang mengesahkan bahawa peningkatan ketidakhadiran amat berkait rapat dengan kumpulan berisiko yang mempamerkan simptom kemurungan. Namun, keputusan

untuk tidak hadir ini bersifat amat kompleks. Haque, Kabir, dan Khanam (2024) mendapati sebahagian besar pelajar cenderung merahsiakan sebab sebenar ketidakhadiran mereka, yang biasanya tersembunyi seperti kejadian buli, kurang pemantauan keluarga, keputusan eksistensial, dan penggunaan internet yang berlebihan.

2.2 Pengaruh Faktor Psikologi

Dimensi psikologi memainkan peranan kritikal terhadap kelangsungan kehadiran dan penglibatan pelajar. Kajian (Van Der Feltz-Cornelis et al., 2020) mendapati bahawa tahap tekanan psikologi, kebimbangan, dan kemurungan yang tinggi mendatangkan impak mendalam terhadap kelaziman ketidakhadiran pelajar. Selain itu, mekanisme dalaman pelajar seperti lokus kawalan dan efikasi kendiri turut mempengaruhi perlakuan akademik. Lokus kawalan dalaman dapat meningkatkan ketahanan pemikiran kritis pelajar daripada terjerumus ke dalam pengabaian moral (Tahrir et al., 2020) dan bertindak sebagai pengantara untuk merangsang penglibatan akademik menerusi penerapan nilai kesyukuran dan kesejahteraan (Cui et al., 2023). Sebaliknya, pelajar yang memiliki gaya keputusan yang sering teragak-agak atau tertunda cenderung mempamerkan sikap suka menangguh kerja (*procrastination*), sekaligus menjejaskan gred (Sagone & Indiana, 2021). Malah, impak persekitaran luar seperti ketidaksopanan kelas dapat diminimumkan sekiranya pelajar memiliki kekuatan lokus kawalan dalaman yang mantap (Cahyadi et al., 2021).

2.3 Pengaruh Gaya Hidup, Kualiti Tidur

Gaya hidup moden yang didominasi peranti digital mencetuskan impak buruk terutama terhadap tahap kualiti tidur pelajar. Dianggarkan sebahagian besar pelajar berdepan masalah tidur yang teruk, kesan dipengaruhi oleh amalan ketidakaktifan fizikal (Mahfouz et al., 2020), tekanan akademik, dan keletihan (Schmickler et al., 2023). Antara pendesak utama kemerosotan kualiti tidur ini ialah kelaziman ketagihan telefon pintar dan pendedahan skrin pada waktu malam. Kajian mendapati tabiat menatap peranti pintar melebihi empat hingga lima jam sehari, serta radiasi skrin cahaya biru sebelum tidur, bukan sahaja memusnahkan kelenaan tidur tetapi mendorong peningkatan gejala kemurungan dan tekanan (Huang et al., 2020; Jniene et al., 2019.; Nikolic et al., 2023). Lebih membimbangkan, masalah kecelaruan media sosial dan penagihan pemainan video bertindak selaku rantaian yang menajamkan krisis kemerosotan kesihatan mental dan insomnia pelajar (Altintas et al., 2019; Wong et al., 2020). Keseluruhan amalan gaya hidup negatif ini termasuk tidak mengendahkan ulangkaji, bersosial secara tidak terkawal, dan akses internet berlebihan telah dibuktikan oleh (Sivakumar et al., 2021).

2.4 Motivasi Pembelajaran

Di sebalik kerumitan faktor psikologi dan gaya hidup, peranan institusi melalui pelaksanaan pendekatan pedagogi dilihat berupaya memulihkan kehadiran pelajar. Castro-Lopes et al. (2021) mendapati pelajar mula mempamerkan reaksi minat yang positif serta penglibatan yang rancak apabila sesi kelas diubah daripada sistem tradisional kepada strategi pengajaran yang aktif. Ini diperkukuhkan oleh (Husain., 2022) melalui kerangka pendekatan MAJA; di mana elemen penggunaan muzik, kelonggaran rutin fizikal, serta penyepaduan hobi pelajar dalam

topik pembelajaran secara drastik berjaya mengurangkan ketidakhadiran dengan mengembalikan rasa selamat dan keterikatan emosi dalam diri pelajar.

Kesimpulannya, sorotan literatur ini jelas menunjukkan bahawa penularan isu ketidakhadiran tidak boleh dilihat hanya dari sudut kelonggaran disiplin semata-mata. Ia merupakan natijah tindak balas daripada kelompangan kesejahteraan psikologi, kepincangan amalan gaya hidup peranti digital, kemerosotan kualiti pemulihan tidur, dan persekitaran sokongan kelas. Justeru, pelaksanaan tinjauan mendalam menerusi konteks kajian kes di Kolej Komuniti Paya Besar adalah sangat signifikan dan bertepatan dengan lompong dapatan kajian lepas.

3.0 METODOLOGI KAJIAN

Bab ini akan membincangkan proses pelaksanaan kajian ini dijalankan.

3.1 Reka Bentuk Kajian

Menggunakan pendekatan kualitatif dengan reka bentuk kajian kes bagi meneroka secara mendalam fenomena pelajar yang menerima surat amaran dan tunjuk sebab.

3.2 Persampelan Kajian

Dipilih secara sengaja (*purposive sampling*) melibatkan 7 orang pelajar daripada 14 pelajar yang memenuhi kriteria. Kriteria pemilihan adalah pelajar aktif di KKPB bagi Sesi 1 atau 2 2025/2026 yang pernah menerima surat tersebut, dengan dua (2) daripada mereka mempunyai kes ketidakhadiran berulang.

3.3 Instrumen Kajian

Melibatkan penyelidik sendiri sebagai alat utama menggunakan protokol temu bual separa berstruktur dan analisis dokumen ke atas rekod rasmi. Protokol temu bual diadaptasi daripada tiga sumber piawai iaitu *Pittsburgh Sleep Quality Index (PSQI)* untuk kualiti tidur, *Motivated Strategies for Learning Questionnaire (MSLQ)* untuk strategi pembelajaran, dan *Locus of Control* untuk persepsi punca tindakan.

3.4 Prosedur Pengumpulan Data

Dijalankan merentasi dua sesi akademik melalui kelulusan pentadbiran KKPB, temu bual mendalam secara bersemuka, berserta pemerhatian terhadap tingkah laku dan emosi peserta semasa temu bual.

3.5 Analisis Data

Data yang dikumpul dianalisis menerusi analisis tematik yang melibatkan proses transkripsi, pengekodan, dan akhirnya pembentukan tema.

4.0 DAPATAN KAJIAN

Dapatan kajian kualitatif yang diperoleh melalui temu bual separa berstruktur melibatkan tujuh orang responden (R1-R7) dalam kalangan pelajar KKPB yang mempunyai rekod ketidakhadiran ke kelas. Aanalisis tematik telah merumuskan enam tema utama.

4.1 Tema 1: Kualiti Tidur & Keletihan Fizikal

Dapatan kajian menunjukkan bahawa pengurusan rutin tidur yang lemah dikenal pasti sebagai penyumbang utama kepada isu ponteng kelas. Majoriti pelajar kerap tidur lewat akibat ketagihan peranti dan media sosial, yang mencetuskan kelesuan melampau dan hilang daya tumpuan.

"Saya biasanya tidur lewat, dalam pukul 1–2 pagi sebab main phone." (R1) *"Saya main game sampai pukul 2–3 pagi."* (R3); *"Kalau tak cukup tidur, saya terus tak datang kelas."* (R1); *"Kalau datang pun saya mengantuk dan tak boleh fokus."* (R4)

4.2 Tema 2: Motivasi & Atribusi Kendiri

Dapatan menunjukkan bahawa sikap pelajar terhadap pembelajaran sangat bergantung kepada tahap motivasi yang tidak konsisten mengikut emosi atau situasi. Walaupun wujud faktor pendorong seperti keluarga, motivasi mudah merudum jika mereka gagal menguasai subjek.

"Entah, tengok mood, ada masa ok, ada masa tak ok." (R5); "Saya datang sebab tak nak repeat subjek." (R2); *"Saya belajar sebab ibu saya." (*R3); *"Saya malas datang sebab tak faham subjek."* (R1)

4.3 Tema 3: Strategi Pembelajaran Kendiri

Dapatan kajian mendapati strategi pembelajaran kendiri dalam kalangan responden pula agak lemah, di mana mereka sering menangguhkan kerja *(procrastinate*), tidak pandai mengurus masa, dan terikat dengan tabiat menyiapkan tugasan pada saat-saat akhir. Apabila pelajar tidak memahami sesuatu topik atau berhadapan dengan kelas yang membosankan, mereka cenderung untuk putus asa, hilang minat, dan memilih untuk ponteng.

"Saya tak pandai urus masa... Selalu lewat sebab siapkan kerja last minute." (R4, R1) *"Saya selalu tangguh kerja... Kalau tak faham saya biarkan je... Saya diam sahaja bila tak faham."* (R6, R1)

4.4 Tema 4: Pengaruh Persekitaran

Rakan sebaya dan persekitaran memberi pengaruh langsung terhadap tingkah laku ponteng. Wujud "normalisasi ponteng" dalam kalangan mereka, di samping kekangan logistik seperti masalah kenderaan dan kewangan.

"Saya banyak ikut kawan, kalau kawan berjaga saya pun berjaga... Kawan ajak ponteng sekali." (R7, R1); "Kalau kawan tak masuk, saya ikut." (R7); "Yalah kadang motor rosak, duit pun takde nak isi minyak." (R1)

4.5 Tema 5: Lokus Kawalan (Psikologi)

Dapatan menunjukkan pelajar mempunyai persepsi berbeza terhadap punca ketidakhadiran. Sebahagian pelajar mengaitkan ketidakhadiran dengan faktor dalaman seperti sikap dan disiplin diri. Sebahagian pelajar memiliki lokus kawalan dalaman di mana mereka mengakui ketidakhadiran dan surat amaran yang diterima adalah akibat kesalahan serta pilihan mereka sendiri. Namun, sebahagian besar yang lain lebih didorong oleh lokus kawalan luaran, di mana mereka menyalahkan keadaan (seperti motosikal rosak atau tiada wang) serta terpengaruh secara langsung oleh rakan sebaya.

"Saya sendiri yang malas." (R6); *"Kawan dan suasana buat saya tak datang kelas."* (R1)

4.6 Tema 6: Pengalaman Tindakan Disiplin

Majoriti pelajar mengakui bahawa tindakan disiplin yang diterima adalah berpunca daripada kegagalan menguruskan rutin harian, terutamanya tabiat tidur. Faktor keletihan fizikal akibat aktiviti malam menjadi pemangkin utama kepada isu ketidakhadiran ke kuliah.

Punca Amaran: *"Tertidur sebab tidur lewat... Penat sebab game... Malas." (R2, R3, R6, R7)*

Kesedaran Impak: *"Saya tahu ia boleh jejaskan masa depan... kerja nanti lambat... Susah nak berjaya.*" (R1, R7)

5.0 PERBINCANGAN

5.1 Tema 1: Kualiti Tidur & Keletihan Fizikal

selari dengan kajian (Altintas et al., 2019) yang mendapati intensiti bermain permainan video mempunyai korelasi negatif yang signifikan terhadap kualiti tidur. Penggunaan peranti digital dan media sosial secara berlebihan sebelum tidur menjejaskan masa rehat serta menyumbang kepada masalah kemurungan dan kelesuan (Wong et al., 2020). Keletihan melampau ini secara langsung mendorong kepada masalah ketidakhadiran, sebagaimana yang ditekankan oleh (Nikolic et al., 2023; Huang et al., 2020). Isu ketagihan telefon pintar yang merosotkan kualiti tidur perlu ditangani lebih awal bagi mengelakkan kemerosotan prestasi akademik secara keseluruhan (Rathakrishnan et al., 2021)

5.2 Tema 2: Motivasi & Atribusi Kendiri

Sikap pelajar yang kurang berdisiplin dan sering menangguhkan kerja juga selari dengan huraian (Sagone & Indiana., 2021). Dalam konteks kebergantungan pelajar kepada faktor luar seperti "nasib", (Bahçekapılı dan Karaman., 2020) berhujah bahawa dominasi lokus kawalan luar akan mendatangkan kerugian mutlak kepada kedudukan akademik seseorang pelajar. Kepentingan atribusi dalaman ini diperkukuhkan oleh kajian (Cui et al., 2023), yang mendapati bahawa minda yang sejahtera beserta lokus kawalan dalaman bertindak sebagai pengantara (mediator) bersiri yang dominan bagi menerbitkan semangat motivasi dan merangsang penglibatan akademik di dalam kelas.

Seterusnya, pendedahan responden yang meletakkan sokongan keluarga sebagai salah satu faktor pendorong utama kehadiran menyokong kajian (Dewi Niki Annisa et al., 2021). Sebagai langkah intervensi bagi mengelakkan pelajar hilang motivasi akibat kelas yang membosankan atau subjek yang mencabar, tenaga pengajar amat disyorkan untuk mengaplikasikan strategi pembelajaran aktif (Castro-Lopes et al., 2021) dan merangka persekitaran kelas yang interaktif serta inklusif (Husain, 2022) bagi merangsang kembali minat kognitif, emosi, serta kelakuan pelajar untuk kekal hadir ke kuliah.

5.3 Tema 3: Strategi Pembelajaran Kendiri

Isu ketiadaan minat terhadap subjek yang menjurus kepada ketidakhadiran ini menyokong penemuan (Chatterjee dan Sinha., 2019) yang membuktikan bahawa pelajar yang kurang minat terhadap bidang pengajian mempunyai kebarangkalian ponteng kelas yang tinggi, seterusnya menjejaskan gred akhir. Kelemahan pengurusan masa serta amalan menangguhkan kerja juga mempunyai perkaitan dengan kelemahan strategi membuat keputusan dalam kalangan pelajar

yang menjejaskan pencapaian akademik (Sagone & Indiana., 2021). Dari sudut intervensi, permintaan pelajar terhadap kaedah pengajaran yang interaktif disokong kuat oleh (Castro-Lopes et al., 2021), di mana strategi pembelajaran aktif menjadikan pelajar menganggap kuliah lebih menarik dan meningkatkan penglibatan. Hal ini juga bertepatan dengan rangka kerja pengajaran (Husain., 2022) yang membuktikan penyediaan persekitaran kelas yang interaktif.

5.4 Tema 4: Pengaruh Persekitaran

Dominasi pengaruh rakan sebaya ke atas ketidakhadiran pelajar ini selari dengan pemerhatian (Sivakumar & Lam., 2021). Kajian mereka membuktikan pelajar yang kerap ponteng kelas umumnya mempunyai gaya hidup yang cenderung ke arah aktiviti sosial luar, seperti meluangkan masa bersama rakan, terlibat dalam hubungan romantik, serta melayari internet secara berkumpulan. Hubungan dinamik dengan rakan sebaya yang menjurus kepada ketidakhadiran ini juga selari dengan faktor tersembunyi di sebalik masalah ketidakhadiran pelajar yang diketengahkan oleh (Haque et al., 2024), iaitu kurangnya elemen sokongan persekitaran yang sihat menyumbang kepada keputusan dan keciciran akademik.

Berdasarkan pandangan (Cahyadi et al., 2021), tahap lokus kawalan dalaman pelajar akan bertindak sebagai mediator apabila berhadapan dengan sebarang persekitaran yang tidak sihat di sekeliling mereka. Bagi mengelakkan pelajar mudah hanyut dengan ajakan rakan sebaya untuk ponteng, penemuan (Tahrir et al., 2020) berhujah bahawa pelajar memerlukan lokus kawalan dalaman bagi membentuk pemikiran kritis. Sekiranya pengaruh rakan yang bersifat memajukan berjaya dibentuk di dalam kelas, ia mampu mewujudkan persekitaran dan penyertaan yang selamat sekaligus berjaya mengurangkan masalah ketidakhadiran (Husain, 2022).

5.5 Tema 5: Lokus Kawalan (Psikologi)

Dalam konteks lokus kawalan, (Bahçekapılı & Karaman., 2020) menjelaskan bahawa kecenderungan terhadap lokus kawalan luar mendatangkan kerugian besar kepada penglibatan akademik, berbanding lokus kawalan dalaman yang meningkatkan keyakinan efikasi kendiri. Oleh itu, seperti yang digariskan oleh (Cahyadi et al., 2021; Cui et al., 2023), pembentukan nilai lokus kawalan dalaman yang teguh sangat kritikal bagi berfungsi sebagai penampan (mediator) dalam mendepani pengaruh luaran negatif, di samping menyemarakkan rasa tanggungjawab pelajar terhadap kehadiran ke kelas.

5.6 Tema 6: Pengalaman Tindakan Disiplin

Sebahagian pelajar mengakui bertanggungjawab penuh atas kesilapan diri, manakala yang lain meletakkan diri mereka sebagai mangsa keadaan atas alasan kerosakan motosikal mahupun ketiadaan wang saku. Dari sudut literatur psikologi, respons pelajar yang menyalahkan keadaan sekeliling ini melambangkan dominasi lokus kawalan luaran yang secara mutlak mendatangkan kerugian kepada kedudukan akademik pelajar, berbanding efikasi kendiri yang mampu meningkatkan prestasi akademik (Bahçekapılı & Karaman., 2020). Sebaliknya, pengakuan bersalah secara rasional oleh sesetengah responden setelah menerima surat amaran menunjukkan wujudnya kefahaman lokus kawalan dalaman yang positif. Kefahaman ini selari dengan hujah (Tahrir et al., (2020), di mana lokus kawalan dalaman amat mempengaruhi

keupayaan pemikiran kritis seseorang pelajar bagi memberikan tindak balas dalam membasmi isu keciciran nilai etika, di samping bertindak teguh dalam menghalang isu pelepasan moral seperti menjustifikasikan dan menormalisasikan perbuatan ponteng kelas akibat terpengaruh dengan keadaan semasa.

6.0 IMPLIKASI KAJIAN

Dapatan kajian ini membawa implikasi signifikan terhadap kerangka pengurusan pelajar di KKPB, di mana pihak institusi perlu mengintegrasikan program pembangunan *self-regulated learning* dan intervensi pengurusan masa yang sistematik guna memperkukuh disiplin serta autonomi pelajar. Di peringkat instruksional, para pensyarah bertanggungjawab merangka strategi pembelajaran aktif yang lebih dinamik disertakan dengan pemantauan kebajikan secara berterusan bagi meningkatkan motivasi intrinsik pelajar untuk hadir ke kuliah. Manakala bagi pihak pelajar, pengajuran bengkel kesedaran regulasi kendiri dan kempen gaya hidup sihat adalah kritikal untuk membina daya tahan psikologi serta rutin harian yang stabil, sekali gus memastikan faktor kesihatan mental dan fizikal tidak lagi menjadi penghalang utama kepada kehadiran mereka ke institusi.

7.0 KESIMPULAN

Kajian ini menegaskan bahawa ketidakhadiran pelajar merupakan refleksi kepada kelemahan dalam regulasi kendiri, motivasi dan gaya hidup. Penerokaan telah memperluaskan pemahaman terhadap dimensi tingkah laku pembelajaran yang sebelum ini kurang diberi perhatian.

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HUBUNGAN MOTIVASI DAN STRATEGI PEMBELAJARAN DENGAN PEMATUHAN TINGKAH LAKU BENGKEL DALAM KALANGAN PELAJAR SIJIL TEKNOLOGI ELEKTRIK

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Abstrak

Motivasi dan strategi pembelajaran merupakan antara faktor penting yang mempengaruhi tingkah laku pelajar dalam persekitaran pembelajaran berasaskan kemahiran, khususnya di bengkel teknikal. Dalam konteks pendidikan dan latihan teknikal dan vokasional (TVET), pematuhan terhadap peraturan dan prosedur bengkel amat penting bagi memastikan keselamatan, disiplin kerja serta keberkesanan proses pembelajaran amali. Oleh itu, kajian ini dijalankan bagi mengenal pasti hubungan antara motivasi dan strategi pembelajaran dengan pematuhan tingkah laku bengkel dalam kalangan pelajar Sijil Teknologi Elektrik. Kajian ini menggunakan pendekatan kuantitatif berbentuk tinjauan dengan melibatkan seramai 94 orang pelajar Sijil Teknologi Elektrik di Kolej Komuniti Paya Besar. Instrumen kajian yang digunakan ialah soal selidik *Motivated Strategies for Learning Questionnaire* (MSLQ) berskala Likert 7-Mata bagi mengukur tahap motivasi dan strategi pembelajaran, manakala pematuhan tingkah laku bengkel diukur menggunakan Skala Likert 5-Mata berdasarkan *National Occupational Skills Piawai* (NOSS). Data yang diperolehi dianalisis menggunakan statistik deskriptif dan korelasi Pearson menggunakan perisian *SPSS*. Dapatan kajian menunjukkan tahap motivasi (Min=5.67), strategi pembelajaran (Min = 5.48), dan tahap pematuhan tingkah laku bengkel (Min=4.82) berada pada tahap tinggi. Analisis korelasi menunjukkan terdapat hubungan positif yang signifikan antara motivasi ($r = 0.208$, $p = 0.045$) dan strategi pembelajaran ($r = 0.242$, $p = 0.019$) dengan pematuhan tingkah laku bengkel dalam kalangan pelajar. Dapatan ini mencadangkan bahawa aspek motivasi dan strategi pembelajaran memainkan peranan dalam membentuk tingkah laku pelajar yang mematuhi peraturan bengkel, walaupun faktor luaran seperti penguatkuasaan peraturan institusi turut menyumbang kepada tahap kepatuhan yang tinggi. Implikasi kajian ini diharapkan dapat membantu pensyarah dan institusi TVET merancang strategi pengajaran yang mengintegrasikan elemen regulasi kendiri bagi meningkatkan disiplin dan profesionalisme pelajar dalam persekitaran bengkel.

Kata kunci: *Motivasi, Strategi Pembelajaran, Pematuhan Tingkah Laku, Pelajar TVET, Teknologi Elektrik, Keselamatan Bengkel*

Abstract

Motivation and learning strategies are among the key factors influencing student behavior in skillbased learning environments, particularly in technical workshops. In the context of Technical and Vocational Education and Training (TVET), compliance with workshop rules and procedures is crucial to ensure safety, work discipline, and the effectiveness of the practical learning process. Therefore, this study was conducted to identify the relationship between motivation and learning strategies with workshop behavioral compliance among Electric Technology Certificate students. This study utilized a quantitative survey approach involving 94 Electric Technology Certificate students at Paya Besar Community College. The research instrument used was the Motivated Strategies for Learning Questionnaire (MSLQ) with a 7-point Likert scale to measure levels of motivation and learning strategies, while workshop behavioral compliance was measured using a 5-point Likert scale based on the National Occupational Skills Piawai (NOSS). Data obtained were analyzed using descriptive statistics and Pearson correlation via SPSS software. The findings showed that the levels of motivation (Mean = 5.67), learning strategies (Mean = 5.48), and workshop behavioral compliance (Mean = 4.82) were at a high level. Correlation analysis indicated a significant positive relationship between motivation (r = 0.208, p = 0.045) and learning strategies (r = 0.242, p = 0.019) with workshop behavioral compliance among students. These findings suggest that motivation and learning strategies play a role in shaping student behavior that complies with workshop regulations, although external factors such as the enforcement of institutional rules also contribute to the high level of compliance. The implications of this study are expected to assist lecturers and TVET institutions in planning instructional strategies that integrate self-regulation elements to enhance student discipline and professionalism within the workshop environment.

Keywords: *Motivation, Learning Strategies, Behavioral Compliance, TVET Students, Electrical Technology, Workshop Safety*

1.0 PENGENALAN

Dalam landskap Pendidikan dan Latihan Teknikal dan Vokasional (TVET), pembelajaran tidak hanya tertumpu kepada penguasaan teori semata-mata, sebaliknya menekankan kemahiran praktikal yang dilaksanakan dalam persekitaran bengkel. Persekitaran amali ini menuntut ahap disiplin dan pematuhan yang tinggi terhadap prosedur kerja bagi memastikan keselamatan serta keberkesanan proses pembelajaran amali. Sebagaimana ditegaskan oleh Zohar (2010), pematuhan prosedur dalam bidang teknikal bukan sekadar tindakan mekanikal, sebaliknya merupakan manifestasi daripada iklim keselamatan yang diamalkan dalam organisasi tersebut. Pematuhan terhadap peraturan bengkel mencerminkan tahap profesionalisme pelajar sebagai bakal tenaga kerja industri yang kompeten. Menurut Vinodkumar dan Bhasi (2010), tingkah laku keselamatan mempunyai kaitan langsung dengan amalan pengurusan serta kepatuhan individu terhadap Prosedur Operasi Piawai (SOP) yang ditetapkan. Kegagalan mematuhi prosedur boleh mengundang risiko kemalangan serta menjejaskan kualiti hasil kerja.

Dalam konteks ini, faktor dalaman pelajar seperti motivasi dan strategi pembelajaran dilihat berpotensi mempengaruhi tingkah laku mereka di bengkel. Pelajar yang mempunyai dorongan belajar yang tinggi lazimnya menunjukkan komitmen yang lebih baik terhadap aktiviti pembelajaran. Begitu juga dengan strategi pembelajaran yang berkesan, yang membantu pelajar memahami prosedur kerja serta mengaplikasikannya dengan tepat. Sehubungan itu, kajian ini bertujuan meneliti hubungan antara motivasi dan strategi pembelajaran dengan tahap pematuhan tingkah laku bengkel dalam kalangan pelajar Sijil Teknologi Elektrik di kolej komuniti.

1.1 Pernyataan Masalah

Isu ketidakpatuhan terhadap peraturan bengkel dalam kalangan pelajar TVET sering menjadi perhatian kerana implikasinya terhadap keselamatan dan disiplin kerja. Walaupun piawai ketat seperti *National Occupational Skills Piawai* (NOSS) telah diperkenalkan, ralat pelajar akibat pelanggaran prosedur masih kerap berlaku dalam persekitaran amali. Kebanyakan pendekatan sedia ada dalam menangani isu ini bersifat luaran, iaitu lebih berfokus kepada penguatkuasaan peraturan yang ketat dan pemantauan berterusan oleh pensyarah tetapi kurang menekankan aspek dalaman pelajar yang mungkin menjadi punca kepada tingkah laku tersebut.

Motivasi pembelajaran merupakan salah satu elemen penting yang mempengaruhi tahap penglibatan pelajar. Kekurangan dorongan ini menyebabkan pelajar cenderung bersikap sambil lewa dan memandang rendah terhadap kepentingan peraturan keselamatan. Selain itu, kelemahan dalam strategi pembelajaran mengakibatkan pelajar gagal memproses maklumat teknikal secara mendalam, seterusnya gagal memahami kepentingan prosedur kerja yang betul. Maka, satu kajian empirikal perlu dijalankan untuk meneliti hubungan antara motivasi dan strategi pembelajaran dengan pematuhan tingkah laku bengkel bagi menyediakan kerangka intervensi yang lebih menyeluruh dalam konteks TVET.

1.2 Objektif Kajian

Kajian ini dijalankan bagi mencapai objektif berikut:

i. Mengenal pasti tahap motivasi dan strategi pembelajaran pelajar.
ii. Menentukan tahap pematuhan tingkah laku bengkel berdasarkan piawai yang ditetapkan.
iii. Menganalisis hubungan antara motivasi dan strategi pembelajaran dengan pematuhan tingkah laku bengkel.

1.3 Kepentingan Kajian

Kajian ini diharapkan dapat memberikan sumbangan yang signifikan kepada beberapa pihak seperti berikut:

1. Kepada Pelajar Sijil Teknologi Elektrik: Meningkatkan keselamatan diri dengan mengaitkan disiplin pembelajaran dengan amalan kerja yang selamat bagi mengelakkan kemalangan elektrik.
2. Kepada Pensyarah: Memberi input kepada pensyarah untuk mengimbangi kemahiran teknikal dengan elemen motivasi serta teknik belajar yang berkesan, sekali gus

membantu merangka pengurusan bengkel dan SOP yang lebih mesra pelajar bagi memudahkan pemantauan tingkah laku yang selamat.

3. Kepada Institusi Pendidikan: Pematuhan yang tinggi akan mengurangkan kadar kemalangan di bengkel, seterusnya meningkatkan imej institusi sebagai persekitaran pembelajaran yang selamat dan profesional.

2.0 SOROTAN LITERATUR

Motivasi pembelajaran, yang merangkumi dorongan dalaman dan luaran, merupakan faktor utama yang menentukan kesungguhan individu dalam proses menuntut ilmu. Berdasarkan Teori Motivasi Kendiri, pelajar yang didorong oleh motivasi intrinsik cenderung untuk terlibat dalam aktiviti pembelajaran secara lebih aktif dan konsisten. Dalam konteks keselamatan, perbandingan antara faktor intrinsik dan ekstrinsik oleh Hassan dan Ismail (2021) membuktikan bahawa dorongan dalaman menghasilkan kesan yang lebih mampan terhadap pematuhan Prosedur Operasi Piawai (SOP), terutamanya apabila pelajar mengintegrasikan aspek keselamatan sebagai sebahagian daripada identiti kerjaya mereka. Keberkesanan ini diperkukuhkan lagi oleh Chen dan Wang (2023) yang menekankan bahawa pembentukan 'iklim keselamatan' atau suasana motivasi oleh pengajar di dalam bengkel berupaya meningkatkan keinginan kendiri pelajar untuk patuh tanpa memerlukan pemantauan berterusan.

Selari dengan aspek motivasi, strategi pembelajaran yang merangkumi pendekatan pelajar untuk memahami, mengingat, dan mengaplikasikan maklumat turut memainkan peranan kritikal. Penggunaan instrumen seperti Motivated Strategies for Learning Questionnaire (MSLQ) sering menjadi rujukan utama dalam menilai dimensi ini, termasuk aspek pengurusan masa, kawalan usaha, dan strategi kognitif. Kajian oleh Thompson (2022) menunjukkan bahawa kecenderungan pelajar untuk merancang langkah kerja secara metakognitif membuahkan tahap pematuhan keselamatan yang lebih tinggi berbanding tindakan melulu. Evolusi kaedah pembelajaran turut dilihat menerusi dapatan Miller dan Davis (2024), di mana penggunaan simulasi digital sebagai strategi pra-pembelajaran berjaya meningkatkan kesediaan mental pelajar sebelum berhadapan dengan risiko elektrik yang nyata.

Selain itu, ketekalan dalam aspek keselamatan seperti penggunaan Alat Pelindung Diri (PPE) sangat berkait rapat dengan strategi penyusunan maklumat yang sistematik, sebagaimana yang ditegaskan oleh Zaid dan Rahman (2025). Dalam ruang lingkup Pendidikan Teknikal dan Latihan Vokasional (TVET), pematuhan tingkah laku bengkel adalah cerminan kepada tahap disiplin dan kecekapan kerja yang berpaksikan piawaian seperti National Occupational Skills Piawai (NOSS). Kajian tempatan oleh Aziz dan Ahmad (2022) di Kolej Vokasional turut menyokong naratif ini dengan menyerlahkan kepentingan strategi pembelajaran kolaboratif dalam meminimumkan risiko kemalangan atau insiden "kecuaian hampir" (*near-miss*).

Secara kesimpulannya, integrasi antara kesediaan mental melalui strategi pembelajaran regulasi kendiri dan dorongan motivasi yang jitu mewujudkan satu sistem pertahanan diri yang

kukuh. Gabungan kedua-dua elemen ini bukan sahaja menghalang pelajar daripada melanggar prosedur kerja elektrik yang kritikal, malah menjadi penentu utama kepada kualiti tingkah laku keselamatan dan kecemerlangan prestasi mereka dalam persekitaran praktikal.

3.0 METODOLOGI KAJIAN

Kajian ini menggunakan pendekatan kuantitatif sepenuhnya bagi memperoleh gambaran data yang lebih luas, objektif, dan tepat mengenai fenomena yang dikaji. Reka bentuk kajian yang dipilih adalah kajian korelasi yang merangkumi analisis deskriptif dan inferensi. Pendekatan ini bertujuan untuk menghuraikan tahap pemboleh ubah yang dikaji serta mengenal pasti kekuatan hubungan antara motivasi dan strategi pembelajaran dengan pematuhan tingkah laku bengkel.

3.1 Sampel Kajian

Populasi kajian ini memfokuskan kepada para pelajar yang mengikuti program Sijil Teknologi Elektrik di Kolej Komuniti Paya Besar. Seramai 117 orang pelajar terdiri daripada pelajar Semester 1, Semester 2 dan Semester 3 telah dipilih sebagai responden. Daripada jumlah tersebut, seramai 94 orang pelajar telah melengkapkan soal selidik. Menurut jadual penentuan saiz sampel Krejcie dan Morgan (1970), jumlah 94 responden ini adalah mencukupi bagi mewakili populasi seramai 117 orang untuk mendapatkan dapatan yang sahih.

Pemilihan populasi ini adalah selaras dengan keperluan kajian yang memerlukan responden yang terlibat secara langsung dengan aktiviti amali di bengkel elektrik yang berisiko tinggi. Pemilihan sampel dilakukan menggunakan kaedah persampelan mudah. Sejajar dengan pandangan Etikan et al. (2016), kaedah ini dipilih kerana responden memenuhi kriteria praktikal seperti kemudahan akses, kesediaan sukarela, dan kesesuaian masa di lokasi kajian bagi menjawab persoalan kajian yang dibangkitkan.

3.2 Instrumen Kajian

Motivated Strategies for Learning Questionnaire (MSLQ) digunakan sebagai instrumen kajian untuk mengukur tahap motivasi dan strategi pembelajaran pelajar. Berdasarkan kajian oleh *Pintrich et al*. (1993) telah mengesahkan bahawa MSLQ mempunyai tahap kebolehpercayaan dan kesahan ramalan (*predictive validity*) yang tinggi dalam mengukur motivasi dan strategi pembelajaran. Instrumen Pematuhan Tingkah Laku Bengkel (NOSS) dibangunkan berdasarkan kriteria yang ditetapkan dalam *National Occupational Skills Piawai* bagi menilai tahap pematuhan pelajar terhadap peraturan bengkel. Penggunaan kriteria NOSS sebagai asas instrumen adalah selari dengan keperluan industri TVET untuk mencerminkan tahap disiplin dan kecekapan kerja yang sebenar.

Bagi tujuan pengumpulan data, instrumen soal selidik ini direka bentuk menggunakan Skala Likert 7 Mata bagi mengukur tahap motivasi dan strategi pembelajaran, manakala Skala Likert 5 Mata digunakan bagi mengukur tahap pematuhan tingkah laku bengkel.

3.3 Analisis Data

Seterusnya, data yang dikumpul akan diproses menggunakan perisian *Statistical Package for the Social Sciences* (SPSS). Statistik deskriptif yang melibatkan pengiraan min dan sisihan piawai akan digunakan untuk menentukan tahap bagi setiap pemboleh ubah. Bagi menguji hubungan antara pemboleh ubah bebas dan pemboleh ubah bersandar, Analisis Korelasi Pearson akan dilaksanakan. Ujian inferensi ini bagi menentukan sama ada terdapat hubungan yang signifikan secara statistik antara motivasi dan strategi pembelajaran terhadap pematuhan tingkah laku bengkel dalam kalangan pelajar

4.0 DAPATAN KAJIAN DAN PERBINCANGAN

Hasil analisis data yang dijalankan telah memberikan gambaran yang jelas mengenai tahap pemboleh ubah kajian serta hubungan antara faktor-faktor yang dikaji. Dapatan kajian diringkaskan seperti berikut:

4.1 Objektif (i): Mengenal pasti tahap motivasi dan strategi pembelajaran pelajar

Analisis deskriptif digunakan untuk menentukan nilai min dan sisihan piawai bagi kedua-dua pemboleh ubah tersebut iaitu motivasi dan strategi pembelajaran. Interpretasi Skor Min (Skala 17) digunakan untuk menguji objektif ini. Bagi skala Likert 7-mata, kajian ini menggunakan klasifikasi seperti dalam Jadual 1 yang diadaptasi daripada Landell, 1997.

Jadual 1: Interpretasi Skor Min bagi Skala Likert Tujuh Mata

Skor Min	Tahap
1.00 – 3.00	Rendah
3.01 – 5.00	Sederhana
5.01 – 7.00	Tinggi

Jadual 2 menunjukkan ringkasan statistik deskriptif bagi Motivasi dan Strategi Pembelajaran.

Jadual 2: Interpretasi Skor Min

	N	Minimum	Maximum	Mean	Std. Deviation
MIN_MOTIVASI	94	2.41	7.00	5.6718	1.02019
MIN_STRATEGI	94	3.00	7.00	5.4807	1.10011

Hasil analisis menunjukkan bahawa tahap motivasi pelajar adalah pada Tahap Tinggi dengan nilai min 5.67 (SD = 1.020). Ini menunjukkan bahawa pelajar mempunyai dorongan dalaman yang kuat, menghargai kepentingan subjek, dan mempunyai keyakinan diri yang tinggi dalam proses pembelajaran mereka. Bagi Strategi Pembelajaran, dapatan menunjukkan pelajar berada pada Tahap Tinggi dengan nilai min 5.48 (SD = 1.100). Nilai ini membuktikan bahawa pelajar secara aktif menggunakan pelbagai teknik pembelajaran seperti pengurusan masa, teknik mencatat nota, dan pemikiran kritis untuk menguasai pelajaran.

Dapatan ini merumuskan bahawa majoriti responden mempunyai profil pembelajaran yang positif, di mana mereka bukan sahaja bermotivasi tinggi tetapi juga mempunyai strategi yang berkesan dalam menuntut ilmu.

4.2 Objektif (ii): Menentukan tahap pematuhan tingkah laku bengkel berdasarkan piawai yang ditetapkan

Analisis deskriptif telah dijalankan ke atas pemboleh ubah Tingkah Laku Bengkel yang merangkumi 30 item soalan. Interpretasi Skor Min (Skala 1-5) digunakan untuk menguji objektif ini. Bagi menentukan tahap pematuhan, kajian ini telah menggunakan jadual interpretasi skor min seperti Jadual 3 yang diadaptasi daripada Jamil Ahmad, 2002.

Jadual 3: Interpretasi Skor Min Skala Likert 5 Mata

Skor Min	Tahap
1.00 – 2.33	Rendah
2.34 – 3.66	Sederhana
3.67 – 5.00	Tinggi

Jadual 4 menunjukkan ringkasan statistik deskriptif bagi min keseluruhan tingkah laku bengkel. Berdasarkan jadual tersebut, hasil analisis terhadap 94 orang responden menunjukkan bahawa tahap pematuhan tingkah laku bengkel adalah berada pada Tahap Tinggi. Nilai min keseluruhan yang dicatatkan adalah sebanyak 4.82 dengan sisihan piawai (*Std. Deviation*) sebanyak 0.316.

Jadual 4: Statistik Deskriptif Tingkah Laku Bengkel

	N	Minimum	Maximum	Mean	Std. Deviation
MIN_TINGKAH_LAKU	94	3.97	5.00	4.8245	.31642

Nilai minimum yang direkodkan oleh responden adalah 3.97, manakala nilai maksimum adalah 5.00 (skor penuh). Hal ini menunjukkan bahawa secara keseluruhannya, hampir semua responden mempunyai tahap disiplin dan pematuhan yang sangat baik terhadap prosedur dan etika kerja semasa berada di dalam bengkel. Dapatan ini merumuskan bahawa objektif kedua kajian telah tercapai. Skor min yang menghampiri nilai maksimum 5.00 menggambarkan bahawa pelajar mempunyai kesedaran yang amat tinggi terhadap aspek keselamatan, kerjasama, dan tanggungjawab teknikal seperti yang ditetapkan dalam piawai bengkel.

4.3 Objektif (iii): Menganalisis hubungan antara motivasi dan strategi pembelajaran dengan pematuhan tingkah laku bengkel

Ujian Korelasi Pearson digunakan untuk menentukan arah dan kekuatan hubungan antara pemboleh ubah. Bagi menghuraikan nilai pekali korelasi (*r*), kajian ini merujuk kepada skala kekuatan seperti di Jadual 5 yang diadaptasi daripada Chua Yan Piaw, 2014.

Jadual 5: Jadual Pekali Korelasi

Nilai Pekali Korelasi (*r*)	Kekuatan Hubungan
0.00 – 0.20	Sangat Lemah
0.21 – 0.40	Lemah
0.41 – 0.60	Sederhana
0.61 – 0.80	Kuat
0.81 – 1.00	Sangat Kuat

Berdasarkan analisis data di Jadual 6, hasil ujian korelasi menunjukkan terdapat hubungan positif yang signifikan antara motivasi dengan pematuhan tingkah laku bengkel ($r = 0.208$, $p = 0.045$) di mana kekuatan hubungan ini berada pada tahap yang sangat lemah. Selain itu, strategi pembelajaran juga mempunyai hubungan positif yang signifikan dengan pematuhan tingkah laku bengkel ($r = 0.242$, $p = 0.019$) namun kekuatan hubungan berada pada tahap yang lemah. Manakala, analisis mendapati terdapat hubungan positif yang sangat kuat dan signifikan antara motivasi dengan strategi pembelajaran ($r = 0.899$, $p = 0.000$), yang membuktikan bahawa pelajar yang bermotivasi tinggi akan secara konsisten mengamalkan strategi pembelajaran yang lebih baik dalam aktiviti akademik mereka.

Jadual 6: Hasil Ujian Korelasi Pearson

Hubungan Pemboleh Ubah	Pekali Korelasi (*r*)	Tahap Signifikan (*p*)	Kekuatan
Motivasi dan Tingkah Laku	0.208*	0.045	Sangat Lemah
Strategi Pembelajaran dan Tingkah Laku	0.242*	0.019	Lemah
Motivasi dan Strategi Pembelajaran	0.899**	0.000	Sangat Kuat

*Signifikan pada aras 0.05
**Signifikan pada aras 0.01

4.4 Perbincangan

Analisis deskriptif menunjukkan bahawa tahap motivasi (Min = 5.67) dan tahap strategi pembelajaran (Min = 5.48) dalam kalangan pelajar Sijil Teknologi Elektrik berada pada tahap tinggi. Dapatan ini selari dengan kerangka kerja Pintrich dan De Groot (1990) yang menjelaskan bahawa pelajar yang mempunyai tahap motivasi dan efikasi kendiri yang tinggi cenderung untuk mengamalkan strategi pembelajaran regulasi kendiri secara lebih aktif dan konsisten. Selain itu, tahap pematuhan tingkah laku bengkel turut mencatatkan skor yang sangat tinggi (Min = 4.82).

Penemuan ini membuktikan bahawa pelajar mempunyai kesedaran yang sangat baik terhadap aspek keselamatan, yang menyokong teori iklim keselamatan oleh Zohar (2010). Teori ini menyatakan bahawa pematuhan keselamatan yang tekal dalam persekitaran teknikal didorong oleh keselarasan antara dorongan dalaman pelajar dengan penguatkuasaan prosedur operasi piawai (SOP) yang ditekankan secara intensif oleh pihak institusi. Seterusnya, hasil analisis

korelasi membuktikan terdapat hubungan positif yang signifikan antara motivasi (r = 0.208, p = 0.045) dan strategi pembelajaran (r = 0.242, p = 0.019) dengan pematuhan tingkah laku bengkel, walaupun kekuatan hubungannya berada pada tahap lemah. Dapatan ini konsisten dengan kajian Vinodkumar dan Bhasi *(*2010) yang menegaskan bahawa motivasi keselamatan merupakan peramal penting kepada tingkah laku selamat, namun sistem pengurusan keselamatan sedia ada sering kali memainkan peranan yang lebih dominan dalam menentukan tahap kepatuhan fizikal.

Walau bagaimanapun, hubungan sangat kuat (r = 0.899) antara motivasi dan strategi pembelajaran menunjukkan bahawa dorongan dalaman yang tinggi adalah pemacu utama kepada penggunaan teknik pembelajaran metakognitif. Sebagaimana ditegaskan oleh Zimmerman (2000), pelajar yang mempunyai matlamat pembelajaran yang jelas dan strategi yang terancang akan mempamerkan disiplin diri yang lebih tinggi, sekaligus menyumbang kepada ketelitian dan pematuhan terhadap prosedur kerja elektrik yang kompleks.

5. RUMUSAN DAN CADANGAN

5.1 Rumusan

Secara keseluruhannya, kajian ini telah berjaya mengenal pasti tahap motivasi, strategi pembelajaran, dan pematuhan tingkah laku bengkel, serta hubungan antara pemboleh ubah tersebut. Dapatan menunjukkan profil pelajar yang sangat positif dalam persekitaran pendidikan teknikal. Dapat dirumuskan di sini bahawa pematuhan tingkah laku bengkel yang cemerlang bukan sahaja bergantung kepada sejauh mana pelajar bermotivasi atau bijak merancang strategi belajar, tetapi ia adalah hasil gabungan disiplin kendiri dan sistem pengurusan bengkel yang berkesan. Motivasi yang tinggi berfungsi sebagai asas, manakala peraturan bengkel berfungsi sebagai pemandu tingkah laku fizikal mereka.

5.2 Cadangan

Berdasarkan dapatan kajian yang telah diperoleh, beberapa cadangan dikemukakan untuk tindakan pihak institusi dan penyelidik akan datang.

Pihak Institusi dan Pensyarah: Memandangkan terdapat hubungan signifikan antara strategi pembelajaran dan pematuhan, pensyarah disarankan untuk mengintegrasikan elemen pembelajaran regulasi kendiri dalam amali. Pensyarah boleh menekankan penggunaan senarai semak metakognitif sebelum pelajar memulakan pendawaian litar bagi mengurangkan ralat teknikal.

Peningkatan Motivasi Intrinsik: Program motivasi yang memfokuskan kepada nilai kerjaya dalam bidang elektrik perlu diteruskan. Apabila pelajar melihat kepentingan tugasan (task value), mereka akan lebih cenderung menggunakan strategi pembelajaran yang mendalam, yang secara tidak langsung meningkatkan disiplin mereka di bengkel.

Kajian Masa Hadapan: Penyelidik akan datang dicadangkan untuk mengkaji faktor luaran lain seperti gaya kepimpinan instruktor atau iklim keselamatan bengkel. Memandangkan korelasi motivasi terhadap tingkah laku adalah lemah, faktor-faktor persekitaran mungkin

mempunyai pengaruh yang lebih besar yang perlu diterokai melalui kaedah kualitatif atau analisis regresi pelbagai.

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PEMODELAN FAKTOR PENENTU PEMBELAJARAN KENDIRI DIGITAL BERASASKAN EFIKASI KENDIRI: PENDEKATAN *STRUCTURAL EQUATION MODELING* (SEM) DI KOLEJ KOMUNITI SEGAMAT 2

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Abstrak

Pembelajaran kendiri digital (D-SDL) merupakan elemen kritikal dalam pendidikan TVET bagi mendepani cabaran industri. Walaupun infrastruktur digital telah disediakan, tahap autonomi pelajar dalam menguruskan pembelajaran masih menjadi persoalan. Kajian ini bertujuan untuk membangun dan menguji model faktor penentu yang mempengaruhi pembelajaran kendiri digital melalui adaptasi Model Input Proses Output (IPO) dan Teori Kognitif Sosial Bandura. Kajian memfokuskan kepada peranan efikasi kendiri sebagai pemboleh ubah pengantara. Kajian kuantitatif ini melibatkan 141 pelajar dari program STM, STS, SKE, dan DTS di Kolej Komuniti Segamat 2. Data dianalisis menggunakan pendekatan Structural Equation Modeling (PLS-SEM) melalui perisian JASP. Analisis model pengukuran mengesahkan kesahan dan kebolehpercayaan setiap konstruk, manakala analisis model kerangka konseptual membuktikan bahawa efikasi kendiri digital berfungsi sebagai mediator (pengantara) yang signifikan, yang memperkukuh hubungan antara literasi digital dan sokongan institusi terhadap amalan pembelajaran mandiri. Dapatan ini memberikan implikasi strategik kepada institusi dalam menyediakan ruang pembelajaran yang lebih berautonomi.

Kata Kunci: Pembelajaran Kendiri Digital, Efikasi Kendiri, SEM, TVET, Kolej Komuniti

Abstract

Digital self-directed learning (D-SDL) is a critical element in TVET education to address industrial challenges. Notwithstanding the availability of digital infrastructure, the level of student autonomy in managing their learning remains a subject of concern. This study aims to develop and test a determinant factor model influencing digital self-directed learning by adapting the Input-Process-Output (IPO) Model and Bandura's Social Cognitive Theory. The research focuses on the role of self-efficacy as a mediating variable. This quantitative study involves 141 students from the STM, STS, SKE, and DTS programs at Kolej Komuniti Segamat 2. Data were analyzed using the Structural Equation Modeling (PLS-SEM) approach via JASP software. The measurement model analysis confirmed the validity and reliability of each construct, while the conceptual framework model analysis proved that digital self-efficacy

functions as a significant mediator. This mediating role strengthens the relationship between digital literacy and institutional support toward self-directed learning practices. These findings offer strategic implications for institutions in fostering more autonomous learning environments.

***Keywords**: Digital Self-Directed Learning, Self-Efficacy, SEM, TVET, Community College*

1.0 PENGENALAN

Dunia pendidikan kini beralih daripada kaedah konvensional kepada ekosistem digital yang dinamik. Dalam mendepani Industri 4.0, Pembelajaran Kendiri Digital (D-SDL) telah menjadi kompetensi utama yang diperlukan bagi menjamin kelestarian ilmu serta kebolehpasaran graduan. Pelajar TVET perlu menguasai kemahiran pembelajaran kendiri bagi memastikan kelestarian ilmu dalam bidang teknikal yang sentiasa berubah.

Namun, pelajar masih mempamerkan kebergantungan yang tinggi terhadap instruksi pensyarah dan kurang autonomi dalam meneroka modul digital secara mandiri. Isu ini sering kali berpunca daripada kegagalan memahami faktor psikologi seperti efikasi kendiri, yang menyebabkan inisiatif pendigitalan di institusi kurang memberi impak yang diharapkan. Dapatan ini selari dengan kajian Ismail et al. (2025) yang menegaskan bahawa peranan efikasi kendiri sebagai mediator adalah kritikal bagi menjamin kelestarian penggunaan teknologi dalam kalangan pelajar. Oleh itu, kajian ini bertujuan membangunkan Kerangka Konseptual Permodelan Faktor Penentu Pembelajaran Kendiri Digital Berasaskan Efikasi Kendiri bagi menilai pengaruh literasi digital dan sokongan institusi terhadap amalan D-SDL dengan efikasi kendiri sebagai pemboleh ubah pengantara.

1.1 Penyataan Masalah

Secara umumnya, penggunaan platform digital disediakan untuk memudahkan akses kepada nota. Namun, terdapat isu di mana pelajar masih mempamerkan kebergantungan tinggi kepada instruksi pensyarah dan kurang keyakinan untuk meneroka modul secara mandiri. Kegagalan memahami faktor psikologi seperti efikasi kendiri menyebabkan inisiatif pendigitalan kurang memberi impak kepada hasil pembelajaran.

1.2 Objektif Kajian

1.2.1 Menilai pengaruh faktor penentu (literasi digital, sokongan pensyarah dan infrastruktur) terhadap efikasi kendiri digital dan amalan pembelajaran kendiri digital (D-SDL).

1.2.2 Menganalisis peranan efikasi kendiri digital sebagai pengantara (mediator) dalam hubungan antara faktor penentu dengan amalan D-SDL.

1.2.3 Membina kerangka konseptual permodelan faktor penentu pembelajaran kendiri digital berasaskan efikasi kendiri.

1.3 Signifikan Kajian

Kajian ini signifikan kepada:

Institusi: Pembangunan kurikulum TVET yang berteraskan pembelajaran digital terarah kendiri (D-SDL) di Kolej Komuniti Segamat 2.

Pensyarah: Membekalkan panduan kepada pensyarah untuk merancang intervensi pedagogi dan psikologi.

Pelajar: Memberi nilai tambah daya tahan digital serta kebolehpasaran graduan dalam ekosistem pendidikan digital yang mampan.

2.0 KAJIAN LITERATUR

Tinjauan literatur merangkumi transformasi Pembelajaran Kendiri (SDL) ke arah dimensi digital (D-SDL). Landasan teori kajian turut diperincikan melalui integrasi Teori Kognitif Sosial Bandura dan Model Input-Proses-Output (IPO) sebagai asas utama pembangunan kerangka konseptual.

2.1 Teori Kajian

Kajian ini diadaptasi daripada Teori Kognitif Sosial (Bandura, 1986, 1997) dan Model Input-Proses-Output (IPO) di mana faktor persekitaran (Input) diproses melalui mekanisme psikologi (Proses) untuk menghasilkan tingkah laku (Output). Dalam sistem ini, input institusi dan literasi tidak secara langsung menjadi amalan, sebaliknya ia bertindak sebagai pemacu yang diproses melalui efikasi kendiri sebagai "enjin" psikologi. Integrasi ini memperincikan bagaimana keyakinan dalaman pelajar menukarkan sokongan luaran kepada hasil amalan pembelajaran kendiri digital (D-SDL) yang mampan.

2.2 Transformasi D-SDL, Peranan AI, dan Faktor Input

Pembelajaran kendiri dalam TVET telah beralih kepada ekosistem digital (D-SDL) yang menjadi keperluan kompetensi utama bagi menghadapi Industri 4.0 (Looi, 2025). Autonomi pelajar dalam mengurus sumber digital juga berkait rapat dengan kebolehpasaran kerja yang menuntut pembelajaran sepanjang hayat (OECD, 2024). Faktor input strategik merangkumi:

- Literasi Digital & AI: Generative AI (seperti ChatGPT dan Gemini) berperanan sebagai scaffolding digital di mana Ahmad et al. (2024) mendapati AI membantu pelajar TVET mengenal pasti kelemahan teknikal secara masa nyata. Penggunaan AI meningkatkan keberkesanan pembelajaran, namun memerlukan literasi tinggi bagi mengelakkan kebergantungan berlebihan (Shamsudin et al., 2023; Nikonova et al., 2025).
- Teknologi Imersif (XR): Penggunaan VR dan AR melalui simulasi digital membolehkan pelajar berlatih praktikal berulang kali tanpa risiko keselamatan (Zheng dan Chen, 2025).
- Sokongan Institusi: Walaupun maju, *Digital Inequality* akibat perbezaan geografi (Alias, 2024) meletakkan kestabilan infrastruktur sebagai faktor penentu utama kejayaan inisiatif digital.

2.3 Faktor Input: Pemacu Strategik Pembelajaran Digital

Berdasarkan integrasi Model IPO oleh Richey et al. (2011) dengan Teori Bandura, kerangka ini memetakan hubungan pemboleh ubah secara sistemik:

- Pemboleh Ubah Tidak Bersandar (IV - Input): Merangkumi Literasi Digital (IVa) dan Sokongan Institusi (IVb) sebagai faktor pemacu tingkah laku.
- Pemboleh Ubah Perantara (MV - Proses): Efikasi Kendiri Digital bertindak sebagai 'enjin' psikologi yang menukarkan input kepada amalan nyata. Asojan dan Omar (2024) membuktikan korelasi kuat konstruk ini dalam TVET, manakala Ismail et al. (2025) menekankan peranannya sebagai mediator kritikal bagi menjamin kelestarian penggunaan teknologi.
- Pemboleh Ubah Bersandar (DV - Output): Amalan Pembelajaran Kendiri Digital (APD) merupakan tingkah laku akhir yang dikaji.

Secara konseptual, model ini mencadangkan bahawa faktor input tidak hanya memberi kesan langsung, malah bertindak secara tidak langsung melalui efikasi kendiri sebagai mediator rujuk Rajah 2.

3.0 METODOLOGI PENYELIDIKAN

3.1 Rekabentuk Kajian

Kajian kuantitatif ini menggunakan reka bentuk tinjauan rentas keratan (*cross-sectional survey*) untuk meneroka hubungan antara pemboleh ubah yang dikaji. Populasi melibatkan 141 pelajar daripada program STM, SKE, STS, dan DTS di Kolej Komuniti Segamat 2. Kajian rintis ke atas 30 responden telah dilaksanakan terlebih dahulu, yang menunjukkan tahap kebolehpercayaan yang sangat baik dengan nilai Cronbach's Alpha antara 0.872 hingga 0.902.

3.2 Instrumen Penyelidikan

Instrumen kajian terdiri daripada borang soal selidik yang mengandungi 20 item secara keseluruhan (5 item bagi setiap konstruk). Pengukuran menggunakan Skala Likert 5-mata bermula daripada nilai 1 (Sangat Tidak Setuju) hingga 5 (Sangat Setuju). Kesahan penumpuan (*convergent validity*) instrumen dipastikan melalui nilai *Average Variance Extracted (AVE*) melebihi 0.50 dan *Composite Reliability (CR*) melebihi 0.70 merujuk kepada kriteria Hair et al. (2019).

3.3 Analisis Data

Data dianalisis menggunakan perisian JASP untuk menilai model pengukuran dan model struktural melalui pendekatan Structural Equation Modeling (SEM). Tahap kecenderungan konstruk dinilai berdasarkan interpretasi skor min yang dibahagikan kepada tiga tahap: Rendah (1.00–2.33), Sederhana (2.34–3.66), dan Tinggi (3.67–5.00) (Nor Syazwanie et al., 2022). Ujian hipotesis dilaksanakan dengan menilai pekali laluan (β), nilai-p, serta kesan mediasi melalui prosedur bootstrapping dengan 5,000 sampel. Kesesuaian model (model fit) dinilai berdasarkan indeks berikut:

- *Comparative Fit Index* (CFI)
- *Tucker-Lewis Index* (TLI)
- *Root Mean Square Error of Approximation* (RMSEA)

- *Standardized Root Mean Square Residual* (SRMR)

4.0 DAPATAN KAJIAN

4.1 Analisis Deskriptif dan Kebolehpercayaan

Analisis deskriptif digunakan untuk menentukan tahap kecenderungan responden bagi setiap konstruk, manakala analisis kebolehpercayaan dilakukan bagi memastikan konsistensi dalaman instrumen kajian. Data lengkap dirumuskan dalam Jadual 1 di bawah:

Jadual 1: Analisis Deskriptif, Kesahan dan Kebolehpercayaan Konstruk (N=141)

Konstruk (Kod)	Bil. Item	Min	Sisihan Piawai	Cronbach 's Alpha	*Composite Reliability* (CR)	Tahap
Literasi Digital (LD)	5	4.27	0.61	0.885	0.925	Tinggi
Sokongan Pensyarah & Infrastruktur (SI)	5	4.14	0.67	0.872	0.890	Tinggi
Efikasi Kendiri Digital (EK)	5	4.15	0.58	0.894	0.941	Tinggi
Amalan Pembelajaran Kendiri Digital (APD)	5	4.09	0.63	0.902	0.941	Tinggi

Jadual 1 menunjukkan literasi digital (Min=4.27) adalah konstruk tertinggi, manakala semua nilai Alpha (p =>0.80) membuktikan instrumen adalah konsisten. Kesemua konstruk berada pada tahap Tinggi, mencerminkan kesediaan pelajar dalam melaksanakan amalan pembelajaran kendiri digital secara efektif.

4.2 Penilaian Model Pengukuran

Berdasarkan kriteria Hair et al. (2019), model pengukuran ini memenuhi syarat kesahan penumpuan dengan nilai CR melebihi 0.70 dan nilai AVE yang memuaskan. Analisis kesesuaian model menunjukkan nilai Comparative Fit Index (CFI) sebanyak 0.828 dan SRMR sebanyak 0.108.

4.3 Ujian Hipotesis (Analisis Model Struktural)

Analisis model struktur dilakukan untuk menguji kekuatan hubungan antara pemboleh ubah melalui nilai pekali laluan (β) dan tahap signifikan (p-value). Kekuatan hubungan ditafsirkan berdasarkan kriteria: $\beta < 0.30$ (lemah), $0.30 \leq \beta < 0.60$ (sederhana), dan $\beta \geq 0.60$ (kuat) (Cohen, 1988). Keputusan ujian hipotesis bagi kesan langsung dan kesan mediasi diperincikan dalam Jadual 2.

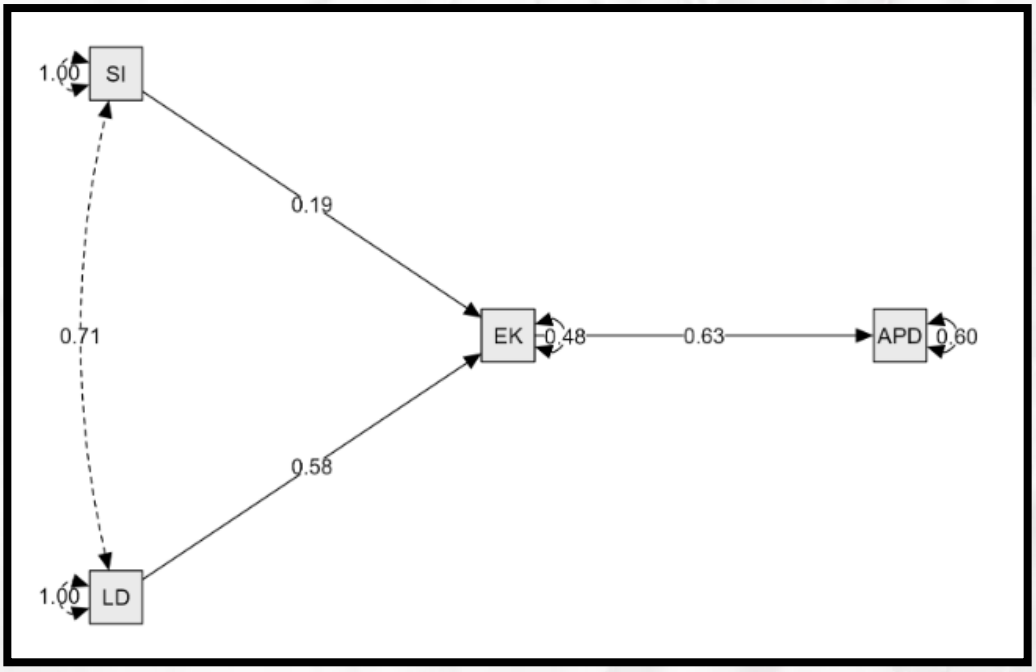
Analisis membuktikan Efikasi Kendiri (EK) adalah pemacu terkuat (H3: β =0.633) dan bertindak sebagai mediator yang signifikan bagi kedua-dua hubungan (H4a & H4b). Walaupun pengaruh sokongan institusi terhadap amalan melalui efikasi kendiri (H4b) adalah kecil, ia tetap signifikan secara statistik (p=0.024), mengukuhkan peranan efikasi kendiri sebagai "enjin psikologi" yang menggerakkan tingkah laku autonomi pelajar.

Jadual 2: Rumusan Keputusan Ujian Hipotesis Model Struktural (SEM)

Hipotesis	Hubungan Laluan	Pekali laluan (β)	Nilai *P*	Kekuatan	Keputusan
H1	literasi digital → efikasi kendiri	0.578	< 0.001	sederhana	Disokong
H2	sokongan pensyarah & infrastruktur →efikasi kendiri	0.188	0.021	lemah	Disokong
H3	efikasi kendiri → amalan D-SDL	0.633	< 0.001	kuat	Disokong
H4a	LD → EK → Amalan D-SDL	0.366	< 0.001	sederhana	Disokong
H4b	SI → EK →Amalan D-SDL	0.119	0.024	lemah	Disokong

4.4 Analisis Model Struktural

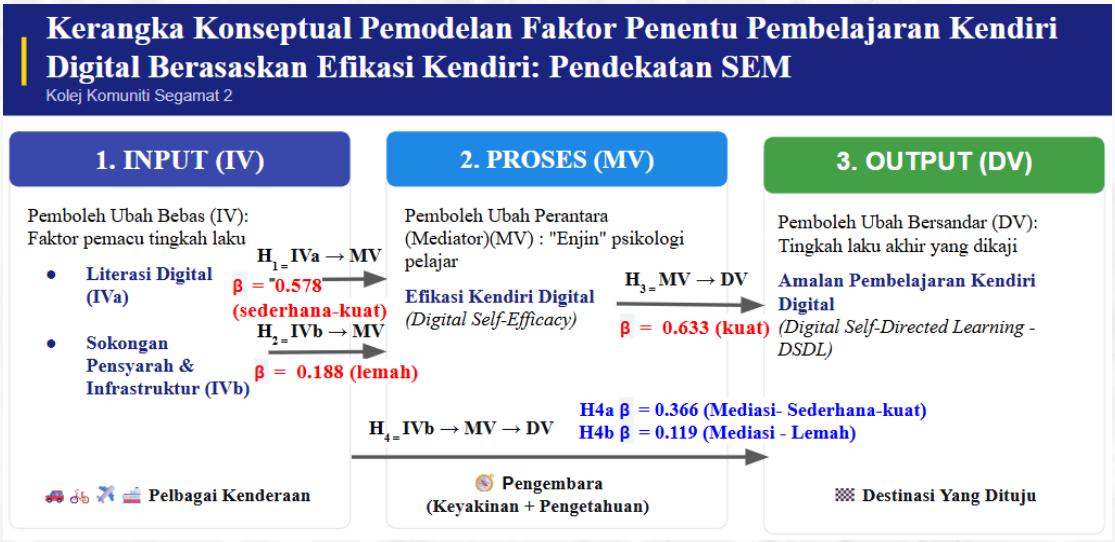
Rajah 1 memaparkan model struktural dengan pekali laluan piawai yang menunjukkan korelasi kuat antara Sokongan Institusi (SI) dan Literasi Digital (LD) (β =0.71). Secara langsung, LD mempunyai pengaruh sederhana-kuat terhadap Efikasi Kendiri (EK) (β =0.58), manakala SI menunjukkan pengaruh yang lemah (β =0.19). EK dikesan sebagai peramal utama yang paling dominan terhadap Amalan Pembelajaran Digital (APD) dengan nilai β =0.63. Secara keseluruhan, model ini mengesahkan bahawa kompetensi personal (LD) memainkan peranan lebih besar dalam membina keyakinan pelajar berbanding sokongan luaran (SI).



Rajah 1: Model Struktural dengan Pekali Laluan Piawai

4.5 Hasil Analisis Kerangka Konseptual

Rajah 2 merumuskan hasil analisis kerangka konseptual yang membuktikan Literasi Digital (LD) sebagai pemacu utama Efikasi Kendiri (EK) (β =0.578) berbanding pengaruh minimum daripada Sokongan Institusi (SI) β =0.188). Dalam fasa output, EK dikenal pasti sebagai faktor paling dominan dalam menentukan Amalan Pembelajaran Kendiri Digital (D-SDL) (β =0.633). Analisis mediasi turut mengesahkan peranan signifikan EK sebagai pengantara bagi hubungan LD (β =0.366, β <0.001) dan SI (β =0.119, β =0.024) terhadap amalan pembelajaran. Dapatan ini membuktikan bahawa transformasi digital pelajar sangat bergantung kepada pengukuhan "enjin psikologi" (EK) untuk menterjemah kemahiran teknikal dan sokongan infrastruktur kepada tingkah laku autonomi yang nyata.



Rajah 2: Hasil Analisis Kerangka Konseptual Permodelan Faktor Penentu Pembelajaran Kendiri Digital Berasaskan Efikasi Kendiri

5.0 PERBINCANGAN PENYELIDIKAN

5.1 Efikasi Kendiri Digital sebagai 'Enjin' Utama(H3)

Dapatan mengesahkan Efikasi Kendiri (EK) sebagai pemacu paling dominan terhadap Amalan Pembelajaran Kendiri Digital (APD) dengan pekali laluan yang kuat (β =0.633, p<0.001). Hal ini selari dengan Teori Bandura (1997) dan dapatan Zimmerman (2002) di mana keyakinan diri menentukan tahap usaha, ketekalan, serta menjadi peramal terbaik kepada tingkah laku pembelajaran kendiri. Pelajar yang mempunyai EK tinggi lebih bersedia dari aspek kognitif dan motivasi untuk mengurus pembelajaran mereka secara bebas, selari dengan pandangan Garrison (1997).

5.2 Pengaruh Literasi dan Sokongan terhadap Efikasi (H1 & H2)

Literasi Digital (LD) mempunyai pengaruh signifikan yang lebih besar terhadap EK (β =0.578) berbanding Sokongan Institusi (SI) (β =0.188). Ini membuktikan penguasaan teknikal dan kecekapan menilai maklumat adalah asas utama pembentukan keyakinan diri, menyokong kajian Hatlevik et al. (2018). Walaupun pengaruh SI lebih lemah, ia tetap signifikan (β =0.021), yang mengukuhkan kajian Al-Rahmi et al. (2018) bahawa sokongan infrastruktur teknologi

adalah komponen kritikal bagi meningkatkan keyakinan pelajar terhadap penggunaan teknologi.

5.3 Peranan Mediasi Efikasi Kendiri (H4a & H4b)

EK terbukti sebagai mediator yang signifikan bagi hubungan antara Literasi Digital dan Amalan DSDL (H4a: $\beta = 0.366$, $p < 0.001$). Ini bermakna, kemahiran teknikal memerlukan intervensi psikologi (keyakinan) untuk diterjemahkan kepada amalan nyata. Dapatan ini menyokong pandangan Pintrich (2004) bahawa aspek afektif seperti efikasi kendiri dan motivasi adalah komponen penting yang membolehkan pelajar tidak lagi bergantung kepada bimbingan pensyarah semata-mata.

5.4 Implikasi Penyelidikan

- Pentadbir: Pembangunan EK perlu menjadi keutamaan strategik melalui program bimbingan rakan sebaya dan latihan digital berperingkat, bukan sekadar penyediaan infrastruktur.
- Pensyarah: Perlu memberikan ruang autonomi untuk meneroka sumber digital secara bebas serta menyediakan maklum balas membina bagi memupuk daya tahan digital pelajar.
- Infrastruktur: Pihak kolej perlu menjamin kestabilan capaian WiFi secara menyeluruh bagi mengelakkan gangguan pada momentum pembelajaran kendiri pelajar.

6.0 KESIMPULAN

Bagi memastikan kelestarian ekosistem digital di Kolej Komuniti Segamat 2, pelan tindakan strategik berikut dicadangkan berdasarkan hasil pemodelan SEM:

Jadual 3: Pelan Tindakan Strategik Pembelajaran Digital

Fokus Strategik	Cadangan Tindakan	Justifikasi (Dapatan Kajian)
Pengukuhan Infrastruktur	Menstabilkan capaian Wi-Fi di seluruh kawasan kolej dan makmal.	Memenuhi keperluan kritikal responden untuk akses tanpa gangguan (Min SI=4.14).
Pembangunan Efikasi	Melaksanakan program peer mentoring dan tugasan berperingkat (scaffolding).	EK adalah peramal paling kuat terhadap amalan pembelajaran ($\beta = 0.633$).
Inovasi Pedagogi	Memperbanyak modul interaktif mandiri dan pendedahan kepada alatan Generative AI.	Tahap literasi pelajar yang tinggi (Min=4.27) memerlukan platform yang lebih mencabar.
Literasi Holistik	Bengkel keselamatan data, etika AI, dan penilaian kredibiliti sumber digital.	Literasi digital menyumbang secara langsung kepada peningkatan EK ($\beta = 0.578$).

Kajian membuktikan bahawa Efikasi Kendiri Digital merupakan faktor paling dominan dalam membentuk Amalan Pembelajaran Kendiri Digital (D-SDL) di Kolej Komuniti Segamat 2. Bertindak sebagai 'enjin psikologi', keyakinan diri menjadi penentu utama sama ada kemahiran teknikal dan sokongan persekitaran dapat diterjemahkan kepada tingkah laku pembelajaran autonomi yang nyata.

Dapatan ini menunjukkan bahawa tanpa elemen efikasi yang kukuh, tahap literasi digital yang tinggi mahupun sokongan institusi yang memadai masih tidak mencukupi untuk menjamin kelestarian pembelajaran kendiri yang konsisten. Oleh itu, pelaksanaan intervensi bersepadu yang menggabungkan pengukuhan infrastruktur, pembangunan efikasi, penyediaan modul interaktif, dan peningkatan literasi holistik adalah kritikal bagi membina ekosistem digital yang kondusif serta melahirkan graduan TVET yang berdikari, berkeyakinan, dan bersedia mendepani cabaran pendidikan abad ke-21.

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TAHAP PEMAHAMAN DAN AMALAN INTEGRITI DALAM KALANGAN PELAJAR KOLEJ KOMUNITI PAYA BESAR, GAMBANG KUANTAN, PAHANG

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Abstrak

Kajian ini bertujuan untuk mengkaji tahap pemahaman dan amalan integriti dalam kalangan pelajar Kolej Komuniti Paya Besar, Gambang Kuantan, Pahang. Integriti merupakan elemen penting dalam pembentukan sahsiah pelajar sebagai bakal tenaga kerja yang beretika dan bertanggungjawab. Walaupun pelbagai inisiatif dan kursus berkaitan integriti telah diperkenalkan di institusi pendidikan tinggi, tahap pemahaman dan pengamalan nilai integriti dalam kalangan pelajar masih perlu dinilai secara empirikal. Kajian ini menggunakan pendekatan kuantitatif dengan kaedah soal selidik sebagai instrumen pengumpulan data berasaskan skala Likert lima mata, dan data yang diperolehi menggunakan statistik deskriptif dengan menggunakan IBM SPSS Statistics versi 26.0. Responden kajian terdiri daripada 37 orang pelajar sijil di Kolej Komuniti Paya Besar yang dipilih melalui kaedah persampelan rawak mudah. bagi menentukan tahap pengetahuan dan amalan integriti pelajar, serta cadangan penambahbaikan bagi memperkasakan integriti itu sendiri. Hasil dapatan kajian ini menunjukkan bahawa tahap pemahaman pelajar adalah tinggi (min = 3.68 hingga 4.73). Manakala tahap amalan integriti mencatatkan tahap tinggi (min = 3.89 hingga 4.65). Meskipun tahap pemahaman dan amalan integriti tinggi, namun adanya jurang dalam aspek keberanian melaporkan salah laku rakan sebaya (min = 3.89), yang menunjukkan keperluan budaya keberanian moral yang lebih telus. Kajian ini diharapkan dapat memberikan gambaran jelas mengenai tahap integriti pelajar serta membantu pihak pengurusan Kolej Komuniti dalam merangka strategi penambahbaikan bagi memperkukuh pembudayaan nilai integriti dalam kalangan mereka. Impilkasi kajian mencadangkan pengukuhan kesedaran dan pendekatan holistik amat penting melahirkan graduan TVET yang bukan sahaja cemerlang dalam kemahiran teknikal, malah mantap sahsiahnya sebagai tonggak integriti negara.

Kata Kunci: Integriti, Pemahaman, Amalan Integriti, Pelajar Kolej Komuniti

Abstract

This study aims to examine the level of understanding and practice of integrity among students of Paya Besar Community College, Gambang Kuantan, Pahang. Integrity is an important element in shaping students' personalities as future ethical and responsible workforce. Although various initiatives and courses related to integrity have been introduced in higher education institutions, the level of understanding and practice of integrity values among students still needs to be assessed empirically. This study uses a quantitative approach with a questionnaire as a data collection instrument based on a five-point Likert scale, and the data obtained using descriptive statistics using IBM SPSS Statistics version 26.0. The study respondents consisted of 37 certificate students at Paya Besar Community College who were selected through simple random sampling. to determine the level of knowledge and practice of students' integrity, as well as suggestions for improvement to strengthen integrity itself. The findings of this study show that the level of understanding of students is high (mean = 3.68 to 4.73). While the level of practice of integrity recorded a high level (mean = 3.89 to 4.65). Despite the high level of understanding and practice of integrity, there is a gap in the aspect of courage to report peer misconduct (mean = 3.89), which indicates the need for a more transparent culture of moral courage. This study is expected to provide a clear picture of the level of integrity of students and assist the management of Community Colleges in formulating improvement strategies to strengthen the culture of integrity values among them. The implications of the study suggest that strengthening awareness and a holistic approach are very important in producing TVET graduates who are not only excellent in technical skills, but also have strong personalities as pillars of national integrity.

Keywords: *Integrity, Understanding, Integrity Practice, Community College Students*

1.0 PENGENALAN

Integriti merupakan nilai teras dalam pembentukan sahsiah individu yang beretika dan bertanggungjawab. Dalam konteks masyarakat moden, integriti bukan sahaja diperlukan dalam kehidupan peribadi tetapi juga dalam sektor profesional dan sistem pendidikan. Manakala dalam konteks pelajar, integriti merangkumi kejujuran akademik, ketelusan dalam tindakan, dan keikhlasan dalam menjalankan tanggungjawab sebagai penuntut ilmu. Menurut kajian-kajian lepas, integrity bukan sekadar pengetahuan tentang apa yang betul, tetapi keupayaan untuk bertindak betul walaupun tanpa pengawasan. Kolej Komuniti sebagai institusi pendidikan teknikal dan vokasional turut menggalakkan pembudayaan nilai integriti sebagai asas kepada profesionalisme graduan masa depan.

Dalam konteks pendidikan tinggi, penerapan nilai integriti amat penting bagi melahirkan graduan yang bukan sahaja berkemahiran tetapi juga mempunyai nilai moral yang tinggi. Pelajar kolej komuniti khususnya merupakan bakal tenaga kerja dalam sektor awam dan swasta yang berpotensi terdedah kepada cabaran integriti. Oleh itu, tahap pemahaman dan amalan integriti dalam kalangan pelajar perlu diberi perhatian serius.

1.1 Penyataan Masalah

Walaupun pelbagai usaha telah dilaksanakan untuk menerapkan nilai integriti dalam sistem pendidikan, masih terdapat isu berkaitan tingkah laku tidak berintegriti seperti penipuan akademik dan kurangnya kesedaran etika. Tahap pemahaman pelajar mengenai integriti tidak semestinya mencerminkan amalan sebenar dalam kehidupan seharian. Namun begitu, kajian khusus berkaitan tahap pengetahuan dan amalan integriti dalam kalangan pelajar Kolej Komuniti Paya Besar masih terhad. Justeru, kajian ini dijalankan untuk mengisi jurang tersebut.

1.2 Objektif Kajian

Kajian ini bertujuan untuk:

a) Mengenal pasti tahap pemahaman integriti dalam kalangan pelajar Kolej Komuniti Paya Besar (KKPB).
b) Menilai tahap amalan integriti dalam kalangan pelajar tersebut.
c) Menganalisis strategi dan cadangan dan penambahbaikan bagi memperkasakan amalan integriti dalam kalangan pelajar.

1.3 Kepentingan Kajian

Kajian ini memberikan gambaran jelas mengenai tahap integriti pelajar kolej komuniti dan sangat sesuai untuk:

Pelajar: Meningkatkan kesedaran diri tentang kepentingan amanah dan tanggungjawab dalam setiap tindakan.

Pihak Pengurusan Kolej: Sebagai asas untuk merangka program nilai murni atau kursus watak yang lebih berkesan.

Masyarakat: Melahirkan graduan yang bukan sahaja mahir teknikal (TVET), tetapi juga mempunyai moral yang tinggi.

Dapatan kajian juga boleh membantu pihak pengurusan kolej komuniti menilai keberkesanan penerapan nilai integriti serta merangka program penambahbaikan yang lebih berkesan.

2.0 SOROTON KAJIAN

Kajian oleh Ahmad et al. (2021) terhadap pelajar institusi teknikal mendapati bahawa tahap pemahaman pelajar terhadap integriti secara umum adalah tinggi, namun pemahaman terhadap integriti akademik secara spesifik masih berada pada tahap sederhana. Pelajar sering kali keliru dalam membezakan antara amalan bekerjasama dalam kumpulan dengan perbuatan meniru tugasan rakan. Hal ini menunjukkan perlunya pendedahan yang lebih mendalam mengenai garis panduan integriti di peringkat kolej.

Menurut kajian Siti & Hassan (2022), amalan integriti dalam kalangan pelajar dipengaruhi secara signifikan oleh disiplin kendiri. Kajian tersebut mendapati bahawa pelajar yang mempunyai tahap kesedaran sivik yang tinggi cenderung untuk lebih jujur dalam peperiksaan dan menepati masa kuliah. Walau bagaimanapun, cabaran utama dalam amalan integriti masa

kini adalah penyalahgunaan teknologi maklumat, di mana kecenderungan untuk memplagiat bahan dari internet tanpa rujukan yang betul semakin meningkat (Zulkifli, 2023).

Penyelidikan oleh Mohd Nazri (2020) menekankan bahawa persekitaran kampus dan kepimpinan institusi memainkan peranan kritikal. Di Kolej Komuniti, penerapan nilai-nilai murni melalui kurikulum dan aktiviti kokurikulum didapati membantu meningkatkan sahsiah pelajar. Kajian ini menyokong teori bahawa amalan integriti bukan sahaja lahir daripada kesedaran individu, tetapi juga dibentuk melalui budaya organisasi yang menekankan ketelusan dan akauntabiliti.

Penyelidikan oleh Ahmad & Ismail (2023) terhadap pelajar institusi pengajian tinggi di Malaysia mendapati bahawa tahap pemahaman pelajar terhadap integriti adalah tinggi pada peringkat teori, namun mencabar pada peringkat amalan. Isu-isu seperti plagiarisme dan ketepatan masa sering menjadi kayu ukur utama dalam menilai sejauh mana pelajar mempraktikkan nilai integriti yang telah dipelajari dalam kuliah atau kursus pendek.

Satu dapatan menarik dalam kajian Lee (2019) menunjukkan wujudnya "jurang integriti" di mana pelajar yang mendapat skor tinggi dalam ujian pengetahuan moral tidak semestinya menunjukkan amalan integriti yang konsisten dalam situasi sebenar. Faktor tekanan rakan sebaya dan desakan untuk mengejar gred cemerlang dikenal pasti sebagai punca utama mengapa amalan integriti sering diketepikan walaupun pelajar mempunyai pemahaman yang baik tentangnya.

3.0 METODOLOGI KAJIAN

Dalam metodologi kajian ini akan membincangkan tentang kajian mengikut kaedah atau instrumen yang sesuai. Kajian ini digunakan bagi mencapai objektif kajian iaitu mengenal pasti tahap pemahaman, menilai amalan integriti, serta menganalisis strategi memperkasakan integriti di Kolej Komuniti Paya Besar. Berikut adalah komponen utama metodologi bagi kajian ini ialah:

3.1 Reka Bentuk Kajian

Kajian ini menggunakan pendekatan kuantitatif berbentuk tinjauan (*survey*) bagi mengkaji tahap pemahaman dan amalan integriti dalam kalangan pelajar Kolej Komuniti Paya Besar. Pendekatan ini dipilih kerana ia sesuai untuk mengumpul data dalam bentuk numerik serta membolehkan analisis statistik dijalankan secara sistematik. Kajian ini juga bersifat keratan rentas (*cross-sectional*) kerana data ini dapat dikumpul sekali sahaja daripada responden melalui borang soal selidik yang berkaitan.

3.2 Populasi dan Sampel

Populasi kajian ini merangkumi keseluruhan pelajar sepenuh masa yang sedang mengikuti pengajian di Kolej Komuniti Paya Besar, Gambang, Kuantan. Populasi ini dipilih kerana mereka merupakan golongan sasaran yang terlibat secara langsung dengan budaya akademik dan persekitaran integriti di kolej tersebut. Manakala sampel kajian ini melibatkan seramai 37

orang pelajar sijil yang dipilih daripada pelbagai program dari latar belakang akademik yang berbeza. Pemilihan responden dilakukan menggunakan teknik persampelan rawak mudah (*simple random sampling*), di mana setiap pelajar mempunyai peluang yang sama untuk dipilih sebagai responden. Teknik ini digunakan bagi meminimumkan bias dalam pemilihan sampel seterusnya memastikan data yang diperolehi dapat menggambarkan tahap pemahaman dan amalan integriti yang sebenar dalam kalangan pelajar.

3.2.1 Instrumen Kajian

Ia menggunakan kaedah borang soal selidik yang dibahagikan kepada empat (4) bahagian:

- **Bahagian A**: Demografi (Jantina, Umur, Pengajian).
- **Bahagian B**: Tahap Pengetahuan Integriti (Menggunakan Skala Likert 5 mata; daripada 1 = Sangat Tidak Setuju hingga 5 = Sangat Setuju).
- **Bahagian C**: Tahap Amalan Integriti (Menggunakan Skala Likert 5 mata; daripada 1 Sangat Tidak Setuju hingga 5 = Sangat Setuju).
- **Bahagian D**: Cadangan Penambahbaikan

3.3 Analisa Data

Data yang dikumpul melalui soal selidik akan diproses dan dianalisis menggunakan perisian *Statistical Package for the Social Sciences* (SPSS) versi 26.0. Analisis kajian dijalankan dengan cara data diambil daripada responden melalui borang soal selidik dan akan dianalisis dalam bentuk analisis deskriptif iaitu melibatkan kekerapan, peratusan, dan skor min. Tujuan analisis secara kekerapan dan peratusan digunakan untuk melihat taburan demografi responden tersebut.

Jadual 1: Interprestasi skor min

Skor Min	Interprestasi (Tahap)
1.00 hingga 2.33	Rendah
2.34 hingga 3.66	Sederhana
3.67 hingga 5.00	Tinggi

Manakala tahap pemahaman dan amalan integriti responden ditentukan berdasarkan interpretasi skor min yang ditetapkan dalam Jadual 1 (Nor Syazwanie binti Mohamad Zainal N.H., 2022), dengan skor min 5.00 menunjukkan tahap tinggi. Melalui persembahan jadual, perbandingan nilai min antara item dan kategori dapat dilakukan dengan lebih tepat, sekali gus membantu pengkaji mengecam jurang prestasi atau titik kelemahan dalam tahap amalan integriti pelajar.

4.0 DAPATAN KAJIAN

4.1 Analisis Demografi

Analiss demografi menunjukkan bahawa sampel kajian terdiri daripada 37 orang responden. Berdasarkan hasil dapatan kajian bahawa majoriti responden adalah lelaki (64.9%) berbanding perempuan (35.1%). Dari segi umur, kebanyakan responden berumur 18 hingga 19 tahun (86.5%). Dari aspek program pengajian, majoriti adalah daripada Sijil Teknologi Maklumat

(54.1%), diikuti Sijil Teknologi Elektrik (32.4%) dan Sijil Multimedia Kreatif (13.5%). Selain itu, sebanyak 75.7% responden pernah mengikuti kursus atau pendedahan berkaitan integriti, manakala 24.3% tidak pernah.

4.2 Tahap Pemahaman Integriti

Dapatan menunjukkan bahawa tahap pemahaman integriti dalam kalangan pelajar adalah tinggi. Majoriti responden memahami maksud integriti, mengetahui contoh perlakuan berintegriti serta menyedari kesan negatif rasuah. Selain itu, pelajar juga mengetahui peraturan berkaitan salah laku akademik dan memahami bahawa meniru adalah perbuatan tidak berintegriti. Mereka juga sedar tentang kepentingan integriti dalam dunia pekerjaan serta mengetahui saluran untuk melaporkan salah laku. Walau bagaimanapun, terdapat sebilangan kecil responden yang masih tidak pasti dalam beberapa aspek, menunjukkan masih terdapat ruang untuk penambahbaikan.

Jadual 2: Tahap Pemahaman Integriti

Kod	Item Penilaian	Nilai Min	Interpretasi
B1	Saya memahami maksud integriti dengan jelas.	4.49	Tinggi
B2	Saya tahu contoh perlakuan berintegriti dalam kehidupan seharian.	4.54	Tinggi
B3	Saya memahami kesan negatif rasuah terhadap masyarakat dan negara.	4.70	Tinggi
B4	Saya mengetahui peraturan berkaitan salah laku akademik.	4.59	Tinggi
B5	Saya sedar meniru peperiksaan adalah tidak berintegriti.	3.68	Tinggi
B6	Saya memahami kepentingan integriti dalam dunia kerja.	4.73	Tinggi
B7	Saya mengetahui saluran melapor salah laku integriti.	4.59	Tinggi
B8	Saya faham integriti merangkumi jujur, amanah & tanggungjawab	4.73	Tinggi

Tahap pengetahuan integriti pelajar KKPB (Item B1) berada pada tahap tinggi (min 4.49). Dengan pengetahuan ini (Item B4, B6 dan B8) di mana skor min untuk aspek peraturan, kepentingan integriti serta konsep asasnya (kejujuran, amanah, dan tanggungjawab) (Item B7) berada dalam julat 4.59 hingga 4.73. Selain itu, pelajar mempunyai kesedaran yang mendalam mengenai kesan negatif rasuah (Item B3) dan tahu saluran pelaporan yang betul (Item B7) juga berada dalam julat iaitu 3.68 hingga 4.59) dengan skor interprestasi yang tinggi. Secara keseluruhan, ini menunjukkan asas pengetahuan pelajar Kolej Komuniti Paya Besar tentang integriti adalah amat baik.

4.3 Tahap Amalan Integriti

Dapatan kajian menunjukkan bahawa tahap amalan integriti dalam kalangan pelajar Kolej Komuniti Paya Besar secara keseluruhan berada pada tahap tinggi (Min = 4.42) berdasarkan Jadual 3 berikut:

Jadual 3: Tahap Amalan Integriti

Kod	Item Penilaian	Nilai Min	Interpretasi
C1	Saya sentiasa jujur dalam menyiapkan tugasan tanpa meniru rakan	4.38	Tinggi
C2	Saya tidak akan menggunakan bahan atau maklumat orang lain tanpa kredit (plagiat)	4.32	Tinggi
C3	Saya hadir ke kelas tepat pada masa yang ditetapkan	4.38	Tinggi
C4	Saya memulangkan harta kolej atau rakan yang dipinjam dalam keadaan baik	4.54	Tinggi
C5	Saya tidak terlibat dengan sebarang aktiviti tidak berintegriti di kolej	4.62	Tinggi
C6	Saya melaporkan salah laku yang saya saksikan kepada pihak berkuasa kolej	3.89	Tinggi
C7	Saya mematuhi peraturan dan etika berpakaian kolej	4.65	Tinggi
C8	Saya menunjukkan sikap amanah dalam menguruskan wang atau aset kolej	4.54	Tinggi

Tahap amalan integriti dalam kalangan pelajar (Item C1, C7 dan C8) dapat dilihat dari segi dan sikap jujur, amanah dan mematuhi peraturan berada dalam julat iaitu 4.38 hingga 4.65. Pelajar juga tidak melakukan plagiat dan tidak terlibat dalam aktiviti tidak berintegriti (Item C2 dan C5) dengan nilai min antara 4.32 hingga 4.62. Selain itu, pelajar tahu melaporkan sebarang salah laku Item C6) mencatatkan nilai min iaitu 3.89. Meskipun nilainya masih dalam julat yang baik, jurang yang agak besar berbanding item lain menunjukkan bahawa pelajar mungkin berasa kurang selesa atau teragak-agak untuk menjadi pemberi maklumat (*whistleblower*) walaupun mereka sendiri mengamalkan integriti.

Secara keseluruhannya, pelajar Kolej Komuniti Paya Besar menunjukkan komitmen yang kukuh terhadap amalan integriti, terutamanya dalam aspek disiplin peribadi dan etika akademik. Pihak kolej boleh memanfaatkan dapatan ini untuk mengukuhkan budaya integriti, khususnya dalam membina keyakinan pelajar untuk melaporkan salah laku bagi menyokong persekitaran kampus yang lebih telus.

4.4 Cadangan Penambahbaikan

Analisis terhadap 37 responden mengenai cadangan dalam meningkatkan amalan integriti di Kolej Komuniti Paya Besar dapat dikategorikan kepada empat tema utama seperti yang ditunjukkan dalam Jadual 4.

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Jadual 4: Analisis Cadangan Langkah Meningkatkan Integriti Pelajar

Tema	**Hasil Dapatan Responden**
Program Kesedaran dan Pendidikan	Mengadakan ceramah, kempen, bengkel, tayangan video kesedaran, dan kursus integriti
Penguatkuasaan dan Disiplin	Tindakan tegas terhadap salah laku, penguatkuasaan peraturan yang lebih ketat, dan konsisten setiap tindakan
Peranan Teladan dan Budaya	Pensyarah sebagai menjadi contoh teladan (*role model*), sokongan rakan sebaya, dan pembentukan budaya integriti secara menyeluruh.
Pengiktirafan dan Motivasi	Memberikan penghargaan atau anugerah kepada pelajar yang menunjukkan sahsiah dan integriti yang tinggi.

Secara keseluruhannya, pelajar Kolej Komuniti Paya Besar sedar akan kepentingan integriti. Untuk meningkatkan amalan ini, pihak kolej disyorkan untuk tidak hanya bergantung kepada tindakan disiplin (*punitive*), tetapi perlu beralih kepada pendekatan membina budaya (*nurturing)* melalui pemberian anugerah sahsiah dan memperkasakan peranan pensyarah sebagai mentor utama di dalam kelas."

5.0 PERBINCANGAN

Kajian ini melibatkan 37 responden yang didominasi oleh pelajar lelaki (64.9%) dalam lingkungan umur 18 hingga 19 tahun (86.5%). Dominasi pelajar daripada program Sijil Teknologi Maklumat (54.1%) memberikan perspektif penting kerana bidang ini sangat terdedah kepada isu etika siber dan integriti akademik. Dari aspek pendedahan, majoriti responden (75.7%) pernah mengikuti kursus integriti, membuktikan inisiatif kolej telah mencapai sasaran utama. Walau bagaimanapun, baki 24.3% yang belum pernah mendapat pendedahan tersebut menunjukkan masih terdapat jurang yang perlu diatasi. Secara keseluruhannya, profil responden ini membuktikan bahawa integriti merupakan nilai asas yang perlu diterapkan secara inklusif merentas semua program pengajian bagi membentuk sahsiah pelajar yang holistik sebelum mereka menamatkan pengajian.

Manakala tahap pemahaman integriti pelajar berada pada tahap tinggi (Min = 4.58). Pelajar menunjukkan pemahaman yang sangat matang mengenai kepentingan integriti dalam dunia kerjaya (B6, Min 4.73) serta nilai teras seperti jujur dan amanah (B8, Min 4.73). Pendedahan mengenai bahaya rasuah (B3, Min 4.70) dan saluran aduan (B7, Min 4.59) juga difahami dengan baik oleh majoriti responden. Walau bagaimanapun, item B5 (Kesedaran meniru peperiksaan tidak berintegriti, Min 3.68) mencatatkan nilai terendah. Walaupun masih pada tahap tinggi, jurang skor ini menunjukkan adanya "zon kelabu" dalam perspektif pelajar terhadap salah laku akademik. Ini mencadangkan bahawa fokus intervensi pada masa hadapan perlu beralih daripada sekadar definisi teori kepada pembinaan ketahanan diri (moral resilience). Langkah ini bertujuan untuk memupuk keberanian dalam diri pelajar agar mereka mampu memilih jalan yang benar dan menolak sebarang perlakuan tidak berintegriti dalam apa jua situasi.

Bagi tahap amalan integriti pelajar berada pada tahap tinggi (Min = 4.42). Pelajar menunjukkan disiplin yang kukuh dalam pematuhan etika berpakaian (C7, Min 4.65) dan integriti peribadi (C5, Min 4.62). Nilai tinggi ini membuktikan bahawa pelajar sangat mematuhi peraturan formal kolej dalam rutin harian mereka. Walau bagaimanapun, item C6 (melaporkan salah laku, Min 3.89) mencatatkan skor terendah. Ini menunjukkan jurang antara "kesedaran" dan "keberanian untuk bertindak". Pelajar cenderung untuk mematuhi peraturan sendiri, namun masih ragu-ragu untuk melaporkan salah laku rakan sebaya. Ini mencadangkan perlunya persekitaran kampus yang lebih selamat dan telus bagi memupuk budaya keberanian moral, supaya pelajar tidak hanya pasif mematuhi peraturan, tetapi berani menjadi pembela integriti secara aktif.

Cadangan responden menunjukkan bahawa pemerkasaan integriti di Kolej Komuniti Paya Besar memerlukan pendekatan holistik meliputi empat aspek utama. Pelajar lebih cenderung kepada program pendidikan interaktif seperti bengkel dan media visual berbanding kaedah syarahan. Selain itu, penguatkuasaan disiplin yang tegas dan konsisten penting untuk membina kepercayaan terhadap sistem kolej. Peranan pensyarah sebagai contoh teladan turut menjadi faktor utama dalam pembentukan sahsiah pelajar. Di samping itu, sistem pengiktirafan seperti anugerah integriti dilihat mampu meningkatkan motivasi pelajar. Secara keseluruhan, gabungan pendidikan kreatif, penguatkuasaan adil dan ganjaran berkesan dapat melahirkan graduan berintegriti tinggi.

6.0 KESIMPULAN

Secara keseluruhannya, kajian ini mendapati bahawa tahap pemahaman dan amalan integriti dalam kalangan pelajar Kolej Komuniti Paya Besar berada pada tahap yang tinggi dan memuaskan. Objektif kajian telah dicapai dengan jayanya, membuktikan bahawa pelajar bukan sahaja memahami konsep integriti, malah melaksanakannya dalam kehidupan akademik dan harian.

Walaupun tahap integriti pelajar adalah memberangsangkan, kajian ini mengenal pasti potensi untuk penambahbaikan berterusan, khususnya dalam memperkasakan penerapan nilai integriti secara lebih holistik. Sebagai tunjang utama graduan TVET, integriti perlu terus dibudayakan agar pelajar bukan sahaja cemerlang dari aspek kemahiran teknikal, malah utuh dari segi sahsiah dan etika. Diharapkan hasil kajian ini menjadi panduan strategik bagi pihak kolej dalam membentuk graduan yang dinamik dan mampu mengamalkannya dalam kehidupan seharian dan dunia kerjaya.

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TAHAP PENGETAHUAN DAN PENERIMAAN APLIKASI I-DAM UMRAH DALAM KALANGAN PELAJAR POLITEKNIK SULTAN HAJI AHMAD SHAH, KUANTAN, PAHANG

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Abstrak

Kajian ini bertujuan untuk menilai tahap pengetahuan dan penerimaan terhadap aplikasi i-Dam Umrah dalam kalangan pelajar di Politeknik Sultan Haji Ahmad Shah (POLISAS), serta mengenal pasti faktor yang mempengaruhi penggunaannya dalam konteks digitalisasi ibadah. Kajian ini menggunakan pendekatan kuantitatif melalui reka bentuk tinjauan keratan rentas melibatkan 119 orang responden yang dipilih secara rawak mudah. Instrumen kajian menggunakan soal selidik berasaskan skala Likert lima mata, manakala analisis data dijalankan menggunakan IBM SPSS Statistics versi 26.0 melalui analisis deskriptif. Dapatan kajian menunjukkan bahawa tahap pengetahuan pelajar berada pada tahap sederhana (min = 3.08 hingga 3.95), manakala tahap penerimaan adalah tinggi (min = 4.58 hingga 4.62). Walaupun tahap kemahiran penggunaan masih belum menyeluruh, pelajar menunjukkan keyakinan yang tinggi terhadap keberkesanan aplikasi dalam membantu pengurusan dam secara sistematik dan patuh syariah. Selain itu, faktor kepatuhan syariah, persepsi kegunaan, kepuasan pengguna dan niat tingkah laku dikenal pasti sebagai pemacu utama kepada penerimaan aplikasi, selaras dengan kerangka Technology Acceptance Model (TAM) dan UTAUT. Kajian ini menyumbang dengan menekankan kepatuhan syariah sebagai dimensi penting dalam penerimaan teknologi berasaskan ibadah. Implikasi kajian mencadangkan keperluan kepada latihan, peningkatan kebolehgunaan aplikasi serta pengukuhan integrasi teknologi dalam pendidikan Islam.

Kata kunci: i-Dam Umrah, pengetahuan, penerimaan, aplikasi digital, pelajar politeknik

Abstract

This study aims to assess the level of knowledge and acceptance of the i-Dam Umrah application among students at Sultan Haji Ahmad Shah Polytechnic (POLISAS), as well as identify factors that influence its use in the context of digitalization of worship. This study uses a quantitative approach through a cross-sectional survey design involving 119 respondents who were selected by simple random sampling. The study instrument uses a questionnaire based on a five-point Likert scale, while data analysis is carried out using IBM SPSS Statistics version 26.0 through descriptive analysis. The study findings show that the level of knowledge

of students is at a moderate level (mean = 3.08 to 3.95), while the level of acceptance is high (mean = 4.58 to 4.62). Although the level of usage skills is not yet comprehensive, students show high confidence in the effectiveness of the application in assisting in systematic and syariah-compliant dam management. In addition, the factors of syariah compliance, perceived usefulness, user satisfaction and behavioral intention are identified as the main drivers of application acceptance, in line with the Technology Acceptance Model (TAM) and UTAUT frameworks. This study contributes by emphasizing syariah compliance as an important dimension in the acceptance of worship-based technology. The implications of the study suggest the need for training, increasing the usability of applications and strengthening the integration of technology in Islamic education.

Keywords: *i-Dam Umrah, knowledge, acceptance, digital applications, polytechnic students*

1.0 PENGENALAN

Dalam era digitalisasi masa kini, penggunaan aplikasi mudah alih semakin berkembang dalam pelbagai aspek kehidupan termasuk dalam pengurusan ibadah. Aplikasi i-Dam Umrah dibangunkan sebagai satu inovasi digital yang bertujuan membantu pengguna memahami, mengira dan menguruskan dam secara lebih sistematik dan tepat. Walau bagaimanapun, keberkesanan sesuatu aplikasi tidak hanya bergantung kepada aspek teknikal semata-mata, tetapi turut dipengaruhi oleh tahap pengetahuan pengguna serta penerimaan mereka terhadap teknologi tersebut. Dalam konteks pelajar di Politeknik Sultan Haji Ahmad Shah (POLISAS), tahap pendedahan terhadap aplikasi i-Dam serta kesediaan untuk menggunakannya masih belum diketahui secara jelas. Sehubungan itu, kajian ini dijalankan bagi menilai tahap pengetahuan dan penerimaan pelajar terhadap aplikasi i-Dam, serta mengenal pasti faktor-faktor yang mempengaruhi penggunaannya.

1.1 Penyataan Masalah

Walaupun pelbagai aplikasi digital berkaitan ibadah telah dibangunkan, tahap pengetahuan dan penerimaan dalam kalangan pelajar masih tidak konsisten. Terdapat kemungkinan bahawa sebahagian pelajar mempunyai pengetahuan yang terhad mengenai konsep dam serta kurang pendedahan terhadap aplikasi i-Dam Umrah. Selain itu, walaupun institusi dan agensi berkaitan telah menyediakan pelbagai panduan berkaitan pengurusan dam, masih wujud kekeliruan dalam kalangan pengguna, khususnya dalam aspek pelaksanaan yang tepat. Hal ini menunjukkan wujud jurang antara ketersediaan teknologi dan tahap pemahaman pengguna. Oleh itu, kajian ini penting untuk meneliti secara empirikal tahap pengetahuan dan penerimaan pelajar terhadap aplikasi i-Dam serta mengenal pasti faktor yang mempengaruhi penggunaannya.

1.2 Objektif Kajian

a) Mengenal pasti tahap pentaquins pelajar tentang aplikasi i-Dam Umrah.
b) Mengkaji tahap penerimaan pelajar terhadap penggunaan aplikasi i-Dam.
c) Menganalisis faktor yang mempengaruhi penggunaan aplikasi i-Dam.

1.2 Kepentingan Kajian

Kajian ini penting untuk mengenal pasti tahap pengetahuan pelajar terhadap aplikasi i-Dam Umrah iaitu melihat sejauh manakah pelajar mempunyai pengetahuan tentang fungsi dan cara penggunaaan aplikasi ini, maka pihak institusi dapat menentukan sama ada kursus atau bengkel perlu diperlukan. Ini memastikan aplikasi tersebut tidak sekadar menjadi hiasan digital, tetapi dapat difahami sebagai satu aplikasi digital yang efektif.

Dapatan kajian mengenai tahap penerimaan akan memberikan gambaran yang jelas sama ada pelajar bersedia dan berminat untuk menggunakan teknologi dalam subjek agama. Kepentingan ini menjurus kepada usaha membuktikan bahawa aplikasi digital mampu meningkatkan daya tarikan pembelajaran berbanding kaedah tradisional. Selain itu, kajian ini dapat menilai kemesraan pengguna dari aspek teknikal seperti reka bentuk antaramuka dan melihat sejauh mana pelajar merasakan aplikasi ini benar-benar membantu mereka dalam proses penggunaan aplikasi itu. Ini amat penting bagi memastikan kandungan aplikasi bukan sahaja menarik dari segi pengisianya malah menepati kehendak hukum selari dengan hukum syarak, malah seterusnya menjadi faktor utama pelajar terus menggunakan aplikasi ini.

2.0 SOROTON KAJIAN

Penggunaan aplikasi mudah alih dalam memudahkan urusan ibadah semakin berkembang dan menjadi satu trend global yang signifikan dalam tempoh beberapa tahun kebelakangan ini. Perkembangan teknologi digital telah membuka ruang kepada pendekatan pembelajaran yang lebih interaktif dan efektif, khususnya dalam konteks ibadah haji dan umrah. Kajian oleh Mohd Ali et al. (2022) menunjukkan bahawa integrasi teknologi digital dalam pembelajaran manasik haji dan umrah mampu meningkatkan tahap kefahaman pengguna melalui elemen visual dan interaktif berbanding kaedah konvensional. Perkara ini selari dengan pembangunan aplikasi i-Dam Umrah yang bertujuan memudahkan proses pengiraan dan pengurusan dam secara lebih sistematik dan teratur.

Dalam konteks institusi pendidikan pula, pelbagai kajian lepas menunjukkan bahawa pelajar mempunyai tahap kesediaan yang tinggi terhadap penggunaan aplikasi digital patuh syariah (Zulkifli, 2023). Walau bagaimanapun, tahap pengetahuan teknikal berkaitan kandungan hukum-hakam dalam aplikasi tersebut sering menjadi faktor penentu kepada tahap penggunaan sebenar. Kekurangan kefahaman terhadap fungsi dan kandungan aplikasi boleh mengurangkan keberkesanan penggunaannya, walaupun aplikasi tersebut mempunyai potensi yang tinggi.

Bagi menjelaskan faktor-faktor yang mempengaruhi penerimaan teknologi, kajian ini berpaksikan model *Technology Acceptance Model* (TAM) yang diperkenalkan oleh Davis (1989), yang menekankan kepentingan persepsi terhadap kegunaan dan kemudahan penggunaan sebagai penentu utama penerimaan teknologi. Selain itu, model *Unified Theory of Acceptance and Use of Technology* (UTAUT) oleh Venkatesh et al. (2003; 2022) turut digunakan bagi memperkukuh pemahaman terhadap faktor-faktor yang mempengaruhi niat tingkah laku pengguna.

Dalam konteks kajian ini, elemen kepatuhan syariah turut diintegrasikan sebagai komponen tambahan bagi menyesuaikan model penerimaan teknologi dengan aplikasi berasaskan ibadah. Pendekatan ini selari dengan pandangan Shaikh dan Karjaluoto (2015) yang menegaskan bahawa faktor kepercayaan pengguna serta persepsi terhadap kegunaan memainkan peranan penting dalam mempengaruhi penerimaan aplikasi mudah alih, khususnya dalam situasi yang melibatkan aspek sensitif seperti amalan ibadah.

3.0 METODOLOGI KAJIAN

Metodologi kajian adala satu prosedur bagaimana kajian dapat dilaksanakan mengikut kaedah-kaedah yang tertentu. Kajian yang melibatkan tahap pengetahuan dan penerimaan dalam kalangan pelajar ini menggunakan kaedah iaitu kajian kuantitatif. Berikut adalah komponen utama metodologi bagi kajian ini ialah:

3.1 Reka Bentuk Kajian

Kajian ini menggunakan reka bentuk kajian kuantitatif melalui kaedah tinjauan deskriptif. Penggunaan reka bentuk ini bertujuan untuk mengenal pasti tahap pengetahuan dan penerimaan pelajar terhadap aplikasi i-Dam Umrah secara objektif. Kaedah tinjauan dipilih kerana ia merupakan cara yang paling efisien untuk mengumpul data daripada sampel yang besar di POLISAS dalam tempoh masa yang singkat. Selain itu, kajian ini bersifat keratan rentas (cross-sectional) di mana data hanya diambil sekali sahaja bagi menggambarkan situasi semasa responden berkaitan pemboleh ubah yang dikaji.

3.2 Populasi dan Sampel

Populasi kajian ini terdiri daripada semua pelajar di Politeknik Sultan Haji Ahmad Shah (POLISAS), yang mewakili pelajar institusi pendidikan teknikal dan vokasional di Malaysia. Sampel kajian melibatkan seramai 118 orang pelajar diploma yang dipilih daripada pelbagai jabatan bagi memastikan kepelbagaian latar belakang akademik. Kaedah persampelan rawak mudah (*simple random sampling*) telah digunakan, di mana setiap individu dalam populasi mempunyai kebarangkalian yang sama untuk dipilih sebagai responden. Kaedah ini dipilih kerana ia dapat meningkatkan kesahan luaran (*external validity*) dan mengurangkan kecenderungan bias dalam pemilihan sampel.

3.3 Instrumen Kajian

Ia menggunakan kaedah borang soal selidik yang dibahagikan kepada empat bahagian:

- **Bahagian A:** Demografi (Jantina, Umur, Jabatan, Pernah pergi Umrah).
- **Bahagian B:** Tahap Pengetahuan (Menggunakan **Skala Likert 5 mata**; daripada 1 = Sangat Tidak Setuju hingga 5 = Sangat Setuju).
- **Bahagian C:** Tahap Penerimaan (Menggunakan **Skala Likert 5 mata**; daripada 1 = Sangat Tidak Setuju hingga 5 = Sangat Setuju).
- **Bahagian D:** Cadangan penambahbaikan.

3.4. Analisa Data

Data yang diperoleh daripada responden melalui borang soal selidik akan dianalisis secara sistematik menggunakan perisian IBM SPSS Statistics versi 26.0. Analisis data dijalankan dalam bentuk analisis deskriptif. Analisis deskriptif yang melibatkan kekerapan, peratusan, dan skor min digunakan untuk menghuraikan profil demografi serta menentukan tahap pengetahuan dan penerimaan pelajar. Analisis deskriptif juga dilakukan untuk melihat faktor yang mempengaruhi penggunaan aplikasi ini. Analisis deskriptif digunakan untuk mencari min (purata) dan Peratusan bagi tahap pengetahuan dan penerimaan dan faktor yang mempengaruhinya. Berikut disertakan jadual interprestasi skor min oleh Nor Syazwanie binti Mohamad Zainal N.H., 2022 untuk memudahkan melakukan perbandingan dan jurang yang berkaitan.

Jadual 1: Interprestasi skor min

Skor Min	Interprestasi (Tahap)
1.00 hingga 2.33	Rendah
2.34 hingga 3.66	Sederhana
3.67 hingga 5.00	Tinggi

4.0 DAPATAN KAJIAN

4.1 Demografi

Seramai 118 orang responden telah terlibat dalam kajian ini. Berdasarkan analisis, didapati majoriti responden adalah lelaki iaitu sebanyak 62.7% (74 orang), manakala selebihnya adalah perempuan iaitu sebanyak 37.3% (44 orang). Bagi analisis tentang umur responden, majoriti responden adalah berumur kurang daripada 20 tahun (82.2%), diikuti oleh 20 hingga 22 tahun (16.1%) dan 23 hingga 25 tahun (1.7%), manakala tiada responden melebihi 25 tahun. Dapatan ini menunjukkan bahawa sampel kajian didominasi oleh golongan pelajar muda yang masih berada dalam fasa pembelajaran dan pembentukan nilai diri.

Manakala majoriti responden didapati belum pernah menunaikan umrah, iaitu seramai 109 orang (92.4%). Manakala hanya sebilangan kecil responden, iaitu 9 orang (7.6%) mempunyai pengalaman menunaikan ibadah umrah. Dapatan ini menunjukkan bahawa kebanyakan pelajar tidak mempunyai pendedahan atau pengalaman langsung berkaitan pelaksanaan ibadah umrah. Kekurangan pengalaman ini berkemungkinan mempengaruhi tahap kefahaman mereka terhadap aspek-aspek penting seperti pelaksanaan dam dan peraturan ihram.

Majoriti responden bagi kajian ini didominasi daripada Jabatan Kejuruteraan Awam (JKA), yang menyumbang lebih daripada separuh jumlah keseluruhan iaitu 56.8%. Selebihnya terdiri daripada pelajar Jabatan Kejuruteraan Mekanikal (JKM) sebanyak 23.7% dan Jabatan Kejuruteraan Elektrik (JKE) sebanyak 19.5%. Terdapat dua jabatan yang tidak diwakili dalam sampel kajian ini, iaitu Jabatan Perdagangan (JP) dan Jabatan Teknologi Maklumat (JTM) dengan peratusan 0%.

4.2 Tahap Pengetahuan tentang Aplikasi i-Dam Umrah

Pengetahuan sedia ada (Item 1) di mana pelajar POLISAS mempunyai pengetahuan yang baik tentang konsep dam secara umum (Min: 3.76). Ini adalah asas yang kuat untuk mereka menerima aplikasi ini Pendedahan Aplikasi (Item 2-4): Skor min untuk aspek kesedaran, kefahaman fungsi, dan kemahiran penggunaan aplikasi berada dalam julat 3.08 hingga 3.34.

Jadual 2: Tahap Pengetahuan tentang Aplikasi i-Dam Umrah

No.	Item Penilaian	Min	Interpretasi
1	Saya mengetahui tentang konsep dam dalam ibadah umrah.	3.76	Tinggi
2	Saya pernah mendengar tentang aplikasi i-Dam Umrah.	3.25	Tinggi
3	Saya memahami fungsi utama aplikasi i-Dam Umrah.	3.34	Tinggi
4	Saya tahu cara menggunakan aplikasi i-Dam Umrah.	3.08	Tinggi
5	Saya percaya aplikasi i-Dam boleh membantu menguruskan dam dengan betul.	3.95	Tinggi

Ini menunjukkan aplikasi i-Dam masih baru bagi mereka atau belum digunakan secara meluas secara praktikal. Keyakinan/Penerimaan (Item 5): Menariknya, walaupun mereka belum mahir menggunakan aplikasi (Item 4), mereka mempunyai kepercayaan yang tinggi (Min: 3.95) bahawa aplikasi ini sangat berguna untuk membantu menguruskan dam dengan betul.

4.3 Tahap Penerimaan Aplikasi i-Dam Umrah

Tahap penerimaan pelajar ditunjukkan dalam jadual 3. Ia menunjukkan bahawa tahap penerimaan pelajar terhadap aplikasi i-Dam adalah tinggi, dengan semua item mencatatkan nilai min melebihi 4.50. Dapatan ini menggambarkan bahawa pelajar mempunyai persepsi yang sangat positif serta kesediaan yang tinggi untuk menggunakan aplikasi ini pada masa hadapan.

Jadual 3: Tahap Penerimaan Pelajar terhadap Aplikasi i-Dam

No.	Item	Min (M)	Sisihan Piawai (SD)	Interpretasi
1	Saya bersedia menggunakan aplikasi ini pada masa akan datang.	4.62	0.58	Tinggi
2	Aplikasi ini sesuai digunakan oleh agensi pelancongan Umrah.	4.62	0.58	Tinggi
3	Panduan yang diberikan menepati hukum Syariah.	4.62	0.58	Tinggi
4	Saya berpuas hati dengan aplikasi ini secara keseluruhan.	4.58	0.58	Tinggi
5	Aplikasi ini memberi pengalaman Umrah yang lebih teratur.	4.58	0.58	Tinggi
6	Aplikasi ini berpotensi menjadi platform rasmi rujukan dam.	4.58	0.58	Tinggi
7	Aplikasi ini sesuai diperluaskan ke peringkat antarabangsa.	4.58	0.58	Tinggi

4.3 Faktor yang Mempengaruhi Penggunaan Aplikasi i-Dam

Jadual 4 pula menunjukkan huraian bahawa faktor kepatuhan syariah, kegunaan, kepuasan pengguna, niat tingkah laku, dan potensi pengembangan berada pada tahap tinggi. Dapatan ini menunjukkan bahawa faktor-faktor tersebut iaitu Kepatuhan Syariah, Kegunaan, Kepuasan Pengguna, Niat Tingkah Laku dan Potensi Pengembangan memainkan peranan penting dalam mempengaruhi penggunaan aplikasi i-Dam dalam kalangan pelajar.

5.0 PERBINCANGAN

Secara keseluruhannya, dapatan kajian ini menunjukkan satu pola yang menarik, iaitu tahap pengetahuan pelajar terhadap aplikasi i-Dam berada pada tahap sederhana, manakala tahap penerimaan pula berada pada tahap yang tinggi. Keadaan ini menunjukkan bahawa penerimaan terhadap sesuatu teknologi tidak semestinya bergantung sepenuhnya kepada tahap kemahiran penggunaan, sebaliknya lebih dipengaruhi oleh persepsi terhadap manfaat dan kepercayaan pengguna terhadap aplikasi tersebut. Dapatan ini selari dengan penegasan dalam model *Technology Acceptance Model* (TAM) yang menyatakan bahawa faktor *perceived usefulness* memainkan peranan utama dalam menentukan penerimaan teknologi (Davis, 1989; Al-Emran et al., 2023).

Bagi aspek pengetahuan, pelajar didapati mempunyai kefahaman yang baik berkaitan konsep asas dam dalam ibadah umrah. Namun begitu, pendedahan terhadap aplikasi i-Dam dari segi kefahaman fungsi dan kemahiran penggunaan masih berada pada tahap sederhana. Situasi ini menunjukkan bahawa aplikasi i-Dam masih berada pada fasa awal pengenalan dalam kalangan pelajar. Dapatan ini selari dengan kajian Mohd Ali et al. (2022) yang menyatakan bahawa penggunaan teknologi dalam konteks ibadah memerlukan proses pendedahan dan

pembelajaran secara berperingkat bagi memastikan pengguna dapat memanfaatkan aplikasi secara optimum.

Jadual 4: Faktor yang Mempengaruhi Penggunaan Aplikasi i-Dam

Faktor	Item Berkaitan	Min (M)	Interpretasi	Huraian
Kepatuhan Syariah (*Shariah Compliance*)	Panduan menepati hukum syariah	4.62	Tinggi	Faktor utama kepercayaan pengguna terhadap aplikasi
Kegunaan (*Perceived Usefulness*)	Pengalaman Umrah lebih teratur, sesuai untuk agensi	4.58	Tinggi	Aplikasi dilihat membantu dan praktikal digunakan
Kepuasan Pengguna (*User Satisfaction*)	Kepuasan keseluruhan terhadap aplikasi	4.58	Tinggi	Pengalaman penggunaan yang positif
Niat Tingkah Laku (*Behavioral Intention*)	Kesediaan menggunakan pada masa hadapan	4.62	Tinggi	Menunjukkan kecenderungan penggunaan berterusan
Potensi Pengembangan (*Scalability*)	Potensi jadi platform rasmi & antarabangsa	4.58	Tinggi	Menunjukkan nilai komersial dan kebolehluasan

Walaupun tahap kemahiran penggunaan masih belum tinggi, pelajar menunjukkan keyakinan yang kuat bahawa aplikasi i-Dam mampu membantu dalam pengurusan dam dengan lebih sistematik. Ini menunjukkan bahawa kepercayaan terhadap fungsi aplikasi telah terbentuk lebih awal berbanding pengalaman penggunaan sebenar. Dapatan ini menyokong kajian oleh Dwivedi et al. (2021) yang menegaskan bahawa niat tingkah laku (*behavioral intention*) boleh terbentuk berdasarkan persepsi dan jangkaan pengguna, walaupun tanpa pengalaman penggunaan yang mendalam.

Dari sudut penerimaan, semua item mencatatkan nilai min yang tinggi, menunjukkan bahawa pelajar mempunyai persepsi yang sangat positif terhadap aplikasi i-Dam. Kesediaan untuk menggunakan aplikasi pada masa hadapan serta persepsi bahawa aplikasi ini sesuai untuk digunakan oleh agensi pelancongan Umrah menunjukkan bahawa aplikasi ini bukan sahaja diterima sebagai alat pembelajaran, malah berpotensi sebagai platform sokongan industri. Dapatan ini selari dengan kajian Zulkifli (2023) yang mendapati bahawa pelajar mempunyai kecenderungan tinggi untuk menerima aplikasi patuh syariah yang memenuhi keperluan praktikal dan nilai agama.

Selain itu, faktor kepatuhan syariah didapati menjadi faktor paling dominan dalam mempengaruhi penggunaan aplikasi i-Dam. Dalam konteks aplikasi berkaitan ibadah, elemen kepercayaan terhadap kesahihan hukum merupakan asas utama kepada penerimaan pengguna. Dapatan ini selari dengan kajian Hassan dan Hamdan (2022) yang menegaskan bahawa elemen patuh syariah meningkatkan tahap kepercayaan dan keyakinan pengguna terhadap aplikasi digital Islamik.

Faktor kegunaan dan kepuasan pengguna turut menyumbang kepada tahap penerimaan yang tinggi. Pelajar melihat aplikasi i-Dam sebagai alat yang mampu membantu menyusun pengalaman Umrah dengan lebih teratur dan sistematik. Pengalaman penggunaan yang positif ini meningkatkan tahap kepuasan, yang seterusnya mempengaruhi niat penggunaan berterusan. Kajian oleh Gupta dan Arora (2023) turut menyokong bahawa kepuasan pengguna merupakan faktor penting dalam memastikan kesinambungan penggunaan sesuatu aplikasi.

Akhir sekali, dapatan kajian menunjukkan bahawa aplikasi i-Dam mempunyai potensi yang tinggi untuk dikembangkan ke peringkat yang lebih luas. Persepsi pelajar bahawa aplikasi ini sesuai dijadikan platform rasmi dan diperluaskan ke peringkat antarabangsa menunjukkan nilai komersial dan kebolehskalaan yang tinggi. Hal ini selari dengan laporan OECD (2023) yang menekankan bahawa aplikasi digital yang memenuhi keperluan pengguna dan mempunyai nilai praktikal berpotensi untuk berkembang dalam ekosistem ekonomi digital global.

Secara ringkas, dapatan kajian ini menunjukkan bahawa penerimaan terhadap aplikasi i-Dam dipengaruhi secara signifikan oleh persepsi terhadap kegunaan, kepatuhan syariah, dan kepuasan pengguna. Implikasi kajian ini menekankan keperluan untuk meningkatkan tahap pendedahan dan latihan penggunaan aplikasi dalam kalangan pelajar, di samping memastikan kandungan aplikasi sentiasa tepat dan mesra pengguna. Selain itu, potensi aplikasi ini untuk diperluaskan ke peringkat industri dan antarabangsa menunjukkan bahawa pembangunan aplikasi berasaskan ibadah perlu diberi perhatian dalam ekosistem digital masa kini.

6.0 IMPLIKASI KAJIAN

6.1 Implikasi Teoretikal

Kajian ini mengukuhkan lagi teori penerimaan teknologi seperti TAM dan UTAUT dengan menunjukkan bahawa faktor *perceived usefulness* dan *behavioral intention* merupakan pemacu utama dalam penerimaan aplikasi i-Dam. Selain itu, kajian ini memperluaskan aplikasi teori tersebut dalam konteks teknologi Islamik dengan memasukkan elemen kepatuhan syariah sebagai faktor kritikal. Ini menunjukkan bahawa dalam pembangunan aplikasi berasaskan ibadah, faktor kepercayaan agama perlu diintegrasikan bersama faktor teknologi.

6.2 Implikasi Praktikal

Dari sudut praktikal, kajian ini memberi beberapa implikasi penting:

1. Pembangunan Aplikasi
   Aplikasi i-Dam perlu diperkukuh dari segi kemudahan penggunaan dan panduan interaktif bagi meningkatkan kefahaman pengguna baharu.
2. Latihan dan Pendedahan
   Pihak institusi perlu menyediakan latihan atau bengkel bagi meningkatkan tahap pengetahuan dan kemahiran penggunaan aplikasi dalam kalangan pelajar.
3. Kolaborasi Industri
   Agensi pelancongan Umrah boleh memanfaatkan aplikasi ini sebagai platform sokongan bagi memastikan pengurusan dam dilakukan dengan lebih sistematik dan tepat.
4. Pengembangan Produk
   Aplikasi ini mempunyai potensi untuk dikembangkan sebagai platform digital rasmi dalam pengurusan dam di peringkat nasional dan antarabangsa.

6.3 Implikasi Dasar

Kajian ini menunjukkan keperluan kepada penggubalan dasar yang menyokong integrasi teknologi digital dalam pengurusan ibadah. Pihak berkaitan boleh mempertimbangkan pembangunan garis panduan penggunaan aplikasi patuh syariah bagi memastikan keseragaman dan ketepatan maklumat yang disampaikan kepada pengguna.

7.0 KESIMPULAN

Kajian ini menunjukkan bahawa tahap penerimaan pelajar terhadap aplikasi i-Dam adalah tinggi walaupun tahap pengetahuan masih berada pada tahap sederhana. Dapatan ini membuktikan bahawa persepsi terhadap manfaat dan kepercayaan terhadap aplikasi memainkan peranan yang lebih dominan dalam mempengaruhi penerimaan pengguna berbanding kemahiran penggunaan semata-mata.

Selain itu, faktor kepatuhan syariah, kegunaan, kepuasan pengguna dan niat tingkah laku dikenal pasti sebagai faktor utama yang mempengaruhi penggunaan aplikasi i-Dam. Gabungan faktor-faktor ini menunjukkan bahawa aplikasi i-Dam mempunyai potensi yang besar untuk diterima secara meluas dan digunakan sebagai platform sokongan dalam pengurusan ibadah umrah.

Secara keseluruhannya, aplikasi i-Dam bukan sahaja berfungsi sebagai alat digital, tetapi juga sebagai medium yang mampu meningkatkan kefahaman dan pengurusan ibadah secara lebih sistematik. Oleh itu, usaha berterusan perlu dilakukan bagi meningkatkan tahap pengetahuan pengguna melalui latihan dan pendedahan, di samping memperkukuh ciri-ciri aplikasi agar selari dengan keperluan pengguna dan perkembangan teknologi semasa.

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PEMBANGUNAN MODEL PELAKSANAAN DAN PEMANTAUAN PROGRAM *WORK-BASED LEARNING* (WBL) DALAM PENDIDIKAN TVET: KAJIAN RINTIS DIPLOMA TEKNOLOGI MEDIA CETAK

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Abstrak

Program *Work-Based Learning* (WBL) merupakan pendekatan strategik dalam memperkukuh pelaksanaan Pendidikan dan Latihan Teknikal dan Vokasional (TVET) yang menekankan integrasi pembelajaran akademik dengan pengalaman industri sebenar. Walau bagaimanapun, pelaksanaan program WBL yang masih baharu dalam Diploma Teknologi Media Cetak menuntut satu kerangka pelaksanaan dan pemantauan yang sistematik bagi memastikan keberkesanan pembelajaran serta pencapaian kompetensi pelajar selaras dengan keperluan industri. Kajian rintis ini bertujuan membangunkan satu model pelaksanaan dan pemantauan bersepadu bagi program WBL dengan menilai tahap kesediaan pelajar, keberkesanan mekanisme pemantauan, serta peranan mentor industri dalam menyokong pembangunan kompetensi teknikal dan profesional pelajar. Kajian ini menggunakan pendekatan kaedah campuran (*mixed-method*) yang melibatkan soal selidik terhadap pelajar serta temu bual separa berstruktur bersama mentor industri dan pensyarah pemantau. Dapatan awal dijangka dapat mengenal pasti jurang pelaksanaan, cabaran pemantauan, serta keperluan penambahbaikan dalam aspek penyelarasan institusi-industri. Hasil kajian ini akan mencadangkan satu model pelaksanaan dan pemantauan WBL yang lebih komprehensif dan praktikal sebagai rujukan kepada institusi TVET lain yang melaksanakan program seumpamanya. Kajian ini menyumbang kepada pengukuhan ekosistem TVET melalui pemantapan kolaborasi industri dan peningkatan kualiti pengalaman pembelajaran berasaskan kerja.

Kata Kunci: *Work-Based Learning* (WBL), Pendidikan TVET, Model Pemantauan, Kompetensi Industri, Kolaborasi Industri-Politeknik dan Teknologi Media Cetak

Abstract

The Work-Based Learning (WBL) program is a strategic approach to strengthening the implementation of Technical and Vocational Education and Training (TVET) by emphasizing the integration of academic learning with real industry experience. However, the implementation of the WBL program, which is still relatively new in the Diploma in Print Media Technology, requires a systematic framework for execution and monitoring to ensure the effectiveness of learning as well as the achievement of student competencies in line with industry requirements. This pilot study aims to develop an integrated implementation and monitoring model for the WBL program by evaluating students' readiness, the effectiveness of

monitoring mechanisms, and the role of industry mentors in supporting the development of students' technical and professional competencies. The study adopts a mixed-method approach, involving questionnaires distributed to students as well as semi-structured interviews with industry mentors and supervising lecturers. The preliminary findings are expected to identify implementation gaps, monitoring challenges, and areas for improvement in institutional-industry coordination. The outcomes of this study will propose a more comprehensive and practical WBL implementation and monitoring model to serve as a reference for other TVET institutions implementing similar programs. This study contributes to strengthening the TVET ecosystem through enhanced industry collaboration and improved quality of work-based learning experiences.

Keywords: *Work-Based Learning (WBL), TVET Education, Monitoring Model, Industry Competencies, Industry-Polytechnic Collaboration, Print Media Technology*

1.0 PENGENALAN

1.1 Latar Belakang

Pendidikan dan Latihan Teknikal dan Vokasional (TVET) memainkan peranan penting dalam membangunkan tenaga kerja berkemahiran tinggi yang mampu memenuhi keperluan industri semasa dan masa depan. Program *Work-Based Learning* (WBL) adalah salah satu pendekatan strategik TVET yang mengintegrasikan pembelajaran akademik di institusi dengan pengalaman kerja sebenar di industri. Dalam konteks Diploma Teknologi Media Cetak (DMC) mode WBL, program ini masih baharu dan belum mempunyai graduan pertama. Oleh itu, pelaksanaan WBL menuntut kerangka pelaksanaan dan pemantauan yang sistematik bagi memastikan pelajar memperoleh pengalaman pembelajaran yang bermakna, kemahiran teknikal dan profesional yang relevan, serta dapat menyesuaikan diri dengan keperluan industri percetakan yang kompetitif.

Kejayaan WBL bukan sahaja bergantung kepada pelajar, tetapi juga melibatkan kerjasama erat antara institusi, mentor industri, dan sistem sokongan seperti latihan, pemantauan, dan penilaian bersepadu. Kekurangan model pemantauan yang terstruktur boleh menjejaskan pencapaian kompetensi pelajar dan keberkesanan keseluruhan program WBL.

1.2 Isu dan Justifikasi Kajian

Beberapa isu utama yang dikenal pasti dalam pelaksanaan awal WBL dalam program DMC ialah:

a) Tahap kesediaan pelajar – pelajar mungkin kurang bersedia menghadapi cabaran industri sebenar.
b) Mekanisme pemantauan – kekurangan model pemantauan yang sistematik untuk mentor dan pensyarah.
c) Peranan mentor industri – perlunya panduan jelas untuk mentor dalam membimbing pelajar.

d) Jurang institusi–industri – perbezaan antara kurikulum akademik dan keperluan kompetensi industri percetakan.

Kajian ini penting kerana ia dapat menyediakan model pelaksanaan dan pemantauan bersepadu yang dapat dijadikan rujukan untuk program TVET lain, sekaligus memperkukuh keberkesanan WBL, meningkatkan integrasi akademik-industri, dan menyokong pembangunan kompetensi pelajar secara optimum.

1.3 Objektif Kajian

a) Membangunkan satu model pelaksanaan dan pemantauan WBL bagi program DMC yang baharu.
b) Menilai tahap kesediaan pelajar dan keberkesanan mekanisme pemantauan dalam konteks WBL.
c) Mengenal pasti peranan mentor industri dan cabaran yang dihadapi dalam menyokong pembelajaran pelajar.

1.4 Skop Kajian

Kajian ini tertumpu kepada:

a) Pelajar semester 4–5 yang terlibat dalam WBL.
b) Mentor industri yang terlibat secara langsung dengan pelajar DMC.
c) Aspek pemantauan, kesediaan pelajar, dan kerjasama institusi–industri.
d) Tempoh kajian: Satu semester akademik (kajian rintis).

1.5 Kepentingan Kajian

Kajian ini diharap dapat:

a) Menyediakan panduan pelaksanaan WBL yang lebih tersusun bagi institusi TVET lain.
b) Meningkatkan kompetensi teknikal dan profesional pelajar DMC.
c) Memperkukuh kerjasama institusi–industri, seterusnya menyokong pembangunan ekosistem TVET yang berkesan.
d) Menjadi model rujukan nasional bagi pembangunan program WBL dalam bidang TVET.

2.0 SOROTAN LITERATUR

Sorotan literatur ini membincangkan konsep dan teori utama berkaitan *Work-Based Learning* (WBL) dan pendidikan TVET, khususnya dari aspek pemantauan pelajar serta kerjasama antara institusi dan industri. Sorotan ini bertujuan untuk memahami asas teori WBL dan TVET, menilai model pelaksanaan dan pemantauan sedia ada, serta mengenal pasti jurang pengetahuan dalam konteks Diploma Teknologi Media Cetak. Selain itu, sorotan literatur ini turut menyokong pembangunan model pelaksanaan dan pemantauan WBL yang dicadangkan dalam kajian ini.

2.1 Pendidikan dan Latihan Teknikal dan Vokasional (TVET)

Pendidikan dan Latihan Teknikal dan Vokasional (TVET) merujuk kepada sistem pendidikan yang menekankan pembangunan kemahiran teknikal, vokasional dan profesional bagi memenuhi keperluan industri. Menurut UNESCO (2017), TVET berperanan dalam

menyediakan kemahiran praktikal dan pengetahuan teknikal, menyokong pembelajaran sepanjang hayat serta menyumbang kepada pembangunan ekonomi melalui penghasilan tenaga kerja berkemahiran tinggi.

Dalam konteks industri, TVET berperanan menyediakan tenaga kerja yang bersedia untuk memasuki pasaran pekerjaan, di samping mengintegrasikan pembelajaran teori dan amali melalui pendekatan seperti *Work-Based Learning* (WBL). Selain itu, TVET turut menyokong keperluan transformasi industri 4.0, termasuk dalam bidang teknologi percetakan yang semakin berkembang ke arah digital dan automasi.

2.2 *Work-Based Learning* (WBL)

Work-Based Learning (WBL) merupakan pendekatan pembelajaran yang menggabungkan pembelajaran akademik di institusi dengan pengalaman kerja sebenar di industri. Menurut Billett (2011), WBL dapat meningkatkan kemahiran praktikal dan profesional pelajar, memberi pendedahan kepada persekitaran kerja sebenar serta memupuk kefahaman terhadap budaya dan standard industri. Pendekatan ini dilihat sebagai kaedah yang berkesan dalam merapatkan jurang antara teori dan amalan, sekali gus meningkatkan kebolehpasaran graduan dalam bidang teknikal dan vokasional.

2.3 Model dan Kerangka WBL

Beberapa model WBL yang dikenalpasti dalam literatur yang dirumuskan pada jadual berikut:

Jadual 1: Model WBL

Model	Fokus	Kelebihan
Internship / Practical Training	Pembelajaran praktikal di syarikat	Mudah dilaksanakan, pengalaman langsung
Apprenticeship	Mentor membimbing pelajar secara formal	Kemahiran mendalam, adaptasi industri
Cooperative Education (Co-op)	Gabungan kelas + industri bergilir	Integrasi teori dan praktikal lebih baik

2.4 Cabaran *Work-Based Learning* (WBL) dalam TVET

Kajian lepas menunjukkan bahawa pelaksanaan *Work-Based Learning* (WBL) dalam TVET masih berhadapan dengan beberapa cabaran utama. Antaranya ialah kekurangan model pemantauan yang sistematik, kekangan mentor industri yang kurang panduan jelas, serta tahap kesediaan pelajar yang berbeza-beza. Selain itu, terdapat juga jurang antara kurikulum institusi dan keperluan standard industri yang boleh menjejaskan keberkesanan pelaksanaan WBL.

2.5 Pemantauan dan Penilaian Pelajar WBL

Pemantauan pelajar WBL merupakan proses penting dalam memastikan prestasi pelajar di industri sentiasa dipantau secara berterusan oleh pensyarah dan mentor industri. Antara instrumen yang digunakan termasuk logbook, jurnal refleksi dan temu bual separa berstruktur. Penilaian kompetensi pula memberi tumpuan kepada kemahiran teknikal, profesional dan insaniah pelajar dalam persekitaran industri sebenar. Menurut kajian, penilaian bersepadu ini

dapat memberikan gambaran yang lebih tepat terhadap prestasi sebenar pelajar dalam konteks pekerjaan.

2.6 Kolaborasi Institusi–Industri

Kejayaan pelaksanaan WBL banyak bergantung kepada tahap kolaborasi antara institusi TVET dan pihak industri. Kerjasama ini melibatkan sokongan seperti latihan, bimbingan mentor, sumber kewangan dan kemudahan infrastruktur. Kajian menunjukkan bahawa kolaborasi yang lemah boleh memberi kesan negatif terhadap pencapaian kompetensi pelajar, manakala kerjasama yang kukuh dapat meningkatkan keberkesanan pembelajaran berasaskan kerja.

2.7 Jurang Kajian

Sorotan literatur menunjukkan beberapa jurang kajian yang masih wujud, khususnya dalam konteks program WBL bidang percetakan. Antaranya ialah ketiadaan data graduan kerana program masih baharu, kekurangan model pemantauan bersepadu, serta perlunya kajian rintis untuk menilai kesediaan pelajar, keberkesanan pemantauan dan peranan mentor industri. Selain itu, integrasi antara teori, amali dan standard industri dalam konteks percetakan konvensional dan digital masih terhad. Oleh itu, kajian ini dijalankan bagi membangunkan model pelaksanaan dan pemantauan WBL yang lebih sistematik dan menyeluruh.

2.8 Kerangka Konseptual Kajian

Kerangka konsep kajian ini merangkumi tiga komponen utama. Input terdiri daripada kesediaan pelajar, mentor industri dan sistem sokongan TVET. Proses pula melibatkan pelaksanaan WBL, pemantauan bersepadu dan bimbingan mentor. Output kajian adalah kompetensi teknikal dan profesional pelajar serta keberkesanan pelaksanaan WBL. Akhirnya, outcome kajian ialah pembangunan model pelaksanaan dan pemantauan WBL yang boleh dijadikan rujukan oleh institusi TVET lain.

3.0 METODOLOGI

Bab ini membincangkan pendekatan dan langkah-langkah yang digunakan dalam kajian rintis ini bagi membangunkan model pelaksanaan dan pemantauan WBL. Metodologi yang dipilih bertujuan untuk menilai tahap kesediaan pelajar, menilai keberkesanan mekanisme pemantauan dan mengenal pasti peranan mentor industri dan cabaran dalam menyokong pembelajaran pelajar. Kajian ini menggunakan pendekatan kaedah campuran (*mixed-method*) bagi mendapatkan gambaran menyeluruh tentang pelaksanaan WBL dalam konteks TVET.

3.1 Reka Bentuk Kajian

Jenis Kajian adalah kajian rintis (*pilot study*) dengan kaedah campuran (*mixed-method*). Fokus kajian kepada Program *Work-Based Learning* (WBL) bagi pelajar Diploma Teknologi Media Cetak. Pendekatan kuantitatif (soal selidik kepada pelajar untuk menilai kesediaan dan pengalaman WBL) dan kualitatif (temu bual separa berstruktur dengan mentor industri dan pensyarah pemantau untuk memahami cabaran dan keberkesanan pemantauan).

3.2 Populasi dan Sampel

3.2.1 Populasi

Populasi kajian melibatkan tiga kumpulan utama iaitu pelajar semester 4–5 program DMC yang mengikuti WBL, mentor industri yang membimbing pelajar, serta pensyarah pemantau WBL dari politeknik.

3.2.2 Sampel

Sampel terdiri daripada kira-kira 30 orang pelajar (keseluruhan semester 4–5), 10 orang mentor industri daripada 7–10 syarikat, dan 3 hingga 5 orang pensyarah pemantau. Pemilihan ini bersesuaian dengan saiz program yang masih kecil dan baharu.

3.3 Instrumen Kajian

Instrumen kajian yang digunakan ditunjukkan pada jadual 2 berikut:

Jadual 2: Instrumen Kajian

Instrumen	Objektif	Kaedah
Soal selidik pelajar	Menilai kesediaan, pengalaman, dan kepuasan semasa WBL	Skala Likert 1–5, terbuka & tertutup
Temu bual separa berstruktur	Mengenal pasti cabaran, keberkesanan pemantauan, peranan mentor	Rakaman + transkripsi
Logbook / Reflektif jurnal	Mengumpul rekod aktiviti harian pelajar di industri	Penilaian kualiti catatan dan kemahiran

3.4 Prosedur Kajian

3.4.1 Persediaan

Mendapatkan kelulusan etika, menyediakan instrumen kajian, serta melantik mentor dan mendapatkan persetujuan pelajar.

3.4.2 Pengumpulan Data

Mengedar soal selidik kepada pelajar, menjalankan temu bual bersama mentor dan pensyarah, serta mengumpul logbook/jurnal reflektif.

3.4.3 Analisis Data

Menganalisis data kuantitatif secara deskriptif dan data kualitatif secara tematik bagi mengenal pasti tahap kesediaan, cabaran, keberkesanan pemantauan dan cadangan mentor

3.4.4 Pembangunan Model

Mengintegrasikan dapatan untuk membangunkan model pelaksanaan dan pemantauan WBL yang sistematik serta menyemak kesesuaian model dengan mentor industri dan pensyarah pemantau.

3.6 Jadual Kerja / *Timeline* (5 Bulan)

Timeline ini mengikuti tempoh 20 minggu WBL / semester, memastikan aktiviti pengumpulan data dan pembangunan model dilakukan secara sistematik sepanjang semester.

Jadual 3: Tempoh Masa Pelaksanaan

Aktiviti	**Bulan 1**	**Bulan 2**	**Bulan 3**	**Bulan 4**	**Bulan 5**
Persediaan instrumen & kelulusan etika	●				
Pengumpulan data pelajar (soal selidik & *logbook*)		●	●		
Temu bual mentor & pensyarah			●	●	
Analisis data kuantitatif & kualitatif				●	●
Pembangunan model pelaksanaan & pemantauan WBL				●	●
Penyediaan laporan akhir & cadangan model					●

3.7 Etika Penyelidikan

Kelulusan menjalankan penyelidikan diperoleh sebelum kajian dijalankan, persetujuan bertulis diambil daripada responden, kerahsiaan data dijamin untuk tujuan akademik, dan data disimpan dengan selamat serta dilupuskan selepas kajian jika perlu.

4.0 ANALISIS DATA DAN DAPATAN

Bab ini membentangkan analisis data daripada kajian rintis yang dijalankan ke atas pelajar Diploma Teknologi Media Cetak (DMC) yang mengikuti WBL, serta pandangan mentor industri dan pensyarah pemantau. Analisis bertujuan untuk:

i. Menilai tahap kesediaan pelajar mengikuti WBL.
ii. Menilai keberkesanan pemantauan oleh mentor dan pensyarah.
iii. Mengenal pasti **c**abaran dan keperluan sokongan semasa pelaksanaan WBL.
iv. Menyokong pembangunan model pelaksanaan dan pemantauan WBL.

Data dikumpulkan melalui soal selidik pelajar, temu bual mentor/pensyarah, dan *logbook/*reflektif jurnal.

4.1 Analisis Data Kuantitatif (Pelajar)

4.1.1 Tahap Kesediaan Pelajar

Jadual 4 menunjukkan tahap kesediaan sederhana hingga tinggi dalam kalangan pelajar, tetapi masih memerlukan bimbingan tambahan dalam kemahiran teknikal.

Jadual 4: Keputusan Pilot Study, n=30

Item	**Min**	**Median**	**Kesimpulan**
Kefahaman terhadap WBL	4.2	4	Tinggi
Keyakinan menghadapi tugasan industri	3.8	4	Sederhana-Tinggi
Kemahiran teknikal semasa	3.5	3	Sederhana
Kemahiran komunikasi/profesional	3.7	4	Sederhana-Tinggi

4.1.2 Kepuasan Terhadap Pemantauan

Jadual 5 memaparkan mentor menunjukkan sokongan yang baik, namun aspek pemantauan masih perlu diperkemas. Manakala kesediaan pelajar pula berada pada tahap memuaskan.

Jadual 5: Kepuasan Terhadap Pemantauan

Item	Min	Median	Kesimpulan
Pemantauan oleh mentor	3.9	4	Sederhana-Tinggi
Panduan pemantauan	3.6	4	Sederhana
Respons mentor terhadap masalah	4.1	4	Tinggi

4.2 Analisis Data Kualitatif (Mentor & Pensyarah)

4.2.1 Cabaran yang Dikenal Pasti

Cabaran utama meliputi kekurangan pengalaman industri dalam kalangan pelajar, ketidakseragaman *logbook*/reflektif, jurang komunikasi mentor–pensyarah, serta kekangan masa pemantauan bersemuka.

4.2.2 Keberkesanan Pemantauan

Bimbingan berstruktur membantu pelajar menyesuaikan diri dengan lebih cepat, manakala temu bual berkala oleh pensyarah menyokong penilaian kemajuan pelajar.

4.3 Dapatan Gabungan (*Mixed-Method*)

Berdasarkan gabungan data kuantitatif dan kualitatif, dapatan data mengikut aspek adalah seperti berikut:

Jadual 6: Dapatan gabungan data kuantitatif dan kualitatif

Aspek	Dapatan
Kesediaan Pelajar	Sederhana-Tinggi, perlu bimbingan teknikal tambahan
Keberkesanan Pemantauan	Baik, tetapi memerlukan panduan lebih tersusun
Peranan Mentor	Sangat penting untuk bimbingan dan penilaian
Jurang Institusi–Industri	Ada, terutama dalam penguasaan kemahiran teknikal dan dokumentasi aktiviti

4.4 Implikasi Untuk Pembangunan Model

a) Model Pemantauan Bersepadu diperlukan untuk menyelaraskan, aktiviti harian pelajar, panduan mentor dan penilaian pensyarah.
b) Bimbingan mentor perlu distandardkan melalui SOP ringkas.
c) *Logbook*/reflektif jurnal perlu dijadikan instrumen utama untuk penilaian.
d) Model ini boleh dijadikan rujukan untuk program WBL TVET lain.

4.5 Perbincangan

Perbincangan kajian ini menumpukan kepada pelaksanaan *Work-Based Learning* (WBL) dalam Diploma Teknologi Media Cetak (DMC) dari aspek kesediaan pelajar, keberkesanan pemantauan, peranan mentor industri, jurang institusi–industri serta implikasi terhadap

pembangunan model WBL. Dapatan menunjukkan bahawa tahap kesediaan pelajar berada pada tahap sederhana hingga tinggi, namun kemahiran teknikal masih memerlukan penambahbaikan. Ini menunjukkan keperluan kepada latihan pra-WBL yang lebih komprehensif bagi meningkatkan keyakinan dan kemahiran pelajar sebelum ke industri.

Dari aspek pemantauan, kajian mendapati pelaksanaannya berada pada tahap memuaskan tetapi masih memerlukan penambahbaikan dari segi standardisasi dan garis panduan yang lebih jelas. Hal ini penting bagi memastikan proses pembelajaran berasaskan pengalaman dapat dilaksanakan secara lebih sistematik dan konsisten. Selain itu, mentor industri memainkan peranan penting dalam membimbing pelajar, namun kekurangan panduan khusus telah dikenal pasti sebagai cabaran. Justeru, pembangunan SOP atau garis panduan mentor adalah perlu bagi menyeragamkan proses bimbingan.

Kajian juga mengenal pasti wujudnya jurang antara institusi dan industri dari segi kemahiran, dokumentasi dan keselarasan kurikulum dengan keperluan industri semasa. Jurang ini boleh dikurangkan melalui kolaborasi yang lebih erat dalam pembangunan kurikulum dan penilaian pelajar. Secara keseluruhannya, dapatan kajian ini menunjukkan keperluan kepada pembangunan satu model WBL yang lebih sistematik dan bersepadu yang mengambil kira elemen kesediaan pelajar, pemantauan, peranan mentor dan kolaborasi industri. Model ini berpotensi meningkatkan keberkesanan pelaksanaan WBL serta menjadi rujukan kepada institusi TVET lain.

5.0 KESIMPULAN DAN CADANGAN MODEL

Bab ini merumuskan dapatan kajian rintis berdasarkan Bab 4 serta mencadangkan satu model pelaksanaan dan pemantauan *Work-Based Learning* (WBL) yang bersepadu. Model ini bertujuan meningkatkan keberkesanan program WBL, menyelaras hubungan antara institusi dan industri, serta membangunkan kompetensi pelajar yang selari dengan keperluan industri percetakan.

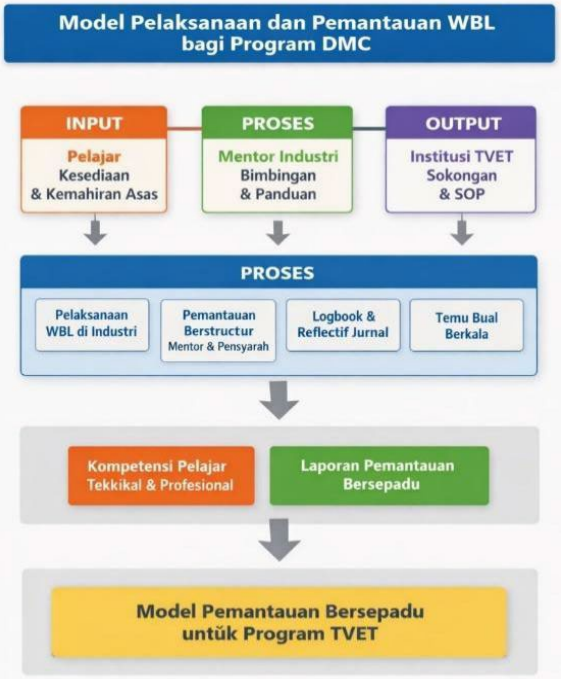
Secara keseluruhan, tahap kesediaan pelajar adalah sederhana hingga tinggi, dengan minat yang baik terhadap WBL namun masih memerlukan bimbingan dalam aspek kemahiran teknikal dan dokumentasi. Pemantauan oleh mentor dan pensyarah berada pada tahap memuaskan, tetapi masih memerlukan SOP yang lebih jelas dan seragam. Dapatan juga menunjukkan bahawa mentor industri memainkan peranan penting dalam membimbing pelajar di tempat kerja. Namun, wujud jurang antara institusi dan industri, khususnya dari segi kemahiran teknikal, pemahaman standard industri, serta penggunaan *logbook* dan jurnal reflektif secara konsisten.
Kajian ini membuktikan keperluan kepada model pemantauan WBL yang lebih sistematik bagi memastikan pengalaman pembelajaran yang lebih bermakna dan relevan dengan kehendak industri.

5.1 Cadangan Model Pelaksanaan dan Pemantauan WBL

Model yang dicadangkan terdiri daripada empat komponen utama:

i. **Input -** Melibatkan pelajar (kesediaan, kemahiran asas, sikap profesional), mentor industri (pengalaman dan bimbingan), serta sokongan institusi seperti SOP, latihan dan logbook.
ii. **Proses –** Merangkumi pelaksanaan WBL di industri, pemantauan berstruktur oleh mentor dan pensyarah, pengumpulan data melalui logbook dan jurnal reflektif, serta sesi bimbingan dan temu bual berkala.
iii. **Output -** Hasil utama ialah pencapaian kompetensi teknikal dan profesional pelajar serta laporan penilaian pemantauan yang lebih standard dan konsisten.
iv. **Outcome -**Akhirnya, model ini menghasilkan satu sistem WBL bersepadu yang boleh dijadikan rujukan oleh institusi TVET lain dalam melaksanakan program yang sama.

Visualisasi Model yang dicadangkan adalah seperti Rajah 1 berikut:



Rajah 1: Model Pelaksanaan dan Pemantauan WBL bagi Program DMC

5.2 Saranan

a) Pendidikan dan latihan tambahan untuk mentor bagi memudahkan pemantauan berstruktur.
b) Standardisasi logbook/reflektif jurnal sebagai instrumen utama penilaian WBL.
c) Kolaborasi erat institusi–industri melalui SOP dan sesi briefing tetap.
d) Kajian lanjutan selepas graduan pertama WBL untuk menilai keberkesanan model terhadap kebolehpasaran pelajar.

5.3 Kesimpulan

Kajian rintis ini berjaya membangunkan satu model pelaksanaan dan pemantauan WBL yang sistematik dan bersepadu bagi program TVET, khususnya Diploma Teknologi Media Cetak. Model ini memberi panduan praktikal kepada institusi lain yang ingin melaksanakan WBL, seterusnya menyumbang kepada peningkatan kualiti pendidikan TVET dan pengembangan kompetensi pelajar sejajar dengan kehendak industri moden.

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KESEDIAAN DAN IMPAK INTEGRASI AI GENERATIF TERHADAP EFIKASI KERJA PEGAWAI PENDIDIKAN PENGAJIAN TINGGI DI KOLEJ KOMUNITI PAYA BESAR DAN KOLEJ KOMUNITI PAYA BESAR CAWANGAN MARAN

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ABSTRAK

Kajian ini dilaksanakan bagi mengenal pasti tahap kesediaan serta kesan integrasi Kecerdasan Buatan (AI) Generatif terhadap keberkesanan tugas (efikasi kerja) dalam kalangan Pegawai Pendidikan Pengajian Tinggi (PPPT) Gred DH di Kolej Komuniti Paya Besar dan Kolej Komuniti Paya Besar Cawangan Maran. Kajian kuantitatif ini menggunakan kaedah banci dengan melibatkan seramai 52 responden (94.5% kadar pulangan). Analisis kebolehpercayaan instrumen menunjukkan nilai *Cronbach's Alpha* yang cemerlang bagi aspek kesediaan (*alpha* = 0.841) dan efikasi kerja (*alpha* = 0.946). Hasil analisis deskriptif mendapati skor min keseluruhan bagi kesediaan berada pada tahap tinggi (M = 4.18), manakala skor min efikasi kerja mencatatkan nilai M = 4.33. Profil demografi menunjukkan majoriti responden (76.9%) terdiri daripada kakitangan senior dengan tempoh perkhidmatan melebihi 15 tahun. Ujian korelasi Pearson mengesahkan wujudnya hubungan positif yang kuat dan signifikan (r = 0.629, $p < 0.001$), sementara analisis regresi linear membuktikan faktor kesediaan menyumbang sebanyak 39.6% terhadap peningkatan efikasi kerja pegawai. Kajian merumuskan bahawa penerimaan AI Generatif merupakan penyelesaian kritikal dalam meringankan beban tugas pentadbiran serta menyanggah mitos mengenai penolakan teknologi dalam kalangan kakitangan senior.

Kata Kunci: AI Generatif, Efikasi Kerja, Kolej Komuniti, *Prompt Engineering*, Transformasi Digital.

ABSTRACT

This study was conducted to identify the level of readiness and the impact of Generative Artificial Intelligence (AI) integration on work efficacy among Higher Education Officers (PPPT) Grade DH at Kolej Komuniti Paya Besar and its Maran Branch. Additionally, the study aims to test the validity of conventional myths regarding technology resistance among senior staff. Using a quantitative census approach, 52 respondents (94.5%) were involved in this study. Instrument reliability analysis recorded excellent Cronbach's Alpha values for readiness (α = 0.841) and work efficacy (α = 0.946). Data were analyzed descriptively and inferentially using IBM SPSS Statistics (Version 29.0) to obtain mean values, Pearson

correlation (r), and linear regression analysis (R^2). The results showed that the level of readiness (M = 4.18) and work efficacy (M = 4.33) are high, where the majority of respondents (76.9%) are senior staff with more than 15 years of service. Correlation tests confirmed a strong and significant positive relationship (r = 0.629, p < 0.001), while regression analysis proved that readiness contributes 39.6% to the increase in officers' work efficacy. The practical implications of the study suggest the need for systematic technical guidance through innovation development such as the AI Guide E-Book to minimize routine administrative burdens. Overall, this study refutes the myth that "digital immigrants" are resistant to technology, proving that age is not a primary barrier to the digital transformation of TVET institutions.

Keywords: *Generative AI, Work Efficacy, Community College, Prompt Engineering, Digital Transformation.*

1.0 PENDAHULUAN

1.1 Latar Belakang Kajian

Di peringkat Kolej Komuniti Paya Besar dan Cawangan Maran, warga pendidik kini mendepani cabaran besar untuk mengimbangi kualiti pengajaran TVET dengan beban pengurusan data yang kian rencam. Sejajar dengan Pelan Hala Tuju Kecerdasan Buatan Negara 2021-2025, integrasi Kecerdasan Buatan (AI) Generatif dilihat mampu menjadi pemudah cara strategik dalam mengautomasikan tugasan harian. Sehubungan dengan itu, Jabatan Pendidikan Politeknik dan Kolej Komuniti (JPPKK) menekankan pemerkasaan literasi digital sebagai teras utama bagi memastikan penyampaian pendidikan kekal relevan dengan dinamika industri masa kini. Walau bagaimanapun, sejauh mana teknologi kognitif ini benar-benar dapat membantu tugasan hakiki pendidik Gred DH sangat bergantung kepada tahap kesediaan mereka dalam mengadaptasi inovasi ini.

1.2 Pernyataan Masalah

Pegawai Pendidikan Gred DH sering terikat dengan lambakan tugasan pentadbiran rutin seperti penyediaan Fail Rekod Pengajaran (FRP) dan pengemaskinian Sistem Pengurusan Rekod (RMS) yang sering meragut waktu berkualiti pendidik. Situasi ini berisiko mencetuskan tekanan teknologi (technostress) yang boleh menjejaskan kualiti pengajaran (Hassan et al., 2023). Walau bagaimanapun, tumpuan kajian AI selama ini lebih banyak terarah kepada respons pelajar semata-mata, sekali gus meminggirkan isu efikasi pentadbiran pendidik di sebalik tabir. Terdapat jurang pengetahuan yang nyata mengenai bagaimana AI boleh berfungsi sebagai penyelesaian kepada kemelut dokumentasi di peringkat Kolej Komuniti.

Dalam pada itu, wujud juga stereotaip konvensional yang menganggap kakitangan senior cenderung menolak perubahan teknologi. Tanggapan ini kekal sebagai satu andaian tanpa bukti empirikal yang kukuh, terutamanya di institusi berskala kecil yang mempunyai dinamika kerja yang berbeza. Memandangkan 76.9% responden kajian ini merupakan kakitangan senior, satu penilaian empirikal amat diperlukan bagi mengisi kelompangan data tersebut. Kajian ini bukan

sahaja bertujuan merangka intervensi yang inklusif, malah ingin menguji sejauh mana kebenaran persepsi berkenaan agar nasib dan usaha pendidik senior lebih dihargai secara adil.

1.3 Objektif Kajian

1. Mengenal pasti tahap kesediaan teknikal dan psikologi PPPT Gred DH terhadap penerimaan AI Generatif.
2. Menilai arah hubungan serta kadar sumbangan pemboleh ubah kesediaan terhadap peningkatan efikasi kerja pegawai.
3. Menentukan kerangka komponen intervensi inovasi digital berteraskan rungutan tugasan hakiki responden.

2.0 TINJAUAN LITERATUR

2.1 Kerangka Teori: Model UTAUT, TAM dan Cabaran Mitos

Penyelidikan ini disandarkan kepada gabungan kerangka *Unified Theory of Acceptance and Use of Technology* (UTAUT) (Venkatesh et al., 2003) dan *Technology Acceptance Model* (TAM) (Davis, 1989). Kedua-dua teori ini menegaskan bahawa penerimaan sesuatu teknologi bergantung kepada persepsi pengguna terhadap keberkesanan hasil kerja serta kemudahan penggunaan teknologi tersebut. Justeru, kakitangan akademik akan lebih terdorong menggunakan AI sekiranya ia terbukti mempermudah tugas tanpa keluk pembelajaran yang terlalu rumit. Namun begitu, literasi klasik oleh Prensky (2001) sering melabelkan golongan senior sebagai *Digital Immigrants* iaitu kelompok yang dianggap sukar mengadaptasi teknologi baharu. Kajian ini menggunakan lensa UTAUT untuk mencabar persepsi berkenaan dengan membuktikan bahawa AI Generatif berpotensi menjadi alat pemudah cara yang bersifat rentas generasi.

2.2 AI Generatif dan Efikasi Organisasi

Dapatan Dwivedi et al. (2023) meletakkan AI Generatif sebagai rakan digital yang mampu melonjakkan kepantasan pendokumentasian. Efikasi kerja dalam konteks ini dirujuk sebagai keupayaan pegawai menghasilkan output yang tepat dalam tempoh masa yang minimum. Penggunaan AI mampu mengurangkan kelesuan tugasan pejabat, seterusnya membolehkan pendidik memberi tumpuan sepenuhnya kepada agenda kemenjadian pelajar (Zhai, 2021).

2.3 *Technostress* dan Peranan *Prompt Engineering*

Peralihan digital tanpa sokongan modul yang mantap berisiko mengundang tekanan teknologi atau ***technostress*** (Bondanini et al., 2020). Hal ini berlaku apabila kakitangan berhadapan dengan teknologi tanpa kemahiran membina arahan AI yang tepat (Alkaissi & McFarlane, 2023). Oleh itu, penguasaan kemahiran ***Prompt Engineering*** (kemahiran memberi arahan kepada AI) dikenal pasti sebagai penyelesaian strategik bagi meningkatkan keyakinan diri serta keberkesanan tugas warga pendidik (Sullivan et al., 2023).

3.0 METODOLOGI KAJIAN

3.1 Reka Bentuk Kajian

Kajian ini menggunakan reka bentuk kuantitatif deskriptif melalui kaedah tinjauan keratan rentas (*cross-sectional survey*). Pendekatan ini dipilih bagi membolehkan penyelidik mengumpul data secara serentak daripada populasi sasaran untuk menggambarkan trend semasa kesediaan digital staf.

3.2 Populasi dan Persampelan

Populasi kajian mencakupi keseluruhan PPPT Gred DH di Kolej Komuniti Paya Besar dan Cawangan Maran (N=55). Memandangkan saiz populasi yang kecil, penyelidik menggunakan kaedah banci (census) atau persampelan keseluruhan populasi bagi menjamin kejituan data. Seramai 52 responden telah mengembalikan soal selidik lengkap (Kadar pulangan: 94.5%). Merujuk parameter yang digariskan dalam jadual Krejcie dan Morgan (1970), penentuan saiz sampel bagi populasi 55 adalah pada angka minimum 48. Keputusan kutipan data n=52 membuktikan bahawa kajian ini telah memenuhi, malah melangkaui tahap kesahan statistik yang ditetapkan.

3.3 Instrumen Kajian

Instrumen kajian merupakan set soal selidik digital berskala Likert 5-mata yang dibahagikan kepada empat bahagian: (A) Profil Demografi, (B) Tahap Kesediaan [8 Item], (C) Impak Efikasi Kerja [7 Item], dan (D) Ruang maklum balas terbuka. Soal selidik ini telah melalui proses pengesahan kandungan bagi memastikan kesesuaian item dengan persekitaran kerja di Kolej Komuniti.

3.4 Prosedur Analisis Data

Data dianalisis secara kuantitatif menggunakan perisian pemprosesan statistik berkomputer. Prosedur analisis dibahagikan kepada dua peringkat:

1. **Analisis Deskriptif:** Digunakan untuk menerangkan taburan profil responden melalui kekerapan dan peratusan. Bagi menjawab Objektif 1, skor min dan sisihan piawai dihitung bagi menentukan tahap kesediaan dan efikasi.
2. **Analisis Inferensi:** Melibatkan ujian Korelasi Pearson bagi mengenal pasti kekuatan dan arah hubungan antara pemboleh ubah. Seterusnya, ujian Regresi Linear Mudah dijalankan bagi mengukur sumbangan varians kesediaan terhadap efikasi kerja (Objektif 2).
3. **Ujian Kebolehpercayaan:** Ketekalan dalaman item diuji menggunakan pekali Cronbach's Alpha.

3.4 Had Kajian

Kajian ini mempunyai beberapa had yang perlu diambil perhatian dalam interpretasi data. Dapatan kajian ini, terutamanya penolakan mitos bahawa kakitangan senior rintang terhadap teknologi, mungkin tidak boleh digeneralisasikan kepada seluruh populasi Politeknik dan Kolej Komuniti di Malaysia. Hal ini kerana faktor geografi dan perbezaan kemudahan infrastruktur setempat di Kolej Komuniti Paya Besar dan Cawangan Maran mungkin

mempengaruhi persepsi serta tahap kesediaan responden. Kajian masa hadapan disarankan untuk melibatkan sampel yang lebih luas merangkumi pelbagai zon bagi mendapatkan gambaran yang lebih komprehensif di peringkat nasional.

4.0 DAPATAN DAN PERBINCANGAN

4.1 Analisis Kebolehpercayaan Instrumen

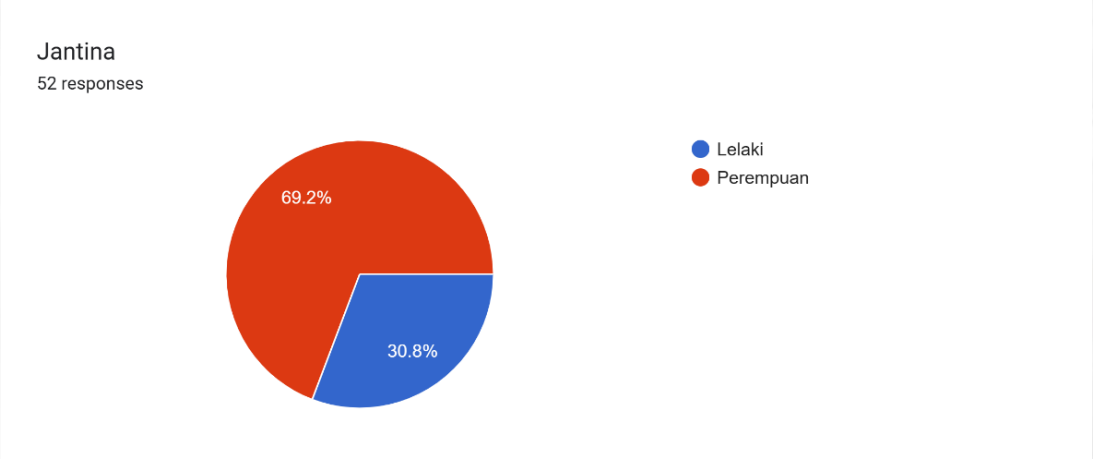
Sebelum analisis dijalankan, ketekalan dalaman instrumen disahkan melalui ujian Cronbach's Alpha. Nilai pekali yang diperoleh membuktikan instrumen adalah sangat tekal dan boleh dipercayai.

Jadual 1: Nilai Kebolehpercayaan Cronbach's Alpha Mengikut Konstruk (N=52)

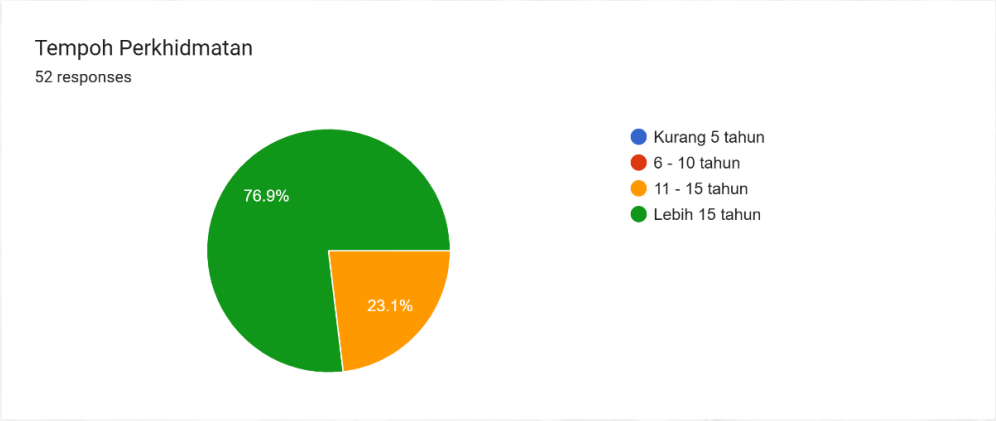
Konstruk Kajian	Bilangan Item	Nilai Cronbach's Alpha (α)	Interpretasi
Kesediaan Penggunaan AI (IV)	8	0.841	Sangat Baik
Impak Efikasi Kerja (DV)	7	0.946	Cemerlang

4.2 Analisis Profil Demografi Responden

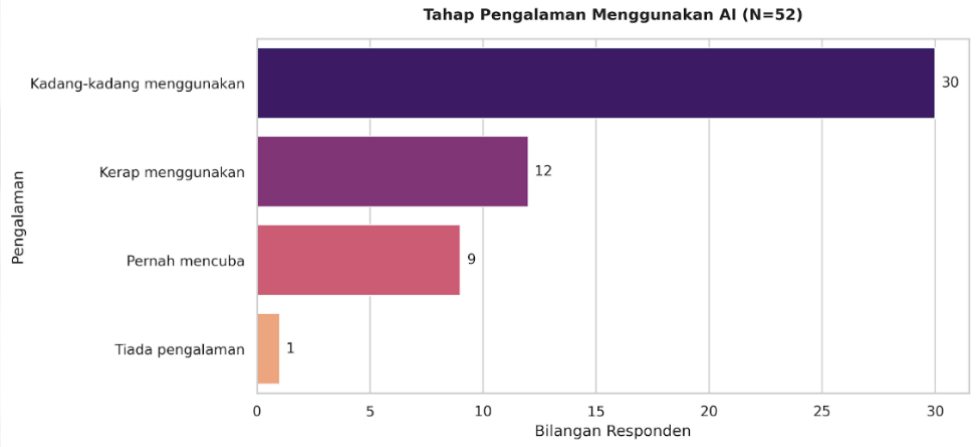
Penelitian terhadap ciri demografi mendedahkan dominasi jantina wanita sebanyak 69.2% (*n*=36) manakala lelaki 30.8% (*n*=16). Dari segi profil perkhidmatan, komposisi utama dibentuk oleh staf veteran di mana 76.9% (*n*=40) telah berkhidmat melebihi 15 tahun.



Rajah 1 : Profil Responden Mengikut Jantina



Rajah 2: Profil Responden Mengikut Tempoh Perkhidmatan



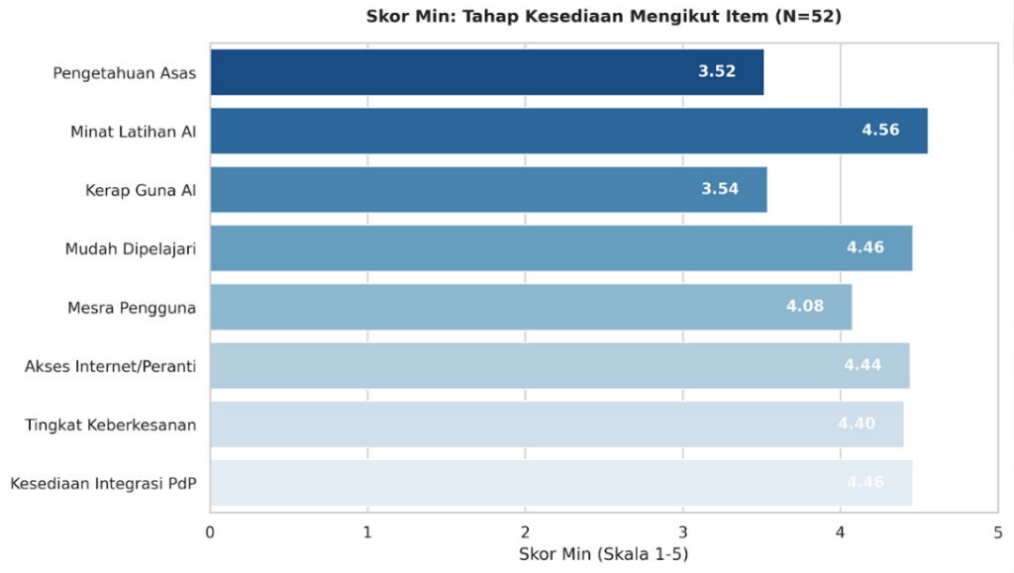
Rajah 3: Tahap Pengalaman dan Pendedahan Sedia Ada Menggunakan AI

4.3 Analisis Deskriptif: Tahap Kesediaan dan Efikasi

Analisis min dalam Jadual 2 mengesahkan satu jurang yang unik; pegawai memiliki minat yang amat tinggi untuk didedahkan dengan latihan (*M*=4.56), namun mengakui pengetahuan asas mereka masih pada tahap sederhana (*M*=3.52).

Jadual 2: Analisis Deskriptif Tahap Kesediaan AI Mengikut Item (N=52)

Item Kesediaan	**Min (M)**	**Sisihan Piawai (SD)**	**Tahap**
Berminat untuk mengikuti latihan berkaitan alatan AI.	4.56	0.67	Tinggi
Merasakan alatan AI mudah dipelajari melalui panduan.	4.46	0.61	Tinggi
Bersedia mengintegrasikan AI dalam aktiviti pengajaran.	4.46	0.61	Tinggi
Mempunyai akses peranti dan internet yang mencukupi.	4.44	0.70	Tinggi
Percaya penggunaan AI meningkatkan keberkesanan tugas.	4.40	0.60	Tinggi
Interaksi dengan alatan AI adalah mesra pengguna.	4.08	0.68	Tinggi
Kerap menggunakan alatan AI untuk tugasan rasmi.	3.54	0.83	Sederhana
Mempunyai pengetahuan asas mengenai alatan AI.	3.52	0.73	Sederhana
Purata Keseluruhan Kesediaan	**4.18**	**0.48**	**Tinggi**



Rajah 4: Perbandingan Skor Min bagi Setiap Item Konstruk Kesediaan AI

Dapatan Jadual 3 membuktikan AI Generatif memberikan impak nyata terutamanya dalam kemudahan menghasilkan bahan bantu mengajar dan penjimatan masa kerja.

Jadual 3: Analisis Deskriptif Impak Efikasi Kerja (N=52)

Item Impak Efikasi Kerja	**Min (M)**	**Sisihan Piawai (SD)**	**Tahap**
Mudah menghasilkan bahan PdP (laporan, slaid, nota).	4.44	0.57	Tinggi
Menjimatkan masa dalam penyediaan bahan pengajaran.	4.44	0.57	Tinggi
Meningkatkan kualiti dokumentasi dan grafik.	4.37	0.56	Tinggi
Membantu menjadi lebih kreatif dalam PdP.	4.33	0.59	Tinggi
Membolehkan penyediaan tugasan (FRP, RMS) dengan lebih pantas.	4.31	0.64	Tinggi
Meningkatkan produktiviti dan efikasi secara keseluruhan.	4.23	0.61	Tinggi
Mengurangkan beban tugasan berulang.	4.21	0.72	Tinggi
Purata Keseluruhan Efikasi	**4.33**	**0.53**	**Tinggi**



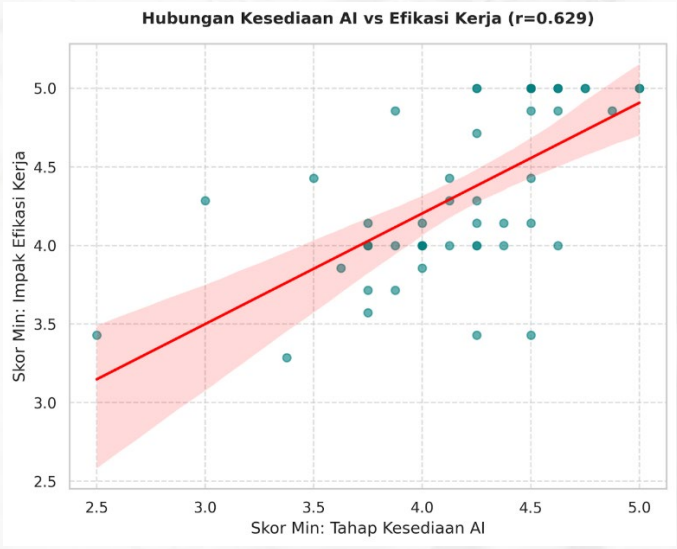
Rajah 5: Perbandingan Skor Min bagi Setiap Item Konstruk Impak Efikasi Kerja

4.4 Analisis Inferensi: Hubungan dan Sumbangan

Graf serakan (Ujian korelasi Pearson) dan Jadual 4 membuktikan keutuhan hubungan positif yang signifikan secara statistik ($r = 0.629$, $p < 0.001$). Semakin tinggi tahap kesediaan staf, semakin ketara peningkatan efikasi kerja mereka.

Jadual 4: Korelasi Pearson antara Tahap Kesediaan dan Efikasi Kerja

Pemboleh Ubah	Tahap Kesediaan AI	Efikasi Kerja
Tahap Kesediaan AI	1	**0.629****
Efikasi Kerja	0.629**	1
** Korelasi adalah signifikan pada aras 0.01 (2-tailed).		



Rajah 6: Graf Serakan Hubungan Linear Antara Kesediaan AI dan Efikasi Kerja

Pemodelan Regresi Linear (Jadual 5) mengabsahkan bahawa 39.6% (berdasarkan *R-Square* = 0.396) pengembangan keupayaan efikasi staf disumbangkan terus oleh faktor kesediaan penggunaan AI.

Jadual 5: Analisis Regresi Linear Mudah Sumbangan Varians

Pemboleh Ubah	**Pekali Beta (β)**	**Nilai t**	**Signifikan (p)**
Pemalar		2.677	0.010
Tahap Kesediaan AI	0.629	5.726	0.000

Nota: R-Square = 0.396; F = 32.79, p < 0.001. Pemboleh Ubah Bersandar: Efikasi Kerja.

4.5 Analisis Keperluan Inovasi

Analisis terhadap maklum balas terbuka mengenal pasti rintihan responden terhadap proses dokumentasi yang "meragut" masa pengajaran. Staf mendesak keperluan bagi panduan automasi penulisan laporan aktiviti, penukaran dokumen kepada format persembahan visual, serta teknik penjanaan soalan pentaksiran yang pantas.

5.0 RUMUSAN DAN CADANGAN

5.1 Rumusan Kajian

Sebagai kesimpulan, penyelidikan ini secara tuntas menyanggah mitos stereotaip yang mendakwa kelompok pendidik senior, yang sering dikategorikan sebagai *digital immigrants*, sukar menerima anjakan teknologi. Walaupun 76.9% responden terdiri daripada golongan tersebut, dapatan kajian membuktikan bahawa mereka sebenarnya mempamerkan keterbukaan yang sangat tinggi terhadap integrasi AI dalam kerjaya. Halangan utama penerimaan teknologi didapati bukanlah berpunca daripada faktor usia, sebaliknya disebabkan oleh ketiadaan panduan teknikal yang sistematik. Malah, kajian ini merumuskan bahawa golongan senior di Kolej Komuniti merupakan perintis yang proaktif dalam mencari penyelesaian digital bagi merungkai kelesuan tugasan harian. Jelaslah bahawa faktor umur mahupun senioriti bukan satu liabiliti dalam transformasi digital; sebaliknya ketiadaan inisiatif bimbingan yang terancanglah yang dikesan sebagai penghalang sebenar kepada pemerkasaan kreativiti pendidik.

5.2 Cadangan Intervensi dan Inovasi Susulan

Bagi memastikan kajian ini memberi impak nyata, penyelidik mencadangkan pelaksanaan inovasi penerbitan e-Book Panduan AI. Sebagai langkah ke hadapan (*way forward*), penyelidik akan membangunkan manual sedia guna yang mengandungi templat arahan AI bagi tugasan harian. Inisiatif ini dijangka dapat menyeragamkan kualiti pelaporan institusi serta membolehkan kakitangan bekerja dengan lebih pintar dan cekap.

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PERSEPSI IBU BAPA TERHADAP IMPAK KURSUS PENDEK CUTI SEKOLAH DALAM PENINGKATAN KOMPETENSI PELAJAR SEKOLAH RENDAH: KAJIAN DI KOLEJ KOMUNITI PAYA BESAR

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Abstrak

Kajian ini bertujuan untuk mengenal pasti persepsi ibu bapa terhadap impak kursus pendek program cuti sekolah di Kolej Komuniti Paya Besar (KKPB) dalam meningkatkan kompetensi pelajar sekolah rendah. Dalam era persaingan global, pembangunan kompetensi holistik kanak-kanak perlu diukur melalui keberkesanan platform alternatif yang membekalkan kemahiran praktikal. Kajian ini menggunakan pendekatan kuantitatif dengan reka bentuk tinjauan, melibatkan sampel seramai 58 orang ibu bapa. Data dikumpul melalui instrumen kaji selidik berskala Likert 5-mata dan dianalisis secara statistik deskriptif menggunakan nilai min (*M*) dan sisihan piawai (*SP*). Dapatan kajian menunjukkan secara keseluruhannya persepsi ibu bapa berada pada tahap yang tinggi dengan nilai min keseluruhan (*M* = 4.12, *SP* = 1.01). Domain kompetensi praktikal mencatatkan skor min tertinggi (*M* = 4.33, *SP* = 0.64), di mana pelajar menunjukkan peningkatan ketara dalam kecekapan menggunakan alatan dan keberanian mencuba kemahiran baharu seperti Robotik, IT, dan Seni Kraf. Domain minat dan akademik (*M* = 4.26, *SP* = 0.80) serta sosioemosi (*M* = 4.25, *SP* = 0.67) turut mencatatkan skor yang tinggi, membuktikan lonjakan keyakinan diri dan semangat belajar dalam kalangan pelajar. Secara keseluruhannya, hasil kajian ini mengukuhkan peranan KKPB sebagai pemangkin transformasi modal insan dan berfungsi sebagai rujukan empirikal bagi pembangunan program pengayaan cuti sekolah yang lebih berimpak pada masa hadapan.

Kata kunci: Persepsi ibu bapa, kursus pendek, kompetensi pelajar, Kolej Komuniti Paya Besar, program cuti sekolah.

Abstract

This study aims to identify parents' perceptions of the impact of short courses offered during school holiday programs at Paya Besar Community College (KKPB) in enhancing the competency of primary school students. In an era of global competition, the development of a child's holistic competency must be measured through the effectiveness of alternative platforms that provide practical skills. This study employed a quantitative approach with a survey design, involving a sample of 58 parents. Data were collected using a 5-point Likert scale survey instrument and analyzed through descriptive statistics, specifically mean (M) and standard deviation (SD). The findings indicate that, overall, parental perception is at a high level, with an overall mean value of (M = 4.12, SD = 1.01). The practical competency domain recorded the highest mean score (M = 4.33, SD = 0.64), where students showed significant improvement

in tool-handling proficiency and the courage to explore new skills such as Robotics, IT, and Arts and Crafts. The interest and academic domain (M = 4.26, SD = 0.80) as well as the socio-emotional domain (M = 4.25, SD = 0.67) also recorded high scores, proving a surge in self-confidence and enthusiasm for learning among students. Overall, the results of this study reinforce the role of KKPB as a catalyst for human capital transformation and serve as an empirical reference for the development of more impactful school holiday enrichment programs in the future.

Keywords: *Parental perception, short courses, student competency, Kolej Komuniti Paya Besar, school holiday programs.*

1.0 PENGENALAN

Pendidikan anak-anak pada masa kini tidak lagi terbatas kepada pembelajaran formal di sekolah semata-mata, sebaliknya melangkaui bilik darjah untuk merangkumi pelbagai aktiviti pembangunan kemahiran di luar waktu persekolahan, terutamanya semasa cuti sekolah. Kursus pendek atau program khas cuti sekolah semakin popular sebagai kaedah berfaedah untuk mengisi masa lapang pelajar, di samping mengejar kecemerlangan akademik. Program-program ini sering dirangka untuk memupuk kemahiran yang mungkin kurang ditekankan dalam kurikulum formal, seperti kemahiran sosial, kreativiti, pemikiran kritis, dan kemahiran praktikal (Hamzah et al., 2021). Pendekatan ini selaras dengan penekanan sistem pendidikan masa kini terhadap pembangunan kompetensi holistik yang merangkumi aspek kognitif, emosi, sosial, dan fizikal, selaras dengan keperluan abad ke-21 (Zailani & Roslan, 2019).

Kolej Komuniti Paya Besar (KKPB), sebagai sebuah institusi pendidikan yang komited kepada pembangunan komuniti, turut proaktif dalam menawarkan pelbagai kursus pendek dan program khas semasa cuti sekolah. Program-program ini menyasarkan pelajar sekolah rendah dengan objektif untuk menyediakan platform pembelajaran yang menyeronokkan dan relevan. Walau bagaimanapun, keberkesanan program seumpama ini sebahagian besarnya bergantung kepada persepsi dan penerimaan pihak berkepentingan utama, iaitu ibu bapa (Lee & Tan, 2017). Persepsi ibu bapa terhadap impak kursus pendek ini ke atas peningkatan kompetensi anak-anak mereka adalah penting kerana ia mencerminkan nilai dan manfaat sebenar yang diperoleh daripada program tersebut. Sebagai pemerhati utama, ibu bapa adalah pihak yang paling rapat dengan anak-anak dan dapat memerhatikan perubahan tingkah laku, minat, dan kemahiran anak-anak mereka secara langsung selepas menyertai sesuatu program (Lim & Chan, 2020). Oleh itu, memahami pandangan mereka tentang peningkatan kompetensi anak-anak adalah kritikal untuk menilai kejayaan program tersebut dan untuk perancangan penambahbaikan di masa hadapan (Lim & Chan, 2020).

Sehubungan itu, kajian ini akan meneliti secara spesifik persepsi ibu bapa terhadap impak kursus pendek program cuti sekolah di Kolej Komuniti Paya Besar dalam konteks peningkatan kompetensi pelajar sekolah rendah. Penemuan kajian ini dijangka akan memberikan gambaran yang jelas mengenai keberkesanan program cuti sekolah dari perspektif ibu bapa, seterusnya

menyumbang kepada penambahbaikan dan pembangunan program seumpamanya di Kolej Komuniti Paya Besar khususnya, dan institusi pendidikan lain secara amnya.

1.1 Pernyataan Masalah

Pembangunan kompetensi pelajar sekolah rendah kini merangkumi aspek kognitif, emosi, sosial, dan fizikal bagi memenuhi keperluan abad ke-21. Di Kolej Komuniti Paya Besar (KKPB), terdapat peningkatan ketara dalam permintaan terhadap program pembangunan kemahiran tidak formal ini. Data menunjukkan pada tahun 2023 sebanyak 27 kursus telah dilaksanakan dengan penglibatan 447 peserta, manakala pada tahun 2024 jumlah ini meningkat kepada 35 kursus dengan 646 orang peserta.

Meskipun data menunjukkan lonjakan penyertaan yang tinggi, keberkesanan sebenar program ini dari sudut kualiti dan impak pembangunan kompetensi masih belum dinilai secara sistematik. Wujud jurang maklumat di mana peningkatan kuantiti peserta tidak semestinya mencerminkan kualiti kompetensi yang diperolehi. Tanpa penilaian empirikal terhadap persepsi ibu bapa sebagai pemerhati utama, KKPB tidak dapat mengukur sejauh mana kursus ini melengkapkan pelajar dengan kemahiran yang relevan dan holistik. Oleh itu, kajian ini kritikal untuk merapatkan jurang antara data penyertaan yang tinggi dengan keberkesanan impak program yang sebenar

1.2 Objekif Kajian

a) Mengenal pasti persepsi ibu bapa terhadap relevansi kandungan dan keberkesanan kaedah PdP dalam kursus pendek program cuti sekolah di Kolej Komuniti Paya Besar.
b) Menilai persepsi ibu bapa terhadap impak kursus dalam peningkatan kompetensi kognitif dan sosioemosi pelajar.
c) Menganalisis persepsi ibu bapa terhadap peningkatan kompetensi praktikal dan motor halus anak-anak melalui aktiviti kursus yang dijalankan

1.2 Kepentingan Kajian

a) Kepada Kolej Komuniti Paya Besar

Kajian ini akan menyediakan maklum balas langsung dan holistik daripada ibu bapa, yang merupakan pengguna utama program cuti sekolah. Maklum balas ini amat penting bagi pihak Kolej Komuniti Paya Besar untuk menilai semula, menambah baik, dan merangka program cuti sekolah yang lebih efektif dan bersesuaian dengan keperluan serta harapan pelajar dan ibu bapa pada masa hadapan. Selain itu, penemuan kajian ini dapat mengukuhkan lagi peranan Kolej Komuniti Paya Besar sebagai pusat pembangunan kemahiran komuniti yang relevan dan berimpak.

b) Kepada Penyedia Program Pendidikan Tidak Formal

Hasil kajian ini boleh berfungsi sebagai panduan praktikal bagi institusi atau organisasi lain yang turut menawarkan program pendidikan tidak formal serupa untuk pelajar sekolah rendah. Ia akan membantu mereka dalam merangka kurikulum yang lebih berkesan, membangunkan kaedah pengajaran yang inovatif, dan merancang strategi promosi yang lebih menyasarkan**.** Ini secara tidak langsung akan meningkatkan kualiti keseluruhan penawaran pendidikan tidak formal di Malaysia.

c) Kepada Ibu Bapa

Kajian ini berpotensi untuk meningkatkan kesedaran ibu bapa tentang pelbagai jenis kursus pendek yang berfaedah yang tersedia di luar kurikulum formal sekolah. Ia akan memberikan pemahaman yang lebih mendalam tentang bagaimana program-program ini boleh menyumbang kepada pembangunan holistik anak-anak mereka dalam aspek kognitif, sosial, emosi, dan praktikal, melangkaui pencapaian akademik semata-mata.

d) Kepada Bidang Penyelidikan Pendidikan

Dari sudut pandang akademik, kajian ini akan menambah kepada korpus literatur sedia ada dalam bidang pendidikan tidak formal, pembangunan kompetensi kanak-kanak, dan kepentingan persepsi ibu bapa dalam penilaian keberkesanan program pendidikan. Ia juga secara khusus akan menyumbang kepada pemahaman yang lebih baik tentang peranan dan konteks Kolej Komuniti di Malaysia sebagai penyedia pendidikan sepanjang hayat yang penting.

2.0 KAJIAN LITERATUR

2.1 Konsep Pembangunan Kompetensi Pelajar Sekolah Rendah

Pembangunan kompetensi pelajar kini merujuk kepada pemerolehan dan aplikasi gabungan pengetahuan, kemahiran, dan sikap yang diperlukan untuk berfungsi dengan berkesan dalam pelbagai konteks. Bagi pelajar sekolah rendah, definisi ini melangkaui pencapaian akademik semata-mata. Sistem pendidikan masa kini semakin menekankan pembangunan kompetensi holistik yang merangkumi aspek kognitif, emosi, sosial, dan fizikal, selaras dengan keperluan abad ke-21 (Zailani & Roslan, 2019). Kompetensi abad ke-21 yang kritikal ini termasuk pemikiran kritis, kreativiti, komunikasi, kolaborasi, literasi digital, dan kemahiran menyelesaikan masalah (Mohd Faizal et al., 2018). Pembangunan holistik ini dianggap penting untuk mempersiapkan pelajar menghadapi cabaran dan peluang di masa hadapan. Walaupun pendidikan formal di sekolah menyediakan asas, program luar kurikulum, termasuk kursus pendek, menawarkan peluang tambahan yang signifikan untuk memperkaya dan memperkukuh kompetensi ini.

2.2 Peranan Program Cuti Sekolah dalam Pendidikan Tidak Formal

Program cuti sekolah, kursus pendek, dan kem motivasi telah menjadi sebahagian penting daripada ekosistem pendidikan tidak formal yang berkembang pesat (Ismail et al., 2016). Program-program ini menyediakan persekitaran pembelajaran yang berbeza daripada bilik darjah tradisional, selalunya lebih santai, berorientasikan aktiviti, dan berfokus kepada minat pelajar. Matlamat utama program ini adalah untuk memperkaya pengalaman pembelajaran pelajar, memupuk minat baharu, dan membangunkan kemahiran yang mungkin tidak dapat diteroka sepenuhnya dalam jadual sekolah yang padat (Abdullah & Salleh, 2018). Penawaran pelbagai kursus, seperti kemahiran STEM, seni dan kraf, kemahiran komunikasi, atau pemikiran kritis, mencerminkan usaha untuk menyediakan pendidikan yang lebih menyeluruh. Kursus-kursus ini dilihat sebagai platform alternatif yang berpotensi untuk membekalkan kemahiran tambahan kepada pelajar.

2.3 Kepentingan Persepsi Ibu Bapa dalam Penilaian Program Pendidikan

Persepsi ibu bapa adalah indikator kritikal dalam menilai kejayaan dan keberkesanan sesuatu program pendidikan, terutamanya yang melibatkan kanak-kanak di bawah umur (Lim & Chan, 2020). Ibu bapa adalah pihak yang paling rapat dengan anak-anak dan dapat memerhatikan perubahan tingkah laku, peningkatan kemahiran, dan perkembangan minat anak-anak mereka secara langsung selepas menyertai sesuatu program. Pandangan ibu bapa, sama ada positif atau negatif, seringkali mempengaruhi keputusan ibu bapa lain untuk mendaftarkan anak-anak mereka dalam program yang sama pada masa hadapan (Lee & Tan, 2017). Oleh itu, memahami persepsi ibu bapa bukan sahaja memberikan maklum balas tentang kualiti program yang ditawarkan, tetapi juga menyumbang kepada legitimasi dan kemampanan program tersebut.

2.4 Kolej Komuniti sebagai Penyedia Program PSH

Kolej Komuniti di Malaysia ditubuhkan dengan mandat untuk menyediakan pendidikan dan latihan teknikal serta vokasional, di samping berperanan dalam pembangunan komuniti setempat melalui program Pembelajaran Sepanjang Hayat (PSH) (Kementerian Pendidikan Tinggi, 2015). Kolej Komuniti Paya Besar, sebagai sebuah institusi pendidikan yang komited kepada pembangunan komuniti, turut proaktif dalam menawarkan pelbagai kursus pendek dan program khas semasa cuti sekolah. Program-program ini menyasarkan pelajar sekolah rendah dengan objektif untuk menyediakan platform pembelajaran yang menyeronokkan dan relevan. Dengan infrastruktur dan fasiliti yang ada, Kolej Komuniti mempunyai potensi besar untuk menjadi pusat rujukan komuniti bagi pembelajaran tidak formal yang berkesan dan relevan. Menerusi kursus pendek yang direka khas, Kolej Komuniti Paya Besar berhasrat untuk menyumbang kepada pembangunan potensi penuh kanak-kanak di samping memupuk minat mereka terhadap pembelajaran sepanjang hayat.

3.0 METODOLOGI KAJIAN

Kajian ini akan menggunakan pendekatan kuantitatif dengan reka bentuk kajian tinjauan (*survey study*). Pendekatan kuantitatif dipilih untuk mengukur dan mengenal pasti persepsi ibu bapa terhadap impak kursus pendek program cuti sekolah secara berstatistik. Reka bentuk tinjauan adalah sesuai kerana ia membolehkan pengumpulan data yang sistematik daripada sebilangan besar responden menggunakan soal selidik yang standard.

3.1 Reka Bentuk Kajian

Reka bentuk kajian tinjauan (*survey study*) akan digunakan. Pendekatan ini memfokuskan kepada pengumpulan data numerik daripada sampel populasi untuk mengenal pasti corak, trend, dan hubungan antara pemboleh ubah. Ini berbeza daripada reka bentuk kajian kes yang bersifat penerokaan mendalam, sebaliknya membolehkan generalisasi penemuan kepada populasi yang lebih besar (Creswell & Creswell, 2018; Yin, 2018). Dalam kajian ini, reka bentuk tinjauan akan membolehkan pengumpulan data mengenai persepsi ibu bapa terhadap impak kursus pendek cuti sekolah dalam konteks Kolej Komuniti Paya Besar (KKPB).

3.2 Sampel Kajian

Populasi kajian ini terdiri daripada 60 orang ibu bapa yang mempunyai anak yang telah mengikuti kursus pendek program cuti sekolah di Kolej Komuniti Paya Besar bagi sesi 2023 dan 2024. Teknik pensampelan bertujuan digunakan untuk memastikan responden yang dipilih mempunyai pengalaman langsung dan mendalam terhadap program yang dinilai. Ibu bapa yang dipilih memenuhi kriteria berikut:

1. Mempunyai anak berumur antara 7 hingga 12 tahun iaitu pelajar sekolah rendah.
2. Anak telah menyertai sekurang-kurangnya satu kursus pendek anjuran Kolej Komuniti Paya Besar.
3. Bersedia memberikan maklum balas secara sukarela dan terperinci melalui soal selidik.

Daripada jumlah keseluruhan populasi, seramai 58 orang responden telah berjaya melengkapkan soal selidik maklum balas. Ini mencatatkan kadar maklum balas yang sangat tinggi iaitu sebanyak 96.7%. Walaupun saiz sampel (N=58) dilihat kecil bagi kajian tinjauan umum, namun jumlah ini adalah sangat signifikan kerana merangkumi hampir keseluruhan populasi sasaran (96.7%). Oleh itu, data yang diperoleh mempunyai kesahan dalaman yang tinggi bagi mewakili persepsi ibu bapa di Kolej Komuniti Paya Besar, sekaligus menjawab keperluan analisis statistik yang sah bagi kajian kuantitatif ini.

3.3 Instrumen Kajian

Instrumen utama kajian ini adalah soal selidik. Soal selidik ini telah direka khusus untuk mengukur persepsi ibu bapa terhadap impak kursus pendek program cuti sekolah. Soal selidik ini terbahagi kepada beberapa bahagian utama:

- **Bahagian A:** Maklumat Demografi Responden - Meliputi jantina, umur, tahap pendidikan tertinggi dan pendapatan isi rumah bulanan serta Latar Belakang Penglibatan Anak dalam Program Cuti Sekolah - Merangkumi umur anak dan jenis kursus pendek yang disertai.
- **Bahagian B:** Persepsi Terhadap Impak Kursus Pendek dalam Peningkatan Kompetensi Anak menggunakan skala Likert 5 mata (1 = Sangat Tidak Setuju, 5 = Sangat Setuju) untuk menilai kemahiran kognitif & akademik (tidak langsung)
- **Bahagian C:** Persepsi Terhadap Relevansi Kandungan Kursus - Menggunakan skala Likert 5 mata (1 = Sangat Tidak Setuju, 5 = Sangat Setuju) untuk menilai kesesuaian kandungan kursus dengan perkembangan kanak-kanak dan keperluan abad ke-21. Item-item ini diadaptasi dari instrumen penilaian kurikulum (Zailani & Roslan, 2019; Abdullah & Salleh, 2018).
- **Bahagian D:** Menilai peningkatan kompetensi - Dibahagikan kepada dua sub-bahagian, menggunakan skala Likert 5 mata (1 = Sangat Tidak Setuju, 5 = Sangat Setuju) untuk menilai peningkatan kompetensi:
    - **D1: Peningkatan Kompetensi Sosial & Emosi** - Menilai keyakinan diri, komunikasi, kerjasama, disiplin diri, dan pengurusan emosi.
    - **D2: Peningkatan Kompetensi Praktikal & Fizikal** - Menilai kemahiran praktikal baharu, kecekapan aktiviti motor halus, sifat berani mencuba, peningkatan keyakinan menggunakan alatan atau bahan dan konsisten dalam melaksanakan tugasan praktikal.

Item-item di Bahagian D diadaptasi dari instrumen penilaian impak program pendidikan (Lim & Chan, 2020; Lee & Tan, 2017).

- **Bahagian E:** Cadangan Penambahbaikan - Menyediakan ruang komen terbuka untuk mendapatkan maklum balas konstruktif.

Soal selidik ini telah disemak oleh Ketua Unit Penyelidikan, Inovasi dan Komersialan KKPB untuk memastikan kesahan kandungan (*content validity*). Selain itu, ujian rintis (*pilot test*) dijalankan dengan 2-3 orang ibu bapa yang tidak terlibat dalam kajian sebenar bagi menguji kejelasan soalan dan kebolehpercayaan instrumen.

3.4 Analisis Data

Data yang dikumpul melalui borang soal selidik telah dianalisis secara sistematik menggunakan perisian statistik komputer bagi memastikan ketepatan dapatan. Proses analisis data ini melibatkan langkah-langkah berikut:

a) **Pembersihan Data:** Data yang diperoleh daripada 58 orang responden diperiksa terlebih dahulu bagi mengenal pasti sebarang ralat atau data yang hilang (*missing data*) bagi menjamin kebolehpercayaan hasil kajian.

b) **Analisis Statistik Deskriptif:** Analisis ini merupakan fokus utama kajian bagi menjawab ketiga-tiga objektif yang ditetapkan. Statistik deskriptif yang merangkumi kekerapan (*f*), peratusan (%), nilai min (*M*), dan sisihan piawai (*SP*) digunakan untuk menghuraikan profil demografi responden serta mengukur tahap persepsi ibu bapa terhadap relevansi, keberkesanan PdP, dan impak kompetensi anak-anak.

c) **Interpretasi Skor Min:** Menginterpretasikan nilai skor min yang diperoleh kepada tiga tahap utama, iaitu Rendah (1.00 – 2.33), Sederhana (2.34 – 3.66), dan Tinggi (3.67 – 5.00) berpandukan piawaian Nor Syazwanie binti Mohamad Zamal et al. (2022).

d) **Analisis Data Terbuka (Kualitatif):** Maklum balas daripada soalan terbuka dianalisis secara tematik untuk mengenal pasti cadangan penambahbaikan yang konstruktif daripada responden bagi tujuan pemerkasaan program pada masa hadapan.

4.0 DAPATAN DAN ANALISIS KAJIAN

Bab ini membincangkan hasil analisis data yang diperolehi daripada borang soal selidik yang telah diedarkan kepada kumpulan sasar. Kajian ini melibatkan jumlah populasi seramai 60 orang ibu bapa, dan daripada jumlah tersebut, seramai 58 orang responden telah berjaya melengkapkan soal selidik ini. Ini menunjukkan kadar maklum balas yang sangat tinggi iaitu sebanyak 96.7%. Kadar maklum balas yang melebihi 90% ini memberikan asas yang sangat kukuh dan representatif bagi menganalisis persepsi ibu bapa terhadap impak kursus pendek di Kolej Komuniti Paya Besar. Analisis dilakukan secara deskriptif dan inferensi bagi menilai tahap relevansi kandungan, keberkesanan kaedah PdP, serta peningkatan kompetensi pelajar sekolah rendah yang terlibat.

4.1 Profil Demografi Responden

Jadual 1 menunjukkan taburan demografi responden yang terlibat dalam kajian ini (*N*=58).

Jadual 1: Profil Demografi Responden

Kategori	Sub-Kategori	Kekerapan (*f*)	Peratusan (%)
Jantina	Perempuan	49	84.5
	Lelaki	9	15.5
Pendidikan	Ijazah Sarjana Muda	22	37.9
	SPM / Setaraf	15	25.9
	Diploma / Sijil	12	20.7
	Pascasiswazah	9	15.5

Berdasarkan analisis, majoriti responden adalah wanita (84.5%), yang menunjukkan penglibatan ibu yang lebih dominan dalam memantau aktiviti luar kurikulum anak-anak.

4.2 Analisis Dapatan mengikut Objektif Kajian

4.2.1 Analisis Mengenal Pasti Persepsi Ibu Bapa Terhadap Relevansi Kandungan Kursus

Dapatan kajian menunjukkan bahawa persepsi ibu bapa terhadap relevansi kandungan kursus berada pada tahap Sederhana Tinggi. Skor purata (min) bagi kategori Relevansi Kandungan Kursus adalah 3.64 (*SP* = 1.53). Walaupun mencatatkan skor yang positif, nilai ini adalah yang terendah berbanding kategori impak yang lain. Responden melalui data kualitatif mencadangkan agar kandungan kursus diselaraskan semula dengan aplikasi kehidupan sebenar atau kurikulum sekolah untuk meningkatkan keberkesanannya. Terdapat juga cadangan untuk menambah kepelbagaian kursus baharu seperti *public speaking*, pengurusan emosi, dan kemahiran hidup (memasak/menjahit) bagi memastikan kandungan kekal relevan dengan keperluan semasa.

4.2.2 Analisis Menilai Persepsi Ibu Bapa Terhadap Keberkesanan Kaedah Pengajaran dan Pembelajaran

Keberkesanan kaedah PdP yang digunakan dalam kursus pendek ini dinilai melalui peningkatan minat dan maklum balas terhadap struktur program. Domain Minat dan Motivasi mencatatkan skor min yang sangat tinggi iaitu 4.32 (*SP* = 0.79), yang menunjukkan kaedah pengajaran yang diaplikasikan berjaya merangsang semangat belajar pelajar. Keberkesanan ini juga dicerminkan melalui penglibatan tinggi dalam kursus teknikal dan kreatif seperti Kursus Asas Komputer (29 peserta) dan Seni Kraf/Canva (28 peserta). Bagi meningkatkan keberkesanan PdP pada masa hadapan, ibu bapa menyarankan agar kursus dilaksanakan secara bertahap (Tahap 1 dan Tahap 2) bagi memastikan kesinambungan pembelajaran yang lebih sistematik.

4.2.3 Analisis Persepsi Terhadap Impak Kursus Dalam Peningkatan Kemahiran Kognitif, Sosial, Emosi, dan Praktikal

Secara keseluruhannya, ibu bapa memberikan persepsi yang sangat positif terhadap impak kursus dalam meningkatkan pelbagai domain kompetensi anak-anak mereka seperti yang ditunjukkan di dalam Jadual 2.

Jadual 2: Jadual Impak Kursus

Domain Kompetensi	Skor Min	Interpretasi
Kemahiran Praktikal & Motor	4.33	Sangat Tinggi
Pembangunan Sosial & Emosi	4.25	Tinggi
Kognitif & Fokus	4.22	Tinggi

- **Impak Praktikal:** Domain ini mencatatkan skor tertinggi, di mana pelajar menunjukkan peningkatan kecekapan menggunakan alatan dan keberanian mencuba kemahiran baharu.
- **Impak Sosial & Emosi:** Program ini berjaya meningkatkan kemahiran interaksi dan kematangan emosi pelajar semasa bergaul dengan rakan sebaya dalam persekitaran kolej.
- **Impak Kognitif:** Ibu bapa bersetuju bahawa kursus ini membantu meningkatkan tahap fokus dan keupayaan kognitif pelajar melalui aktiviti yang mencabar minda.

4.4 Perbincangan

Hasil analisis membuktikan bahawa kursus pendek cuti sekolah di Kolej Komuniti Paya Besar memberikan impak yang signifikan dalam pembangunan modal insan pelajar sekolah rendah. Dapatan kajian menunjukkan keberkesanan program dari sudut kemahiran praktikal berada pada tahap yang sangat membanggakan dengan skor min tertinggi, iaitu $M = 4.33$. Hal ini selari dengan pandangan Abdullah dan Salleh (2018) yang menyatakan bahawa program pendidikan tidak formal berfungsi sebagai platform efektif untuk membekalkan kemahiran tambahan yang mungkin kurang diteroka dalam jadual sekolah yang padat.

Selain itu, tahap motivasi pelajar yang tinggi ($M = 4.32$) mencerminkan keberkesanan persekitaran pembelajaran yang santai dan berorientasikan aktiviti, seiring dengan teori bahawa pendidikan tidak formal mampu memperkaya pengalaman pembelajaran dan memupuk minat baharu dalam kalangan pelajar. Walau bagaimanapun, dapatan menunjukkan aspek relevansi kandungan mencatatkan skor terendah ($M = 3.64$), yang memberi isyarat kepada keperluan untuk menyelaraskan semula pengisian kursus agar lebih bertepatan dengan aplikasi kehidupan sebenar dan keperluan kompetensi abad ke-21. Secara keseluruhannya, persepsi positif ibu bapa ini menjadi indikator kritikal yang menyokong kemampanan dan legitimasi program pengayaan cuti sekolah di Kolej Komuniti pada masa hadapan.

5.0 KESIMPULAN DAN CADANGAN

Pembangunan kompetensi holistik pelajar sekolah rendah melangkaui pembelajaran akademik formal adalah amat penting dalam mempersiapkan mereka menghadapi cabaran abad ke-21. Kajian ini telah berjaya menilai persepsi ibu bapa terhadap impak kursus pendek cuti sekolah di Kolej Komuniti Paya Besar (KKPB). Kajian ini secara khususnya telah mengisi jurang kajian yang wujud sebelum ini, di mana penilaian terhadap keberkesanan program sering kali hanya bersandarkan kepada data kuantiti pendaftaran semata-mata. Walaupun data menunjukkan lonjakan penyertaan yang sangat ketara daripada 447 peserta (2023) kepada 646

peserta (2024), kajian ini membuktikan secara empirikal bahawa peningkatan kuantiti tersebut adalah selari dengan kualiti impak yang diterima oleh pelajar.

Melalui analisis terhadap 58 orang responden (kadar maklum balas 96.7%), kajian ini mengesahkan bahawa program pendidikan tidak formal di KKPB memberikan impak yang sangat positif, terutamanya dalam aspek Kemahiran Praktikal dan Motor (M = 4.33) serta Minat dan Motivasi (M = 4.32). Ini membuktikan bahawa KKPB bukan sahaja berjaya menarik minat komuniti, malah efektif dalam meningkatkan kompetensi pelajar secara holistik.
Walau bagaimanapun, bagi memastikan kelestarian dan kualiti program pada masa hadapan, beberapa cadangan penambahbaikan dikemukakan:

a) **Penyelarasan Kandungan:** Pihak kolej perlu menilai semula Relevansi Kandungan Kursus (M = 3.64) agar lebih selari dengan aplikasi kehidupan sebenar dan menyokong kurikulum sekolah secara lebih efektif.
b) **Kepelbagaian Portfolio Kursus:** Mengambil kira maklum balas ibu bapa, kursus bertemakan kemahiran insaniah seperti *public speaking* dan kemahiran hidup seperti asas memasak dan menjahit wajar diperkenalkan.
c) **Struktur Pembelajaran Berfasa:** Mewujudkan sistem pembelajaran bertahap (contoh: Aras Asas dan Aras Lanjutan) bagi kursus teknikal seperti robotik, catur, dan memanah untuk menjamin kesinambungan kompetensi pelajar.

Secara keseluruhannya, kajian ini menegaskan peranan penting Kolej Komuniti dalam memperkasa komuniti melalui program pembelajaran sepanjang hayat. Diharapkan dapatan ini menjadi pemangkin kepada pembangunan program pendidikan tidak formal yang lebih berimpak tinggi dan relevan dengan aspirasi generasi akan datang.

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SADBot MOBILE APPLICATION: AN ANALYSIS OF STUDENT PERCEPTIONS AT KOLEJ KOMUNITI TEMERLOH

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Abstract

The rapid advancement of future technology has created new opportunities for enhancing teaching and learning, particularly community college. The SADBot mobile innovation project was developed to assist students in the SFC11643 System Analysis and Design Fundamentals course. It was designed as an instructional initiative implemented by lecturers to replace conventional manual notes with an interactive application format. A total of 45 students enrolled in the Sijil Teknologi Maklumat programme at Kolej Komuniti Temerloh participated as respondents in this study. The application is easily accessible and does not require significant development costs. With the advancement of current technology, educators are better supported in delivering teaching and learning processes in accordance with contemporary technological developments. The overall findings of the analysis on the delivery of the SADBot application recorded a mean score of 4.56 with a standard deviation of 0.561, indicating a high level. This suggests that respondents agreed that the developed application has created a more effective learning environment. In conclusion, the effectiveness of the SADBot mobile application is at a high level and serves as an alternative for lecturers in delivering more engaging teaching methods that positively impact students.

Keywords: TVET, software analysis and design, teaching and learning process

Abstrak

Kemajuan pesat teknologi masa hadapan telah mewujudkan peluang baharu dalam mempertingkatkan proses pengajaran dan pembelajaran, khususnya dalam bidang Pendidikan dan Latihan Teknikal dan Vokasional (TVET). Projek inovasi mudah alih SADBot telah dibangunkan bagi membantu pelajar dalam kursus SFC11643 Asas Analisis dan Reka Bentuk Sistem. Aplikasi ini direka sebagai satu inisiatif pengajaran oleh pensyarah untuk menggantikan penggunaan nota manual konvensional kepada format aplikasi yang lebih interaktif. Seramai 45 orang pelajar yang mengikuti program Sijil Teknologi Maklumat di Kolej Komuniti Temerloh telah terlibat sebagai responden dalam kajian ini. Aplikasi ini mudah diakses serta tidak memerlukan kos pembangunan yang tinggi. Seiring dengan perkembangan teknologi semasa, para pendidik kini lebih disokong dalam menyampaikan proses pengajaran dan pembelajaran selaras dengan arus perkembangan teknologi terkini. Secara keseluruhannya, dapatan analisis terhadap pelaksanaan aplikasi SADBot

menunjukkan skor min sebanyak 4.56 dengan sisihan piawai 0.561, yang berada pada tahap tinggi. Hal ini menunjukkan bahawa responden bersetuju bahawa aplikasi yang dibangunkan telah mewujudkan persekitaran pembelajaran yang lebih berkesan. Kesimpulannya, keberkesanan aplikasi mudah alih SADBot adalah pada tahap yang tinggi dan berperanan sebagai alternatif kepada pensyarah dalam menyampaikan kaedah pengajaran yang lebih menarik serta memberi impak positif kepada pelajar.

Kata kunci: *TVET, analisis dan reka bentuk perisian, proses pengajaran dan pembelajaran*

1.0 INTRODUCTION

The integration of digital technologies in education has transformed traditional teaching approaches, especially in technical fields. In TVET institutions, conventional methods often rely on static materials and lecturer-cantered delivery, limiting student engagement and understanding. Recent advancements in artificial intelligence (AI) have introduced new opportunities to enhance learning experiences through interactive and adaptive systems. As highlighted in digital learning research, AI-powered platforms provide real-time feedback, personalized learning, and increased accessibility.

Traditional education in community colleges often depends on static learning materials and slow feedback mechanisms, which can lead to reduced student engagement and less effective learning outcomes. This research is aligned with Industry 4.0 principles, which emphasize the integration of cloud computing, artificial intelligence (AI), and data analytics in educational practices to create flexible and personalized learning environments. (Garcia & Wang, 2022, Singh & Patel, 2021, Brown, Smith, & Thomas, 2021)

Although the demand for technical skills is increasing in the digital age, existing instructional methods frequently lack the interactivity, personalization, and real-time assessment required for effective learning. This study responds to the need for innovative educational approaches by assessing a mobile learning platform designed to revolutionize network education through digital innovation. The platform seeks to improve technical competency and engagement by incorporating interactive modules, instant feedback, and tailored support.

In response to these challenges, SADBot was developed as an AI-enhanced chatbot to support students in the Software Analysis and Design course. The system converts lecture content into a conversational learning interface, allowing students to actively engage with course materials. This innovation aligns with Industry 4.0 trends, emphasizing automation, digitalization, and intelligent systems in education.

1.1 Problem Statement

In Technical and Vocational Education and Training (TVET), particularly in courses such as Software Analysis and Design, traditional teaching approaches often rely heavily on lecture-

based delivery and static learning materials. These methods limit student interaction, reduce engagement, and do not adequately support diverse learning needs. Additionally, students frequently depend on lecturers for clarification, leading to repetitive questions and increased instructional workload. Furthermore, existing learning environments often lack real-time feedback and personalized support, which are essential for effective knowledge acquisition in technical subjects. As a result, students may struggle to fully understand complex concepts and may not develop strong self-directed learning skills.

In the context of rapid digital transformation and Industry 4.0, there is a growing need for innovative learning solutions that can provide interactive, flexible, and accessible learning experiences. Therefore, an AI-driven approach such as SADBot is proposed to address these limitations by offering immediate assistance, personalized interaction, and continuous learning support.

1.2 Research Objectives

The objectives of this study are as follows:

i. To analyse students' perceptions of the SADBot mobile application
ii. To evaluate the effectiveness of the SADBot user interface in supporting student interaction and learning.

1.3 Significant of Research

The implementation of SADBot mobile application provides several key benefits:

For students: Promotes self-directed learning, improves understanding of complex topics, and allows flexible access to learning materials anytime and anywhere.
For lecturers: Reduces repetitive inquiries, enabling lecturers to focus on higher-level teaching and student support.
For institutions: Supports digital transformation initiatives and aligns with Industry 4.0 requirements by integrating AI into education.

2.0 LITERATURE REVIEW

Recent developments in digital education have demonstrated that integrating interactive technologies can significantly enhance student learning outcomes. Interactive learning environments promote active engagement, critical thinking, and deeper understanding of subject matter (Lee & Chen, 2020). Mobile learning has become an important approach in higher education as it allows students to access learning materials anytime and anywhere. This flexibility supports self-directed learning and improves accessibility to educational resources. Studies have shown that mobile learning enhances students' engagement and promotes independent learning behaviour (Crompton & Burke, 2018). In addition, mobile learning enables institutions to integrate technology into teaching practices more effectively (Alrasheedi, Capretz, & Raza, 2015).

Mobile learning methods further contribute to flexibility and accessibility in education. Studies have shown that mobile-based learning applications enable students to engage in self-paced learning while receiving immediate feedback, thereby enhancing comprehension and motivation (Singh & Patel, 2021). Additionally, Traxler (2009) highlighted that mobile learning supports continuous learning beyond the classroom environment. SADBot aligns with these findings by providing 24/7 access to learning resources, allowing students to learn anytime and anywhere. The integration of multimedia elements in digital learning has also been shown to improve student understanding and long-term retention. Chen and Li (2020) found that combining text, visuals, and interactive content enhances cognitive processing and engagement. Furthermore, Sung et al. (2016) reported that multimedia-supported learning environments significantly improve academic performance.

The emergence of Industry 4.0 has accelerated the adoption of Artificial Intelligence (AI) in education. AI technologies, including cloud computing and learning analytics, enable the development of personalized and adaptive learning environments (Garcia & Wang, 2022). These technologies facilitate real-time feedback and continuous improvement in learning processes. SADBot leverages AI capabilities to provide instant responses and personalized support, aligning with the goals of digital transformation in education.

3.0 RESEARCH METHODOLOGY

3.1 Research Design

This study adopts a quantitative approach to assess the impact of the mobile learning platform on Software Analysis and Design (SAD) education using a single survey instrument. The collected data were analyzed using descriptive statistical techniques, with a focus on mean scores to evaluate improvements in technical competency and student engagement.

A study was carried out involving community college students enrolled in Information Technology programme. A single structured survey instrument was administered to evaluate learning improvements (Romero, Ventura, & García, 2008) as well as changes in student engagement.

3.2 Research Instruments

This study employs a quantitative research design comprising three sections: Section A (respondent demographics), Section B (delivery design), which consists of nine items, and Section C (application content), which includes eight items. The questionnaire items were adapted from the study by Norlaila (2024). A total of 45 students enrolled in the SFC11643 (System Analysis and Design Fundamentals) course in STM program participated as respondents and completed the questionnaire provided. The questionnaire employs a five-point Likert scale, where 5 = Strongly Agree, 4 = Agree, 3 = Slightly Agree, 2 = Disagree, and 1 = Strongly Disagree. The data were analyzed using the Statistical Package for Social Sciences (SPSS) version 27.0.

3.3 Data Analysis

The data were analyzed descriptively to compute the mean scores, standard deviations, and frequencies. In analyzing the obtained data, researcher employed a mean score interpretation table, as presented in Table 1.

Table 1: Min Score Value

Min Calculation	Level
1.00 – 2.00	Low
2.01 – 3.00	Average Low
3.01 – 4.00	Average High
4.01 – 5.00	High

This section also explains the procedures for data collection and data analysis in addressing the research questions established by the researcher. The questionnaire data for this phase were analyzed using the Statistical Package for Social Sciences (SPSS) version 27.0. The analysis process involved descriptive statistical methods, including mean scores, standard deviations, and frequencies. To interpret the data obtained, the researcher referred to the mean score interpretation table, as shown in Table 1.

4.0 RESEARCH FINDINGS AND DISCUSSION

4.1 Respondent's Demographics

Table 2 presents the demographic profile of the respondents involved in this study. A total of 45 students enrolled in the SFC11643 (System Analysis and Design Fundamentals) course participated as respondents. Of the total, 22 respondents (48.9%) were male students, while 23 respondents (51.1%) were female students. With respect to ethnicity, the majority of the respondents were Malay (82.2%), followed by Chinese (11.1%) and Indian (6.7%).

Table 2: Respondent's Information

Demographic Characteristic		N	Percent (%)
Gender	Male Student	22	48.9%
	Female Student	23	51.1%
Race	Malay	37	82.2%
	Chinese	5	11.1%
	Indian	3	6.7%

4.2 Delivery of SADBot Mobile Application

This section presents the findings pertaining to the delivery aspect of the SADBot mobile application as perceived by students enrolled in the Information Technology programme at the community college. The analysis was conducted based on nine items measuring the usability,

accessibility, enjoyability, and relevance of the application in the context of the SAD course. The results of the descriptive analysis, including mean scores, standard deviations, and interpretation levels for each item, are presented in Table 3.

Table 3: Delivery of SADBot Mobile Application

No.	Statement	Mean	SD	Level
1	The application is user-friendly.	3.71	0.843	Average High
2	Learning using this application is enjoyable.	4.33	0.674	High
3	The information presented is clear and engaging.	3.76	0.830	Average High
4	The application aligns with the SAD course syllabus.	4.09	0.763	High
5	The application is suitable for use in teaching and learning.	3.84	0.824	Average High
6	The application facilitates easy access to notes.	4.22	0.670	High
7	The application assists me in learning SAD course.	4.04	0.706	High
8	The application can be accessed at any time.	4.24	0.679	High
9	The application increases my interest in learning the SAD course.	4.20	0.694	High
	Overall	**4.03**	**0.453**	**High**

Based on Table 3, the overall mean score for the delivery of the SADBot mobile application was 4.03 (SD = 0.453), which is classified at the High level according to the mean score interpretation table. This indicates that respondents were generally satisfied with the design and delivery of the application in supporting their learning process.

Among the nine items assessed, Item 2 ("Learning using this application is enjoyable") recorded the highest mean score of 4.33 (SD = 0.674), followed by Item 8 ("The application can be accessed at any time") with a mean of 4.24 (SD = 0.679), and Item 6 ("The application facilitates easy access to notes") with a mean of 4.22 (SD = 0.670). All three items were rated at the High level, suggesting that students found the application both engaging and accessible, consistent with the fundamental principles of effective mobile learning design. Conversely, Item 1 ("The application is user-friendly") recorded the lowest mean score within this construct at 3.71 (SD = 0.843), followed by Item 3 ("The information presented is clear and engaging") at 3.76 (SD = 0.830) and Item 5 ("The application is suitable for use in teaching and learning") at 3.84 (SD = 0.824). These items were classified at the Average High level. Although these scores are comparatively lower than other items in the construct, they nonetheless reflect a positive reception from the respondents, indicating that further refinements in the user interface and information presentation may enhance the overall delivery quality of the application.

4.3 Contents of SADBot Mobile Application

This section examines the respondents' perceptions of the content quality of the SADBot mobile application. Eight items were evaluated, encompassing aspects related to content

organisation, clarity of explanation, visual design, button functionality, and typographic suitability. The descriptive statistics for each item are summarised in Table 4.

Table 4: Contents of SADBot Mobile Application

No.	Statement	Mean	SD	Level
1	The content is organized systematically.	4.18	0.684	High
2	The sentences used are easy to understand.	4.24	0.679	High
3	The explanation of each topic is clear.	4.07	0.809	High
4	The design produced is attractive.	4.07	0.780	High
5	The graphics used are appealing.	3.98	0.723	Average High
6	The button functions can be easily identified.	3.96	0.673	Average High
7	The arrangement of buttons is appropriate.	4.00	0.707	Average High
8	The font style used is suitable.	4.07	0.720	High
	Overall	**4.07**	**0.295**	**High**

As shown in Table 4, the overall mean score for the content of the SADBot mobile application was 4.07 (SD = 0.295), which falls under the High level of interpretation. This result demonstrates that the respondents were highly satisfied with the overall quality of the content presented within the application. Item 2 ("The sentences used are easy to understand") obtained the highest mean score of 4.24 (SD = 0.679), followed by Item 1 ("The content is organized systematically") at 4.18 (SD = 0.684). Items 3, 4, and 8 which assessed the clarity of topic explanations, attractiveness of design, and suitability of font style respectively each recorded a mean score of 4.07. All of the aforementioned items were rated at the High level, reflecting that students found the content well-structured, clearly articulated, and aesthetically appealing.

However, Item 6 ("The button functions can be easily identified") recorded the lowest mean score within this construct at 3.96 (SD = 0.673), followed by Item 5 ("The graphics used are appealing") at 3.98 (SD = 0.723) and Item 7 ("The arrangement of buttons is appropriate") at 4.00 (SD = 0.707). These three items were classified at the Average High and High levels respectively. The slightly lower ratings for button-related items suggest that the navigational interface of the application may require further improvement to enhance user experience, particularly in terms of button visibility and graphical elements.

4.4 Discussion

Overall, the findings of this study indicate that the level of student acceptance toward the SADBot mobile application was high for both dimensions assessed, namely delivery (mean = 4.03, SD = 0.453) and content (mean = 4.07, SD = 0.295). These results are consistent with findings from prior studies which affirm that well-designed mobile learning platforms are capable of enhancing student engagement and motivation in the learning process. With regard to the delivery aspect, students rated the application highly in terms of the enjoyment it offered during learning and its accessibility at any time and place. This finding underscores the

importance of flexibility and anytime access as critical determinants of mobile learning effectiveness.

With respect to the content dimension, students evaluated the clarity of language and systematic organisation of content positively, indicating that these elements play a pivotal role in facilitating comprehension of course material. Nevertheless, the comparatively lower scores recorded for graphic appeal and button functionality suggest that the visual interface and navigational design of the application warrant further attention. Addressing these areas would not only elevate the overall user experience but also strengthen the pedagogical effectiveness of the SADBot application as a supplementary learning tool for the SAD course.

5.0 CONCLUSION AND RECOMMENDATIONS

In conclusion, this study has successfully evaluated the level of student acceptance toward the SADBot mobile application across two key dimensions: delivery and content. Both dimensions recorded High mean scores, with the delivery aspect obtaining a mean of 4.03 (SD = 0.453) and the content aspect obtaining a mean of 4.07 (SD = 0.295). These findings suggest that the SADBot mobile application is well-received by students and holds considerable potential as a supplementary learning tool in the teaching and learning of the System Analysis and Design course at the community college level.

It is recommended that future improvements to the application focus on enhancing the user interface, particularly in relation to graphical elements and button navigation, which obtained comparatively lower ratings in the content dimension. In addition, the user-friendliness of the application should be further refined to ensure a seamless learning experience for all users. Future research may also consider expanding the sample size and employing additional statistical analyses, such as inferential statistics, to provide a more comprehensive understanding of the factors influencing student acceptance of mobile learning applications in technical education settings.

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