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Integrating PLC-Based Automated Beverage Dispensing Systems into Engineering Education: A Sustainable and Hygienic Approach to Service Optimization

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Abstract

This paper presents the design and implementation of a PLC-based automated beverage dispensing system featuring a conveyor mechanism and dual proximity sensors to optimize service efficiency, dispensing accuracy, and hygiene management. The conveyor transports cups through the dispensing station, while the proximity sensors detect cup position and presence, enabling precise timing control for beverage filling. The PLC coordinates sensor inputs and actuator outputs to automate the process, ensuring consistent portion sizes and minimizing spillage or waste. Importantly, the system incorporates cleanliness objectives by minimizing direct human contact with beverages and cups, reducing contamination risks and maintaining sanitary conditions throughout operation. This integration of automation and hygiene control enhances operational flow, reliability and repeatability, making it ideal for high-volume beverage service in events and commercial settings. The modular design supports customization and scalability, contributing to improved user experience, operational efficiency, and food safety compliance.

Keywords: PLC-based automated beverage dispensing

I. INTRODUCTION

The increasing demand for efficient, hygienic, and environmentally sustainable solutions in the food and beverage industry has driven the development of automated dispensing systems that leverage advanced control technologies. Programmable Logic Controllers (PLCs) have emerged as a reliable and flexible platform for automating beverage dispensing processes, enabling precise control over liquid flow, portioning, and system operation. This paper presents the design and implementation of a PLC-based automated beverage dispensing system that integrates cleanliness protocols and environmental sustainability measures to optimize service quality. By incorporating sensors, actuators, and conveyor mechanisms, the system minimizes human contact with beverages and reduces waste through accurate portion control. The automation not only enhances operational efficiency and consistency but also addresses critical hygiene standards and environmental concerns, making it suitable for high-volume commercial and event-based applications. This research contributes to the advancement of smart beverage dispensing technologies by demonstrating how PLC-driven automation can simultaneously improve service delivery, maintain sanitary conditions, and promote eco-friendly practices..

II. LITERATURE REVIEW

A comprehensive review of literature on PLC-based automated beverage dispensing systems reveals significant advancements in automation technologies that enhance efficiency, precision, and hygiene in beverage production and service. Lohar et al. (2024) emphasized the role of PLCs in automating bottle filling processes, highlighting improvements in speed, accuracy, and waste reduction by coordinating sensors, actuators, and conveyor systems to replace manual operations. Their work demonstrates that PLC-controlled systems ensure precise liquid dispensing and flexible adaptation to different bottle sizes, which is critical for industries such as beverages, pharmaceuticals and cosmetics. Similarly, the integration of PLC and SCADA in beverage vending machines, as explored by Abhiyantriki (2025), shows how automation can optimize beverage preparation and packaging while enabling remote monitoring and control, thereby reducing manpower needs and operational costs. This approach also supports scalability and real-time fault detection, which are essential for efficient mass production.

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Additional studies reinforce the benefits of PLC automation in liquid filling systems. For instance, research by Lu et al. and Baladhandabany et al. highlights the flexibility and cost-effectiveness of PLC-based systems using ladder logic for controlling conveyors and filling mechanisms, improving throughput while minimizing sensor requirements. Innovations such as ultrasonic sensors and image processing for volume control further enhance accuracy and reduce maintenance complexity compared to traditional pneumatic systems. The design of beverage vending machines based on PLC, as discussed in other works, integrates human-machine interfaces and supervisory control software like KingView, facilitating user-friendly operation and system monitoring. Moreover, the use of microcontrollers such as AT Mega 328 in automated liquid dispensing machines demonstrates alternative control architectures that maintain precise volume delivery.

From a sustainability and hygiene perspective, PLC-based automation reduces manual handling, which lowers contamination risks and ensures consistent product quality. Automated systems also contribute to waste minimization through precise filling and optimized resource use, aligning with sustainable production goals. The literature further suggests that integrating such systems into engineering education can provide students with practical skills in automation, programming, and process optimization, preparing them for industry demands in sustainable and hygienic service delivery.

The research shows that using PLCs in automation can lead to better productivity and economic growth. Companies can produce more products in less time, which can help them make more money. Furthermore, as technology continues to improve, more companies are likely to adopt automation systems. This will help them stay competitive and reduce costs in the long run. (Suramwar et al., 2022)

The literature review in this paper is essential for framing the research within the existing body of knowledge, identifying gaps, and establishing the significance of the proposed automatic fluids filling unit. It provides a foundation for understanding the advancements in industrial automation and the role of PLCs in enhancing operational efficiency and safety.(Shekhar et al., 2024

Various sensors and actuators are integrated into the system to enhance its functionality. Sensors are used for detecting the presence of bottles and monitoring the filling levels, while actuators control the dispensing of liquid and the capping process. This integration is crucial for achieving precision and efficiency in filling operations. (Lohar, 2025)

IoT-Based Bottle Filling System using PLC not only streamlines the filling process but also enhances monitoring, accuracy, and cost-effectiveness, making it a valuable solution for modern manufacturing environments. (Sureshkumar et al., 2023)

The automated bottle filling system offers numerous advantages in terms of efficiency and accuracy, it also presents several limitations related to programming complexity, initial costs, maintenance challenges, flexibility, mechanical reliability, and the need for interdisciplinary knowledge. (Viraktamath et al., 2020).

Overall, the reviewed literature establishes that PLC-based automated beverage dispensing systems offer robust solutions for enhancing operational efficiency, product safety, and environmental sustainability. These systems' adaptability and real-time control capabilities make them ideal for integration into both industrial applications and educational curricula aimed at training future engineers in sustainable automation technologies.

III. RESEARCH METHODOLOGY

The automated beverage dispensing system utilizes proximity sensors, water pump motor, and a conveyor motor, all orchestrated by a PLC for precise control. Upon detection of a cup by the first proximity sensor, the PLC initiates the water pump motor to dispense a calibrated volume of liquid into the cup over a predefined time interval. Following completion of the filling cycle, the PLC activates the conveyor motor to advance the cup toward the pickup station. The second proximity sensor detects the cup's arrival at this station and signals the PLC to halt the conveyor motor, maintaining the cup in a stationary position. The system continuously monitors the presence of the cup; once the cup is removed by the user, indicated by the loss of the sensor signal, the PLC resumes conveyor operation to position the next cup for filling. This control sequence ensures accurate dispensing, efficient cup handling, and hygienic operation by minimizing unnecessary movement and allowing user interaction only when the beverage is ready for collection.

PLC-based automated beverage dispensing system, list of input and output assignments

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are as follow.

Table 1 Input assignment

Input Device	Description	PLC Input Address
Start Push Button(PB)	To start the beverage dispensing operation	I:0.00
Capacitive Proximity Sensor 1	Detects presence of glass/bottle at position 1	I:0.01
Capacitive Proximity Sensor 2	Detects presence of glass/bottle at position 2	I:0.02

Table 2 Output assignment

Output Device	Description	PLC Output Address
AC Motor1 (240V)	Drives conveyor Motor 1	O:100.00
AC Motor 2(240V)	Drives water pump Motor 2	O:100.01
Pilot Light 1(Green)	Indicates Motor 1 On	O:100.02
Pilot Light 2(Red)	Indicate Motor 2 On(Water Filling)	O:100.03
Buzzer	Alert Errors	O:100.04

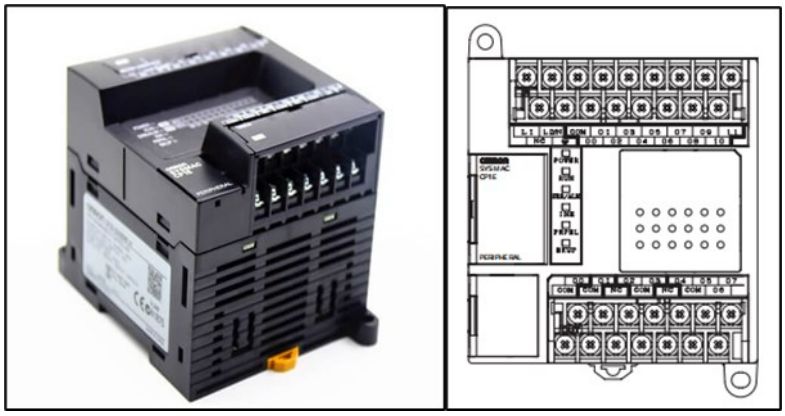

Figure 1 Omron CP1E PLC controller

The Omron CP1E20 (specifically models like CP1E-NA20DR-A) is a compact programmable logic controller (PLC) designed for small to medium automation tasks. It features 20 digital input/output points, typically with 12 inputs and 8 relay outputs, making it suitable for controlling a variety of devices such as sensors, motors, and actuators. The PLC operates on a wide power supply range of 100 to 240 VAC (with an operating range of 85 to 264 VAC) and consumes up to 70 VA at 240 VAC. It uses a stored program control method with a program capacity of 8K steps and data memory of 8K words, programmed primarily in ladder logic with approximately 200 instructions available.

The CP1E20 supports cyclic scan I/O control with immediate refreshing, ensuring timely and reliable response to input changes. It includes built-in protection features such as insulation resistance of 20 MΩ and dielectric strength of 2300 VAC for one minute between AC terminals and ground, along with noise resistance and vibration/shock resistance compliant with industrial standards. The unit is compact, measuring roughly 90 mm × 79 mm × 86 mm and weighing about 680 grams, designed for panel mounting.

Additional features include support for external power supplies for input devices, and some variants offer built-in communication ports (USB, RS-232C, RS-485) for programming and integration. The

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CP1E20 is well-suited for applications requiring precise control of digital I/O with moderate program complexity, such as small machine automation, packaging, and process control, offering a robust, energy-efficient, and easy-to-program solution for industrial automation. Motors and sensors are integrated to control and monitor the filling process, ensuring that each bottle receives the correct amount of liquid with high accuracy.

Figure 2 Capacitive proximity sensor

A capacitive proximity sensor is a non-contact device that detects the presence or absence of objects by measuring changes in capacitance between the sensor and the target. It consists of a high-frequency oscillator connected to a sensing surface made of metal electrodes, which together form a capacitor. When an object—whether metal, plastic, liquid, or even human skin—approaches the sensor, it alters the electrostatic field and changes the capacitance value. This change affects the oscillator's frequency and amplitude, triggering the sensor to switch its output state to indicate the object's presence. Capacitive sensors can detect a wide range of materials, unlike inductive sensors that only detect metals, and typically have a short sensing range of up to around 25 millimeters. They are adjustable in sensitivity, non-contact, wear-free, and offer high switching speeds, making them suitable for applications such as liquid level detection, object counting, and material handling in industrial automation. Their ability to sense through non-metallic barriers and their durability make capacitive proximity sensors versatile and reliable components in many automated systems.

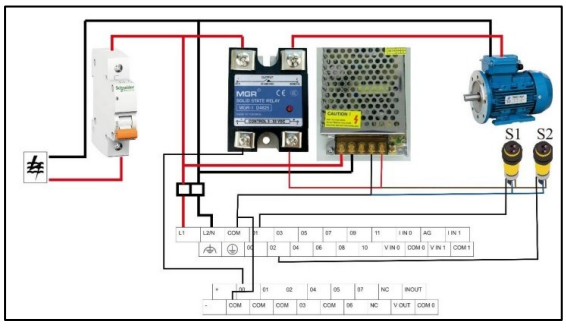

Figure 3 Wiring diagram

The wiring diagram illustrates an automated control system using a PLC, two capacitive proximity sensors (S1 and S2), a solid state relay (SSR), a power supply, and an AC motor. The system is powered by an AC source protected by a circuit breaker, which supplies power to both the SSR and a DC power supply module. The DC power supply converts AC voltage to DC, providing the necessary power for the PLC and the proximity sensors. The proximity sensors are positioned to detect objects, such as cups, and are connected to the input terminals of the PLC. When either sensor is triggered, it sends a signal to the PLC, which processes the input according to the programmed logic. If the logic conditions are met, the PLC sends an output signal to the SSR, which then switches the AC motor on or off. The motor can be used to drive a conveyor or pump, depending on the system's application. This setup ensures automated, precise, and safe control of the motor based on real-time sensor feedback, with electrical isolation and protection provided by the SSR and circuit breaker.

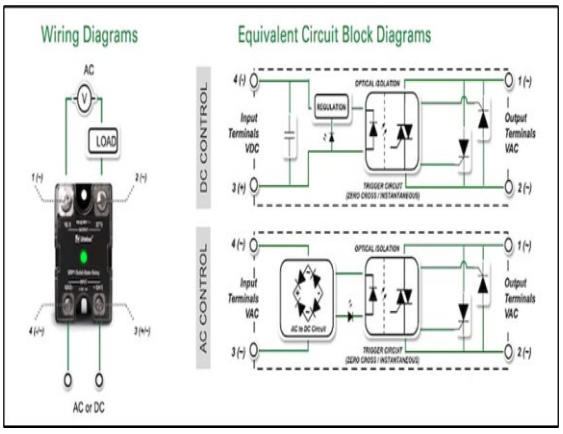

Figure 4 Solid State Relay (SSR)

A Solid State Relay (SSR) is an electronic switching device that controls power to a load without any mechanical moving parts, using semiconductor components instead of traditional electromechanical contacts. This design gives SSRs several advantages, including longer service life, faster switching speeds, silent operation, and greater resistance to shock, vibration, dust, and harsh environments. SSRs are widely used in the food and beverage industry for controlling heating elements, motors, and pumps because they provide precise temperature control, high reliability, and low electromagnetic interference. For example, SSRs manage heating in ovens, coffee machines, and vending machines, as well as motor control for pumps and fans. Their semiconductor-based construction enables them to handle frequent

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switching cycles without wear, making them ideal for applications requiring high switching frequency and consistent performance. Additionally, SSRs contribute to hygienic and safe operation by minimizing mechanical failures and electrical noise, which is critical in food processing and preparation equipment. Overall, SSRs offer a compact, energy-efficient, and maintenance-free solution for controlling electrical loads in demanding industrial and commercial environment.

CX Programmer

CX-Programmer is a specialized programming software developed by Omron for creating, editing, and debugging ladder logic programs used in Omron PLCs (Programmable Logic Controllers). CX-Programmer provides an easy-to-use ladder editor where users can design control logic using familiar electrical relay logic symbols such as contacts, coils, timers, counters and arithmetic operations. It also supports advanced programming features like Sequential Function Charts (SFC) and Structured Text (ST) for complex control tasks. The software includes tools for simulation and online debugging, allowing programmers to test and verify their logic before deploying it to real hardware. CX-Programmer facilitates the integration of inputs from sensors and outputs to actuators, enabling automation of industrial processes such as water filling systems. Its interface allows addressing and managing I/O points, monitoring real-time operation, and troubleshooting. Overall, CX-Programmer is widely used in industrial automation for its comprehensive functionality, ease of use, and compatibility with Omron PLC hardware.

In a water filling machine, CX-Programmer acts as the software tool used to create and manage the PLC ladder logic program that automates the entire filling process. The PLC program developed in CX-Programmer controls the sequence of operations such as detecting the presence of bottles via sensors, stopping the conveyor belt, activating the filling valve or pump for a preset duration, and then restarting the conveyor to move the filled bottle forward. For instance, a timer (TONR) can be programmed in CX-Programmer to open the filling valve for a specific time (e.g., 7 or 15 seconds), and if the process is interrupted, the timer resumes from the remaining time to avoid overfilling. The program also includes interlocks and memory bits to maintain the system state, ensuring the valve only opens when a bottle is correctly positioned and the system is running. Through real-time monitoring and debugging features, CX-Programmer enables fine-tuning of the filling cycle, conveyor control, and safety interlocks, making the water filling machine efficient, reliable, and fully automated.

IV. RESULT AND DISCUSSION

The automated beverage dispensing system, orchestrated by a PLC and incorporating two proximity sensors along with water pump and conveyor motors, delivers precise and efficient operation through a well-defined control sequence.

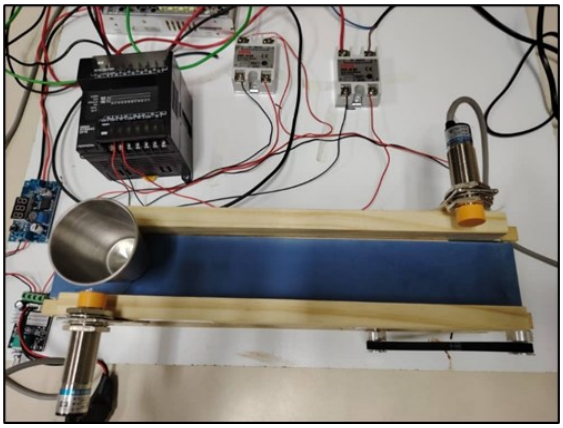

Figure 5 Prototype

When the first proximity sensor detects the presence of a cup at the filling station, the PLC immediately activates the water pump motor to dispense a calibrated volume of liquid over a predetermined time interval. This ensures that each cup receives an accurate and consistent amount of beverage, reducing waste and maintaining quality standards. Upon completion of the filling cycle, the conveyor motor is engaged to transport the filled cup to the pickup station. The second proximity sensor then detects the cup's arrival, signaling the PLC to halt the conveyor motor and hold the cup in a stationary position, ready for user collection. Throughout this process, the system continuously monitors the cup's presence at the pickup station; once the user removes the cup, indicated by the loss of the sensor signal, the PLC resumes conveyor operation to position the next cup for filling. This intelligent sequence minimizes unnecessary conveyor movement, thereby reducing mechanical wear and energy consumption, while also enhancing hygiene by restricting user interaction to the moment the beverage is ready.

The PLC's precise timing and sensor feedback enable reliable automation, easy adaptability to different cup sizes or beverage volumes, and seamless integration into commercial or industrial settings. Overall, the methodology results in a robust, accurate, and user-friendly automated

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dispensing system that improves operational efficiency, ensures product consistency, and enhances user safety and convenience.

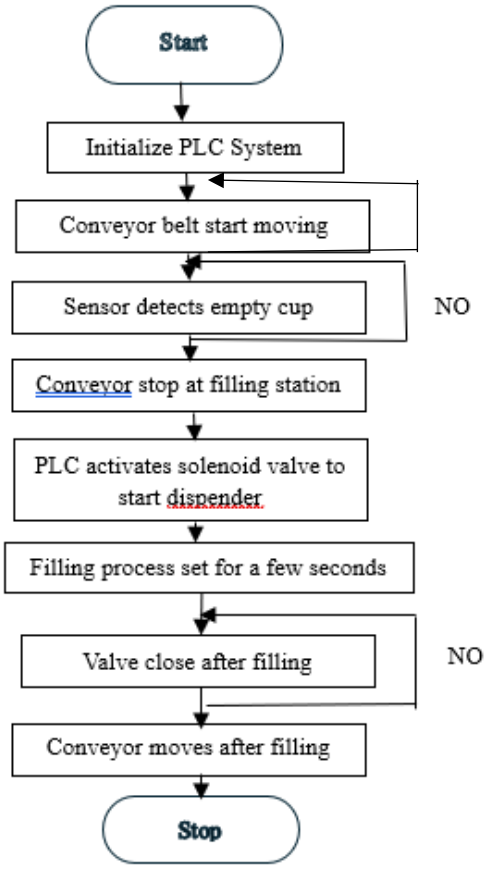

Figure 6 Flowchart of system

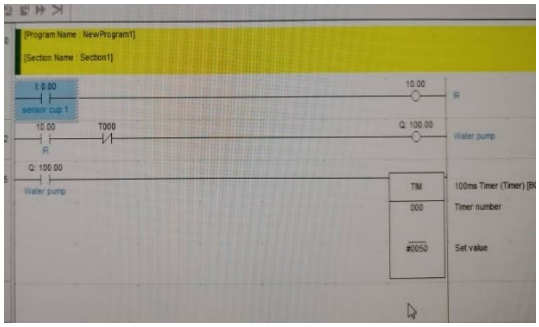

Figure 7 Ladder diagram from Cx Programmer

V. CONCLUSION

Integrating PLC-based automated beverage dispensing systems into engineering education is expected to have a multifaceted impact on both student learning and industry readiness. This integration enhances technical competencies by providing hands-on experience in PLC programming, system integration, and troubleshooting, fostering interdisciplinary skills in mechatronics and automation. It promotes sustainable engineering practices by encouraging resource efficiency, energy conservation, and environmental awareness in system design. Additionally, the focus on hygienic design and automation reduces contamination risks and aligns with public health standards, which is especially critical in food and beverage services. The system also demonstrates how automation can optimize service delivery by streamlining processes, improving quality control, and reducing operational costs. From an educational perspective, this project-based learning approach increases student engagement, facilitates skill demonstration, and better prepares learners for industry demands. Furthermore, it serves as a platform for innovation and research, encouraging cross-disciplinary collaboration and the exploration of advanced technologies such as IoT and AI in service optimization. Overall, this integration equips students with practical skills and sustainable mindsets essential for modern engineering and hospitality industries.

The expected research outcomes from integrating PLC-based automated beverage dispensing systems into engineering education encompass significant contributions in publication, intellectual property, and collaborative opportunities. In terms of publications, the development and evaluation of such systems provide valuable case studies and experimental results suitable for journals and conferences focused on automation, control systems, and sustainable engineering, similar to documented works on PLC-based water dispensing and bottle filling systems. These publications enhance academic visibility and contribute to the body of knowledge in automation applied to hospitality and service industries. Regarding intellectual property, the novel design aspects such as hygienic dispensing mechanisms, sustainable resource management, and educational integration can lead to patentable innovations or proprietary control algorithms, offering protection and potential

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commercialization avenues. This also encourages the development of customized PLC programs and hardware configurations that can be licensed or further developed. Finally, the project fosters collaboration among academia, industry, and government institutions by providing a platform for interdisciplinary research and development. Partnerships can be formed with hospitality businesses, automation companies and educational institutions to refine the technology, expand its applications, and promote sustainable practices in service optimization. Such collaborations may also support funding opportunities, joint publications, and technology transfer initiatives, ultimately bridging the gap between theoretical education and practical industrial needs.

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Teaching and Delivery Methods in Computer Science Higher Education (2020–2025): A Systematic Review

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Abstract

This article presents a systematic review of teaching and delivery methods in university-level computer science education in recent years. Following the PRISMA methodology, 113 articles were initially identified for abstract screening; irrelevant studies were excluded, and full-text reviews were conducted on the remaining articles. Studies not aligned with the scope of this review were further eliminated. By synthesizing evidence from 11 core studies, the review identifies a significant transition from traditional lectures toward interactive, student-centered approaches such as blended learning, project-based learning (PjBL), and flipped classrooms. The findings indicate that these methods effectively enhance student engagement, academic performance, and the development of transferable soft skills, although significant gaps remain regarding standardized assessment and instructor support. This review contributes by providing a consolidated understanding of current methods and offering directions for future research, ultimately supporting the advancement of computer science education.

Keywords **:** *Blended and Project-Based Learning; Behavior-Driven Development; Computer Science higher education; Teaching and Delivery Methods*

I. INTRODUCTION

University students are exposed to a variety of teaching methods and strategies, such as lectures, group activities, and demonstrations, which are designed to enhance motivation, support learning, and improve academic performance [1]. The application of teaching methods varies considerably, shaped by factors such as class size and level, educational philosophy, intended learning outcomes, student characteristics, and academic discipline. In undergraduate education, teaching approaches are often categorized into two broad pedagogical frameworks: teacher-centered methods and student-centered methods [2]. Teacher-centered approaches place emphasis on the instructor as the primary source of knowledge, typically through lectures, while students work individually and assume a passive role in the learning process. The lecture as one of the most traditional and widely used teacher-centered instructional methods [3]. For instance, in a computer science lecture, the lecturer presents programming concepts on the board while students listen and take notes, with limited interaction or collaboration. According to [4], learning activities that emphasize collaboration, communication, and interaction are categorized as student-centered approaches. For example, in computer science education, practices such as pair programming, group software development projects, or peer code reviews allow students to actively engage with content while developing problem-solving and teamwork skills.

In recent years, teaching methods have shifted from conventional lecture-based models to more interactive and student-centered approaches, such as blended learning, project-based learning (PjBL), and flipped classrooms. The COVID-19 pandemic further accelerated these innovations, pushing educators to adopt technology-enabled solutions and rethink course delivery. Despite the proliferation of innovative teaching methods, most studies focus narrowly on individual courses or contexts, leaving their broader applicability underexplored. Moreover, systematic evidence on the effectiveness and limitations of these approaches in computer science education remains fragmented.

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This study addresses these gaps by presenting a systematic literature review of teaching and delivery methods in university-level computer science education from 2020 to 2025. Guided by the PRISMA methodology, the review synthesizes evidence from peer-reviewed journals and conferences to identify key approaches, assess their impacts, and highlight areas for future research.

II. RESEARCH METHDOLOGY

To deepen the understanding of teaching and delivery methods employed in university-level computer science courses, this section has been conducted following the systematic literature review (SLR) guidelines outlined by [5].

A. Question formalisation

The purpose of this section is to highlight the key teaching and delivery methods in Computer Science higher education between 2020 and 2025. Based on this, the study addresses the following research questions:

RQ1: What are the main teaching and delivery methods used in university-level Computer Science education from 2020 to 2025?

RQ2: What are the reported impacts of these methods on student engagement and learning outcomes?

RQ3: What gaps remain for future research and practice in teaching Computer Science at the university level?

This process ensures that the study produces comprehensive and well-structured answers within its defined scope. Once the research needs were established, research questions were formulated and embedded into a review protocol. The protocol was developed through the following stages:

1. Search query - Defining relevant keywords, synonyms, and Boolean operators to construct effective search strings.
2. Source selection - Identifying appropriate academic databases and publishers to retrieve relevant studies.
3. Selection criteria - Establishing clear rules to determine which studies are relevant and which should be excluded.

Quality assessment and data extraction - Using PRISMA technique for systematic review and analyzing the extracted data to answer the research questions.

B. Search query

The search strategy was designed by identifying keywords and setting inclusion and exclusion criteria for academic databases. The development of search strings involved defining synonyms and alternative spellings for each element of the research question, which were then structured with Boolean operators OR and AND. To ensure alignment with the study's subject, the search string was defined using the most suitable keywords. For this review, four primary keywords were identified: 'Delivery method,' 'Teaching method,' 'University,' and 'Computer Science Courses. In accordance with PRISMA guidelines, the systematic search was conducted in August 2025 across multiple academic databases, limiting the inclusion to studies published between 2020 and 2025.

C. Sources selection

We restricted our search to journal articles and conference papers, categorizing publishers for relevance, and used IEEE and Web of Science as the primary databases.

D. Selection criteria

A quality assessment checklist (QAC), adapted from [6], was developed to evaluate individual peer-reviewed journal articles published between 2020 and 2025 for inclusion in this review. Table 1 shows the summary of the criteria for inclusion and exclusion.

Table 1. Summary of the criteria for inclusion and exclusion

Criterion	Rational
Inclusion 1: A study that is published in the computer science field.	Computer science is our reference field.
Inclusion 2: A study that is written in English.	Studies not published in English were excluded due to feasibility constraints in translation and interpretation.
Inclusion 3: A study that clearly describes the teaching and delivery method of a university lecturer to deliver the computer science courses	Inclusion 3: A study that clearly describes the teaching and delivery method of a university lecturer to deliver the computer science courses
Inclusion 4: Eligible studies were restricted to journal articles and conference papers.	Only peer-reviewed journal articles and conference papers were included to ensure the quality,

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	credibility, and comparability of the evidence base, while grey literature such as reports, dissertations, or non-peer-reviewed sources was excluded due to its limited reliability
Exclusion 1: A study that does not focus on university level.	Studies not focusing on university-level education were excluded, as the review is limited to higher education contexts to ensure relevance of teaching and delivery methods in Computer Science courses.

E. Quality assessment and data extraction

For a systematic and transparent review process, our study followed the PRISMA [7] reporting guidelines. In the data extraction phase, key details from the eligible research articles are recorded and structured to facilitate further synthesis and analysis. At the initial stage of the search, a total of 114 studies were retrieved. The abstracts were screened to identify relevant keywords and themes that aligned with the study's focus. After abstract screening, the full texts of the remaining studies were assessed for eligibility. Articles that did not align with the application of the research focus were excluded at this stage. Following the application of the inclusion and exclusion criteria, along with the quality assessment checklist (QAC), 11 studies met the eligibility requirements and were included in the final synthesis.

III. LITERATURE REVIEW

[8] proposed a teaching approach that integrates Problem-Based Learning (PBL) with the flipped classroom model, designed within the framework of PBL instruction. This method not only reinforces knowledge acquisition but also enhances students' practical skills and creative abilities. The approach used micro-curricula in the form of short instructional videos, which introduced key concepts such as IP addressing, VLAN configuration, and router/switch setup. Students first studied these videos to build foundational knowledge and then applied problem-driven methods through group projects.

The teaching process involved multiple stages:

1. Preparation: Students watched micro-videos to understand core concepts and challenges.
2. Group Work: Students formed groups (initially free-formed with teacher guidance, later restructured) to analyze and solve specific network design problems.
3. Project Practice: Groups collaborated on practical tasks, such as configuring and managing campus network equipment.
4. Iteration: The problem-solving cycle was repeated, with students progressively refining solutions through discussion and feedback.
5. Evaluation: Both the final designs and the problem-solving process were assessed to measure outcomes.

[9] introduced an alternative method through an in-browser slideshow system called Interactive Code Playgrounds (ICPs). ICPs provide a unified environment that makes programming lectures more accessible while enabling direct code execution. This approach addresses the challenge of bridging static teaching materials (slides) with the dynamic nature of programming practice. ICPs allow slideshows to be exported as HTML, ZIP packages for web hosting, or cross-platform executables that run via a local web server. A total of ten interventions were conducted: two in *Introduction to Programming with Python*, five in *Elements of Programming I*, and three in *Computer Programming 2*. These sessions took place several weeks after the start of the courses, allowing students to become familiar with the official IDE before using ICPs. Regular course instructors delivered the lectures, while the research team converted existing slides into ICPs—a largely straightforward process. Data was collected through pre- and post-experience surveys, combining open- and closed-ended questions. The pre-survey gathered demographic data, explored students' initial views on programming, and introduced ICPs, while the post-survey reassessed perceptions, evaluated ICP usability and quality, and gathered feedback. Results indicated that students understood ICPs' functionalities and were able to use them effectively during lectures, often at their own pace and tailored to their needs. The study highlights those educational technologies, such as ICPs, can enhance teaching and learning incrementally without requiring radical changes to existing course structures.

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[10] examined the use and impact of Test-Driven Development (TDD) and Behavior-Driven Development (BDD) as teaching approaches in Software Engineering. The study was conducted within the *Software Engineering Laboratory (SEL)* course, taken in the fourth semester (second year) of Bachelor programs in Information Systems and Computer Science, through a software development project. Test-Driven Development (TDD) is a programming practice focused on producing high-quality software within a short timeframe, while Behavior-Driven Development (BDD) emphasizes deriving specifications directly from client requirements during the needs analysis stage. The course involved 35 students, divided into five groups, each tasked with developing a software product over eight weeks. Groups adopted different methodologies: Group 1 and 2 used BDD, Group 3 combined Partial BDD with TDD, Group 4 used TDD, and Group 5 did not apply agile practices. All groups presented project progress weekly. Students actively engaged in problem-solving, interacting with professors and peers in a collaborative learning environment. Professors played dual roles: as coaches providing technical guidance and as clients communicating project requirements. The course began with 12 hours of training on TDD and BDD fundamentals, after which students chose their methodologies and developed their projects. Throughout the 78-hour course, students presented progress twice formally (after 40 and 78 hours), while professors continuously monitored work through GitHub and Trello. This structure fostered continuous improvement, collaboration, and reflection, allowing students to evaluate both their own and peers' methodological choices. Results from this study showed fewer absences, higher satisfaction, improved grades, and successful short-term project delivery, highlighting BDD's potential as an effective teaching method.

[11] introduced an innovative, demand-driven teaching model called IT-integrated Project-Based Learning (PjBL). This approach was implemented in the *Modern Education Technology* course to examine its impact on teaching reform in the context of the information age. PjBL engages students in complex, project-centered tasks requiring research, problem-solving, and decision-making, usually ending with a presentation or final product. In the study, students worked in self-selected teams of 4–6 members, each led by a team captain who coordinated communication, quality control, and task allocation. Team members independently took responsibility for different aspects of the project, such as teaching design, PPT preparation, content explanation, recording, dubbing, and editing. Students first analyzed project requirements and identified the necessary tools and knowledge, using online platforms for self-directed learning. Projects were divided into sub-tasks and shared via Tencent Docs, with materials stored in cloud platforms. Progress and challenges were regularly discussed in video conferences, while instant messaging tools facilitated day-to-day collaboration. Teachers evaluated submissions through Tencent Video, after which students revised their work until it met the required standards. The process concluded with group presentations, peer exchanges, and personal reflections, where students reported achievements, challenges, and solutions, supported by final course learning reports.

[12] presented a set of laboratory exercises aimed at raising awareness of online security while teaching fundamental cybersecurity knowledge and skills. These labs were integrated into an introductory information security course for IT students with little to no prior experience. Designed using the Design Science Research (DSR) methodology, the exercises can be delivered both in traditional classrooms and virtual lab environments.The Design Science Research (DSR) approach is outcomes-driven, offering a structured framework for developing and evaluating artefacts, which may include theories, models, designs, or tangible products. The first lab exercise demonstrated the simplicity of creating scam and phishing websites. Students designed fake websites and learned how to set up targeted phishing pages. The second lab focused on email header manipulation, where students used command-line tools to send emails from fabricated addresses. This showed the insecurity of email as a medium and raised awareness of phishing and other attack vectors. The third lab addressed phishing, spoofing, and password vulnerabilities by having students build a credential-harvesting portal. They copied a legitimate webpage, redirected victims via the Linux hosts file, and learned how browsers provide indicators of site legitimacy. To evaluate learning, students completed reflection tasks. Out of 39 reports, 22 that discussed phishing and spoofing were analyzed using thematic analysis. These reflections provided insights into how effectively the labs improved students' awareness and understanding of cybersecurity risks.

[13] designed and delivered a postgraduate course on *Design and Evaluation of Interactive Systems* using a flipped classroom approach, which was shifted entirely online due to the COVID-19 lockdown. Students were first provided with online study materials, and synchronous sessions were conducted via Microsoft Teams using breakout channels for group work. Tools such as Adobe Creative Cloud, Whiteboard, and Kahoot! quizzes supported collaboration and preparation checks. Students worked in small groups on modular

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projects inspired by real-world scenarios, engaging in activities such as persona creation, mockups, prototypes, peer evaluations, and final presentations. The methodology was evaluated through formal course surveys, structured interviews, and comparative analysis with other online courses in the same program. The results indicated that students rated both course content and teaching methods significantly higher than in other online courses, with Wilcoxon signed-rank tests confirming the differences as statistically significant. Qualitative feedback highlighted that students found the projects engaging and realistic, fostering strong collaboration with peers and instructors despite remote delivery. They also felt more active and less isolated compared to traditional online lecture-based courses. Although opinions on Kahoot! quizzes were mixed, some students appreciated them as a motivator for preparation. Overall, the flipped classroom online model proved more effective in enhancing satisfaction, engagement, and collaborative learning than conventional online teaching.

The study conducted by [14] reported the transition of undergraduate Computer Science courses from traditional face-to-face delivery to a blended learning model. Following flipped classroom principles, students were provided with online lectures, quizzes, and readings before class, while in-class sessions emphasized active learning, group discussions, and collaborative problem-solving. The transition was designed gradually to ensure smoother adoption and minimize disruption. Data were collected through student surveys, course performance metrics, and comparisons with prior traditional offerings. The results showed that students appreciated the flexibility and accessibility of online resources and reported greater engagement and deeper understanding during interactive in-class activities. Overall satisfaction with blended learning was higher than with traditional delivery. However, challenges were noted, including increased preparation workload for instructors, difficulties among some students in maintaining self-discipline with online tasks, and occasional technical issues such as unstable internet access. Despite these limitations, the blended approach was found to enhance learning outcomes and improve student experiences, provided adequate support and course design are in place.

[15] presented a hybrid software engineering project course that adopted a flipped classroom approach. Their model emphasized active learning and incorporated authentic assessment practices, such as reflective writing and peer evaluation, to enhance student engagement and learning outcomes. In this course, classroom activities were designed to motivate students to develop software products and apply software engineering techniques to real-world problems. Small group activities were incorporated, where students provided written or oral summaries—either in person or online—about their strategies and lessons learned. The course also adopted authentic assessment methods, emphasizing frequent, low-stakes graded activities rather than high-stakes exams.

[16] introduced Team Project-Based Learning (TPBL), a method that integrates project-based learning with teamwork to simulate real-world professional contexts. This approach was applied over four academic years in database courses. The model included structured teamwork formation, defined activities and timelines, and the development of both technical and soft skills. The TPBL approach included two sets of activities. The first set consisted of simple tasks to introduce fundamental database concepts. The second set comprised more complex, core activities, which were tackled by student teams as part of the main project. These core activities covered all stages of database design, conceptual, logical, and physical, along with implementation in a DBMS, the definition of business rules, and the preparation of a final report with a database backup. Throughout the project, students were asked to complete self-evaluations and peer assessments of their teammates' performance using questionnaires. These evaluations offered valuable insights into the students' progress and development over the course of the project. Therefore, TPBL enhances the learning experience by combining teamwork with project-based learning, creating a synergistic environment that simulates real workplace conditions where groups must collaboratively address authentic organizational or institutional problems.

[17] introduced the Gurukul platform, designed to apply design patterns and concepts for developing specialized LLM-based applications aimed at improving engagement and learning experiences in *Data Structures and Algorithms (DSA)* courses. Gurukul integrates Retrieval-Augmented Generation (RAG) and Guardrails into its LLMs to provide educational content that is accurate, relevant, and ethically aligned with academic standards. This design aims to foster critical thinking skills in students rather than promoting over-reliance on LLMs. The evaluation was carried out in two stages: first, a user expert review with faculty members from a U.S. public university, and second, a user study involving students who were either enrolled in or interested in DSA courses. Results showed high success and pass rates, reflecting effective learning of DSA concepts. Students emphasized the usefulness of the LLM in delivering accurate and relevant responses that supported their

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understanding. Expert reviewers confirmed these outcomes, particularly noting the effectiveness of the guardrails in ensuring safe and contextually appropriate content.

[18] examined the use of a blended project-based learning approach supported by visualization technology in teaching mobile application development to IT students. This method combined project-based learning, pair programming, teamwork, and digital educational resources as visual learning content. Students engaged in hands-on workshops through active doing, interactive tasks, and the creation of various mobile application projects. The study highlighted how these teaching strategies and resources enhanced students' cognitive skills and practical experience in mobile app development. The study involved 89 students from Computer Science programs. The two-week workshop (60 hours) focused on developing iOS mobile applications using Xcode and the Swift programming language, which integrates object-oriented and functional programming principles. The teaching approach combined project-based learning with visual and kinesthetic learning styles, supported by Digital Educational Resources (DER). Each DER consisted of three components: (1) a theoretical unit with multimedia, diagrams, animations, and videos; (2) a training unit with interactive task simulators to reinforce skills and motivation; and (3) a control unit with quizzes and feedback to promote self-analysis and self-development. The study demonstrated that using DER as a visualization tool significantly reduced lecture time from 50 minutes to around 10–12 minutes. The interactive tasks enabled repeated practice, helping students consolidate knowledge and build hands-on skills, and supported the development of cognitive skills.

IV. FUTURE RESEARCH

This study presents a systematic review of teaching and delivery methods used in university-level computer science courses. The following section highlights key directions for future research in this important area of computer science education:

1. The delivery and teaching methods examined in prior studies have largely been confined to single courses with limited scope and context. Their effectiveness across diverse subjects and broader curricular settings remains underexplored. Consequently, future research should move beyond isolated course implementations and investigate the adaptability and impact of these methods across the wider computer science curriculum.

2. Existing delivery and teaching methods often rely on limited assessment approaches, such as student satisfaction surveys or course grades, which provide only a partial view of effectiveness. There is a need for a standardized and robust assessment framework that can more accurately capture the multidimensional outcomes of learning. Such a framework should incorporate not only cognitive aspects, such as knowledge acquisition and critical thinking, but also higher-order skills, including creativity, teamwork, problem-solving, and adaptability. Developing and validating this comprehensive evaluation metrics will allow for more meaningful comparisons across studies and ensure that innovative teaching approaches contribute to both academic achievement and professional readiness.

3. While many studies introduce innovative teaching and delivery methods, such as flipped classrooms, project-based learning, and blended learning, limited attention has been given to the role of instructors in effectively implementing these approaches. Most research assumes that faculty are already equipped with the necessary pedagogical and technological skills, overlooking the challenges lecturers face in adapting to new methods. Future research should emphasize the development of structured training programs and continuous professional support for educators.

4. Future research should investigate the integration of interactive coding environments, and AI-assisted learning platforms in authentic, large-scale classroom contexts. This includes examining how such technologies influence student engagement, critical thinking, collaboration, and long-term learning outcomes. Studies should also explore issues of inclusivity, accessibility,

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and equity, ensuring that the adoption of advanced technologies does not widen the digital divide among students with different backgrounds. Furthermore, longitudinal research is needed to assess how these technologies evolve alongside curriculum design and teacher practices, providing deeper insights into their sustainability and overall impact on higher education.

V. CONCLUSION

This study presents a systematic review of the teaching and delivery methods employed in universities for delivering computer science courses, offering insights into their effectiveness, limitations, and potential for improvement. Through the three exploratory research questions, this study identified several interactive teaching and delivery methods, with blended learning, project-based learning, and flipped classrooms being the most prominent. These approaches primarily aim to enhance problem-solving skills, foster creativity, promote teamwork, and expose students to real-world projects. A notable trend was observed during the COVID-19 pandemic, when the shift to online learning led to a surge in innovative teaching practices. However, in the post-pandemic period, fewer studies have focused on developing or evaluating new interactive teaching methods, highlighting a gap in current research. Across these innovative teaching and delivery methods, students demonstrated positive outcomes, including a deeper understanding of learning content, enhanced teamwork, and the development of self-directed learning skills. Such approaches not only improved academic performance but also fostered essential soft skills. For instance, teamwork was consistently strengthened, equipping students with a lifelong competency that is highly valuable in professional settings. Similarly, self-directed learning skills enable students to cultivate perseverance and adaptability when encountering challenges and it shows critical abilities for continuous learning beyond graduation. Overall, these methods highlight that innovative pedagogy contributes not only to academic success but also to the development of transferable, lifelong skills. This review provides researchers with a comprehensive overview of recent years existing teaching and delivery methods in computer science courses, serving as a foundation for developing new approaches that can further advance the field of computer science education.

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Strengthening Teaching Innovation through Digital Preparedness: Evidence from Malaysian Polytechnics and Community Colleges

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Abstract

Digital innovation has become increasingly important in higher education, particularly within Technical and Vocational Education and Training (TVET) institutions where lecturers are expected to integrate digital tools into more flexible and innovative teaching practices. However, the extent to which lecturers' digital preparedness contributes to pedagogical innovation remains insufficiently understood in the Malaysian TVET context. This study examines the role of digital preparedness in strengthening teaching innovation among lecturers in Malaysian polytechnics and community colleges. A quantitative cross-sectional survey was conducted involving 200 lecturers selected through purposive sampling, and the data were analysed using descriptive statistics, Pearson correlation, and simple linear regression with IBM SPSS Version 26. The findings show that lecturers demonstrate a moderate-to-high level of digital preparedness ($M = 3.65$, $SD = 0.50$), while pedagogical innovation remains at a moderate level ($M = 3.45$, $SD = 0.52$). The results further indicate a significant positive relationship between digital preparedness and pedagogical innovation ($r = 0.377$, $p < 0.01$), with digital preparedness explaining 14.2% of the variance in innovative teaching practices ($R^2 = 0.142$). These findings suggest that digital preparedness is an important enabler of teaching innovation, but sustained pedagogical change also requires institutional support, continuous professional development, and structured capacity-building initiatives in Malaysian TVET institutions.

Keywords**:** *Digital preparedness; Innovative teaching practices; Pedagogical innovation; TVET institutions; Polytechnic and community colleges*

I. INTRODUCTION

The integration of digital technologies has become an essential component of teaching and learning practices in higher education institutions worldwide. The rapid shift towards online and blended learning environments, particularly during and after the COVID-19 pandemic, has accelerated the adoption of digital tools and platforms to support instructional continuity and flexibility [1]. Within the Malaysian context, Technical and Vocational Education and Training (TVET) institutions, particularly polytechnics and community colleges, play a strategic role in developing a workforce equipped with relevant technical competencies and digital capabilities aligned with Industry 4.0 requirements [13].

Despite increased access to digital infrastructure, the effectiveness of technology integration in teaching remains uneven. Lecturers' ability to utilise digital tools meaningfully is influenced not only by availability of technology but also by their preparedness, confidence, and institutional support mechanisms. Prior studies have highlighted that successful digital teaching practices depend on lecturers' technical competence, pedagogical adaptability, and organisational readiness [7], [8]. In Malaysia, challenges such as inconsistent digital skills, limited training opportunities, and varying institutional support continue to affect the depth of technology-enhanced teaching practices in TVET institutions [2].

Recent research further emphasises that digital competence is a multidimensional construct encompassing knowledge, skills, and attitudes required for effective technology integration in teaching practices [19]. It has been increasingly recognised as a critical factor influencing teaching effectiveness and the ability of educators to

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implement innovative pedagogical approaches in higher education settings [19].

Existing literature suggests that lecturers' preparedness to engage with digital technologies has a direct influence on teaching effectiveness and innovation. Studies have shown that lecturers who demonstrate higher levels of digital preparedness are more likely to experiment with diverse instructional strategies and adopt technology-supported teaching approaches [11]. From a pedagogical perspective, the integration of technological, pedagogical, and content knowledge has been recognised as a key enabler of innovative teaching practices that enhance student engagement and learning outcomes [16].

However, empirical evidence examining how lecturers' digital preparedness contributes to teaching innovation within Malaysian polytechnics and community colleges remains limited. Previous studies in the TVET context have largely focused on technology adoption, blended learning implementation, or general readiness for Industry 4.0, with less emphasis on how preparedness translates into sustained pedagogical innovation [10], [13]. Furthermore, institutional factors such as leadership commitment, professional development structures, and organisational culture have been identified as critical elements that shape lecturers' capacity to innovate, yet these aspects are often discussed separately rather than in relation to digital preparedness [14].

In response to this gap, the present study examines the role of digital preparedness in strengthening teaching innovation among lecturers in Malaysian polytechnics and community colleges. Specifically, this study aims to: (i) determine the level of digital preparedness among TVET lecturers, (ii) assess the extent of innovative teaching practices implemented in their instructional activities, and (iii) analyse the relationship between digital preparedness and pedagogical innovation. By providing empirical evidence from the Malaysian TVET context, this study seeks to inform institutional leaders and policymakers in designing targeted strategies that enhance digitally enabled teaching innovation within higher education.

II. LITERATURE REVIEW

A. Digital Preparedness in Higher Education

Digital competence has evolved into a multidimensional construct encompassing knowledge, skills, and attitudes required for effective technology integration in teaching [19], [20].

Digital preparedness among educators refers to their ability to engage with digital technologies in a confident, purposeful, and pedagogically meaningful manner. In the context of higher education, preparedness extends beyond basic technological access and encompasses digital competence, adaptability, and sustained motivation to integrate technology into instructional practices. The rapid transition to online and blended learning during the COVID-19 pandemic exposed significant variations in lecturers' levels of preparedness, particularly in terms of digital skills and instructional readiness [7].

Previous studies indicate that lecturers' preparedness is influenced by multiple factors, including access to infrastructure, familiarity with digital platforms, institutional training, and organisational support. Mukhtar et al. [7] reported that effective online teaching requires not only technical proficiency but also institutional facilitation and instructional adaptability. Similarly, Rasheed et al. [8] highlighted that limited training opportunities, time constraints, and unstable connectivity remain persistent challenges that restrict lecturers' capacity to implement technology-enhanced teaching approaches effectively.

Within the Malaysian TVET landscape, the issue of digital preparedness has received increasing attention. Hashim and Hamidon [2] observed that although blended learning initiatives have been widely introduced in TVET institutions, the level of pedagogical integration varies considerably among lecturers. Their findings suggest that uneven preparedness contributes to superficial technology use, where digital tools are adopted for content delivery rather than for deeper instructional transformation. Hani et al. [9] further emphasised the importance of systematic digital upskilling by proposing a digital competence model tailored for TVET educators, highlighting preparedness as a continuous developmental process rather than a static condition.

In addition to technical competence, digital preparedness also encompasses psychological and emotional readiness. Tajuddin et al. [1] demonstrated that lecturers' emotional presence and comfort in online teaching environments significantly affect instructional quality and student engagement. This perspective suggests that preparedness is multidimensional, involving cognitive, technical, and affective components that collectively influence lecturers' willingness to engage with digital teaching practices.

B. Pedagogical Innovation in TVET Teaching Practices

Pedagogical innovation refers to the adoption of creative and technology-supported instructional strategies aimed at enhancing learning effectiveness, student engagement, and skill development. In TVET education, innovation is particularly critical due to the need to align teaching practices with industry demands, employability skills, and

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evolving technological trends. Innovative pedagogy often involves the redesign of teaching activities, assessment methods, and collaborative learning processes to better support experiential and applied learning outcomes.

Several studies have demonstrated that technology plays a significant role in enabling pedagogical innovation. Omar et al. [10] found that gamification strategies can enhance student motivation and participation in vocational education; however, the successful implementation of such approaches depends heavily on lecturers' preparedness and resource availability. Similarly, Saiman et al. [11] reported that lecturers who exhibit higher levels of technological readiness tend to demonstrate stronger teaching performance and greater confidence in experimenting with digital teaching tools.

The Technological Pedagogical Content Knowledge (TPACK) framework provides a theoretical basis for understanding how pedagogical innovation emerges through the integration of technology, pedagogy, and subject content. Shafie et al. [16] argued that lecturers who effectively integrate these knowledge domains are better positioned to design innovative learning experiences that foster 21st-century skills. This view aligns with Davis's Technology Acceptance Model (TAM), which posits that perceived usefulness and ease of use influence individuals' adoption of technology for instructional purposes [5].

Despite positive attitudes toward digital teaching tools, challenges in implementing pedagogical innovation remain evident within Malaysian TVET institutions. Zulnaidi and Majid [13] noted that many lecturers' experience uncertainty when integrating Industry 4.0 technologies into teaching due to limited exposure and insufficient training. Furthermore, Kholifah et al. [12] emphasised that pedagogical innovation must be aligned with workforce readiness and employability competencies to ensure that instructional practices remain relevant to labour market expectations.

C. Linking Digital Preparedness and Pedagogical Innovation

Recent studies also indicate that continuous professional development plays a crucial role in enhancing educators' digital competence. Training programmes, blended learning support systems, and professional development initiatives have been shown to significantly improve lecturers' confidence and ability to integrate digital technologies into their teaching practices [19].

The relationship between lecturers' digital preparedness and pedagogical innovation has been increasingly recognised in educational research. Empirical evidence suggests that lecturers who are digitally prepared are more likely to adopt innovative teaching approaches and engage in instructional experimentation. Hashim and Hamidon [2] argued that meaningful blended learning implementation is achievable only when lecturers possess sufficient digital competence and pedagogical confidence. This assertion is supported by Saiman et al. [11], who found that preparedness enhances lecturers' willingness to apply technology in diverse instructional contexts.

Professional development has been identified as a critical mechanism linking preparedness to innovation. Hani et al. [9] suggested that continuous training in digital literacy serves as a catalyst for pedagogical creativity, enabling lecturers to move beyond basic technology usage toward more innovative teaching designs.

However, preparedness alone does not guarantee sustained innovation. Institutional conditions such as leadership support, policy direction, and infrastructure quality play a complementary role in shaping lecturers' capacity to innovate [14].

Research has also highlighted the importance of inclusivity and learner readiness in the digital transformation process. Kamal and Awang [17] extended the discussion by examining digital competence among TVET students with special needs, emphasising that pedagogical innovation must accommodate diverse learner profiles. Similarly, Nasaruddin et al. [18] demonstrated that communication and problem-solving skills significantly influence students' work readiness, reinforcing the need for innovative teaching practices that support holistic skill development.

Collectively, these studies indicate that digital preparedness functions as a foundational enabler of pedagogical innovation, but its impact is moderated by institutional support structures and professional development opportunities. While existing literature acknowledges the connection between preparedness and innovation, limited empirical research has focused specifically on Malaysian polytechnics and community colleges. This gap underscores the need for further investigation into how lecturers' digital preparedness contributes to strengthening innovative teaching practices within the Malaysian TVET context.

Despite the increasing emphasis on improving digital competence, existing research remains limited, particularly in the context of in-service educators and real teaching environments, as most studies have focused on pre-service teachers or controlled training interventions [19]. This highlights the need for empirical studies that examine how digital preparedness translates into

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actual pedagogical innovation within specific institutional contexts.

III. RESEARCH METHODOLOGY

A. Research Design

This study employed a quantitative cross-sectional survey design to examine the influence of digital preparedness on pedagogical innovation among lecturers in Malaysian polytechnics and community colleges. The cross-sectional approach was selected because it enables data to be collected from a defined population at a single point in time and allows for the statistical examination of relationships between variables [4]. This design is commonly adopted in educational research investigating lecturers' preparedness and technology-enhanced teaching practices [1], [2].

The study is conceptually supported by the Technology Acceptance Model (TAM), which explains how perceptions of usefulness and ease of use shape technology-related behaviour [5]. In this study, TAM serves as a supporting framework to explain how lecturers' preparedness to use digital tools may facilitate innovative pedagogical practices, rather than focusing solely on technology adoption.

B. Research Framework

This study is guided by a conceptual framework that explains the relationship between lecturers' digital preparedness and pedagogical innovation within Malaysian polytechnics and community colleges. The framework was developed based on established theories and empirical findings that highlight the importance of lecturers' preparedness in enabling innovative teaching practices in digitally mediated learning environments.

Digital preparedness in this study refers to lecturers' capability, confidence, and willingness to integrate digital technologies into their instructional practices in a meaningful manner. Prior research has demonstrated that lecturers who possess adequate digital competence and technological confidence are better positioned to adapt teaching strategies and respond to changing educational demands [7], [8]. Within the TVET context, preparedness is particularly important due to the applied and skills-oriented nature of teaching and learning activities [2], [9].

The framework is conceptually aligned with the Technology Acceptance Model (TAM), which emphasises perceived usefulness and perceived ease of use as key determinants of technology adoption [5]. In the present study, TAM provides a theoretical foundation to explain how lecturers' perceptions of digital tools influence their preparedness to utilise technology for teaching purposes. However, rather than focusing solely on technology acceptance, this study extends the discussion by positioning digital preparedness as an enabling condition that supports pedagogical innovation.

Pedagogical innovation is conceptualised as the implementation of technology supported teaching strategies that enhance instructional delivery, assessment practices, and student engagement. Previous studies suggest that lecturers who are digitally prepared are more likely to redesign learning activities, experiment with new instructional approaches, and adopt interactive teaching methods [11], [16]. As such, pedagogical innovation is viewed as an outcome that emerges when digital preparedness is translated into instructional practice.

The proposed framework assumes a direct relationship between digital preparedness and pedagogical innovation. Lecturers with higher levels of preparedness are expected to demonstrate greater capacity to implement innovative pedagogical practices, particularly in technology-enhanced learning environments. At the same time, the framework recognises that pedagogical innovation does not occur in isolation. Institutional conditions such as leadership support, professional development opportunities, and organisational culture provide an important contextual backdrop that influences how preparedness is enacted in practice [13], [14].

The conceptual structure illustrated in Figure 1 outlines the proposed relationship between digital preparedness and pedagogical innovation, positioning digital preparedness as the explanatory factor influencing innovative teaching practices among lecturers.

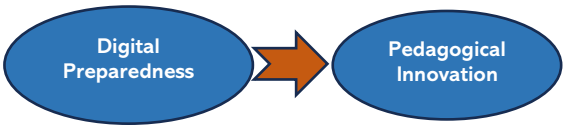

Figure 1
Proposed research framework linking digital preparedness and pedagogical innovation

C. Research Process

Figure 2 illustrates the overall research process, outlining the key stages from problem identification to findings and implications. The sequence reflects a structured approach adopted to ensure the rigor of the study.

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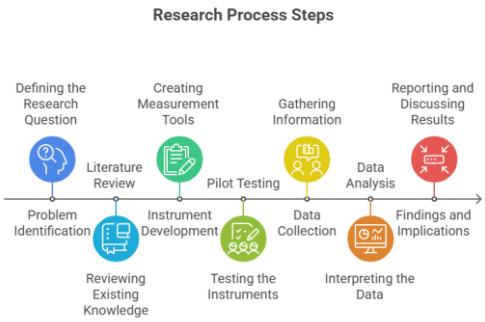

Figure 2
Research process of the study

The research process consists of several systematic stages:

1). ***Problem Identification***.
The study begins by identifying gaps related to lecturers' digital preparedness and its influence on teaching innovation in Malaysian TVET institutions.

2). ***Literature Review***
Relevant theories and prior studies, including TAM and TPACK, are reviewed to establish the conceptual foundation of the study.

3). ***Instrument Development***
A structured questionnaire is developed based on validated constructs from previous studies, focusing on digital preparedness and pedagogical innovation.

4). ***Pilot Testing***
A pilot study is conducted to assess the reliability and clarity of the instrument, ensuring consistency of measurement.

5). ***Data Collection***
Data are collected from lecturers in polytechnics and community colleges using purposive sampling techniques.

6). ***Data Analysis***
The collected data are analysed using IBM SPSS Version 26, including descriptive statistics, Pearson correlation, and simple linear regression.

7). ***Findings and Implications***
The results are interpreted to identify key insights and practical implications for enhancing teaching innovation in TVET institutions.

D. Population and Sampling

The population of this study comprised lecturers from Malaysian polytechnics and community colleges under the Department of Polytechnic and Community College Education (JPPKK). Given the diverse teaching contexts and levels of digital exposure across TVET institutions, purposive sampling was employed to ensure that respondents had relevant teaching experience and were actively engaged in instructional activities involving digital tools [3]. A total of 200 lecturers participated in the study. This sample size satisfies recommended guidelines for correlational and regression analyses in educational research [6], [15]. The respondents represented various academic disciplines, institutional types, and years of teaching experience, providing an appropriate basis for examining the relationship between digital preparedness and pedagogical innovation.

E. Research Instrument

Data were collected using a structured questionnaire adapted from validated instruments in prior studies on digital readiness and pedagogical practices [7]–[9]. The questionnaire consisted of three sections: demographic information, digital preparedness, and pedagogical innovation. Digital preparedness was measured through items related to access, digital skills, and attitudes, while pedagogical innovation focused on instructional strategies, assessment practices, and student engagement.

All items were measured using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). A pilot study involving 30 lecturers was conducted to assess item clarity and reliability. The reliability analysis indicated excellent internal consistency, with Cronbach's alpha values exceeding 0.90 for both constructs, confirming the suitability of the instrument for the main study.

F. Data Collection and Analysis

Data collection was conducted online using Google Forms and distributed through official institutional channels and professional lecturer networks. Participation was voluntary, and respondents were informed of the study objectives and confidentiality of responses. The survey remained open for four weeks to ensure sufficient participation across institutions.

Data analysis was performed using IBM SPSS Statistics Version 26. Descriptive statistics were used to determine the levels of digital preparedness and pedagogical innovation. Pearson correlation analysis examined the relationship between the two constructs, while simple linear regression analysis assessed the predictive effect of digital preparedness on pedagogical innovation. Mean score interpretation followed established benchmarks commonly used in educational research [7], [17].

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IV. RESULTS AND DISCUSSION

A. Demographic Profile of Respondents

The respondent profile summarised in **Table 1** indicates that the sample consisted of lecturers from both polytechnics and community colleges, with polytechnic lecturers forming the larger proportion (65%) compared to those from community colleges (35%). The gender distribution shows a slightly higher representation of female lecturers (56%) than male lecturers (44%), reflecting the overall institutional composition of the Malaysian TVET system.

In terms of age, most respondents were between 30 and 39 years old (45%), followed by those aged 40–49 (30%). The majority held a Master's degree (45%), and a substantial proportion reported between five and ten years of teaching experience (40%). Additionally, most lecturers indicated frequent use of Learning Management Systems (LMS) such as CIDOS, Moodle, or Google Classroom. This profile suggests that the respondents possess adequate academic qualifications and practical exposure to digital teaching environments, providing a suitable context for examining digital preparedness and pedagogical innovation.

Table 1
Demographic Profile of Respondents (n=200)

Variable	Category	Frequency	Percentage
Gender	Male	88	44.0%
	Female	112	56.0%
Age	<30	25	12.5%
	30–39	90	45.0%
	40–49	60	30.0%
	≥50	25	12.5%
Education	Diploma	20	10.0%
	Bachelor	70	35.0%
	Master	90	45.0%
	PhD	20	10.0%
Institution	Polytechnic	130	65.0%
	Community College	70	35.0%
Experience	<5 years	40	20.0%
	5–10 years	80	40.0%
	11–15 years	50	25.0%
	>15 years	30	15.0%
LMS usage	Rarely	20	10.0%
	Sometimes	50	25.0%
	Often	80	40.0%
	Very Often	50	25.0%

B. Reliability of Measurement Instruments

The internal consistency outcomes reported in Table 2 demonstrate that both measurement constructs achieved excellent reliability, with Cronbach's alpha coefficients well above the acceptable threshold. This indicates that the items used in the study consistently measured digital preparedness and pedagogical innovation, supporting their suitability for subsequent analyses.

Table 2
Reliability Analysis

Measurement construct	Cronbach's Alpha
Digital preparedness	0.981
Pedagogical innovation	0.983

C. Levels of Digital Preparedness and Pedagogical Innovation

The descriptive results summarised in Table 3 indicate that digital preparedness achieved a moderate-to-high average score (M = 3.65, SD = 0.50), suggesting that lecturers generally demonstrate adequate confidence, access, and foundational digital capabilities. By comparison, pedagogical innovation reflects a moderate level of practice (M = 3.45, SD = 0.52).

Table 3
Summary of Descriptive Statistics for Study Variables

Construct	N	Average Score (M)	Variability (SD)
Digital preparedness	200	3.65	0.50
Pedagogical innovation	200	3.45	0.52

These results suggest that while lecturers are reasonably prepared to use digital technologies, the application of these tools for innovative pedagogical purposes remains limited. Digital tools appear to be used more frequently to support existing teaching practices rather than to redesign instructional strategies or assessment approaches.

A closer examination of the dimension-level results summarised in Tables 4 and 5 offers further insight into lecturers' digital practices. Within the digital preparedness construct, attitude and readiness emerged as the most prominent dimension, followed by infrastructure and access, while digital literacy and skills remained at a moderate level. In terms of pedagogical innovation,

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higher mean scores were observed for teaching innovation compared to assessment innovation and student engagement, suggesting that lecturers tend to apply digital tools more readily in instructional delivery than in assessment design or collaborative learning activities.

Table 4
Descriptive Profile of Digital Preparedness Dimensions (n = 200)

Digital preparedness dimension	Average score	Score variability (SD)	Interpretation
Infrastructure and access	3.72	0.46	High
Digital Literacy and skills	3.58	0.49	Moderate
Attitude and readiness	3.80	0.44	High
Overall score	**3.65**	**0.50**	**Moderate-High**

Table 5
Summary of Pedagogical Innovation Components (n = 200)

Pedagogical innovation component	Average score	Score variability (SD)	Interpretation
Teaching innovation	3.52	0.48	Moderate
Assessment innovation	3.41	0.50	Moderate
Collaboration and engagement	3.43	0.51	Moderate
Overall score	**3.45**	**0.52**	**Moderate**

D. Relationship between Digital Preparedness and Pedagogical Innovation

The Pearson correlation analysis results presented in Table 6 indicate a statistically significant positive relationship between digital preparedness and pedagogical innovation ($r = 0.377$, $p < 0.01$).

Table 6
Association between Study variables

Variable	Correlation value (r)	Significance (p)
Digital preparedness	0.377	<0.01

This relationship is further illustrated in Figure 3, which shows an upward trend between the two variables. The scatter plot, together with the regression line, indicates that higher levels of digital preparedness are generally associated with higher levels of pedagogical innovation, although the relationship is moderate.

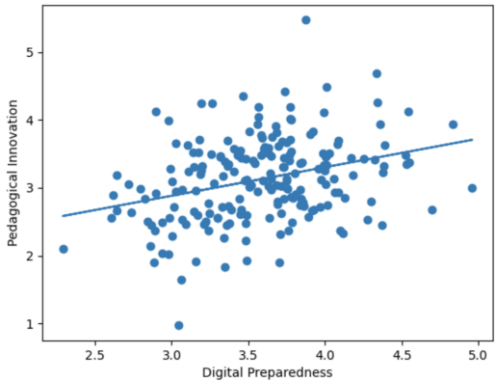

Figure 3
Scatter plot with regression line showing the relationship between digital preparedness and pedagogical innovation

E. Predictive Effect of Digital Preparedness

The predictive relationship summarised in Table 7 demonstrates that digital preparedness contributes significantly to pedagogical innovation. The results indicate that digital preparedness significantly predicts pedagogical innovation ($\beta = 0.377$, $p < 0.05$). The model explains 14.2% of the variance ($R^2 = 0.142$), indicating that digital preparedness contributes meaningfully to teaching innovation.

While the explanatory power of the model is modest, it is considered meaningful in educational research, where teaching practices are shaped by multiple interacting factors. These findings suggest that digital preparedness contributes to pedagogical innovation but should be complemented by

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institutional support, professional development, and conducive organisational conditions.

Table 7
Regression Output for Prediction Relationship

Independent variable	Unstandardized B	Standardized β	Explained variance (R^2)
Digital preparedness	0.385	0.377	0.142

F. Discussion of Finding

The findings indicate a moderate positive relationship between digital preparedness and pedagogical innovation among lecturers in Malaysian TVET institutions. Although lecturers demonstrate readiness to use digital technologies, this preparedness does not consistently translate into innovative teaching practices.

This finding is consistent with the integration of the Technology Acceptance Model (TAM) and Technological Pedagogical Content Knowledge (TPACK) frameworks, which emphasise that technological readiness must be supported by effective pedagogical integration to enhance teaching practices [16], [20].

Furthermore, this result aligns with previous studies [19], [20], which highlight the importance of institutional strategies that support pedagogical experimentation and continuous professional development. Without such support, lecturers may continue to use digital tools primarily for routine instructional purposes rather than for transformative teaching innovation. These findings reinforce the need for a holistic approach that integrates individual preparedness with organisational and policy-level support.

This may be due to several underlying factors, including limited access to structured training programmes, insufficient institutional encouragement for innovation, and a lack of continuous professional development opportunities. In addition, lecturers may experience constraints such as time limitations, heavy workload, and limited exposure to advanced digital pedagogical practices, which can hinder their ability to fully utilise digital tools in innovative ways. Therefore, strengthening both individual competencies and institutional support mechanisms is essential to foster sustainable pedagogical innovation in higher education.

V. CONCLUSION

This study examined the role of digital preparedness in strengthening pedagogical innovation among lecturers in Malaysian polytechnics and community colleges. Overall, the findings indicate that lecturers demonstrate a moderate to high level of digital preparedness, while the implementation of innovative teaching practices remains at a moderate level. The statistical analyses confirm that digital preparedness has a significant positive influence on pedagogical innovation, although its explanatory power is relatively modest.

These findings suggest that digital preparedness serves as an important enabling factor for teaching innovation, but it does not operate in isolation. While lecturers are generally equipped with the necessary digital confidence and basic skills, the translation of preparedness into innovative pedagogical practices requires additional support. This includes continuous professional development, structured pedagogical training, and institutional strategies that encourage experimentation with technology enhanced teaching approaches.

From a practical perspective, the results highlight the need for TVET institutions to move beyond infrastructure provision and focus on strengthening lecturers' pedagogical capacities. Institutional leaders and policymakers should prioritise targeted training programmes that integrate digital tools with instructional design, assessment strategies, and student engagement practices. Such initiatives are essential to ensure that digital preparedness contributes meaningfully to sustained teaching innovation rather than remaining limited to routine technology use. More specifically, structured capacity-building in TVET institutions may include peer-mentoring schemes for digital teaching, targeted workshops on assessment redesign and gamification, and short industry attachment or exposure programmes that help lecturers align digital pedagogy with current workplace practices. These initiatives would enable lecturers not only to improve technical confidence, but also to translate digital preparedness into more meaningful and innovative teaching practices.

In terms of theoretical contribution, this study extends existing discussions on digital readiness by demonstrating its role as a foundational condition for pedagogical innovation within the Malaysian TVET context. By linking digital preparedness to innovative teaching practices, the study provides empirical support for frameworks that emphasise the interaction between technological competence and pedagogical application in higher education.

Despite its contributions, this study has several limitations. The use of a cross-sectional survey design limits the ability to draw causal conclusions regarding the relationship between digital preparedness and pedagogical innovation. Additionally, the reliance on self-reported data may not fully capture actual teaching practices. Future research is therefore encouraged to adopt

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longitudinal or mixed method approaches to explore changes in lecturers' preparedness and innovation over time. Incorporating qualitative insights and institutional level variables such as leadership support, organisational culture, and policy alignment would provide a more comprehensive understanding of how pedagogical innovation can be sustained in TVET institutions.

In conclusion, digital preparedness is a necessary but insufficient condition for fostering pedagogical innovation. A holistic, system-driven approach that integrates individual competencies with institutional support is essential to strengthen innovative teaching practices and align Malaysian TVET institutions with evolving educational and workforce demands.

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Physicochemical Properties and Sensory Evaluation of Mayonnaise Using Soursop Vinegar

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Abstract

The quality and acceptability of mayonnaise are greatly influenced by the type of acidifying agent used in its formulation. The use of natural fruit vinegar in mayonnaise has recently gained attention due to its functional properties and consumer preference for natural ingredients. Therefore, this study aimed to evaluate the feasibility of using soursop vinegar (Annona muricata) as a natural alternative to synthetic vinegar in mayonnaise production by assessing its physicochemical properties and sensory acceptance. Three mayonnaise formulations were prepared using different types and concentrations of vinegar, namely synthetic vinegar, soursop vinegar, and soursop vinegar with added soursop essence. Physicochemical analyses included pH and viscosity measurements, while sensory evaluation was conducted through hedonic and scoring tests involving 30 semi-trained panellists from the Department of Food Technology, Politeknik Sultan Haji Ahmad Shah, Pahang. Data were analysed using one-way ANOVA to determine significant differences among formulations. The results indicated that all mayonnaise samples exhibited a safe acidic pH range between 3.6 and 3.8, comparable to commercial mayonnaise products. Viscosity analysis showed acceptable textural characteristics, particularly for formulations containing soursop vinegar. Sensory evaluation demonstrated that the formulation incorporating soursop vinegar with soursop essence achieved the highest overall acceptability, with significantly higher scores for aroma, taste, and texture ($p < 0.05$). In conclusion, soursop vinegar can be successfully utilised as a natural acidifying agent in mayonnaise formulation, maintaining desirable physicochemical qualities while enhancing sensory appeal. This study highlights the potential of soursop vinegar as a functional and healthier alternative to synthetic vinegar in mayonnaise production

Keywords **:** *mayonnaise, soursop vinegar, natural alternative*

I. INTRODUCTION

Mayonnaise is a widely consumed condiment used in many food products such as sandwiches, salads, and burgers. Traditional mayonnaise is produced from vegetable oil, egg yolk, vinegar, and seasoning ingredients that form a stable oil-in-water emulsion [1]. Vinegar plays an important role in mayonnaise production as it contributes to acidity, flavor, and microbial stability. In the food industry, synthetic vinegar is commonly used due to its low cost and availability. However, consumers are increasingly demanding natural food ingredients due to concerns about health and nutrition [2].

Natural vinegar derived from fruits has gained attention as a healthier alternative because it contains beneficial compounds such as organic acids, vitamins, and antioxidants [3]. Soursop (Annona muricata) is a tropical fruit widely cultivated in Malaysia and other tropical regions. The fruit is known for its distinctive flavor and nutritional value. Soursop contains various nutrients including vitamin C, dietary fiber, and antioxidants that may provide health benefits [4]. The fermentation of soursop juice can produce fruit vinegar containing organic acids that contribute to its acidic taste and preservation properties. Recent studies have shown that fruit vinegar can improve the physicochemical properties and sensory quality of emulsion-based food products such as mayonnaise and salad dressing [5]. Therefore, the use of soursop vinegar in mayonnaise formulation may influence both physicochemical characteristics and sensory acceptance of the product.

II. LITERATURE REVIEW

Mayonnaise is classified as an oil-in-water emulsion food product in which oil droplets are dispersed in an aqueous phase. The stability of mayonnaise is influenced by emulsifying agents such as egg yolk, which contains lecithin that helps stabilize the mixture of oil and water [1]. However, fruit vinegar has been explored as an alternative ingredient due to its nutritional and functional properties. Fruit-based vinegar is produced through fermentation processes where sugars are converted into alcohol and subsequently into acetic acid by microorganisms [3]. This fermentation process not only produces acetic acid but also retains bioactive compounds from the fruit. Soursop (Annona muricata) has been widely

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studied for its nutritional and medicinal properties. The fruit contains bioactive compounds such as acetogenins, flavonoids, and vitamin C, which have antioxidant and antimicrobial properties [4]. These bioactive compounds may contribute to emulsion stability, flavour development, and overall sensory acceptance when fruit vinegar is used in mayonnaise formulation [5].

III. RESEARCH METHODOLOGY

This study involved the preparation of mayonnaise using soursop vinegar followed by physicochemical and sensory analyses. Three formulations were prepared with different proportions of soursop vinegar to evaluate its effect on the final product refer to table 1. The raw materials used in this study included egg yolk, vegetable oil, sugar, salt, mustard, and soursop vinegar.

The soursop vinegar used in this study was commercially obtained from a local producer with an acetic acid content of approximately 5%.

The preparation of mayonnaise began by mixing egg yolk with seasoning ingredients until a homogeneous mixture was obtained. Vegetable oil was gradually added while continuously mixing to form a stable emulsion. Soursop vinegar was then added according to the predetermined formulations. The mixture was stirred continuously until a smooth and thick mayonnaise texture was achieved.

Physicochemical analysis was conducted to determine the pH and viscosity of the mayonnaise samples. The pH value was measured using a pH meter (Mettler Toledo pH meter) to determine the acidity level of each formulation. Viscosity was measured using a Brookfield Viscometer at room temperature. All measurements were carried out in triplicate.

Sensory evaluation was performed using 30 semi-trained panellists from the Department of Food Technology, Politeknik Sultan Haji Ahmad Shah, Pahang who evaluated the samples based on several attributes including appearance, aroma, taste, texture, and overall acceptability. A hedonic scale was used to measure the degree of liking among panellists as commonly applied in food sensory studies [2]. Statistical analysis was performed using Microsoft Excel. One-way analysis of variance (ANOVA) was used to determine significant differences among the formulations at a significance level of $p < 0.05$.

Table 1: Formulation

FORMULATION	F1%	F2%	F3%
Soursop vinegar	-	13.14	9.12
Synthetic vinegar	9.12	-	-
Soursop essences	1.92	-	1.92
Sugar	11.54	11.27	11.54
Salt	0.77	0.75	0.77
Egg yolk	7.42	7.25	7.42
Canola oil	69.23	67.59	69.23
Percentage	100	100	100

IV. RESULT AND DISCUSSION

The results of this study indicate that the addition of soursop vinegar significantly influenced the physicochemical properties and sensory characteristics of the mayonnaise samples.

The pH analysis showed that formulations containing higher amounts of soursop vinegar produced lower pH values. This result is expected because fruit vinegar contains organic acids that contribute to the acidity of the product [3]. The acidic environment is important for maintaining product safety and preventing microbial growth in mayonnaise.

Viscosity analysis showed variations in the consistency of the mayonnaise samples depending on the amount of vinegar added. An appropriate level of vinegar contributed to a stable emulsion and desirable creamy texture. However, excessive vinegar may disrupt the emulsion system, resulting in a thinner consistency.

The results of the sensory evaluation are presented in Table 2 with three formulations (F1, F2, and F3) were evaluated based on colour, aroma, texture, taste, and overall acceptance using a hedonic scale. The sensory evaluation results revealed that panelists preferred formulation 3 compared to the other formulations. or colour, F3 obtained the highest mean score (5.0 ± 0.94), which was significantly different ($p < 0.05$) from F1 and F2. This indicates that the panelists preferred the colour of formulation F3. For aroma, significant

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differences were observed among all formulations, with F3 recording the highest score (5.5 ± 0.93), followed by F1 (4.3 ± 0.87), while F2 had the lowest score (2.9 ± 0.95). This suggests that the aroma of F3 was more acceptable to the panelists.

A similar trend was observed for texture and taste. Formulation F3 showed significantly higher scores for texture (5.5 ± 1.00) and taste (5.7 ± 0.81) compared to F1 and F2. Meanwhile, no significant difference was observed between F1 and F2 for texture. These findings indicate that the ingredient composition in F3 may have contributed to a more desirable sensory profile. For overall acceptance, F3 recorded the highest score (5.9 ± 0.86), followed by F1 (4.9 ± 0.78), while F2 showed the lowest score (3.1 ± 1.01). The results indicate that formulation F3 was the most preferred sample among the panelists.

Table 2 : HEDONIC Test

MEAN	COLOUR	AROMA	TEXTUR E	TASTE	OVERALL ACCEPTANC E
F 1	4.5±0.93a	4.3±0.87a	4.6±0.88a	3.8±0.69a	4.9±0.78a
F 2	4.7±1.11a	2.9±0.95b	4.0±0.76a	3.3±0.95a	3.1±1.01b
F 3	5.0±0.94b	5.5±0.93c	5.5±1.00b	5.7±0.81b	5.9±0.86c

V. CONCLUSION

This study successfully evaluated the use of soursop vinegar as a natural substitute for synthetic vinegar in mayonnaise production. The results demonstrated that the addition of soursop vinegar influenced both physicochemical properties and sensory acceptance of the product.

Among the three formulations tested, formulation 3 showed the highest consumer acceptance due to its balanced acidity, desirable texture, and pleasant flavor. The physicochemical analysis also confirmed that the incorporation of soursop vinegar affected the pH and consistency of mayonnaise.

The findings suggest that soursop vinegar has strong potential to be utilized as a natural ingredient in mayonnaise production. The use of fruit-based vinegar may also contribute to the development of healthier food products that meet the increasing demand for natural ingredients. Future studies are recommended to evaluate the microbiological stability, shelf life, and commercial potential of mayonnaise produced using soursop vinegar.

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Teacher Participation in Decision-Making and Its Influence on Professional Learning Communities in Malaysian Schools

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Abstract

Professional Learning Communities (PLCs) are recognized as structured collaborative groups that enable teachers to enhance their competencies through continuous and systematic learning activities and contribute to school improvement. However, the effective implementation of PLCs in Malaysian schools remains challenging due to issues such as heavy teacher workload, limited institutional support, and lack of shared understanding. These challenges highlight the need for stronger organizational mechanisms, particularly teacher participation in decision-making. Therefore, this study investigates the influence of teacher participation in decision-making on PLCs. A quantitative cross-sectional survey design was employed, involving 284 secondary school teachers in Penang selected through simple random sampling. Data were analyzed using Partial Least Squares Structural Equation Modelling (PLS-SEM). The findings reveal that teacher participation in decision-making has a significant positive influence on PLCs. This study provides empirical evidence that inclusive decision-making practices strengthen collaborative professional cultures and enhance the sustainability of PLCs implementation in Malaysian schools.

Keywords**:** *Partial least squares structural equation modelling (PLS-SEM); Professional learning communities; Teacher participation in decision-making*

I. INTRODUCTION

Professional Learning Communities (PLCs) are widely recognized for their role in improving teaching and learning by promoting collaboration and reflective practices among educators. Nevertheless, the effective implementation of PLCs often encounters several obstacles, including heavy teacher workloads, limited clarity regarding their purpose, and uneven levels of practice across schools [1]–[2]. A key organizational factor influencing the sustainability and effectiveness of PLCs is teachers' participation in school decision-making. Teacher participation in decision-making significantly influences the effectiveness of PLCs, as participative practices enhance teacher empowerment and improve the overall academic climate [3]. When teachers are involved in institutional decisions, their goals become better aligned with school leadership objectives, strengthening collaboration within PLCs [4].

In the Malaysian context, increasing administrative demands, curriculum changes, and accountability pressures have significantly intensified teachers' workload, limiting their active engagement in collaborative practices such as PLCs. Furthermore, top-down management approaches commonly practiced in schools may reduce teachers' sense of ownership and professional agency. These challenges create a gap between policy expectations and actual PLCs implementation. Therefore, enhancing teacher participation in decision-making is not only desirable but necessary to address these systemic challenges, as it fosters shared responsibility, improves communication, and strengthens teachers' commitment to collaborative professional learning. Hence, this study aims to examine the influence of teacher participation in decision-making on PLCs.

II. LITERATURE REVIEW

A. Professional Learning Communities (PLCs)

PLCs refer to groups of educators who work collaboratively through continuous reflection, shared instructional practices, and collective inquiry with the aim of improving teaching quality and student outcomes [5]–[6]. Core characteristics of PLCs include a shared vision, professional

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autonomy among teachers, openness in classroom practices, and an emphasis on continuous learning for both educators and students [7]. In Western educational settings, PLCs typically highlight voluntary participation, professional trust, and teacher autonomy [8]. In contrast, within the Malaysian context, differing interpretations of the PLC concept and limited stakeholder understanding have contributed to inconsistencies in its implementation [9].

Recent studies have further emphasized the importance of PLCs in enhancing teacher collaboration and student outcomes, particularly in Asian educational contexts. For instance, [10] shows that teacher collaboration particularly when supported by self-efficacy enhances teaching practices, highlighting the critical role of collaborative cultures such as PLCs in improving instructional quality.

B. Teacher Participation in Decision-Making

Teacher participation in decision-making is increasingly acknowledged as a vital organizational practice that enhances teacher empowerment, promotes instructional innovation, and improves the overall academic environment of schools. The way decisions are structured, especially the degree to which participatory approaches are applied, plays a significant role in shaping teachers' sense of ownership and organizational effectiveness [11]. When teachers are involved in activities such as developing school policies, shaping institutional missions, and making professional-related decisions, alignment between leadership and staff objectives is strengthened, positioning participative decision-making as an effective strategy for improving organizational performance [12]. Therefore, teacher engagement in decision-making processes has become a key mechanism for fostering empowerment and advancing school effectiveness [13].

C. Teacher Participation in Decision-Making and PLCs

Teacher participation in decision-making positively influences the effectiveness of PLCs by fostering shared responsibility, collaboration, and collective commitment to school improvement. When teachers are actively involved in instructional and managerial decisions, they feel valued and empowered, which strengthens motivation, trust, and willingness to engage in collaborative professional learning activities [14]. Teacher participation in decision-making also enhances information sharing, shared understanding of school goals, and professional knowledge exchange, all of which are essential elements of effective PLCs functioning [15]. Consequently, greater teacher participation in decision-making supports stronger professional collaboration and contributes to the sustainability and impact of PLCs initiatives within schools [16]. Therefore, the following hypothesis is proposed:

H1: Teacher participation in decision-making has a significant influence on PLCs.

Based on hypothesis development, the research model is shown in Figure 1.

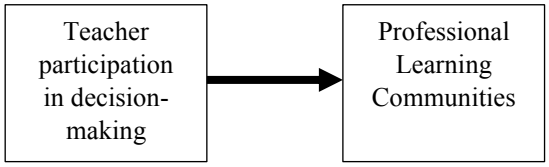

Figure 1. Research model

III. RESEARCH METHODOLOGY

This study used a quantitative cross-sectional survey involving 284 secondary school teachers in Penang, selected through simple random sampling. The research examined two constructs, i.e., teacher participation in decision-making and PLCs, measured using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). The teacher participation in decision-making, adapted from [17], showed high reliability (Cronbach's alpha = 0.949), while the PLCs instrument from [18] also demonstrated strong reliability (Cronbach's alpha = 0.934). Data were analyzed using partial least squares structural equation modelling (PLS-SEM). First, the measurement model was tested for convergent and discriminant validity. Next, the structural model was evaluated using bootstrapping with 5,000 resamples, following the procedure recommended by [19].

IV. RESULT AND DISCUSSION

A. Assessment of Measurement Model (First Order Construct)

Table 1 presents the measurement model for the 5 first-order constructs. All item loadings exceeded the recommended threshold of 0.70, while the composite reliability (CR) and average variance extracted (AVE) values were also above the required levels of 0.70 and 0.50, respectively. These results confirm that all constructs demonstrated satisfactory convergent validity. In addition, Table 2 shows that

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all Heterotrait-Monotrait (HTMT) ratio values were below the recommended threshold of 0.90 [20], indicating that the constructs have adequate discriminant validity.

B. Assessment of Measurement Model (Second Order Construct)

Table 3 displays the measurement model for a second-order construct. All factor loadings, composite reliability (CR), and average variance extracted (AVE) values were above the recommended thresholds of 0.70, 0.70, and 0.50, respectively, indicating satisfactory convergent validity. In addition, Table 4 shows that all Heterotrait-Monotrait (HTMT) ratio values were below the suggested cut-off value of 0.90 [20], confirming adequate discriminant validity for the second-order constructs.

C. Assessment of Structural Model

Table 5 presents the hypothesis testing results, indicating that teacher participation in decision-making significantly influenced PLCs ($\beta = 0.642$, $p = 0.000$), thus supporting H1. Figure 2 shows the structural model, where teacher participation in decision-making explained 41.2% of the variance in PLCs. Based on [18], the R^2 value of 0.412 indicates a moderate level of explanatory power.

Table 1. Measurement model of first-order constructs

Construct and item	Loading	Alpha	CR	AVE
Organising learning (OL)		0.901	0.931	0.772
OL1	0.839			
OL2	0.900			
OL3	0.894			
OL4	0.881			
Shared responsibility (SR)		0.899	0.930	0.768
SR1	0.882			
SR2	0.883			
SR3	0.914			
SR4	0.825			
Reflective dialogue (RD)		0.893	0.926	0.758
RD1	0.863			
RD2	0.840			
RD3	0.904			
RD4	0.874			
De-privatized practices (DP)		0.877	0.916	0.730
DP1	0.856			
DP2	0.870			
DP3	0.847			
DP4	0.846			
Teacher participation in decision-making (TM)		0.949	0.959	0.795
TM1	0.888			
TM2	0.900			
TM3	0.907			
TM4	0.879			
TM5	0.888			
TM6	0.889			

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Table 2. Discriminant validity (HTMT.90) for first-order constructs

	DP	RD	SR	TM
DP				
OL	0.796			
RD	0.884			
SR	0.870	0.889		
TM	0.660	0.641	0.608	

Note. DP=de-privatized practices, OL=organization learning, RD=reflective dialogue, SR=shared responsibility, TM=Teacher participation in decision-making

Table 3. Measurement model of second-order constructs

Construct and item	Loading	Alpha	CR	AVE
PLCs		0.934	0.953	0.835
OL	0.907			
SR	0.934			
RD	0.916			
DP	0.898			

Note. All the first-order constructs were converted to latent variable scores.

Table 4. Discriminant validity (HTMT.90) for second-order constructs

	PLC	TM
PLC		
TM	0.681	

Note. PLC=Professional learning communities, TM=Teacher participation in decision-making

Table 5. Results of hypothesis testing

Hypothesis	Beta	SD	*t* value	*p* values	LL	UL	Decision
H1: TM → PLC	0.642	0.048	13.366	0.000	0.543	0.735	Supported

Note. TM=Teacher participation in decision-making, PLC=professional learning communities

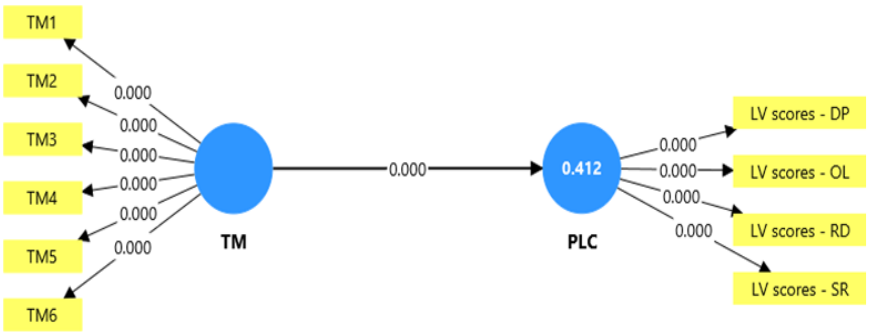

Figure 2. Structural model

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The findings show that teacher participation in decision-making has a significant influence on PLCs. When teachers are meaningfully included in instructional and organizational decision-making processes, they develop a stronger sense of recognition and empowerment, which increases their willingness to participate in reflective discussions, exchange teaching strategies, and engage consistently in collaborative professional learning activities [14]. Such involvement also promotes a collaborative school culture that supports effective PLCs functioning.

In addition, participation in decision-making improves communication and information sharing, and helps ensure that classroom practices match school goals, which encourages teachers to share professional knowledge and work together to solve problems [15]. Consequently, schools are more likely to sustain PLCs initiatives, as greater teacher involvement strengthens collective commitment and ensures that PLCs practices become embedded in continuous professional learning processes [16].

V. CONCLUSION

The findings imply that promoting teacher participation in decision-making is a strategic leadership approach for strengthening the effectiveness and sustainability of PLCs. School leaders should therefore establish participatory governance structures that actively involve teachers in instructional and organizational decisions, as such involvement enhances collaborative professional learning and supports continuous school improvement.

However, this study is limited by its cross-sectional design, which restricts causal interpretation, and the reliance on self-reported data that may introduce response bias. Future research is recommended to employ longitudinal or mixed-method approaches to better understand the long-term influence of teacher participation in decision-making on PLCs development.

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Tahap Pengetahuan Pelajar Jabatan Perdagangan Politeknik Kuching Sarawak Terhadap Penggunaan Kecerdasan Buatan (*Artificial Intelligence*) Dalam Membantu Proses Pembelajaran

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Abstrak

Kajian ini bertujuan mengenal pasti tahap pengetahuan pelajar Jabatan Perdagangan Politeknik Kuching Sarawak terhadap penggunaan kecerdasan buatan (AI) dalam pembelajaran, selaras dengan perkembangan teknologi yang semakin pesat dan berperanan meningkatkan kecekapan serta memperkaya pengalaman pendidikan yang lebih adaptif dan berpersonal. Walaupun AI tidak dapat menggantikan peranan guru, teknologi ini berpotensi menyokong pendidik dalam menyediakan bahan pengajaran yang lebih efisien serta membantu pelajar mengoptimumkan pembelajaran mengikut gaya dan tahap kefahaman masing-masing. Kajian ini menggunakan pendekatan kuantitatif melalui instrumen soal selidik yang diedarkan secara dalam talian kepada sampel pelajar diploma Jabatan Perdagangan menggunakan teknik pensampelan rawak. Data yang diperoleh dianalisis secara deskriptif bagi menilai tahap pengetahuan pelajar terhadap penggunaan AI. Dapatan kajian menunjukkan bahawa tahap pengetahuan pelajar berada pada tahap sederhana, menandakan mereka mempunyai pemahaman yang agak baik serta sikap yang positif terhadap teknologi ini, namun masih terdapat ruang untuk penambahbaikan. Kesimpulannya, kajian ini memberi implikasi penting dalam merangka kurikulum yang lebih komprehensif serta membantu pembuat dasar pendidikan dalam merancang inisiatif yang lebih efektif bagi mengintegrasikan AI dalam pengajaran dan pembelajaran.

Kata kunci: AI; kecerdasan buatan; pembelajaran; tahap pengetahuan

Abstract

This study aims to identify the level of knowledge among students of the Commerce Department at Politeknik Kuching Sarawak regarding the use of artificial intelligence (AI) in learning, in line with the rapid development of technology that enhances efficiency and enriches more adaptive and personalized educational experiences. Although AI cannot replace the role of teachers, it has the potential to support educators in delivering more efficient teaching materials and assist students in optimizing their learning according to their individual learning styles and levels of understanding. This study adopts a quantitative approach using a questionnaire instrument distributed online to a sample of diploma students from the Commerce Department through random sampling techniques. The data obtained were analysed descriptively to assess the students' level of knowledge regarding the use of AI. The findings indicate that the students' level of knowledge is at a moderate level, suggesting that they possess a good understanding and a positive attitude towards this technology, although there is still room for improvement. In conclusion, this study provides important implications for designing a more comprehensive curriculum and assists policymakers in planning more effective initiatives to integrate AI into teaching and learning.

Keywords: *AI; artificial intelligence; learning; level of knowledge*

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I. PENGENALAN

Dalam era pembangunan teknologi masa kini, proses pengajaran dan pembelajaran boleh dipertingkatkan dengan penggunaan kecerdasan buatan (AI). Dalam konteks pendidikan masa kini, AI menawarkan pelbagai kemudahan dalam analisis data, pengurusan kelas, serta sokongan pembelajaran yang dipersonalisasi. AI melibatkan penerapan algoritma dan pemprosesan data untuk menganalisis maklumat, memahami situasi dan bertindak berdasarkan data yang diperoleh (Srinivasi et al. 2022). Namun, tahap pengetahuan pelajar mengenai penggunaan AI dalam konteks pendidikan masih belum mendapat perhatian yang mencukupi. Kertas kerja ini bertujuan untuk mengkaji tahap pengetahuan pelajar terhadap penggunaan AI dalam pembelajaran serta mengenal pasti cabaran dan potensi yang ada dalam menerapkan teknologi ini dikalangan pelajar institusi pengajian tinggi terutamanya.

II. OBJEKTIF KAJIAN

Objektif kajian ini dijalankan adalah untuk

a) mengenal pasti platform Kecerdasan Buatan (AI) yang kerap anda gunakan oleh pelajar untuk proses pembelajaran
b) mengenal tahap pengetahuan pelajar tentang penggunaan Kecerdasan Buatan (AI) dalam membantu proses pembelajaran
c) mengenal pasti cabaran yang dihadapi oleh pelajar terhadap penggunaan Kecerdasan Buatan (AI) dalam pembelajaran

III. SOROTAN KAJIAN

Menurut Aina dan Salami (2020), tahap pengetahuan pelajar tentang AI masih pada tahap asas dan banyak yang tidak memahami sepenuhnya aplikasi dan potensi teknologi ini dalam pendidikan. Penerimaan pelajar terhadap penggunaan AI dalam pendidikan dipengaruhi oleh faktor-faktor seperti kesedaran teknologi, kebimbangan terhadap privasi, dan kepercayaan terhadap keberkesanan teknologi tersebut (Muniandy & Lee, 2021). Kesedaran pelajar tentang etika penggunaan AI adalah penting dalam memahami bagaimana AI boleh mempengaruhi proses pembelajaran dan kehidupan sosial pelajar. Ini kerana menurut Berryman et al. (2021) menyatakan bahawa pelajar yang terdedah kepada aplikasi AI dalam pembelajaran menunjukkan peningkatan dalam prestasi akademik dan penglibatan dalam kelas. Mereka juga lebih cenderung untuk menunjukkan minat terhadap penggunaan teknologi dalam pendidikan masa depan. Begitu juga kajian yang dijalankan oleh Alimisis (2016) yang menunjukkan bahawa AI dapat meningkatkan pembelajaran melalui interaksi yang lebih personal atau pembelajaran yang lebih peribadi dan sesuai dengan keperluan pelajar. Wang et al. (2020) menyatakan bahawa AI berpotensi untuk meningkatkan kecekapan pembelajaran melalui penggunaan platform e-pembelajaran yang didorong oleh AI. Kecerdasan buatan telah digunakan dalam banyak aplikasi pembelajaran seperti tutor maya, sistem pembelajaran adaptif, dan analisis data untuk memahami prestasi pelajar. Guru memainkan peranan yang besar dalam meningkatkan pengetahuan pelajar tentang AI, dan kajian menunjukkan bahawa program latihan untuk pendidik dapat membantu meningkatkan pemahaman pelajar mengenai teknologi ini (Mouza et al., 2020). Kajian juga menekankan pentingnya memasukkan pengajaran AI dalam kurikulum pendidikan di sekolah-sekolah dan institusi pengajian tinggi terutamanya untuk mempersiapkan pelajar menghadapi cabaran dan peluang yang dibawa oleh kemajuan teknologi ini (Khan et al., 2021).

IV. METODOLOGI

Kajian ini dijalankan menggunakan pendekatan kuantitatif. Instrumen kajian adalah soal selidik berstruktur digunakan untuk mengumpul. Item kajian dibina sendiri dan telah disemak oleh pakar penyelidikan yang terdiri daripada pensyarah PhD. Selain itu, ujian keboleh percayaan item (Cronbach Alpha) di mana nilai yang diperoleh bagi setiap pemboleh ubah ialah 0.940 (Pengetahuan) dan 0.929 (Cabaran). Sampel kajian dipilih secara rawak. Sampel kajian adalah pelajar diploma dari Politeknik Kuching Sarawak. Analisis yang digunakan dalam kajian ini adalah analisis deskriptif untuk mencari tahap berdasarkan nilai min. Penentuan tahap berdasarkan skor min adalah seperti yang ditunjukkan dalam Jadual 1 yang dipetik dalam kajian Ngadiman et al. (2019).

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Jadual 1: Tafsiran Skor Min

Skor min	Tafsiran
1.00– 1.99	Lemah
2.00– 2.99	Rendah
3.00– 3.99	Sederhana
4.00– 5.00	Tinggi

(Sumber: Nagadiman et al., 2019)

V. HASIL KAJIAN

Responden kajian ini adalah seramai 152 pelajar Jabatan Perdagangan Politeknik Kuching Sarawak. Latar belakang responden adalah seperti yang ditunjukkan dalam Jadual 2. Majoriti responden mencapai HPNM pada tahap sederhana (2.00 – 2.99) tidak mengambil kira pelajar semester 1 yang belum lagi mempunyai HPNM.

a) Latar Belakang Responden

Jadual 2: Latar Belakang Responden

Item		n	%
Semester	1	50	32.9
	2	18	11.8
	3	62	40.8
	4	2	1.3
	5	11	7.2
	6	9	5.9
HPNM	1.00 - 2.00	1	0.7
	2.00 - 2.99	40	26.3
	3.00 - 3.33	34	22.4
	3.43 - 3.67	17	11.2
	3.68 - 4.00	10	6.6
	Semester 1 (Tiada HPNM)	50	32.9
Min	1.00	4	2.6
	2.00	13	8.6
	3.00	69	45.4
	4.00	49	32.2
	5.00	17	11.2
Tempoh Penggunaan AI setiap kali anda membuka platform tersebut	1 hingga 2 jam	18	11.8
	30 minit hingga 1 jam	64	42.1
	Kurang dari 30 minit	59	38.8
	Lebih daripada 2 jam	11	7.2

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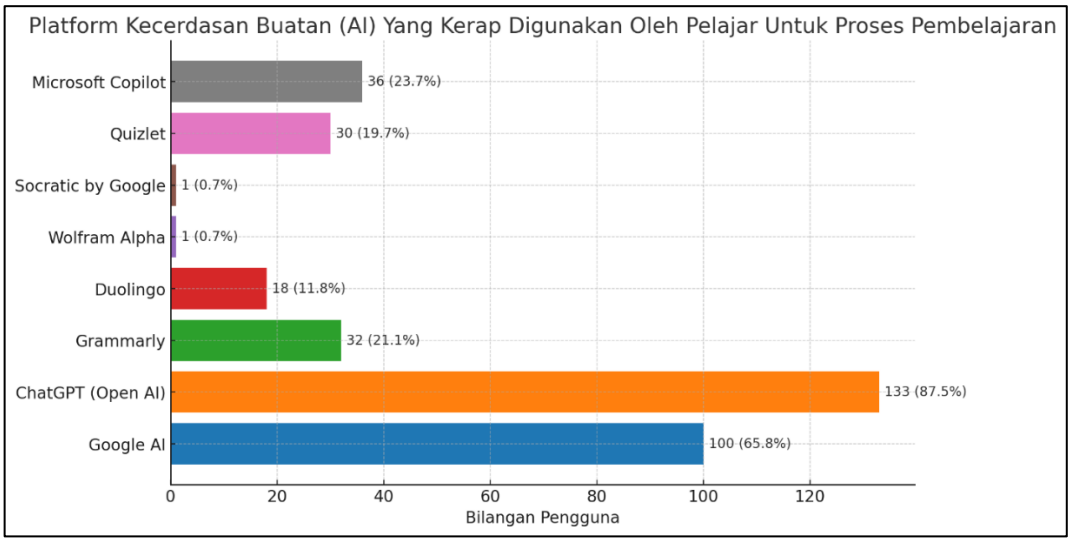
b) Platform Kecerdasan Buatan (AI) Yang Kerap Gunakan Oleh Pelajar Untuk Proses Pembelajaran



Rajah 1: Dapatan Analisis

Rajah 1 menunjukkan platform kecerdasan buatan (AI) yang kerap digunakan oleh pelajar dalam proses pembelajaran. Dapatan menunjukkan bahawa ChatGPT (OpenAI) mencatatkan penggunaan tertinggi dengan 133 orang pelajar (87.5%), diikuti oleh Google AI sebanyak 100 orang (65.8%). Selain itu, platform lain yang turut digunakan termasuk Microsoft Copilot (23.7%), Grammarly (21.1%), Quizlet (19.7%) dan Duolingo (11.8%). Sementara itu, penggunaan Wolfram Alpha dan Socratic by Google amat rendah, masing-masing hanya 0.7%. Dapatan ini membuktikan bahawa pelajar lebih cenderung menggunakan platform AI yang bersifat interaktif dan mesra pengguna seperti ChatGPT dan Google AI berbanding aplikasi khusus yang lebih niche. Penggunaan aplikasi Wolfram Alpha dan Socratic agak rendah kerana pendedahan yang kurang dikalangan pengguna di Malaysia. Socratic terhad kepada subjek sekolah dan ianya sangat popular di peringkat sekolah menengah di negara barat berbanding Malaysia. .

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c) Tahap Pengetahuan Pelajar Tentang Penggunaan Kecerdasan Buatan (AI) Dalam Membantu Proses Pembelajaran

Jadual 3: Dapatan Analisis

No	Item	Min	S.P	Tahap
P1	Saya mempunyai pengetahuan yang jelas mengenai apa itu kecerdasan buatan (AI).	3.520	0.869	Sederhana
P2	Saya tahu tentang penggunaan AI dalam pembelajaran akademik.	3.803[2]	0.854	Sederhana
P3	Saya sering mencari maklumat mengenai AI untuk memperkaya pengetahuan saya.	3.743[3]	0.931	Sederhana
P4	Saya pernah menggunakan alat berasaskan AI untuk membantu dalam pembelajaran.	3.711	0.904	Sederhana
P5	Saya percaya AI boleh membantu mempercepatkan proses pembelajaran saya.	3.717	0.931	Sederhana
P6	Penggunaan AI dalam pembelajaran membantu saya memahami konsep atau topik yang sukar dengan lebih baik.	3.816[1]	0.909	Sederhana
P7	Saya rasa penggunaan AI dalam pembelajaran sangat membantu dalam menyiapkan tugasan atau projek saya	3.671	0.919	Sederhana
P8	Saya merasa yakin untuk menggunakan AI dalam menyelesaikan masalah atau tugasan akademik.	3.401	0.998	Sederhana
P9	Saya menggunakan alat berasaskan AI untuk meningkatkan productiviti pembelajaran saya.	3.520	0.949	Sederhana
P10	Saya menggunakan alat berasaskan AI kerana memberi maklumat yang lebih tepat dan cepat.	3.388	0.942	Sederhana

Nota: [1,2,3] Min Tertinggi

Jadual 3 menunjukkan dapatan untuk menilai tahap pengetahuan pelajar tentang penggunaan AI dalam membantu proses pembelajaran. Secara keseluruhan, tahap pengetahuan adalah sederhana. Ini menunjukkan bahawa pelajar mempunyai pengetahuan yang agak baik dan kearah positif terhadap AI, namun begitu tahap pengetahuan mereka masih belum mencapai tahap yang tinggi dalam semua aspek. Item yang memperoleh min tertinggi ialah item P6 di mana penggunaan AI membantu pelajar memahami konsep atau topik yang sukar dengan lebih baik (min = 3.8161, S.P = 0.909), diikuti oleh P2 iaitu pelajar juga mempunyai kesedaran tentang penggunaan AI dalam pembelajaran akademik (min = 3.8032, S.P = 0.854) dan P3 menjelaskan bahawa terdapat pelajar yang kerap mencari maklumat tambahan mengenai AI untuk memperkayakan pengetahuan mereka (min = 3.7433, S.P = 0.931).

d) Cabaran Yang Dihadapi Oleh Pelajar Terhadap Penggunaan Kecerdasan Buatan (AI) Dalam Pembelajaran

Jadual 4: Dapatan Kajian

No	Item	Min	S.P	Tahap
C1	Saya menghadapi kesukaran untuk memahami cara menggunakan alat berasaskan AI untuk pembelajaran.	2.467	0.934	Rendah

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C2	Ketiadaan kemahiran teknikal saya menjadi halangan untuk menggunakan AI dalam pembelajaran.	2.362	0.946	Rendah
C3	Saya tidak mempunyai akses yang mencukupi kepada teknologi yang diperlukan untuk menggunakan AI, seperti internet atau peranti yang sesuai.	2.204	1.038	Rendah
C4	Saya merasa AI tidak selalu memberikan maklumat yang tepat atau relevan untuk keperluan pembelajaran saya.	2.809	1.072	Rendah
C5	Saya tidak tahu platform AI mana yang sesuai untuk membantu saya dalam pembelajaran.	2.678	1.160	Rendah
C6	Saya sering merasa kurang yakin dengan cadangan atau jawapan yang diberikan oleh alat AI.	2.855[3]	1.057	Rendah
C7	Terlalu banyak pilihan platform AI membuatkan saya bingung untuk memilih yang paling sesuai.	2.868[2]	1.102	Rendah
C8	Saya merasa AI tidak cukup menyokong gaya pembelajaran saya yang lebih berfokus kepada interaksi manusia (seperti dengan guru atau rakan pelajar).	2.921[1]	1.013	Rendah
C9	Saya menghadapi masalah dalam memahami arahan atau antaramuka pengguna (UI) dalam aplikasi berasaskan AI.	2.618	0.949	Rendah
C10	Saya merasakan penggunaan AI dalam pembelajaran memerlukan masa yang terlalu banyak untuk mempelajari dan menguasainya.	2.658	0.977	Rendah

Nota: [1,2,3] Min Tertinggi

Sementara itu Jadual 4 menjawab objektif ketiga iaitu untuk mengenal pasti cabaran yang dihadapi oleh pelajar terhadap penggunaan Kecerdasan Buatan (AI) dalam pembelajaran. Secara keseluruhannya, semua cabaran yang letakkan dalam soal selidik adalah berada pada tahap rendah. Ini menunjukkan mungkin pelajar sudah biasa menggunakan AI ini secara kerap sehingga mereka dapat mengatasi sebarang masalah yang timbul akibat penggunaannya. Walaupun begitu, dapatan ini menunjukkan cabaran utama pelajar adalah (C8) di mana pelajar merasa AI tidak cukup menyokong gaya pembelajaran saya yang lebih berfokus kepada interaksi manusia (min = 2.9211, S.P = 1.013). Ini menjelaskan bahawa sebahagian pelajar masih lebih selesa dengan kaedah pembelajaran berasaskan interaksi manusia. Selain itu, (C7) di mana pelajar juga berdepan kekeliruan kerana terlalu banyak pilihan platform AI (min = 2.8682, S.P = 1.102), dan diikuti oleh item C6, di mana pelajar rasa kurang yakin terhadap cadangan atau jawapan yang diberikan oleh AI (min = 2.8553, S.P = 1.057).

VI. KESIMPULAN

Penggunaan AI dalam pembelajaran memberikan banyak potensi untuk meningkatkan pengalaman pendidikan bagi pelajar institusi pengajian tinggi terutamanya. Penggunaannya semakin meluas, memberikan peluang untuk memperibadikan pembelajaran, meningkatkan kualiti pengajaran dan mempermudah proses penilaian. Tahap pengetahuan pelajar terhadap penggunaan AI dalam pembelajaran adalah penting untuk memastikan mereka dapat memanfaatkan potensi teknologi ini secara lebih efektif. Oleh itu, kajian ini penting untuk memberi gambaran mengenai bagaimana AI boleh dimanfaatkan untuk memperbaiki kualiti pembelajaran serta untuk menyediakan pelajar dengan pengetahuan dan kemahiran yang diperlukan untuk menghadapi dunia yang semakin bergantung kepada teknologi. Secara keseluruhan, tahap pengetahuan adalah sederhana. Ini menunjukkan bahawa pelajar mempunyai pengetahuan yang agak baik dan kearah positif terhadap penggunaan AI, namun begitu tahap pengetahuan mereka masih belum mencapai tahap yang tinggi dalam semua

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aspek. Semua cabaran yang letakkan dalam soal selidik adalah berada pada tahap rendah. Ini menunjukkan mungkin pelajar sudah biasa menggunakan AI ini secara kerap sehingga mereka dapat mengatasi sebarang masalah yang timbul akibat penggunaannya. Namun demikian, sebahagian pelajar masih lebih selesa dengan kaedah pembelajaran berasaskan interaksi manusia. Kajian ini boleh digunakan untuk merangka kurikulum yang lebih baik dalam mendidik pelajar mengenai penggunaan AI dalam pembelajaran. Disamping itu juga, secara tidak langsung dapat membantu dasar pendidikan dalam merancang inisiatif yang lebih baik untuk mengintegrasikan teknologi AI dalam pembelajaran.

PENGHARGAAN

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Keberkesanan Laman Sesawang *MyHydrology* dalam Pengajaran dan Pembelajaran Kursus DCC50212 *Hydrology*

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Abstract

This study evaluates the effectiveness of the MyHydrology website as a digital learning platform for the DCC50212 Hydrology course. MyHydrology was developed as a one-stop center providing comprehensive sets of practice questions with answers, aiming to support Teaching and Learning (T&L) in an interactive and flexible manner across the five main topics of the course. A descriptive quantitative approach was employed, involving 56 fifth-semester students selected based on the Krejcie and Morgan table. Data were collected through a four-point Likert scale questionnaire and the achievement of Course Learning Outcome (CLO) 1. The findings indicate that the website design was very well received by students, with mean scores ranging from 3.93 to 4.00, while the usability aspect recorded an average score of 3.98, reflecting high levels of accessibility, usability, and content effectiveness. Analysis of CLO 1 achievement showed a significant improvement after using MyHydrology, with Group Attainment (%) data recorded at 69.8% in Session 1: 2024/2025 and declining to 63.7% in Session 2: 2024/2025 before the implementation of this innovation. After its use in Session 1: 2025/2026, achievement increased to 73.7%, indicating a positive impact on students' understanding and performance. In conclusion, MyHydrology has proven to be an effective, interactive, and innovative digital learning platform that enhances motivation, comprehension, and academic achievement, with potential for broader application in other technical courses to support more effective and modern T&L.

Keywords: *MyHydrology, Hydrology, Teaching and Learning, Digital Learning, Course Learning Outcome*

Abstrak

Kajian ini menilai keberkesanan laman sesawang MyHydrology sebagai platform pembelajaran digital bagi kursus DCC50212 Hydrology. MyHydrology dibangunkan sebagai pusat sehenti yang menyediakan set soalan latihan lengkap berserta jawapan, bertujuan menyokong Pengajaran dan Pembelajaran (PdP) secara interaktif dan fleksibel bagi lima topik utama kursus ini. Pendekatan kuantitatif deskriptif digunakan, melibatkan 56 pelajar Semester 5 yang dipilih berdasarkan jadual Krejcie dan Morgan. Data dikumpul melalui soal selidik skala Likert empat mata serta pencapaian Course Learning Outcome (CLO) 1. Hasil kajian menunjukkan reka bentuk laman sesawang diterima dengan sangat baik oleh pelajar, dengan skor min 3.93 hingga 4.00, manakala aspek penggunaan mencatat purata skor 3.98, menunjukkan tahap kebolehgunaan, aksesibiliti, dan keberkesanan kandungan yang tinggi. Analisis pencapaian CLO 1 memperlihatkan peningkatan ketara selepas penggunaan MyHydrology, dengan data Group Attainment (%) merekodkan 69.8% pada Sesi 1: 2024/2025 dan menurun kepada 63.7% pada Sesi 2: 2024/2025 sebelum inovasi ini diperkenalkan. Selepas penggunaan pada Sesi 1: 2025/2026, pencapaian meningkat kepada 73.7%, menandakan impak positif terhadap kefahaman dan prestasi pelajar. Kesimpulannya, MyHydrology terbukti sebagai platform pembelajaran digital yang efektif, interaktif, dan inovatif, meningkatkan motivasi, kefahaman, serta pencapaian akademik, dengan potensi diperluaskan kepada kursus teknikal lain untuk menyokong PdP yang lebih berkesan dan moden.

Kata Kunci: MyHydrology, Hidrologi, Pengajaran dan Pembelajaran (PdP), Pembelajaran Digital, Course Learning Outcome

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I. PENGENALAN

Pengajaran dan pembelajaran (PdP) yang berkesan memerlukan sokongan bahan bantu mengajar yang sistematik, mudah dicapai, dan selari dengan keperluan pembelajaran pelajar. Dalam konteks pendidikan kejuruteraan awam, kursus *Hydrology* merupakan kursus teras yang menekankan penguasaan konsep, analisis data serta aplikasi pengiraan berkaitan kitaran hidrologi. Namun demikian, pelaksanaan PdP secara tradisional sering berhadapan dengan kekangan masa dan cabaran dalam memastikan kefahaman pelajar secara menyeluruh, khususnya bagi topik yang bersifat abstrak dan teknikal [1].

Seiring dengan perkembangan teknologi digital, penggunaan platform pembelajaran berasaskan web dalam pendidikan semakin meluas kerana keupayaannya menyediakan persekitaran pembelajaran yang fleksibel, interaktif dan bersifat kendiri, di samping meningkatkan kebolehcapaian (accessibility) kepada sumber pembelajaran [2].

Penyelidikan terdahulu juga menunjukkan bahawa platform e-pembelajaran dan pembelajaran digital mampu menyokong peningkatan prestasi akademik pelajar apabila kandungan direka bentuk secara terancang dan dilaksanakan secara strategik [3],[4].

Google Sites merupakan salah satu platform berasaskan web yang mesra pengguna dan membolehkan pensyarah membangunkan laman pembelajaran tanpa memerlukan kemahiran pengaturcaraan yang kompleks. Melalui platform ini, bahan pembelajaran seperti nota, video dan latihan dapat disusun secara sistematik serta diakses oleh pelajar pada bila-bila masa dan di mana sahaja, selari dengan konsep pembelajaran fleksibel dan pembelajaran kendiri [5].

Berdasarkan laporan pencapaian kursus DCC50212 *Hydrology*, pencapaian *Course Learning Outcome* (CLO) 1 iaitu apply basic concept of applied *Hydrology* in civil engineering bagi dua semester sebelum penggunaan inovasi digital menunjukkan peratusan yang sederhana.

Sehubungan itu, laman sesawang *MyHydrology* dibangunkan pada Sesi 2: 2024/2025 dan mula digunakan secara rasmi pada Sesi 1: 2025/2026 sebagai satu inisiatif inovasi PdP bagi membantu meningkatkan kefahaman pelajar dan seterusnya pencapaian CLO 1. Justeru, kajian ini dijalankan untuk menilai keberkesanan penggunaan *MyHydrology* dalam PdP kursus DCC50212 *Hydrology*.

A. Pernyataan Masalah

Pengajaran dan pembelajaran (PdP) kursus DCC50212 *Hydrology* di Politeknik Malaysia masih banyak bergantung kepada kaedah tradisional seperti kuliah bersemuka dan penggunaan nota bercetak. Kaedah ini menghadapi beberapa kekangan, antaranya keterbatasan masa untuk menamatkan silibus, kesukaran pelajar memahami konsep yang abstrak secara menyeluruh, serta akses yang terhad kepada bahan pembelajaran tambahan di luar waktu kuliah [1].

Selain itu, kebanyakan pelajar didapati menghadapi kesukaran dalam menyelesaikan soalan latihan yang melibatkan pengiraan dan analisis kerana kekurangan panduan langkah demi langkah serta bahan rujukan yang tersusun. Keadaan ini berpotensi menjejaskan pencapaian *Course Learning Outcome* (CLO), khususnya CLO 1 yang menekankan penguasaan konsep asas hidrologi dan aplikasi prinsip dalam penyelesaian masalah kejuruteraan [6].

Seiring dengan perkembangan teknologi digital dalam pendidikan, terdapat keperluan untuk memperkenalkan platform pembelajaran yang interaktif, mudah diakses dan menyediakan bahan pembelajaran yang lengkap. Kajian terdahulu menunjukkan bahawa penggunaan platform pembelajaran dalam talian dapat meningkatkan keterlibatan pelajar, motivasi serta prestasi akademik apabila kandungan digital disusun secara sistematik dan berfokuskan keperluan pelajar [7], [3].

Laman sesawang *MyHydrology* dibangunkan bagi memenuhi keperluan tersebut, namun tahap keberkesanannya dalam meningkatkan kefahaman pelajar dan pencapaian akademik masih perlu dinilai secara empirikal. Oleh itu, kajian ini dijalankan untuk mengenal pasti tahap keberkesanan *MyHydrology* dalam menyokong PdP dan impaknya terhadap pencapaian CLO 1 bagi kursus DCC50212 *Hydrology*.

B. Objektif

i. Menilai keberkesanan reka bentuk laman sesawang *MyHydrology* dalam menyokong PdP kursus DCC50212 *Hydrology*.

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ii. Menilai keberkesanan penggunaan *MyHydrology* sebagai bahan pembelajaran dalam kalangan pelajar.

iii. Menganalisis pencapaian CLO 1 kursus DCC50212 *Hydrology* sebelum dan selepas penggunaan *MyHydrology*.

C. Skop Kajian

Kajian ini memfokuskan kepada penilaian keberkesanan laman sesawang *MyHydrology* yang dibangunkan menggunakan platform *Google Sites* sebagai bahan sokongan Pengajaran dan Pembelajaran (PdP) bagi kursus DCC50212 *Hydrology*. Kajian ini melibatkan populasi seramai 64 orang pelajar bagi Sesi 1: 2025/2026. Berdasarkan Jadual Penentuan Saiz Sampel oleh Krejcie dan Morgan (1970) [9], bagi populasi tersebut, saiz sampel minimum yang dicadangkan ialah 56 orang pada tahap keyakinan 95% dan margin ralat ±5%. Oleh itu, kajian ini melibatkan seramai 56 orang pelajar yang dipilih sebagai responden kajian.

Kajian ini menilai aspek reka bentuk laman sesawang, kemudahan penggunaan, serta kesan penggunaannya terhadap pencapaian *Course Learning Outcome* (CLO) 1. Laman sesawang ini menyediakan set soalan tutorial bagi lima topik utama kursus ini yang disertakan dengan penyelesaian lengkap secara langkah demi langkah untuk membantu pelajar memahami kaedah pengiraan secara lebih sistematik, di samping menyokong pengukuhan kefahaman terhadap kandungan kursus.

Data dikumpul melalui soal selidik dan laporan pencapaian CLO daripada *Course Outcome Review Report* (CORR), dan dianalisis menggunakan skor min dan perbandingan pencapaian CLO1 antara sesi. Kajian terdahulu menunjukkan bahawa platform pembelajaran digital yang menekankan aspek kebolehcapaian (accessibility) dan kandungan interaktif berupaya memberi kesan positif terhadap prestasi pelajar apabila diintegrasikan secara sistematik dalam PdP formal [9], [10].

D. Kepentingan Kajian

Kajian ini penting kerana ia memberikan penilaian sistematik terhadap keberkesanan penggunaan laman sesawang *MyHydrology* dalam menyokong Pengajaran dan Pembelajaran (PdP) kursus DCC50212 *Hydrology*. Dapatan kajian dapat membantu pensyarah mengenal pasti kekuatan dan kelemahan bahan digital yang digunakan, seterusnya menambah baik strategi PdP agar lebih berkesan dan interaktif. Penyelidikan terdahulu turut membuktikan bahawa penggunaan teknologi pembelajaran digital mampu meningkatkan keterlibatan, motivasi dan prestasi pelajar apabila kandungan direka bentuk secara strategik dan disokong oleh pendekatan pedagogi yang sesuai [7], [3].

Selain itu, kajian ini memberi gambaran empirikal tentang impak penggunaan platform digital terhadap pencapaian *Course Learning Outcome* (CLO), khususnya CLO 1 yang menekankan pemahaman konsep asas hidrologi dan aplikasi praktikal. Dari perspektif pelajar, kajian ini menunjukkan sejauh mana bahan digital seperti *MyHydrology* dapat memudahkan akses kepada soalan latihan yang tersusun, seterusnya meningkatkan kefahaman, motivasi dan keyakinan dalam penguasaan topik kursus. Dapatan kajian ini juga boleh dijadikan rujukan dalam pembangunan platform digital bagi kursus kejuruteraan atau subjek teknikal lain, selaras dengan keperluan transformasi digital dalam pendidikan tinggi.

II. TINJAUAN LITERATUR

Pelbagai kajian terdahulu telah dijalankan bagi menilai keberkesanan penggunaan platform pembelajaran digital dan berasaskan web dalam menyokong pengajaran dan pembelajaran di peringkat pendidikan tinggi. Secara umum, dapatan kajian menunjukkan bahawa penggunaan e-pembelajaran dan platform digital memberi kesan positif terhadap kefahaman, penglibatan serta pencapaian akademik pelajar. Kajian oleh [11] mendapati bahawa pelaksanaan e-pembelajaran di Kolej Komuniti Hulu Langat berada pada tahap keberkesanan yang tinggi walaupun berhadapan dengan beberapa kekangan teknikal, sekali gus membuktikan potensi pembelajaran digital dalam konteks pendidikan teknikal dan vokasional.

Selain itu, faktor sokongan infrastruktur dan sikap pelajar turut memainkan peranan penting dalam menentukan kejayaan pelaksanaan e-pembelajaran. Menurut [12] melaporkan bahawa terdapat hubungan positif antara kemudahan infrastruktur, sikap pelajar dan keberkesanan e-pembelajaran dalam kalangan pelajar institusi pengajian tinggi swasta. Dapatan ini selari dengan

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kajian [3] yang menegaskan bahawa tahap penglibatan (engagement) dan pengalaman pembelajaran pelajar dalam penggunaan Sistem Pengurusan Pembelajaran (LMS) mempengaruhi keberkesanan pembelajaran teradun dan penerimaan berterusan terhadap platform digital.

Dari aspek reka bentuk dan kemudahan penggunaan, [13] mendapati bahawa persepsi pelajar terhadap kemudahan penggunaan dan kegunaan platform pembelajaran berasaskan web seperti LMS *Canvas* memberi kesan signifikan terhadap niat penggunaan dan kepuasan pembelajaran. Ulasan sistematik oleh [14] pula menyimpulkan bahawa keberkesanan pembelajaran dalam talian banyak dipengaruhi oleh kualiti kandungan digital, tahap interaktiviti, serta motivasi pelajar. Hal ini menunjukkan bahawa platform pembelajaran yang tersusun dan mesra pengguna mampu menyokong pencapaian hasil pembelajaran secara lebih berkesan.

Kajian lain turut menekankan kesan positif penggunaan platform e-pembelajaran terhadap prestasi dan kepuasan pelajar. Menurut [15] mendapati bahawa platform pembelajaran digital yang direka bentuk dengan baik dapat meningkatkan kebolehcapaian, kefahaman konsep dan kepuasan pelajar dalam pendidikan tinggi. Manakala menurut [16] pula menegaskan bahawa kehadiran dalam kelas dalam talian, kepuasan pembelajaran dan prestasi akademik merupakan indikator penting dalam menilai kejayaan pelaksanaan PdP digital.

Dalam konteks pembelajaran teradun (blended learning), [17] melaporkan bahawa pendekatan ini memberi kesan positif terhadap pengurusan masa dan pencapaian akademik pelajar. Dapatan ini disokong oleh [18] yang mendapati bahawa pembelajaran teradun meningkatkan interaksi pelajar dan keberkesanan pembelajaran di pendidikan tinggi. Sementara itu, kajian oleh [19] menekankan bahawa motivasi pelajar merupakan faktor kritikal yang mempengaruhi keberkesanan penggunaan teknologi dalam e-pembelajaran.

Secara keseluruhannya, kajian-kajian terdahulu menunjukkan bahawa penggunaan platform pembelajaran digital dan berasaskan web berpotensi meningkatkan keberkesanan pengajaran dan pembelajaran, terutamanya apabila kandungan disusun secara sistematik dan mudah diakses. Namun begitu, kebanyakan kajian memfokuskan kepada konteks umum e-pembelajaran dan LMS, manakala kajian khusus yang menilai impak laman sesawang pembelajaran terhadap pencapaian *Course Learning Outcome* (CLO) bagi kursus teknikal seperti *Hydrology* masih terhad. Oleh itu, kajian ini dijalankan untuk mengisi jurang tersebut dengan menilai keberkesanan laman sesawang *MyHydrology* dalam menyokong PdP dan meningkatkan pencapaian CLO 1 kursus DCC50212 *Hydrology*.

III. METODOLOGI KAJIAN

A. Reka Bentuk Kajian

Kajian ini menggunakan pendekatan kuantitatif berbentuk deskriptif bagi menilai persepsi pelajar terhadap keberkesanan reka bentuk dan penggunaan laman sesawang *MyHydrology* sebagai bahan sokongan pengajaran dan pembelajaran. Pendekatan deskriptif digunakan untuk menerangkan fenomena kajian secara sistematik dan objektif tanpa melibatkan manipulasi pembolehubah [20], [21]. Instrumen utama kajian ialah borang soal selidik yang diedarkan kepada responden melalui *Google Form*. Soal selidik tersebut terdiri daripada dua bahagian utama, iaitu maklumat demografi responden dan item-item yang menilai keberkesanan penggunaan laman sesawang, selaras dengan amalan penyelidikan pendidikan yang mengaplikasikan instrumen soal selidik bagi pengumpulan data kuantitatif secara efisien dan tersusun [22].

B. Sampel Kajian

Sampel bagi kajian ini terdiri daripada pelajar Semester 5 yang mengikuti kursus DCC50212 *Hydrology*. Populasi kajian seramai 64 orang pelajar, dan saiz sampel dipilih sebanyak 56 orang berdasarkan Jadual Penentuan Saiz Sampel oleh Krejcie dan Morgan (1970) bagi Sesi 1: 2025/2026 yang telah menggunakan laman sesawang *MyHydrology* sebagai bahan sokongan pengajaran dan pembelajaran. Pemilihan responden adalah berdasarkan keseluruhan pelajar yang menggunakan laman sesawang ini, bagi memastikan konsistensi pengalaman pembelajaran dalam penilaian keberkesanan platform tersebut.

C. Analisis Data

Instrumen kajian menggunakan skala Likert empat mata bagi mengukur tahap persetujuan responden terhadap item yang berkaitan dengan reka bentuk dan penggunaan laman sesawang *MyHydrology*. Pemilihan skala *Likert* empat mata adalah bertujuan

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untuk mengelakkan pilihan neutral serta menggalakkan responden membuat keputusan yang lebih jelas sama ada bersetuju atau tidak bersetuju terhadap setiap pernyataan yang dikemukakan [22]. Skala yang digunakan merangkumi 1 – Sangat Tidak Setuju, 2 – Tidak Setuju, 3 – Setuju dan 4 – Sangat Setuju.

Data soal selidik dianalisis menggunakan skor min untuk menentukan tahap persepsi responden terhadap setiap item dan konstruk kajian, manakala interpretasi skor min dibuat berdasarkan julat yang ditetapkan seperti yang ditunjukkan dalam Jadual 1. Pendekatan ini adalah selaras dengan kaedah analisis statistik deskriptif yang digariskan oleh [23] yang sesuai untuk menilai kecenderungan dan taburan respons responden secara kuantitatif.

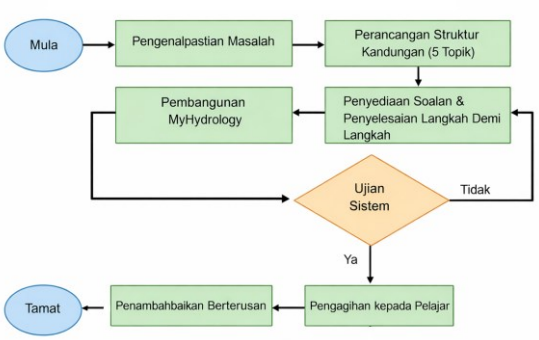
Jadual 1: Interpretasi Julat Skor Min Skala *Likert* Empat Mata

Skor Min	Interpretasi
1.00 – 1.75	Rendah
1.76 – 2.50	Sederhana Rendah
2.51 – 3.25	Sederhana Tinggi
3.26 – 4.00	Tinggi

Selain itu, data pencapaian *Course Learning Outcome* (CLO) 1 diperoleh daripada laporan *Course Outcome Review Report* (CORR) bagi tiga semester berturut-turut dan dianalisis secara perbandingan bagi menilai perubahan pencapaian pelajar sebelum dan selepas penggunaan *MyHydrology*. Kaedah ini membolehkan penilaian secara empirikal terhadap impak penggunaan platform digital dalam menyokong penguasaan konsep asas hidrologi.

D. Pembangunan *MyHydrology*

Laman sesawang *MyHydrology* dibangunkan sebagai alat bantu pembelajaran bagi kursus DCC50212 *Hydrology* di Politeknik Malaysia. Laman sesawang ini bertujuan memudahkan capaian pelajar dengan menyediakan pusat sehenti (one-stop centre) bagi rujukan interaktif yang merangkumi penyelesaian masalah pengiraan bagi setiap topik secara terperinci. Rajah 1 menunjukkan carta alir pembangunan laman sesawang *MyHydrology*.



Rajah 1: Carta Alir Pembangunan *MyHydrology*

Kandungan utama laman sesawang ini merangkumi soalan tutorial bagi setiap bab yang dilengkapi dengan penyelesaian lengkap secara langkah demi langkah, bertujuan membantu pelajar menguasai kaedah pengiraan dengan lebih sistematik dan menyokong pengukuhan kefahaman terhadap kandungan kursus. Rajah 2 menunjukkan antaramuka utama laman sesawang *MyHydrology*.

Rajah 2: Paparan antaramuka utama laman sesawang *MyHydrology*

Laman sesawang *MyHydrology* menyediakan set soalan pengiraan yang disusun mengikut silibus kursus DCC50212 *Hydrology*, lengkap dengan penyelesaian langkah demi langkah, bagi membolehkan pelajar mengulangkaji dan menguasai kaedah pengiraan secara kendiri dan sistematik. Laman sesawang ini direka untuk mesra pengguna dan boleh diakses melalui peranti mudah alih, membolehkan pelajar dan pensyarah menggunakannya secara fleksibel pada bila-bila masa dan di mana sahaja, menjadikannya alat sokongan pembelajaran yang relevan dan berkesan. Rajah 3 menunjukkan contoh paparan laman sesawang bagi Topik 1, *Introduction to Hydrology* dan Topik 4, *Hydrograph*. Manakala paparan bagi topik yang lain juga mengekalkan struktur dan format yang sama.

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Rajah 3: Kandungan *MyHydrology* Topik 1 dan Topik 4

IV. DAPATAN KAJIAN

A. Demografi Responden

Sampel kajian ini terdiri daripada 56 orang pelajar Semester 5 yang mengikuti kursus DCC50212 *Hydrology* bagi Sesi 1: 2025/2026, daripada populasi seramai 64 orang pelajar yang menggunakan laman sesawang *MyHydrology*. Majoriti responden adalah pelajar lelaki, manakala baki terdiri daripada pelajar perempuan seperti diperincikan dalam Jadual 2.

Jadual 2: Demografi Responden

Jantina	Bilangan Responden	Peratus (%)
Lelaki	31	55.4
Perempuan	23	41.1
Jumlah	56	100

B. Keberkesanan Reka Bentuk dan Penggunaan *MyHydrology*

Analisis terhadap keberkesanan laman sesawang *MyHydrology* menunjukkan dapatan yang sangat positif daripada responden. Dari segi rekabentuk laman sesawang, semua item mencatatkan min yang tinggi (3.93–4.00), menandakan pelajar menilai laman sesawang sebagai teratur, kemas, menarik, mesra pengguna, dan mudah dinavigasi. Item 4, 7, 8, 10, dan 13 memperoleh skor min maksimum 4.00, menunjukkan konsistensi tinggi dan penerimaan yang sangat baik terhadap kandungan yang bersesuaian dengan silibus kursus.

Jadual 3: Analisis Reka Bentuk *MyHydrology*

Bil.	Item	Min
1	Paparan antara muka laman sesawang *MyHydrology* teratur, kemas dan menarik.	3.95
2	Laman sesawang ini mudah digunakan dan difahami (user-friendly).	3.93
3	Fungsi butang dan navigasi laman sesawang dapat dikenal pasti dengan mudah	3.96
4	Kandungan di laman sesawang bersesuaian dengan topik yang dipelajari dalam kursus *Hydrology*.	4.00
5	Laman sesawang *MyHydrology* adalah menarik dan memberi motivasi untuk belajar.	3.98
	Purata	3.96

Berdasarkan analisis data penggunaan laman sesawang *MyHydrology*, semua item menunjukkan tahap penilaian yang tinggi daripada responden. Item yang mencatat skor min tertinggi ialah Item 7, 8, 10, dan 13 dengan min 4.00, menunjukkan bahawa pelajar berpendapat laman sesawang ini sangat membantu dalam meningkatkan kefahaman terhadap subjek, menyediakan bahan latihan yang berguna, serta membolehkan akses mudah pada bila-bila masa. Jadual 4 pula memaparkan analisis penggunaan *MyHydrology* di kalangan pelajar.

Jadual 4: Analisis Penggunaan *MyHydrology*

Bil.	Item	Min
6	Laman sesawang ini meningkatkan minat saya dalam sesi pembelajaran dan mengulangkaji topik selepas kelas.	3.98
7	Laman sesawang ini membantu meningkatkan kefahaman saya terhadap subjek *Hydrology*.	4.00
8	Laman sesawang ini menyediakan contoh soalan berserta langkah penyelesaian yang mudah difahami bagi setiap soalan.	4.00
9	Laman sesawang ini boleh dijadikan bahan rujukan tambahan semasa mengulangkaji atau membuat Latihan.	3.96
10	Saya dapat mengakses laman sesawang ini pada bila-bila masa dan di mana sahaja.	4.00

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11	Ketersediaan set soalan latihan di laman sesawang membantu saya membuat persediaan untuk peperiksaan.	3.98
12	Saya tidak perlu mencari atau meminta kebenaran pihak tertentu untuk mendapatkan soalan latihan.	3.98
13	Laman sesawang ini berfungsi dengan baik pada pelbagai peranti, termasuk telefon pintar, *tablet* dan computer.	4.00
14	Kandungan bahan digital di laman sesawang ini memberi gambaran yang jelas tentang topik.	3.96
15	Laman sesawang *MyHydrology* dapat mengurangkan kos pelajar kerana ia boleh diakses secara percuma.	3.98
	Purata	3.98

Item 12, yang menumpukan kepada kemudahan pelajar mendapatkan soalan latihan tanpa perlu meminta kebenaran pihak tertentu, mencatatkan skor min 3.98, menunjukkan penilaian yang tinggi. Keputusan ini menekankan bahawa *MyHydrology* berfungsi dengan baik dan inovatif dalam menyediakan akses latihan yang mudah dan pantas.

Berbeza dengan laman sesawang seperti CIDOS, yang memerlukan nama pengguna dan kata laluan untuk log masuk, pelajar sering menghadapi masalah terlupa maklumat ini, sekali gus menjejaskan minat dan kelancaran pembelajaran. Analisis ini jelas menunjukkan bahawa *MyHydrology* menyokong pembelajaran pelajar dengan kaedah yang interaktif, fleksibel dan mudah diakses.

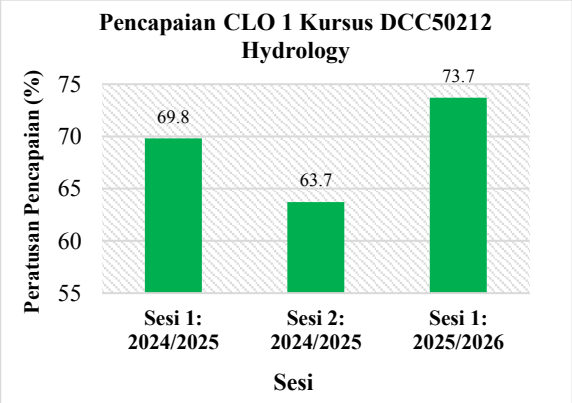
Secara keseluruhan, purata min bagi semua item adalah 3.98, menandakan bahawa penggunaan laman sesawang *MyHydrology* berada pada tahap tinggi. Hal ini menunjukkan bahawa laman sesawang ini dianggap sebagai sumber yang berguna dan relevan dalam menyokong pembelajaran pelajar, khususnya dalam memberikan contoh soalan, langkah penyelesaian, dan kemudahan pengulangan semula pembelajaran di luar kelas.

Dapatan ini juga mencerminkan keberkesanan laman sesawang *MyHydrology* sebagai platform sokongan pembelajaran interaktif yang bukan sahaja memudahkan akses kepada bahan pembelajaran, tetapi juga meningkatkan minat dan kefahaman pelajar terhadap subjek DCC50212 *Hydrology*.

C. Pencapaian CLO 1 Kursus DCC50212 *Hydrology*

Analisis pencapaian CLO 1 menunjukkan peningkatan ketara selepas penggunaan *MyHydrology*. Data *Group Attainment* (%) bagi CLO 1 merekodkan pencapaian sebanyak 69.8% pada Sesi 1: 2024/2025 dan menurun kepada 63.7% pada Sesi 2: 2024/2025 sebelum inovasi ini digunakan.

Walau bagaimanapun, selepas penggunaan *MyHydrology* pada Sesi 1: 2025/2026, pencapaian CLO 1 meningkat kepada 73.7%. Peningkatan ini menunjukkan bahawa penggunaan *MyHydrology* telah memberi impak positif terhadap kefahaman pelajar dan seterusnya pencapaian CLO 1 bagi kursus ini. Rajah 4 menunjukkan carta bar pencapaian CLO1 bagi kursus DCC50212 *Hydrology* untuk tiga sesi Pengajaran dan Pembelajaran.



Rajah 4: Pencapaian CLO 1 Kursus DCC50212 *Hydrology*

V. KESIMPULAN

Secara keseluruhan, dapatan kajian ini mengesahkan bahawa laman sesawang *MyHydrology* merupakan platform pembelajaran digital yang berkesan, relevan, dan berimpak tinggi dalam menyokong pelaksanaan Pengajaran dan Pembelajaran (PdP) kursus DCC50212 *Hydrology* di Politeknik Malaysia. Analisis menunjukkan bahawa dari aspek reka bentuk dan antaramuka, skor min yang tinggi, iaitu antara 3.93 hingga 4.00, membuktikan pelajar menilai platform ini sebagai tersusun, kemas, mesra pengguna, dan mudah dinavigasi, selaras dengan

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prinsip reka bentuk sistem interaktif yang efektif. Dari aspek penggunaan pula, purata skor 3.98 menunjukkan tahap kebolehgunaan, aksesibiliti, dan keberkesanan kandungan yang tinggi. *MyHydrology* memudahkan pelajar melaksanakan latihan secara sistematik melalui penyelesaian langkah demi langkah, sekaligus menyokong pembelajaran kendiri yang interaktif dan fleksibel. Keberkesanan ini diterjemahkan melalui peningkatan kefahaman terhadap konsep asas hidrologi serta pengaplikasian pengetahuan dalam penyelesaian masalah, yang memberi impak positif terhadap pencapaian CLO 1, meningkat daripada 63.7% kepada 73.7% selepas penggunaannya. Justeru, *MyHydrology* bukan sahaja memperkukuh keberkesanan PdP dan penguasaan konsep pelajar, malah menyumbang kepada pencapaian akademik yang lebih mantap dan berdaya saing. Platform ini berpotensi diperluaskan ke kursus lain dalam bidang Kejuruteraan Awam, manakala kajian lanjutan dicadangkan bagi menilai kesannya terhadap CLO lain serta melibatkan sampel yang lebih besar untuk meningkatkan kebolehpercayaan dan generalisasi dapatan kajian.

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Efikasi Kendiri Guru Sebagai Peramal Kepuasan Kerja di Sekolah Rendah Luar Bandar: Keningau, Sabah

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Abstrak

Kepuasan kerja guru merupakan elemen kritikal dalam menentukan keberkesanan pengajaran dan kelestarian profesion perguruan, khususnya di sekolah rendah luar bandar yang berhadapan dengan kekangan sumber dan sokongan profesional. Berasaskan Teori Kognitif Sosial Bandura, kajian ini bertujuan meneliti efikasi kendiri guru sebagai peramal kepada kepuasan kerja dalam konteks sekolah rendah luar bandar di daerah Keningau, Sabah. Kajian ini menggunakan pendekatan kuantitatif dengan reka bentuk tinjauan melibatkan sampel guru sekolah rendah luar bandar, di mana data dianalisis menggunakan analisis deskriptif dan inferensi seperti korelasi dan regresi bagi menentukan hubungan dan sumbangan efikasi kendiri terhadap kepuasan kerja. Efikasi kendiri guru diukur melalui tiga dimensi utama iaitu efikasi pengajaran, pengurusan bilik darjah dan penglibatan murid. Dapatan kajian menunjukkan bahawa efikasi kendiri guru mempunyai hubungan yang signifikan dan berperanan sebagai peramal utama kepada kepuasan kerja guru. Kesimpulannya, efikasi kendiri merupakan mekanisme psikologi penting yang dapat meningkatkan kesejahteraan dan kepuasan kerja guru, justeru implikasi kajian menekankan kepentingan sokongan kepimpinan sekolah dan pembangunan profesional berterusan dalam memperkukuh efikasi kendiri guru di sekolah luar bandar.

Abstract

Teacher job satisfaction is a critical element in determining the effectiveness of teaching and the sustainability of the teaching profession, especially in rural primary schools that face resource constraints and professional support. Based on Bandura's Social Cognitive Theory, this study aims to examine teacher self-efficacy as a predictor of job satisfaction in the context of rural primary schools in the Keningau district, Sabah. This study uses a quantitative approach with a survey design involving a sample of rural primary school teachers, where the data is analyzed using descriptive and inferential analysis such as correlation and regression to determine the relationship and contribution of self-efficacy to job satisfaction. Teacher self-efficacy is measured through three main dimensions, namely teaching efficacy, classroom management and student engagement. The study findings show that teacher self-efficacy has a significant relationship and serves as a main predictor of teacher job satisfaction. In conclusion, self-efficacy is an important psychological mechanism that can improve teachers' ni-being and job

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satisfaction, thus the implications of the study emphasize the importance of school leadership support and continuous professional development in strengthening teacher self-efficacy in rural schools.

Kata kunci: efikasi kendiri guru, kepuasan kerja, sekolah rendah luar bandar, Keningau, Sabah

I. Pengenalan

Kepuasan kerja guru telah lama diiktiraf sebagai asas kepada keberkesanan sistem pendidikan dan kesejahteraan profesional pendidik. Guru yang berpuas hati dengan kerjaya mereka cenderung menunjukkan komitmen organisasi yang lebih tinggi, kualiti pengajaran yang lebih baik serta kecenderungan yang rendah untuk meninggalkan profesion. Walau bagaimanapun, tahap kepuasan kerja guru sering kali dipengaruhi oleh konteks persekitaran kerja, khususnya di sekolah rendah luar bandar.

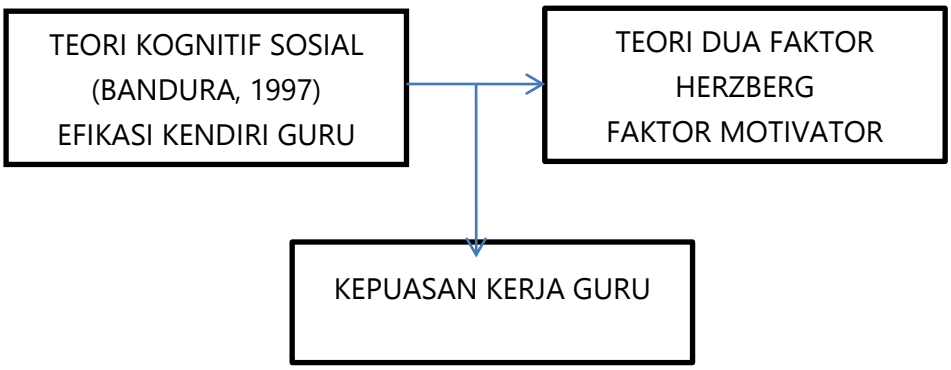
Di daerah Keningau, Sabah, sekolah rendah luar bandar berhadapan dengan pelbagai cabaran seperti kekangan infrastruktur, kekurangan sumber pengajaran, beban tugas yang pelbagai serta sokongan profesional yang terhad. Keadaan ini berpotensi menjejaskan kesejahteraan psikologi dan kepuasan kerja guru. Oleh itu, faktor dalaman guru seperti efikasi kendiri menjadi semakin signifikan sebagai sumber kekuatan psikologi yang membantu guru mengekalkan motivasi dan kepuasan kerja.

II. Sorotan Literatur

2.1 Konsep Efikasi Kendiri Guru

Efikasi kendiri merujuk kepada kepercayaan individu terhadap keupayaan mereka untuk melaksanakan tugasan tertentu dengan berkesan. Dalam konteks pendidikan, efikasi kendiri guru merujuk kepada keyakinan guru terhadap kebolehan mereka dalam merancang dan melaksanakan pengajaran, mengurus bilik darjah serta melibatkan murid secara aktif dalam proses pembelajaran.

Tschannen-Moran dan Hoy menggariskan tiga dimensi utama efikasi kendiri guru iaitu efikasi pengajaran, efikasi pengurusan bilik darjah dan efikasi penglibatan murid. Ketiga-tiga dimensi ini membentuk asas kepada kecekapan profesional guru dan mempengaruhi sikap serta tingkah laku mereka dalam bilik darjah.



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Rajah 1

Integrasi Teori Kognitif Sosial dan Teori Dua Faktor Herzberg dalam menjelaskan kepuasan kerja guru.

2.2 Kepuasan Kerja Guru

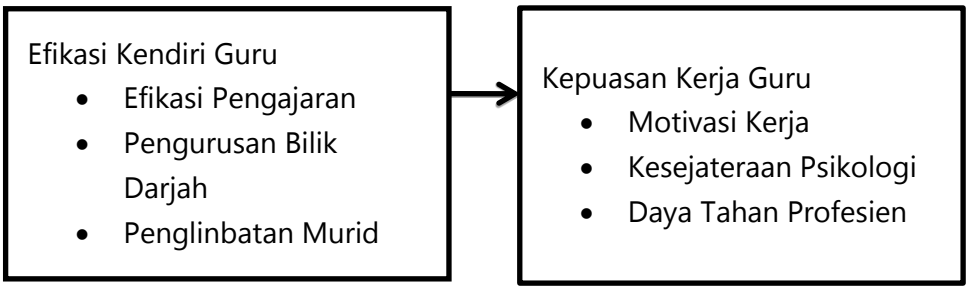
Kepuasan kerja guru merujuk kepada tahap perasaan positif atau negatif guru terhadap kerjaya dan persekitaran kerja mereka. Kepuasan kerja yang tinggi sering dikaitkan dengan motivasi dalaman, kesejahteraan emosi dan komitmen terhadap profesion. Dalam konteks sekolah luar bandar, kepuasan kerja guru menjadi isu yang kritikal kerana keterbatasan faktor luaran seperti kemudahan fizikal dan ganjaran material.

2.3 Hubungan Efikasi Kendiri dan Kepuasan Kerja

Kajian empirikal menunjukkan bahawa efikasi kendiri guru mempunyai hubungan yang signifikan dan positif dengan kepuasan kerja. Guru yang mempunyai keyakinan tinggi terhadap kebolehan profesional mereka cenderung mengalami tekanan kerja yang lebih rendah dan menunjukkan daya tahan yang lebih tinggi dalam menghadapi cabaran pengajaran. Dalam persekitaran luar bandar, efikasi kendiri guru berfungsi sebagai penampan psikologi yang membantu guru mengekalkan kepuasan kerja walaupun berhadapan dengan kekangan sumber.

III. Kerangka Konseptual Kajian

Kajian ini mencadangkan bahawa efikasi kendiri guru, yang merangkumi efikasi pengajaran, pengurusan bilik darjah dan penglibatan murid, bertindak sebagai pemboleh ubah peramal terhadap kepuasan kerja guru. Kerangka konseptual ini berasaskan Teori Kognitif Sosial Bandura dan disokong oleh Teori Dua Faktor Herzberg yang menekankan peranan faktor motivator intrinsik dalam pembentukan kepuasan kerja.



Rajah 2

Kerangka konseptual hubungan antara efikasi kendiri guru dan kepuasan kerja guru sekolah rendah luar bandar.

IV. Perbincangan

Dapatan konseptual kajian ini menyokong pandangan bahawa efikasi kendiri guru memainkan peranan penting dalam mengekalkan kepuasan kerja guru sekolah rendah luar bandar. Walaupun guru berhadapan dengan kekangan persekitaran kerja, kepercayaan terhadap keupayaan diri membolehkan mereka mentafsir cabaran sebagai peluang untuk berkembang. Dari perspektif motivasi, efikasi kendiri sejajar dengan faktor motivator intrinsik seperti pencapaian, perkembangan profesional dan makna kerja.

Peranan kepimpinan sekolah adalah signifikan dalam membina dan memperkukuh efikasi kendiri

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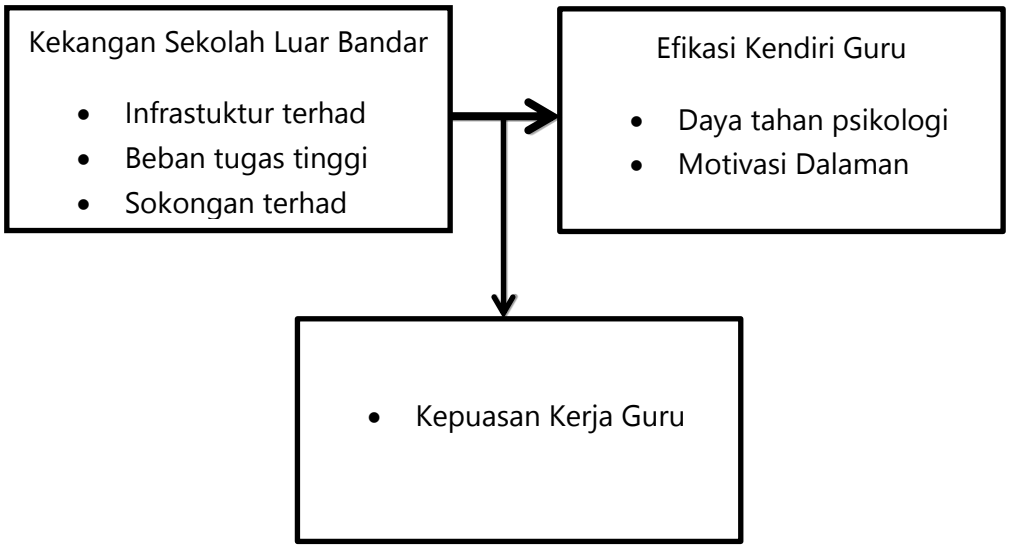
guru melalui sokongan instruksional, maklum balas profesional yang konstruktif serta peluang pembangunan profesional berterusan. Amalan kepimpinan yang menyokong pembelajaran profesional berupaya meningkatkan keyakinan guru dan seterusnya menyumbang kepada peningkatan kepuasan kerja.



Rajah 3

Peranan efikasi kendiri guru sebagai mekanisme psikologi dalam mengekalkan kepuasan kerja di sekolah rendah luar bandar.

V. Implikasi dan Cadangan

Kajian ini mencadangkan agar pihak pengurusan sekolah dan pembuat dasar memberi penekanan kepada usaha memperkukuh efikasi kendiri guru sebagai strategi meningkatkan kepuasan kerja. Program pembangunan profesional yang berfokus kepada penguasaan pedagogi, pengurusan bilik darjah dan strategi penglibatan murid wajar dilaksanakan secara sistematik, khususnya di sekolah rendah luar bandar.

VI. Kesimpulan

Secara keseluruhannya, efikasi kendiri guru merupakan peramal psikologi yang signifikan terhadap kepuasan kerja guru sekolah rendah luar bandar di Keningau, Sabah. Guru yang memiliki tahap efikasi kendiri yang tinggi lebih berupaya mengekalkan motivasi, kesejahteraan psikologi dan kepuasan kerja walaupun berhadapan dengan pelbagai cabaran persekitaran. Oleh itu, pemerkasaan efikasi kendiri guru wajar dijadikan fokus utama dalam usaha meningkatkan kualiti pendidikan dan kesejahteraan guru di kawasan luar bandar.

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Penggunaan *Still Air Box* Melalui *PlantClone Edu Kit* dalam Pelaksanaan Amali Pensterilan Kultur Tisu Tumbuhan

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Abstrak

Pelaksanaan amali kultur tisu tumbuhan di institusi Pendidikan dan Latihan Teknikal dan Vokasional (TVET) sering terbatas disebabkan kos peralatan yang tinggi serta keperluan fasiliti makmal yang sofistikated. Kajian ini bertujuan menilai keberkesanan penggunaan *Still Air Box* (SAB) melalui *PlantClone Edu Kit* sebagai alternatif ruang kerja aseptik kos rendah bagi proses pensterilan eksplan. Kajian ini menggunakan reka bentuk eksperimental berskala kecil yang melibatkan pelajar Kolej Komuniti Rembau, di mana aktiviti pensterilan dan inokulasi dilaksanakan berdasarkan Prosedur Operasi Standard (SOP) yang ditetapkan. Keberkesanan SAB dianalisis menggunakan analisis statistik deskriptif melalui pemerhatian kadar kontaminasi kultur pada hari ke-3, ke-5 dan ke-7 selepas inokulasi. Dapatan menunjukkan min kadar kontaminasi berjaya dikawal di bawah 20%, sekali gus membuktikan bahawa SAB mampu menyokong pelaksanaan proses pensterilan secara terkawal walaupun dalam persekitaran makmal yang terhad. Selain itu, maklum balas pelajar melalui analisis tematik menunjukkan bahawa SOP yang dibangunkan adalah mudah difahami, membantu meningkatkan kefahaman terhadap proses pensterilan serta meningkatkan keyakinan dalam mengendalikan eksplan secara kendiri. Secara keseluruhannya, kajian ini menunjukkan bahawa penggunaan SAB melalui *PlantClone Edu Kit* berpotensi sebagai pendekatan praktikal dan kos rendah dalam menyokong pelaksanaan latihan amali pensterilan kultur tisu tumbuhan di institusi TVET yang berhadapan dengan kekangan fasiliti makmal.

Kata kunci**:** *Amali kultur tisu tumbuhan; Institusi TVET; Kekangan makmal; Pensterilan eksplan; Still air box; Teknik aseptic*

Abstract

The implementation of plant tissue culture practical sessions in Technical and Vocational Education and Training (TVET) institutions is often limited by high equipment costs and the requirement for sophisticated laboratory facilities. This study aims to evaluate the effectiveness of the Still Air Box (SAB) through the PlantClone Edu Kit as a low-cost alternative aseptic workspace for the explant sterilization process. Utilizing a small-scale experimental design involving students from Kolej Komuniti Rembau, sterilization and inoculation activities were conducted based on established Standard Operating Procedures (SOP). The effectiveness of the SAB was analyzed using descriptive statistical analysis through observations of culture contamination rates on days 3, 5, and 7 post-inoculations. Findings indicated that the mean contamination rate was successfully controlled below 20%, proving that the SAB is capable of supporting controlled sterilization processes even within limited laboratory environments. Furthermore, student feedback via thematic analysis showed that the developed SOP was easy to understand, improved their comprehension of the sterilization process, and increased their confidence in handling explants independently. Overall, this study demonstrates that the use of the SAB through the PlantClone Edu Kit has potential as a practical and low-cost approach to support plant tissue culture sterilization training in TVET institutions facing laboratory facility constraints.

Keywords**:** *Explant sterilization; Plant tissue culture; Still air box; Technical and vocational education and training (TVET); Aseptic technique; Laboratory constraints*

I. PENGENALAN

Bioteknologi pertanian merupakan salah satu bidang penting dalam pembangunan sektor pertanian moden, khususnya dalam usaha menghasilkan bahan tanaman yang berkualiti, seragam dan bebas penyakit. Antara teknik bioteknologi yang sering diaplikasikan dalam sektor pertanian ialah kultur tisu tumbuhan, iaitu kaedah pembiakan sebahagian kecil tumbuhan secara in vitro dalam persekitaran terkawal bagi menghasilkan anak benih secara klon dalam kuantiti yang besar [1]. Teknik ini telah digunakan secara meluas dalam industri pertanian bagi pengeluaran bahan tanaman bernilai tinggi serta menyokong agenda keterjaminan makanan negara [2].

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Dalam konteks pendidikan, khususnya bagi program Sijil Agroteknologi di Kolej Komuniti, pengetahuan berkaitan kepentingan dan aplikasi bioteknologi pertanian, terutamanya kultur tisu tumbuhan, diterapkan melalui kursus Pengenalan Bioteknologi Pertanian yang ditawarkan pada semester tiga pengajian. Kursus ini menekankan pendekatan pembelajaran yang menggabungkan elemen teori dan amali bagi membolehkan pelajar memahami prinsip asas bioteknologi kultur tisu serta aplikasinya dalam sektor pertanian secara lebih menyeluruh.

Walau bagaimanapun, pelaksanaan pembelajaran amali kultur tisu tumbuhan dalam institusi Pendidikan dan Latihan Teknikal dan Vokasional (TVET) sering berhadapan dengan pelbagai cabaran. Antara cabaran utama termasuk keperluan kemudahan makmal yang lengkap, kos penyediaan peralatan yang tinggi, keperluan kawalan steril yang ketat serta tahap kerumitan prosedur yang memerlukan kemahiran teknikal tertentu. Kekangan ini secara tidak langsung mengehadkan peluang pelajar, khususnya di peringkat asas, untuk melaksanakan aktiviti amali kultur tisu secara menyeluruh dan berulang, sekali gus menjejaskan keberkesanan proses pembelajaran. Situasi ini selaras dengan dapatan kajian terdahulu yang melaporkan bahawa kekurangan fasiliti dan sumber dalam institusi TVET boleh membataskan pelaksanaan aktiviti amali secara berkesan [3].

Sehubungan itu, satu pendekatan pembelajaran yang lebih praktikal dan realistik perlu dilaksanakan bagi memenuhi keperluan pelajar TVET selaras dengan tahap pendidikan dan kemudahan sedia ada. Pendekatan ini menuntut penggunaan alat atau kit pembelajaran yang praktikal, selamat, kos rendah serta mudah dilaksanakan walaupun dalam keadaan fasiliti makmal yang terhad. Oleh itu, inovasi alat atau kit pembelajaran memainkan peranan penting dalam menyokong keberkesanan pengajaran dan pembelajaran dalam institut TVET [4].

Berdasarkan keperluan tersebut, penggunaan *Still Air Box* (SAB) dilihat sebagai satu alternatif yang sesuai dalam konteks pembelajaran kultur tisu tumbuhan di institusi TVET. SAB merupakan persekitaran kerja aseptik alternatif yang berfungsi berdasarkan prinsip aliran udara statik bagi mengurangkan risiko pencemaran semasa pelaksanaan aktiviti kultur tisu tumbuhan. Berbanding kabinet aliran laminar konvensional yang memerlukan kos yang tinggi serta penyelenggaraan khusus, SAB menawarkan pendekatan yang lebih ringkas, kos rendah dan mudah dikendalikan, sekali gus menjadikannya sesuai digunakan dalam persekitaran makmal terhad [5].

Seiring dengan itu, *PlantClone Edu Kit* telah dibangunkan oleh Kolej Komuniti Rembau dengan mengintegrasikan penggunaan SAB sebagai komponen utama bagi menyokong pelaksanaan latihan amali kultur tisu tumbuhan dalam persekitaran pembelajaran TVET. Kit ini direka bentuk untuk membolehkan pelajar menjalankan prosedur asas kultur tisu seperti pensterilan, pengendalian aseptik dan inokulasi eksplan secara terkawal dan selamat walaupun dalam keadaan fasiliti makmal yang terhad.

Namun demikian, tahap keberkesanan penggunaan SAB sebagai persekitaran kerja aseptik bagi pelaksanaan proses pensterilan dalam aktiviti kultur tisu tumbuhan masih kurang dikaji secara sistematik, khususnya dalam konteks makmal terhad di institusi latihan teknikal. Oleh itu, kajian ini dijalankan bagi menilai keberkesanan penggunaan SAB melalui *PlantClone Edu Kit* dalam menyokong pelaksanaan proses pensterilan eksplan secara terkawal serta mengurangkan risiko pencemaran dalam amali kultur tisu tumbuhan di persekitaran pendidikan TVET.

A. Objektif Kajian

- Menilai keberkesanan SAB sebagai persekitaran kerja aseptik dalam mengurangkan pencemaran semasa proses pensterilan eksplan kultur tisu tumbuhan.
- Menganalisis kadar kejayaan kultur bebas kontaminasi selepas proses pensterilan dan inokulasi dijalankan menggunakan *PlantClone Edu Kit*.
- Menilai kesesuaian penggunaan SAB sebagai alternatif kepada kabinet aliran laminar dalam konteks pelaksanaan amali kultur tisu tumbuhan di institusi TVET yang mempunyai fasiliti terhad.

II. KAJIAN LITERASI

Kultur tisu tumbuhan merupakan satu teknik pembiakan secara *in vitro* yang dijalankan dalam keadaan aseptik dan terkawal bagi mengkultur sel atau tisu tumbuhan. Aplikasi teknik ini dalam sektor pertanian merangkumi peningkatan hasil dan kualiti tanaman, pemuliharaan spesies tumbuhan terancam serta penghasilan bahan tanaman yang bebas penyakit sepanjang tahun [6]. Kultur tisu tumbuhan memainkan peranan penting dalam pembangunan pertanian moden dengan meningkatkan produktiviti secara mampan serta memperkukuh daya saing sektor pertanian selari dengan keperluan pembangunan lestari [7].

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A. Prinsip Kerja Aseptik dan Pensterilan dalam Kultur Tisu

Keberhasilan aktiviti kultur tisu tumbuhan bergantung kepada pelaksanaan aseptik dan pensterilan yang berkesan. Pensterilan adalah proses penghapusan mikroorganisma bagi memastikan peralatan dan medium bebas pencemaran. Dalam kultur tisu, kehadiran bakteria atau kulat boleh menjejaskan pertumbuhan dan kejayaan perbanyakan tisu [8]. Kaya et al. [9] menyatakan bahawa pensterilan eksplan merupakan faktor utama dalam kejayaan program pembiakan tumbuhan melalui kultur tisu. Aktiviti ini mesti dijalankan dalam persekitaran aseptik, dengan penggunaan peralatan asas seperti kabinet aliran laminar dan autoklaf untuk mengekalkan sterilisasi media dan peralatan [10].

B. Cabaran Pelaksanaan Amali Kultur Tisu dalam Pendidikan TVET

Dalam konteks Pendidikan dan Latihan Teknikal dan Vokasional (TVET), kekangan kemudahan makmal khusus dan peralatan asas seperti kabinet aliran laminar sering mengehadkan pelaksanaan amali kultur tisu tumbuhan serta penguasaan kemahiran praktikal pelajar. Daniel et al. [11] melaporkan bahawa kekurangan peralatan moden, bengkel, dan makmal memberi kesan negatif kepada kualiti aktiviti praktikal dalam pengajaran pertanian TVET. Kekurangan sumber, peralatan, dan infrastruktur juga mengehadkan kemampuan pensyarah menzahirkan pengetahuan dan kemahiran praktikal dalam pengajaran [12]. Kajian di institusi TVET di Nigeria mendapati antara cabaran utama ialah kekurangan kemudahan dan peralatan mencukupi [12]. Di Malaysia, isu serupa dilaporkan, di mana kekangan pembiayaan menyebabkan ketidakcukupan fasiliti dan infrastruktur penting, melemahkan keupayaan ekosistem TVET untuk bersaing secara mampan [13]. Selain itu, Rashidah et al. [14] mengenal pasti kekurangan alat bantu mengajar sebagai isu utama dalam pembelajaran bioteknologi, termasuk aktiviti amali seperti pensterilan dalam kultur tisu tumbuhan.

C. Inovasi Alat dan Kit Pembelajaran dalam Pendidikan TVET

Penggunaan alat dan kit pembelajaran berasaskan amali merupakan antara pendekatan penting dalam pendidikan TVET bagi menyokong pembelajaran berasaskan kemahiran. Penggunaan kit inovatif terbukti meningkatkan penguasaan kemahiran praktikal, motivasi, pemahaman konsep, serta kemahiran berfikir [15], [16], [17]. Inovasi alat pembelajaran yang bersifat praktikal, selamat dan kos rendah dapat membantu pelajar memahami prosedur teknikal melalui pengalaman sebenar. Dapatan empirikal menunjukkan bahawa penggunaan alat dan kit pembelajaran yang praktikal, selamat serta kos rendah dapat meningkatkan kefahaman terhadap prosedur teknikal melalui pengalaman amali sebenar, di samping berperanan sebagai medium penyeragaman prosedur makmal yang membantu mengurangkan kesilapan dan meningkatkan kebolehulangan aktiviti amali [18] - [20].

D. Still air box sebagai alternatif Persekitaran Aseptik

Still Air Box (SAB) merupakan alternatif persekitaran kerja aseptik yang menggunakan prinsip aliran udara statik untuk mengurangkan risiko pencemaran semasa aktiviti makmal. Berbanding kabinet aliran laminar, SAB menawarkan pendekatan kos rendah, mudah dibina, dan tidak memerlukan penyelenggaraan kompleks. Kajian terdahulu menunjukkan penggunaan *glove box* yang dirawat dengan etanol dan SAB tanpa penutup menghasilkan sifar koloni dalam persampelan udara pasif selepas satu jam, dengan beban bioaerosol aktif yang minimum (≈1.9–2.3 log CFU/m³), menandakan kesesuaiannya untuk aktiviti makmal separa steril [21]. Penggunaan laminar aliran udara ubah suai sebagai ruang kerja alternatif juga didapati berkesan dalam mengurangkan kadar pencemaran media, menyokong konsep persekitaran udara pegun seperti SAB bagi prosedur aseptik dalam pendidikan makmal [22].

III. METADOLOGI KAJIAN

A. Reka Bentuk Kajian

Kajian ini menggunakan reka bentuk eksperimental makmal berskala kecil dengan sokongan data kualitatif ringkas. Fokus utama kajian adalah untuk menilai keberkesanan penggunaan SAB melalui *PlantClone Edu Kit* sebagai persekitaran kerja aseptik bagi pelaksanaan amali pensterilan kultur tisu tumbuhan dalam persekitaran makmal TVET yang terhad.

B. Persekitaran Kajian

Kajian dijalankan di makmal Kultur Tisu di Kolej Komuniti Rembau. Makmal ini dipilih kerana ia mewakili persekitaran latihan TVET yang mempunyai kekangan fasiliti makmal (tiada kabinet aliran laminar atau jumlah terhad). Subjek kajian terdiri daripada pelajar yang mengikuti modul Pengenalan Biotkenologi Pertanian, di mana mereka dikehendaki menjalankan amali pensterilan dan inokulasi secara individu menggunakan SAB.

C. Bahan dan Peralatan

Bagi memastikan kelestarian amali dalam persekitaran kos rendah, bahan-bahan berikut telah digunakan:

- *Still Air Box* (SAB): Kotak lutsinar yang diubah suai sebagai ruang kerja aseptik statik.

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- Eksplan Model: Biji benih tumbuhan (sebagai model latihan yang tahan lasak dan mudah didapati).
- Medium Kultur: Medium Murashige & Skoog (MS) asas tanpa hormon.
- Agen Pensterilan: Etanol 70%, Natrium Hipoklorit (NaOCl) 30%, dan Tween-20.
- *PlantClone Edu Kit*: Set lengkap yang merangkumi SOP visual dan peralatan asas inokulasi.

D. Subjek kajian

Subjek kajian terdiri daripada 24 orang pelajar Sijil Agroteknologi dari Kolej Komuniti Rembau yang mengikuti modul Pengenalan Bioteknologi Pertanian, di mana saiz sampel ditentukan berdasarkan jumlah pendaftaran satu kumpulan praktikal. Pemilihan sampel dilakukan secara pensampelan bertujuan (*purposive sampling*) bagi memastikan semua responden mempunyai latar belakang teori yang seragam sebelum melaksanakan amali menggunakan Still Air Box (SAB). Saiz sampel ini dianggap memadai dan bersesuaian dengan reka bentuk kajian eksperimental berskala kecil, khususnya dalam menilai keberkesanan teknikal serta penerimaan awal terhadap penggunaan inovasi dalam persekitaran makmal yang terhad.

E. Prosedur Pelaksanaan Amali

Pelaksanaan amali dibahagikan kepada tiga fasa utama yang menekankan aspek pedagogi TVET:

1) Penyediaan Ruang Kerja (Aseptik)

Pelajar melakukan sanitasi dalaman SAB menggunakan alkohol 70% dan memastikan semua peralatan diletakkan secara sistematik di dalam kotak bagi meminimumkan pergerakan udara semasa amali berlangsung.

2) Protokol Pensterilan Eksplan

Pelajar melaksanakan prosedur pensterilan mengikut Prosedur Operasi Standard (SOP) seperti jadual 1.

Rajah 1: Carta alir prosedur pensterilan eksplan

Jadual 1: Protokol Pensterilan Eksplan

Langkah	Prosedur	Tempoh
1	Rendaman air bersih	5 minit
2	Rendaman Etanol 70%	30 saat
3	Bilasan air suling steril	3 kali
4	NaOCl 10% + Tween-20	5 minit
5	Bilasan air suling steril	3 kali

3) Inokulasi

Eksplan yang telah steril dipindahkan ke dalam botol medium kultur di dalam SAB. Pelajar perlu mempraktikkan teknik kerja aseptik (seperti membakar peralatan dan meminimumkan pendedahan mulut botol) dalam ruang statik tersebut.

Rajah 2: Penggunaan SAB Untuk Pensterilan dan Inokulasi Eksplan

F. Pengumpulan dan Analisis Data

Dua jenis data dikumpul bagi menilai keberkesanan kit pembelajaran ini:

- **Analisis Statistik Deskriptif (Kuantitatif)**: Pemerhatian visual dilakukan ke atas setiap kultur pada hari ke-3, ke-5, dan ke-7. Data dianalisis secara deskriptif untuk mengukur kadar peratusan (%) kontaminasi. Jika min kadar kontaminasi adalah rendah (sasaran < 20%), maka SAB dianggap berkesan sebagai ruang kerja alternatif.
- **Analisis Tematik (Kualitatif)**: Maklum balas dikumpul melalui sesi perbincangan tidak berstruktur dan pemerhatian tingkah laku pelajar. Data dianalisis secara tematik untuk mengenal pasti corak dalam aspek kefahaman SOP, kemudahan pengendalian alat, dan keyakinan pelajar melakukan kerja aseptik secara kendiri

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IV. KEPUTUSAN DAN PERBINCANGAN

Hasil kajian menunjukkan bahawa penggunaan SAB dengan PlantClone Edu Kit membolehkan amali pensterilan dan inokulasi eksplan kultur tisu dijalankan dengan berkesan walaupun dalam makmal TVET yang mempunyai fasiliti terhad dan tanpa kabinet aliran laminar. SAB menyediakan persekitaran udara statik yang mengurangkan risiko pencemaran, menunjukkan bahawa latihan asas kultur tisu dapat dilaksanakan secara kos efektif tanpa menjejaskan kualiti pengajaran. Semua langkah amali, termasuk pembersihan awal eksplan, pensterilan, pengendalian aseptik, dan inokulasi ke dalam medium kultur, dapat dilaksanakan dengan baik menggunakan SAB mengikut SOP yang telah dibangunkan.

A. Tahap Kontaminasi Kultur Tisu

Pemerhatian terhadap kultur tisu yang diinokulasi menggunakan SAB dilakukan pada hari ke-3, ke-5 dan ke-7 selepas inokulasi. Hasil pemerhatian menunjukkan bahawa sebahagian besar kultur berada dalam keadaan bebas kontaminasi sepanjang tempoh pemerhatian. Kes kontaminasi yang dikesan adalah minimum dan tidak berlaku secara menyeluruh pada semua kultur.

Jadual 2: Kadar Peratus Kontiminasi Mengikut Hari

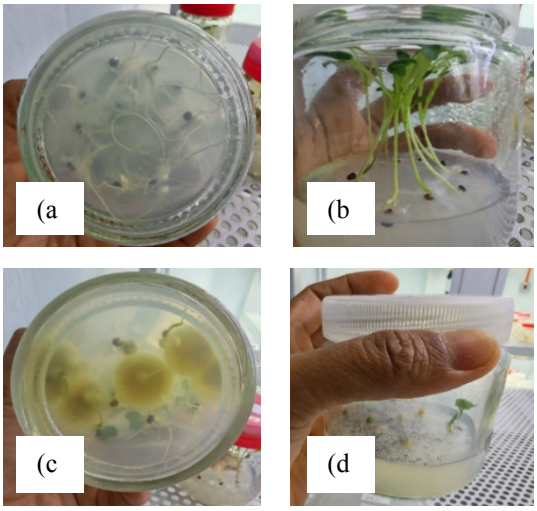
Hari Pemerhatian	Bilangan Kultur Terkontiminasi (%)	Bilangan Kultur Bebas Kontiminasi (%)
Hari ke - 3	0	100
Hari ke - 5	10	90
Hari ke - 7	16.67	83.33

Berdasarkan Jadual 2, analisis deskriptif menunjukkan perkara berikut:

- **Hari ke-3**: Mencatatkan kadar bebas kontaminasi sempurna (100%), membuktikan keberkesanan awal prosedur pensterilan permukaan dan persekitaran kerja menggunakan SAB berada dalam keadaan terkawal.
- **Hari ke-5**: Kadar kontaminasi meningkat sedikit kepada 10%, menunjukkan permulaan kehadiran mikroorganisma dalam sebahagian kecil sampel kultur. Walau bagaimanapun, peningkatan ini masih berada dalam julat yang rendah dan boleh diterima dalam amali kultur tisu peringkat asas
- **Hari ke-7**: Kadar kontaminasi kumulatif mencatatkan 16.67%, manakala kadar kejayaan adalah 83.33%. Walaupun terdapat peningkatan secara berperingkat, majoriti kultur masih kekal bebas daripada kontaminasi, iaitu melebihi 80% kejayaan. Corak peningkatan ini adalah konsisten dengan sifat kultur tisu di mana kontaminasi biasanya muncul secara beransur-ansur akibat faktor persekitaran atau teknik pengendalian.

Secara keseluruhan, data menunjukkan peningkatan kontaminasi yang minimum dan terkawal, sekali gus mencerminkan keberkesanan penggunaan SAB dalam menyediakan persekitaran aseptik alternatif. Tambahan pula, variasi kadar kontaminasi yang rendah antara tempoh pemerhatian menunjukkan bahawa prosedur operasi standard (SOP) yang digunakan adalah konsisten dan boleh diulang dengan hasil yang stabil. Berdasarkan standard latihan makmal, kadar kontaminasi di bawah 20% bagi penggunaan alat alternatif adalah sangat memberangsangkan.

Rajah 1: (a), (b) Hasil inokulasi yang berjaya dan (c), (d) Hasil inokulasi yang tercemar



Dapatan kadar kontaminasi yang rendah ini juga dipengaruhi oleh pemilihan biji benih sebagai eksplan model. Penggunaan biji benih bertujuan untuk meminimumkan risiko kontaminasi dalaman (endophytic), membolehkan tumpuan diberikan sepenuhnya kepada penilaian keberkesanan SAB sebagai ruang kerja aseptik. Walaupun begitu, bagi penggunaan eksplan yang lebih kompleks seperti tisu vegetatif dari lapangan, prosedur pensterilan yang lebih intensif mungkin diperlukan bagi mengimbangi ketiadaan aliran udara aktif di dalam SAB.

Dapatan ini selari dengan kajian oleh Kosel dan Ropret [21] yang menyatakan bahawa reka bentuk SAB sangat sesuai untuk aplikasi makmal separa steril kerana keupayaannya mengekalkan beban bioaerosol aktif pada tahap minimum melalui prinsip udara pegun. Pencapaian kadar kontaminasi

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di bawah sasaran ralat 20% ini membuktikan bahawa SAB adalah alternatif yang saintifik kepada kabinet aliran laminar (LAF) dalam konteks pembelajaran amali, terutamanya apabila melibatkan eksplan model yang tahan lasak seperti biji benih.

Meskipun terdapat kehadiran kontaminasi, tuntutan keberkesanan ini disokong oleh beberapa hujah utama:

- ***Pencapaian Standard Minimum Latihan***
  Dalam konteks pembelajaran kultur tisu, kadar kejayaan melebihi 80% adalah satu pencapaian yang signifikan, terutamanya apabila dijalankan di dalam makmal yang tidak mempunyai kemudahan LAF. Tahap ini membuktikan bahawa prinsip udara statik dalam SAB mampu menghalang pergerakan agen pencemar bawaan udara secara efektif semasa proses inokulasi.
- **Analisis Ralat vs. Kegagalan Alat**
  Kadar kontaminasi sebanyak 18% tidak semestinya mencerminkan kelemahan fungsi SAB, tetapi lebih berkait dengan faktor pelaksanaan semasa latihan. Dalam konteks pembelajaran amali, tahap kemahiran psikomotor pelajar yang masih berkembang boleh mempengaruhi ketepatan prosedur aseptik. Selain itu, ketidaksempurnaan semasa pensterilan permukaan eksplan atau kesilapan manipulasi alatan di dalam kotak turut berpotensi menyumbang kepada berlakunya kontaminasi.
- **Keberkesanan Berasaskan Kos (Cost-Effectiveness)**
  Berbanding pelaburan kabinet aliran laminar (LAF) yang memerlukan kos tinggi, Still Air Box (SAB) menyediakan alternatif yang lebih mampu milik dengan fungsi asas yang mencukupi untuk latihan amali. Penggunaannya membolehkan lebih ramai pelajar menjalankan inokulasi secara individu, bukan sekadar memerhati demonstrasi pensyarah akibat kekangan peralatan. Keadaan ini secara tidak langsung meningkatkan peluang penguasaan kemahiran praktikal dalam kalangan pelajar.
- **Nilai Pedagogi TVET**
  Dari sudut pendidikan, kehadiran sedikit kontaminasi sebenarnya memberikan nilai pengajaran tambahan. Pelajar dapat melakukan analisis punca ralat (troubleshooting), yang merupakan kemahiran penting dalam latihan teknikal. Ini membantu pelajar memahami bahawa disiplin kerja aseptik adalah faktor penentu utama, bukan sekadar bergantung kepada kecanggihan mesin.

B. Maklumbalas penerimaan pelajar

Analisis tematik yang dijalankan ke atas maklum balas pelajar melalui sesi perbincangan tidak berstruktur dan pemerhatian tingkah laku telah mengenal pasti tiga tema utama yang menyokong keberkesanan *PlantClone Edu Kit*:.

- **Kefahaman Prosedur yang Lebih Jelas**
  Sebahagian besar pelajar menyatakan bahawa langkah-langkah dalam SOP PlantClone Edu Kit mudah difahami kerana disusun secara sistematik dan dipersembahkan secara langkah demi langkah. Turutan kerja yang jelas, bermula daripada penyediaan eksplan hingga proses inokulasi, membantu pelajar memahami keseluruhan aliran prosedur secara menyeluruh. Kefahaman ini membantu mereka mengaitkan konsep teori dengan pelaksanaan praktikal, sekali gus meningkatkan keyakinan serta penguasaan kemahiran aseptik dalam konteks latihan TVET.
- **Peningkatan Keyakinan Diri**
  Walaupun bekerja dalam ruang yang terhad (SAB), pelajar berasa lebih yakin untuk mengendalikan eksplan secara kendiri. Ketiadaan pergantungan kepada mesin LAF yang besar dan mahal membuatkan pelajar rasa teknologi ini "boleh dicapai" (accessible).
- **Kemudahan Penggunaan**
  Pelajar mendapati bahawa SAB bersifat ringan, mudah dipasang dan tidak memerlukan persediaan teknikal yang kompleks. Faktor ini membolehkan sesi amali dijalankan dengan lebih efisien tanpa keperluan menunggu giliran yang lama untuk menggunakan peralatan terhad. Keadaan ini menyokong penglibatan aktif pelajar secara lebih menyeluruh dalam tempoh masa yang ditetapkan.

V. KESIMPULAN

Secara keseluruhannya, dapatan kajian membuktikan bahawa Still Air Box (SAB) merupakan alternatif yang berkesan, kos rendah, dan praktikal bagi pelaksanaan amali kultur tisu di institusi TVET. Dengan kadar kejayaan melebihi 80%, inovasi ini bukan sahaja mengatasi kekangan fasiliti, malah berjaya meningkatkan kualiti pengajaran dan pembelajaran (PdP) melalui pendekatan hands-on yang lebih inklusif. Dari sudut pendidikan, pendekatan ini memberi peluang kepada pelajar Kolej Komuniti dan Politeknik untuk mengalami pembelajaran berasaskan amali secara lebih autentik, walaupun tanpa kemudahan LAF. Penggunaan kit pembelajaran yang praktikal, selamat dan kos rendah bukan sahaja meningkatkan kefahaman kemahiran teknikal, malah menyokong

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standardisasi latihan amali dalam konteks pendidikan TVET.

Pembangunan kit pembelajaran berasaskan amali seperti *PlantClone Edu Kit* adalah selari dengan trend global dalam pendidikan TVET yang menekankan penggunaan kit inovatif bagi meningkatkan visualisasi, motivasi, dan kefahaman konsep teknikal yang kompleks dalam kalangan pelajar. Penggunaan alat bantu mengajar yang praktikal dan kos rendah ini bukan sahaja meningkatkan kemahiran psikomotor, malah berfungsi sebagai medium penyeragaman prosedur makmal yang mengurangkan ralat manusia semasa amali.

Kesimpulannya, Still Air Box melalui PlantClone Edu Kit berpotensi menjadi alternatif praktikal dan berdaya guna bagi memperluas pelaksanaan latihan amali kultur tisu tumbuhan dalam institusi TVET, seterusnya menyumbang kepada pengukuhan pendidikan bioteknologi pertanian berasaskan kemahiran. Kajian lanjutan dicadangkan bagi menilai keberkesanan penggunaan SAB pada skala pelaksanaan yang lebih besar serta melibatkan pelbagai jenis eksplan tumbuhan.

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Analisis Kefahaman dan Penerimaan Pelajar Semester Satu Politeknik Kota Kinabalu terhadap Penggunaan AI dalam Kejuruteraan Mekanikal

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Abstrak

Kajian ini dijalankan untuk menganalisis tahap kefahaman dan penerimaan pelajar semester satu Jabatan Kejuruteraan Mekanikal, Politeknik Kota Kinabalu terhadap penggunaan teknologi Kecerdasan Buatan (Artificial Intelligence, AI) dalam pengajaran dan pembelajaran. Dengan perkembangan pesat AI dalam era Revolusi Industri 4.0, pelajar kejuruteraan perlu bersedia menghadapi cabaran teknologi semasa dan masa depan. Kajian ini menggunakan pendekatan kuantitatif melalui soal selidik yang melibatkan seramai 235 pelajar semester satu yang dipilih secara rawak, dan data dianalisis menggunakan statistik deskriptif serta inferens melalui SPSS versi 26. Hasil kajian menunjukkan bahawa tahap kefahaman pelajar terhadap AI adalah sederhana tinggi (min = 3.72), manakala tahap penerimaan terhadap penggunaannya dalam pembelajaran adalah tinggi (min = 4.18). Analisis korelasi mendapati terdapat hubungan positif yang signifikan antara kefahaman dan penerimaan pelajar terhadap AI ($r = 0.46$, $p < 0.01$). Secara keseluruhannya, peningkatan kefahaman pelajar berpotensi meningkatkan penerimaan mereka terhadap penggunaan AI dalam pembelajaran kejuruteraan mekanikal, dan dapatan ini diharapkan dapat membantu institusi merancang pendekatan pengajaran yang lebih sistematik melalui integrasi teknologi AI, khususnya bagi pelajar politeknik di peringkat awal.

Kata Kunci: *Kecerdasan Buatan (AI), kefahaman pelajar, penerimaan teknologi, kejuruteraan mekanikal, politeknik.*

I. PENGENALAN

Revolusi Industri 4.0 telah membawa perubahan yang besar terhadap landskap pendidikan dan perindustrian melalui integrasi teknologi digital seperti automasi, Internet of Things (IoT), analitik data dan Kecerdasan Buatan (*Artificial Intelligence*, AI). AI khususnya dikenal pasti sebagai salah satu teknologi teras yang berupaya meningkatkan kecekapan sistem, mempercepatkan proses membuat keputusan serta mengoptimumkan penggunaan sumber dalam pelbagai sektor termasuk pendidikan dan kejuruteraan (Tumiran et al., 2025). Perkembangan pesat teknologi ini menuntut institusi pendidikan untuk menyesuaikan pendekatan pengajaran dan pembelajaran (PdP) agar selari dengan keperluan industri semasa.

Dalam bidang kejuruteraan mekanikal, AI memainkan peranan penting dalam menyokong aktiviti reka bentuk, simulasi, pemodelan, analisis data dan sistem kawalan pintar. Penggunaan AI dalam pendidikan kejuruteraan berpotensi meningkatkan kefahaman pelajar terhadap konsep yang kompleks melalui kaedah pembelajaran berasaskan simulasi, automasi dan pembelajaran adaptif (Samsudin & Mohd Bukhar, 2025). Pendekatan ini bukan sahaja membantu pelajar memahami teori dengan lebih mendalam, malah menyediakan mereka dengan kemahiran yang relevan untuk menghadapi persekitaran kerja berteknologi tinggi.

Walau bagaimanapun, keberkesanan penerapan AI dalam pendidikan tidak hanya bergantung kepada ketersediaan teknologi semata-mata, tetapi turut dipengaruhi oleh tahap kefahaman dan penerimaan pelajar terhadap teknologi tersebut. Beberapa kajian menunjukkan bahawa walaupun pelajar menunjukkan minat terhadap AI, tahap kefahaman mereka terhadap aplikasi sebenar AI dalam bidang pengajian masih berada pada tahap sederhana, terutamanya dalam kalangan pelajar di peringkat awal pengajian tinggi (Ahmad et al., 2025). Kekurangan kefahaman ini berpotensi menjejaskan keberkesanan PdP sekiranya teknologi AI digunakan tanpa persediaan yang mencukupi.

Sehubungan itu, kajian terhadap tahap kefahaman dan penerimaan pelajar terhadap penggunaan AI dalam pembelajaran kejuruteraan mekanikal adalah amat penting bagi memastikan pelaksanaan teknologi ini benar-benar memberi impak positif.

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Kajian ini menjadi lebih signifikan dalam konteks institusi pendidikan teknikal seperti politeknik yang berperanan melahirkan graduan berkemahiran dan bersedia menghadapi perubahan teknologi. Oleh itu, kajian ini dijalankan bagi menilai tahap kefahaman dan penerimaan pelajar terhadap penggunaan AI dalam pembelajaran kejuruteraan mekanikal di Politeknik Kota Kinabalu, sejajar dengan keperluan pendidikan berteraskan Revolusi Industri 4.0.

1.1 Objektif Kajian

Dalam kajian ini, kami menetapkan beberapa objektif kajian yang boleh merungkai kepada permasalahan tersebut antaranya:

1. Mengenal pasti tahap kefahaman pelajar semester satu Politeknik Kota Kinabalu terhadap penggunaan AI dalam bidang kejuruteraan mekanikal.
2. Mengenal pasti tahap penerimaan pelajar terhadap penggunaan AI dalam pembelajaran kejuruteraan.
3. Mengenal pasti hubungan antara kefahaman pelajar dan penerimaan terhadap penggunaan AI.
4. Mengenal pasti faktor-faktor yang mempengaruhi kefahaman dan penerimaan pelajar terhadap AI.

1.2 Skop kajian

Kajian ini dilaksanakan di Politeknik Kota Kinabalu yang mana ia melibatkan pelajar baru iaitu pelajar semester satu daripada Jabatan Kejuruteraan Mekanikal bagi Sesi I: 2025/2026. Fokus kajian adalah terhadap kefahaman dan penerimaan terhadap penggunaan AI dalam pembelajaran, bukan kepada pembangunan sistem AI itu sendiri. Data kajian ini diambil secara rawak melalui soal selidik yang diagihkan pada Majlis Minggu Transformasi Siswa (MTS) anjuran Jabatan Kejuruteraan Mekanikal, Politeknik Kota Kinabalu sebanyak 235 orang pelajar.

II. KAJIAN LITERATUR

2.1 Kecerdasan Buatan (Artificial Intelligence, AI)

Kecerdasan Buatan (Artificial Intelligence, AI) merujuk kepada cabang sains komputer yang menumpukan kepada pembangunan sistem atau mesin yang berupaya melaksanakan tugasan yang lazimnya memerlukan kecerdasan manusia. Tugasan tersebut merangkumi kepada keupayaan membuat keputusan, pengecaman corak, pembelajaran kendiri, serta pemprosesan bahasa semula jadi (Awang, A., 2016).

Dalam konteks kejuruteraan mekanikal, aplikasi AI semakin meluas sejajar dengan keperluan industri terhadap sistem yang lebih cekap, pintar dan berautonomi. Antara aplikasi utama AI dalam bidang ini termasuk automasi sistem kawalan, pemantauan dan penyelenggaraan ramalan bagi mengesan kerosakan secara lebih awal, reka bentuk berbantukan komputer (Computer-Aided Design, CAD) untuk mengoptimumkan proses reka bentuk, serta pembangunan robotik pintar yang mampu beroperasi secara adaptif dalam persekitaran industri.

2.2 Kefahaman Pelajar terhadap Penggunaan AI dalam Bidang Kejuruteraan Mekanikal

Beberapa kajian terdahulu menunjukkan bahawa tahap kefahaman pelajar terhadap penggunaan kecerdasan buatan (Artificial Intelligence, AI) dalam bidang kejuruteraan mekanikal masih berada pada tahap sederhana, terutamanya di peringkat awal pengajian tinggi. Walaupun AI semakin meluas digunakan dalam industri, pendedahan pelajar terhadap konsep dan aplikasi praktikal teknologi ini masih terhad (Samsudin & Mohd Bukhar, 2025). Situasi ini mencerminkan wujudnya jurang antara minat pelajar terhadap AI dan tahap kefahaman sebenar mereka dalam konteks pembelajaran dan pengajaran kejuruteraan mekanikal.

Tahap kefahaman yang rendah ini sering dikaitkan dengan beberapa faktor, termasuk kurangnya pendedahan awal dalam kurikulum, ketiadaan pengalaman praktikal atau latihan berasaskan aplikasi sebenar, serta persepsi bahawa AI adalah bidang yang kompleks dan sukar difahami. Keadaan ini menekankan kepentingan menyediakan peluang pembelajaran berasaskan teknologi serta bimbingan yang mencukupi untuk membantu pelajar memahami dan mengaplikasikan AI secara berkesan dalam pengajian mereka.

2.3 Penerimaan Pelajar terhadap Penggunaan AI dalam Pembelajaran Kejuruteraan

Penerimaan pelajar terhadap penggunaan kecerdasan buatan (Artificial Intelligence, AI) dalam pembelajaran kejuruteraan boleh dianalisis menggunakan *Unified Theory of Acceptance and Use of Technology 2* (UTAUT2) yang diperkenalkan oleh Venkatesh et al. (Dewi et al., 2025). Model UTAUT2 merupakan lanjutan kepada model UTAUT asal dan direka bagi menerangkan tingkah laku penerimaan teknologi moden oleh individu, khususnya dalam konteks pendidikan dan pembelajaran berasaskan teknologi.

UTAUT2 menekankan beberapa konstruk utama yang mempengaruhi niat dan tingkah laku penggunaan teknologi, termasuk *Performance Expectancy*, *Effort Expectancy*, *Social Influence*, *Facilitating Conditions*, *Hedonic Motivation*, *Price Value*, dan *Habit* (Putri & Sundari, 2024). Dalam

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konteks pembelajaran kejuruteraan mekanikal, *Performance Expectancy* merujuk kepada persepsi pelajar bahawa AI dapat meningkatkan keberkesanan pembelajaran dan prestasi akademik, manakala *Effort Expectancy* merujuk kepada kemudahan penggunaan teknologi tersebut. Selain itu, faktor sosial dan sokongan persekitaran, termasuk pandangan pensyarah, rakan sebaya, latihan serta kemudahan infrastruktur turut memainkan peranan penting dalam mempengaruhi tahap penerimaan pelajar.

Menurut kajian Mizan & Norman (2024) pula menunjukkan bahawa pelajar yang mempunyai persepsi positif terhadap keberkesanan dan kemudahan penggunaan AI lebih cenderung menerima teknologi ini dalam pembelajaran. Walau bagaimanapun, terdapat juga kebimbangan mengenai implikasi jangka panjang, termasuk risiko kebergantungan kepada teknologi serta kemungkinan pengurangan peluang pekerjaan akibat automasi. Kebimbangan ini berpotensi menjejaskan sikap pelajar dan menurunkan tahap penerimaan mereka terhadap penggunaan AI dalam pembelajaran kejuruteraan.

2.4 Penerapan AI dalam Sistem Pendidikan Kejuruteraan Mekanikal

Penerapan kecerdasan buatan (Artificial Intelligence, AI) dalam sistem pendidikan kejuruteraan mekanikal semakin meluas selaras dengan perkembangan teknologi dan keperluan industri terhadap graduan yang berkemahiran tinggi serta bersedia menghadapi cabaran Revolusi Industri 4.0. Dalam konteks ini, AI digunakan sebagai alat sokongan pembelajaran dan latihan bagi membantu pelajar memahami konsep teknikal yang kompleks melalui kaedah pengajaran dan pembelajaran yang lebih berkesan dan berasaskan teknologi.

Antara aplikasi AI dalam pendidikan kejuruteraan mekanikal termasuk pengoptimuman reka bentuk produk, simulasi dan pemodelan sistem kejuruteraan, pembangunan sistem kawalan pintar, serta latihan teknikal berasaskan simulasi realiti maya dan realiti terimbuh. Menurut Samsudin & Mohd Bukhar (2025), pendedahan kepada kemahiran digital dan teknologi AI adalah penting bagi memastikan pelajar kekal relevan dan berdaya saing dalam era Revolusi Industri 4.0, di samping menyokong pembangunan kemahiran berfikir aras tinggi, penyelesaian masalah dan kebolehan adaptasi teknologi.

2.5 Faktor-faktor yang Mempengaruhi Kefahaman dan Penerimaan Pelajar terhadap AI

Tahap kefahaman dan penerimaan pelajar terhadap penggunaan kecerdasan buatan (Artificial Intelligence, AI) dalam pembelajaran kejuruteraan dipengaruhi oleh beberapa faktor utama, termasuk latar belakang pendidikan, pendedahan awal kepada teknologi, serta sokongan institusi pendidikan. Pelajar yang mempunyai asas dalam bidang sains komputer, teknologi maklumat atau kejuruteraan berasaskan teknologi cenderung lebih mudah memahami konsep dan aplikasi AI (Abdullah, N. et al., 2020). Selain itu, pengalaman awal dengan perisian atau sistem AI juga meningkatkan sikap positif dan keterbukaan pelajar terhadap penggunaan teknologi ini dalam pembelajaran (Mizan & Norman, 2024).

Sokongan daripada pensyarah dan institusi pendidikan turut memainkan peranan penting dalam mempengaruhi penerimaan pelajar. Bimbingan berterusan daripada tenaga pengajar, latihan praktikal yang bersesuaian, serta kemudahan infrastruktur teknologi yang mencukupi dapat membantu pelajar menggunakan AI dengan lebih yakin dan berkesan (Samsudin & Mohd Bukhar, 2025). Persekitaran pembelajaran yang kondusif dan sokongan institusi yang mantap mampu meningkatkan tahap kefahaman serta penerimaan pelajar terhadap penerapan teknologi AI dalam pendidikan kejuruteraan mekanikal.

III. METODOLOGI KAJIAN

3.1 Reka Bentuk Kajian, Populasi dan Sampel

Kajian ini menggunakan pendekatan kuantitatif dengan reka bentuk deskriptif bagi menilai tahap kefahaman dan penerimaan pelajar terhadap penggunaan kecerdasan buatan (AI) dalam pembelajaran kejuruteraan mekanikal. Instrumen utama yang digunakan ialah soal selidik, yang merangkumi profil demografi, tahap kefahaman terhadap AI, persepsi keberkesanan AI, serta faktor-faktor yang mempengaruhi penerimaan teknologi. Populasi kajian terdiri daripada pelajar baharu semester satu di Jabatan Kejuruteraan Mekanikal, Politeknik Kota Kinabalu bagi Sesi I:2025/2026, dengan seramai 235 orang dipilih sebagai sampel menggunakan pensampelan rawak mudah. Kaedah ini memastikan data yang diperoleh boleh dipercayai dan representatif, serta dianalisis secara kuantitatif untuk memberikan gambaran menyeluruh mengenai kefahaman dan penerimaan pelajar terhadap penggunaan AI dalam pembelajaran kejuruteraan mekanikal.

3.2 Instrumen Kajian

Instrumen utama bagi pengumpulan data dalam kajian ini ialah satu **soal selidik berstruktur** yang dibangunkan khusus untuk menilai tiga aspek utama:

i. Tahap kefahaman pelajar terhadap konsep dan

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aplikasi AI dalam kejuruteraan mekanikal.
ii. Tahap penerimaan pelajar terhadap penggunaan AI dalam pembelajaran.
iii. Faktor-faktor yang mempengaruhi kefahaman dan penerimaan pelajar terhadap AI.
Soal selidik ini mengandungi 21 item tertutup**,** di mana 15 item dinilai menggunakan skala Likert lima mata**:**
1 = Sangat Tidak Setuju,
2 = Tidak Setuju,
3 = Tidak Pasti,
4 = Setuju,
5 = Sangat Setuju.

Manakala 6 item lagi merangkumi maklumat demografi dan cadangan terbuka bagi menyokong dapatan kajian ini. Struktur soal selidik dibahagikan kepada beberapa bahagian seperti berikut:

Bahagian A: Maklumat Demografi (Soalan A1 – A4)

Bahagian ini mengumpul maklumat umum responden, termasuk jantina, umur, kelas semasa, serta pengalaman awal dengan teknologi AI atau perisian berasaskan AI.

Bahagian B: Tahap Kefahaman Pelajar terhadap AI (Soalan B1 – B5)

Bahagian ini menilai tahap penguasaan pelajar terhadap konsep AI dan aplikasinya dalam bidang kejuruteraan mekanikal. Aspek yang dinilai merangkumi pemahaman teori AI, penggunaan alat simulasi berasaskan AI, pengaplikasian AI dalam reka bentuk atau analisis sistem, serta kemampuan menyelesaikan masalah menggunakan AI secara kendiri.

Bahagian C: Tahap Penerimaan Pelajar terhadap Penggunaan AI (Soalan C1 – C4)

Bahagian ini menilai persepsi pelajar terhadap keberkesanan, kemudahan penggunaan, dan sikap mereka terhadap integrasi AI dalam proses pembelajaran. Skop soalan termasuk kesediaan pelajar menggunakan AI dalam tugasan, latihan dan projek, serta penerimaan terhadap perubahan kaedah PdP berasaskan teknologi AI.

Bahagian D: Faktor-faktor yang Mempengaruhi Kefahaman dan Penerimaan (Soalan D1 – D4)

Bahagian ini mengumpul data mengenai faktor yang mempengaruhi tahap kefahaman dan penerimaan pelajar, termasuk latar belakang pendidikan, pengalaman awal dengan teknologi, sokongan pensyarah, kemudahan infrastruktur, serta motivasi individu.

Bahagian E: Cadangan dan Penambahbaikan (Soalan E1 – E3)

Bahagian terakhir ini memberikan ruang kepada responden untuk mencadangkan penambahbaikan dalam penggunaan AI bagi menyokong pembelajaran kejuruteraan mekanikal, termasuk cadangan mengenai latihan, sumber pembelajaran, dan penyediaan kemudahan teknologi.

3.3 Kaedah Analisis Data

Analisis Deskriptif

Analisis deskriptif dijalankan untuk menentukan tahap kefahaman dan penerimaan pelajar terhadap penggunaan kecerdasan buatan (AI) dalam pembelajaran kejuruteraan mekanikal. Statistik skor min digunakan bagi mengenal pasti corak umum responden terhadap item-item soal selidik yang dikemukakan. Nilai skor min akan ditafsir berdasarkan skala pada Jadual 3.1 iaitu Jadual Intrerpretasi Skor Min seperti berikut:

Jadual 3.1: Jadual Interpretasi Skor Min

Julat Min	Tahap
1.00–2.33	Rendah
2.34–3.66	Sederhana
3.67–5.00	Tinggi

Hasil analisis deskriptif ini membolehkan penyelidik menilai sejauh mana pelajar memahami konsep AI, menerima penggunaan AI dalam pembelajaran, serta faktor-faktor yang mempengaruhi kefahaman dan penerimaan tersebut.

Ujian Korelasi Pearson

Ujian korelasi Pearson digunakan untuk mengenal pasti hubungan antara tahap kefahaman pelajar (pemboleh ubah bersandar) dengan tahap penerimaan mereka terhadap penggunaan AI (pemboleh ubah bebas). Analisis ini membantu menentukan sama ada wujud hubungan yang signifikan antara kefahaman pelajar dan penerimaan teknologi AI dalam konteks pembelajaran kejuruteraan mekanikal. Koefisien korelasi Pearson (r) akan ditafsir mengikut Jadual 3.2 iaitu Jadual Koefisien Korelasi Pearson (r) seperti berikut:

Jadual 3.2: Jadual Koefisien Korelasi Pearson (r)

Nilai r	Hubungan
0.00–0.19	Sangat lemah
0.20–0.39	Lemah
0.40–0.59	Sederhana
0.60–0.79	Kuat
0.80–1.00	Sangat kuat

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Ujian korelasi ini akan menggunakan aras keertian (**$p < 0.05$**) untuk menentukan sama ada hubungan yang diperoleh adalah signifikan secara statistik. Analisis ini membolehkan penyelidik membuat kesimpulan mengenai sejauh mana kefahaman pelajar terhadap AI mempengaruhi penerimaan mereka terhadap teknologi tersebut dalam pembelajaran kejuruteraan.

IV. DAPATAN KAJIAN

4.1 Tahap Kefahaman Responden Terhadap Kecerdasan Buatan (AI)

Jadual 4.1 menunjukkan skor min bagi tahap kefahaman responden terhadap Kecerdasan Buatan (AI) berada pada tahap sederhana ke tinggi**.** Item B3 mencatat skor min tertinggi (M = 4.26), menunjukkan responden mempunyai pendedahan yang baik terhadap penggunaan AI, manakala item B5 (M = 3.75) menunjukkan kefahaman terhadap peranan AI dalam membantu kerja dan pembelajaran. Namun begitu, item berkaitan kefahaman konsep asas AI dan perbezaan AI dengan automasi biasa mencatat skor min sederhana, menandakan keperluan untuk memperkukuhkan kefahaman konseptual melalui pendedahan dan latihan yang lebih sistematik.

Jadual 4.1: Skor Min Tahap Kefahaman Responden Terhadap Kecerdasan Buatan (AI)

Bil	Item	Skor Min
B1	Saya mengetahui maksud asas Kecerdasan Buatan (AI).	3.43
B2	Saya tahu AI digunakan dalam bidang kejuruteraan / teknikal.	3.63
B3	Saya pernah melihat atau menggunakan aplikasi berasaskan AI.	4.26
B4	Saya tahu perbezaan antara AI dan automasi biasa.	3.53
B5	Saya faham bagaimana AI boleh membantu kerja atau pembelajaran.	3.75
	Skor Min Keseluruhan	**3.72**

4.2 Tahap Penerimaan Responden Terhadap Penggunaan Kecerdasan Buatan (AI)

Jadual 4.2 menunjukkan bahawa skor min bagi tahap penerimaan responden terhadap penggunaan Kecerdasan Buatan (AI) berada pada tahap tinggi bagi semua item yang dikaji. Item C1 mencatat skor min tertinggi (M = 4.36), menunjukkan minat yang tinggi untuk mempelajari AI, diikuti keterbukaan menerima penggunaan AI dalam pembelajaran melalui item C2 (M = 4.31). Skor min yang tinggi bagi item C3 dan C4 (M = 4.26) pula mencerminkan keyakinan responden terhadap manfaat AI dalam pemahaman konsep teknikal serta pembelajaran dan kerjaya, manakala item C5 walaupun mencatat skor min yang sedikit lebih rendah (M = 3.73), masih menunjukkan sokongan yang positif terhadap integrasi AI dalam silibus pembelajaran.

Jadual 4.2: Skor Min Tahap Penerimaan Responden Terhadap Penggunaan Kecerdasan Buatan (AI)

Bil	Item	Skor Min
C1	Saya berminat untuk belajar lebih lanjut tentang AI.	4.36
C2	Saya terbuka menerima penggunaan AI dalam pembelajaran.	4.31
C3	AI mampu memudahkan pemahaman konsep kejuruteraan/teknikal.	4.26
C4	Saya yakin AI akan membantu saya dalam pembelajaran/kerjaya.	4.26
C5	AI patut dijadikan sebahagian daripada silibus pembelajaran.	3.73
	Skor Min Keseluruhan	**4.18**

4.3 Faktor yang Mempengaruhi Kefahaman dan Penerimaan Kecerdasan Buatan (AI)

Jadual 4.3 menunjukkan bahawa skor min bagi faktor-faktor yang mempengaruhi kefahaman dan penerimaan responden terhadap Kecerdasan Buatan (AI) berada pada tahap sederhana**,** kecuali faktor minat terhadap teknologi yang berada pada tahap tinggi. Item D5 mencatat skor min tertinggi (M = 3.97), menandakan minat terhadap teknologi sebagai faktor utama yang mendorong kefahaman dan penerimaan AI. Sebaliknya, kekurangan pendedahan awal serta bahan rujukan (D1 dan D2) dikenal pasti sebagai kekangan, manakala faktor sokongan melalui penerangan dan pembelajaran kendiri (D3 dan D4) menunjukkan peranan yang penting tetapi masih perlu diperkukuhkan bagi meningkatkan keberkesanan pembelajaran AI.

Jadual 4.3: Skor Min Faktor yang Mempengaruhi Kefahaman dan Penerimaan Kecerdasan Buatan (AI)

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Bil	Item	Skor Min
D1	Saya kurang didedahkan kepada AI sebelum mengikuti pembelajaran ini.	2.77
D2	Kekurangan bahan atau rujukan menghalang saya memahami AI.	2.92
D3	Penerangan daripada pensyarah / orang lain membantu kefahaman AI saya.	3.31
D4	Saya belajar AI secara kendiri melalui video atau sumber dalam talian.	3.48
D5	Minat terhadap teknologi mendorong saya mempelajari AI.	3.97
	Skor Min Keseluruhan	**3.29**

4.4 Ujian Korelasi Pearson antara Tahap Kefahaman dan Tahap Penerimaan Penggunaan AI

Ujian Korelasi Pearson telah dijalankan bagi mengenal pasti hubungan antara tahap kefahaman responden terhadap Kecerdasan Buatan (AI) dan tahap penerimaan penggunaan AI. Dapatan kajian menunjukkan terdapat hubungan positif yang signifikan antara kedua-dua pemboleh ubah, dengan nilai korelasi r = 0.46, $p < .01$, yang berada pada tahap sederhana.

Dapatan ini menunjukkan bahawa semakin tinggi tahap kefahaman responden terhadap AI, semakin tinggi tahap penerimaan mereka terhadap penggunaannya dalam pembelajaran dan kerjaya. Oleh itu, hipotesis nol (H_0) adalah ditolak dan hipotesis alternatif (H_1) diterima, sekali gus membuktikan kepentingan kefahaman AI dalam membentuk penerimaan teknologi tersebut.

Jadual 4.4: Hubungan antara Tahap Kefahaman dan Tahap Penerimaan Penggunaan AI

Pemboleh Ubah	Koefisien Korelasi (r)	Nilai p	Keertian
Tahap Kefahaman AI & Tahap Penerimaan AI	0.46	< 0.001	Signifikan

V. PERBINCANGAN DAN CADANGAN

5.1 Perbincanagn Mengikut Objektif Kajian

i) Tahap Kefahaman Responden Terhadap Kecerdasan Buatan (AI)

Berdasarkan analisis skor min dalam Jadual 4.1, tahap kefahaman responden terhadap Kecerdasan Buatan (AI) berada pada tahap sederhana ke tinggi dengan skor min keseluruhan 3.72 dalam kalangan pelajar di Politeknik Kota Kinabalu. Item B3 mencatat skor min tertinggi (4.26), menunjukkan kebanyakan responden pernah melihat atau menggunakan aplikasi berasaskan AI, manakala item B5 (3.75) menunjukkan mereka memahami peranan AI dalam membantu kerja dan pembelajaran. Walau bagaimanapun, item berkaitan kefahaman konsep asas AI serta perbezaan antara AI dan automasi biasa mencatat skor min sederhana, menandakan bahawa walaupun pelajar mempunyai pendedahan kepada penggunaan AI, kefahaman teori mereka masih perlu diperkukuhkan melalui integrasi topik AI dalam silibus, bengkel praktikal, dan aktiviti pembelajaran berasaskan projek agar pemahaman mereka menjadi lebih menyeluruh dan aplikatif dalam bidang kejuruteraan (Abdul Jalil, D., 2024).

ii) Tahap Penerimaan Responden Terhadap Penggunaan Kecerdasan Buatan (AI)

Berdasarkan analisis dalam Jadual 4.2, tahap penerimaan responden terhadap penggunaan Kecerdasan Buatan (AI) berada pada tahap tinggi dengan skor min keseluruhan 4.18. Item C1 mencatat skor min tertinggi (4.36), menunjukkan minat yang tinggi untuk mempelajari AI, diikuti item C2 (4.31) yang menunjukkan keterbukaan responden menerima penggunaan AI dalam pembelajaran. Skor min yang tinggi bagi item C3 dan C4 (4.26) pula mencerminkan keyakinan pelajar terhadap keupayaan AI dalam membantu pemahaman konsep teknikal serta menyokong pembelajaran dan kerjaya masa depan, manakala item C5 walaupun mencatat skor min sedikit lebih rendah (3.73), masih menunjukkan sokongan positif terhadap integrasi AI dalam silibus. Dapatan ini menunjukkan pelajar mempunyai sikap yang sangat positif terhadap penggunaan AI, sejajar dengan kajian terdahulu yang menunjukkan bahawa penerimaan teknologi meningkat apabila pelajar memahami manfaat dan aplikasinya (Sabran, S. et al., 2025).

iii) Faktor yang Mempengaruhi Kefahaman dan Penerimaan Kecerdasan Buatan (AI)

Berdasarkan dapatan dalam Jadual 4.3, faktor yang mempengaruhi kefahaman dan penerimaan responden terhadap AI berada pada tahap sederhana dengan skor min keseluruhan 3.29. Item D5 mencatat skor min tertinggi (3.97), menunjukkan minat terhadap teknologi merupakan faktor utama yang mendorong pelajar memahami dan menerima

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AI, manakala item D1 dan D2 dengan skor min lebih rendah menunjukkan kekurangan pendedahan awal serta bahan rujukan sebagai antara kekangan utama. Item D3 dan D4 pula menunjukkan bahawa penerangan pensyarah dan pembelajaran kendiri melalui sumber dalam talian memainkan peranan penting dalam meningkatkan kefahaman, namun masih perlu diperkukuhkan melalui penyediaan bahan rujukan sistematik, latihan praktikal, serta sokongan pembelajaran berstruktur (Abd Razak, R. H., & Mohd Rusli, N. F., 2022). Secara keseluruhannya, dapatan ini menunjukkan bahawa walaupun pelajar mempunyai minat terhadap teknologi, usaha lebih menyeluruh dari segi pendedahan awal, sokongan pensyarah, dan penyediaan sumber pembelajaran diperlukan bagi meningkatkan kefahaman dan penerimaan AI secara lebih berkesan dalam konteks pendidikan kejuruteraan.

iv) Hubungan antara Tahap Kefahaman dan Tahap Penerimaan Penggunaan AI

Berdasarkan ujian Korelasi Pearson dalam Jadual 4.4, terdapat hubungan positif yang signifikan antara tahap kefahaman responden terhadap AI dan tahap penerimaan penggunaan AI dengan nilai $r = 0.46$, $p < .01$. Nilai korelasi pada tahap sederhana ini menunjukkan bahawa peningkatan kefahaman pelajar terhadap konsep dan aplikasi AI berkait rapat dengan peningkatan penerimaan mereka terhadap penggunaan AI dalam pembelajaran serta kerjaya masa depan. Dapatan ini sejajar dengan model penerimaan teknologi dan kajian terdahulu yang menunjukkan kefahaman teknologi menyokong penerimaan pengguna terhadap inovasi digital (Hashim, S. et al., 2024). Oleh itu, pendedahan ilmu AI yang lebih sistematik dan berstruktur mampu meningkatkan sikap positif pelajar terhadap teknologi tersebut, sekaligus menyokong penolakan hipotesis nol (H_0) dan penerimaan hipotesis alternatif (H_1).

5.2 Cadangan Kajian

Berdasarkan dapatan kajian, berikut ialah cadangan praktikal yang boleh dipertimbangkan oleh pensyarah, pihak institusi dan pembuat dasar:

i. Integrasi topik asas AI dalam silibus awal kejuruteraan – Pelajar perlu diberi pendedahan awal terhadap konsep asas Kecerdasan Buatan (AI) supaya mereka memahami perbezaan antara AI dan automasi serta aplikasi AI dalam bidang teknikal. Integrasi secara berperingkat dalam kursus pengenalan kejuruteraan dapat meningkatkan kefahaman dan penerimaan pelajar terhadap teknologi ini.

ii. Pembangunan modul latihan digital dan tutorial AI – Penyediaan bahan pembelajaran seperti video tutorial, nota interaktif dan contoh projek AI yang boleh diakses pada bila-bila masa akan membantu pelajar mengulang kaji serta memahami konsep AI dengan lebih mendalam. Pensyarah disarankan membangunkan kandungan pembelajaran berkaitan aplikasi AI dalam CAD, simulasi dan analisis teknikal.

iii. Latihan peningkatan profesional untuk pensyarah – Pensyarah perlu didedahkan kepada teknologi AI terkini dan pendekatan pengajaran inovatif supaya mereka lebih yakin dalam menyampaikan kandungan berkaitan AI. Program latihan atau kursus profesional berkaitan AI dapat meningkatkan kualiti pengajaran dan keberkesanan pembelajaran pelajar.

iv. Pendekatan pembelajaran berasaskan projek AI – Pelajar boleh diberikan tugasan projek mini yang menggunakan aplikasi AI dalam reka bentuk atau analisis kejuruteraan bagi meningkatkan pemahaman praktikal. Kaedah ini dapat menggalakkan kreativiti, pemikiran kritikal dan kemahiran penyelesaian masalah dalam kalangan pelajar.

v. Kolaborasi industri dan penggunaan teknologi pembelajaran interaktif – Kerjasama dengan industri yang menggunakan AI serta penggunaan platform pembelajaran interaktif seperti LMS, simulasi atau teknologi AR/VR dapat meningkatkan minat dan pemahaman pelajar terhadap topik AI yang kompleks. Pendedahan kepada situasi sebenar industri juga membantu pelajar memahami kepentingan AI dalam kerjaya masa depan.

5.3 Impak dan Sumbangan Kajian

Dapatan dan cadangan kajian ini diharap dapat:

i. Memberikan gambaran yang jelas mengenai tahap kefahaman dan penerimaan pelajar terhadap Kecerdasan Buatan (AI), termasuk kekuatan dan kelemahan utama dalam aspek konseptual serta aplikasi dalam pembelajaran teknikal.

ii. Mengenal pasti faktor-faktor yang mempengaruhi kefahaman dan penerimaan AI, khususnya minat terhadap teknologi, pendedahan awal, bahan rujukan, serta sokongan pensyarah dan pembelajaran kendiri.

iii. Memberi cadangan praktikal bagi meningkatkan keberkesanan pengajaran dan pembelajaran AI, termasuk keperluan modul latihan digital, bengkel praktikal, dan pendekatan pedagogi berasaskan projek.

iv. Menyumbang kepada pengukuhan kandungan kurikulum Kejuruteraan Mekanikal, melalui

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integrasi elemen AI yang lebih sistematik dan relevan dengan keperluan industri semasa.

v. Menjadi asas kepada penyelidikan lanjutan berkaitan integrasi AI dalam pendidikan teknikal**,** termasuk pembangunan modul interaktif, kajian keberkesanan pedagogi digital, atau pembangunan sistem sokongan pembelajaran berasaskan AI untuk pelajar politeknik.

5.4 Cadangan Kajian Lanjutan

Bagi memperluas skop penyelidikan pada masa hadapan, beberapa cadangan kajian lanjutan boleh dilakukan oleh penyelidik akan datang seperti berikut:

i. Penilaian terhadap keberkesanan modul pembelajaran AI dalam pendidikan kejuruteraan**,** khususnya dari segi peningkatan kefahaman dan penerimaan pelajar.

ii. Perbandingan tahap kefahaman dan penerimaan AI antara politeknik atau institusi teknikal yang berbeza**,** bagi melihat perbezaan pendekatan dan keberkesanan pelaksanaan.

iii. Penyelidikan tentang penggunaan teknologi interaktif seperti AR/VR dalam pengajaran AI dan topik teknikal**,** bagi menilai impaknya terhadap motivasi dan pemahaman pelajar.

iv. Kajian tentang kesan penggunaan sistem pembelajaran berasaskan AI dalam proses pengajaran dan pembelajaran**,** termasuk analisis hubungan antara kefahaman, penerimaan dan pencapaian akademik pelajar.

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KAJIAN AWAL KEFAHAMAN PELAJAR UPNM MENGENAI ISU PERCERAIAN DAN SOLUSI BERDASARKAN PERSPEKTIF ISLAM

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Abstrak

Kajian ini bertujuan meneliti kefahaman awal pelajar Universiti Pertahanan Nasional Malaysia (UPNM) terhadap isu perceraian dalam kalangan pasangan Muslim di Malaysia. Kajian ini mengenal pasti faktor konflik rumah tangga serta implikasi perceraian terhadap kesejahteraan sosial dan kestabilan institusi keluarga. Pendekatan campuran digunakan melalui analisis kandungan dan soal selidik dalam talian melibatkan 191 orang pelajar Pegawai Kadet UPNM. Data dianalisis secara deskriptif bagi mendapatkan kekerapan dan peratusan. Dapatan menunjukkan bahawa faktor utama perceraian ialah masalah kewangan, ketidakserasian, keganasan rumah tangga dan komunikasi yang lemah. Perceraian juga memberi kesan terhadap emosi, hubungan sosial dan kestabilan keluarga. Kajian ini menegaskan kepentingan pendedahan awal kepada golongan muda berkaitan pengurusan konflik rumah tangga menurut perspektif Islam bagi membentuk masyarakat yang lebih sejahtera.

Abstract

This study examines the preliminary understanding of Universiti Pertahanan Nasional Malaysia (UPNM) students regarding divorce issues among Muslim couples in Malaysia. The study identifies contributing factors to marital conflict and examines the implications of divorce on social well-being and family stability. A mixed-method approach was employed using content analysis and an online survey involving 191 Officer Cadet students. The data were analysed descriptively to obtain frequencies and percentages. The findings indicate that financial problems, incompatibility, domestic violence, and weak communication are the main contributing factors. Divorce also affects emotional well-being, social relationships, and family stability. The study highlights the importance of early exposure among youth to conflict management from an Islamic perspective.

Keywords **:** *Perceraian; konflik rumah tangga; pelajar UPNM; perspektif Islam; komunikasi; keluarga*

I. PENGENALAN

Perkahwinan secara umum merupakan satu ikatan yang sah antara dua individu yang bersetuju untuk hidup bersama dalam sebuah hubungan yang berlandaskan kasih sayang, tanggungjawab dan komitmen yang berpanjangan dalam mengekalkan hubungan secara harmoni. Pernikahan merupakan sebuah institusi yang mendalam dan kaya akan makna dalam memegang peranan sentral menurut pandangan hukum Islam serta pernikahan bukan sekadar ikatan antara dua individu melainkan sebuah konsep yang merangkul nilai-nilai agama, moral dan sosial [1]. Perkahwinan juga merupakan satu ikatan yang suci dalam Islam untuk membina sebuah institusi kekeluargaan. Di sebalik keindahannya, perkahwinan juga menuntut kematangan dalam membuat keputusan dan kesabaran dalam menghadapi cabaran serta menekankan kebijaksanaan dalam menyesuaikan perbezaan antara dua individu yang datang dari latar belakang yang berbeza. Oleh itu, perkahwinan bukan hanya sekadar memenuhi keperluan emosi atau budaya tetapi merupakan satu bentuk perkongsian hidup yang menuntut kejujuran, tolak ansur dan usaha berterusan bagi mencapai kesejahteraan bersama.

Tambahan pula, perkahwinan juga adalah suatu tuntutan agama dalam meraikan fitrah semula jadi penciptaan manusia untuk hidup secara berpasang-pasangan serta dalam memenuhi keinginan hati dan nurani dalam mendapatkan rasa cinta dari orang yang ingin dijadikan teman serumah. Setiap pasangan yang ingin membina mahligai cinta seharusnya mempunyai ilmu pengetahuan berkaitan syarat-syarat, hukum-hukum dalam perkahwinan agar satu ikatan perkahwinan itu sah di sisi syarak dan undang-undang. Berikut juga disertakan dalil berkaitan tuntutan agama dalam

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perkahwinan seperti dalam Surah An-Nisaa' 4; Ayat 1 :

"Wahai sekalian manusia! Bertakwalah kepada Tuhan-mu yang telah menciptakan kamu dari diri yang satu, dan daripadanya Allah menciptakan isterinya; Dan daripada keduanya Allah memperkembang biakkan lelaki dan perempuan yang ramai. Dan bertakwalah kepada Allah yang dengan (mempergunakan) nama-Nya kamu saling meminta satu sama lain, dan (peliharalah) hubungan silaturahmi. Sesungguhnya Allah selalu menjaga dan mengawasi kamu."

Namun jika dilihat dari perspektif dan realiti dunia semasa, masyarakat sering terpalit dengan isu perceraian yang telah menghantui setiap institusi kekeluargaan. Perceraian telah menjadi perkara lazim dan buah mulut dalam kalangan masyarakat muslim di negara kita. Persoalannya, mengapakah mutakhir ini isu kekeluargaan di negara ini semakin diperbincangkan dengan acap kali. Soal keruntuhan institusi keluarga yang tidak dapat bertahan lama dan pelbagai kes yang tidak sihat sering berlaku dalam keluarga. Perceraian ini juga berlaku terhadap pasangan yang baru sahaja menjejakkan langkah dalam membina rumah tangga. Perceraian awal perkahwinan merujuk kepada perceraian atau pembubaran perkahwinan yang berlaku pada fasa awal perkahwinan [17]. Fenomena ini menimbulkan persoalan besar terhadap kesediaan pasangan dalam menghadapi realiti perkahwinan yang sebenar. Mengetahui hakikat kehidupan berkeluarga, sejak awal lagi Islam telah meletakkan satu garis panduan dalam memilih pasangan agar bahtera perkahwinan yang bakal dilayarkan dapat belayar dengan aman. Sekiranya badai melanda di tengah-tengah pelayaran, nakhoda tahu akan tugasnya untuk mengendali dan memandu bahtera tersebut betul pada laluannya kembali. Oleh itu, Islam menyarankan umatnya untuk mencari dan memilih pasangan hidup yang dirasakan bersesuaian, selesa serta serasi dengan mereka bagi menjamin kehidupan yang lebih bahagia dan teratur [15].

Sehubungan itu, menjadi tanggungjawab terhadap kita untuk menelusuri dan memahami punca perceraian, kesan serta kefahaman awal golongan muda terhadap cara menangani isu ini dari perspektif pendekatan Islam dan realiti dunia semasa.

II. SOROTAN LITERATUR

Tujuan utama kajian lepas ini adalah bagi memberi pendedahan yang lebih terperinci dan jelas terhadap masyarakat muslim di negara ini tentang konsep perceraian serta impaknya terhadap dalam pelbagai aspek. Pendedahan ini perlu diberikan bagi menemukan jalan keluar daripada isu hangat ini. Menurut Ketua Perangkawan, Datuk Sri Dr. Mohd Uzir Mahidin kadar perceraian di negara ini pada tahun 2022 meningkat 43.1% iaitu 62,890 berbanding tahun sebelumnya 43,936 dan daripada jumlah itu pada tahun 2022, kumpulan umur yang tinggi kadar perceraiannya adalah 35-39 tahun bagi pengantin lelaki, sementara pengantin perempuan di kumpulan umur 30-34 tahun [6]. Polemik ini menunjukkan bahawa isu perceraian kian meningkat saban tahun dalam kalangan masyarakat di negara ini serta menjadi isu yang perlu diberi perhatian.

Selain itu, kegagalan pasangan suami isteri memainkan peranan masing-masing akan menyumbang kepada konflik dan ketidakstabilan dalam rumahtangga. Perkahwinan merupakan satu kitaran hidup yang dibangunkan oleh komunikasi, jangkaan, penyesuaian dan pencapaian [12]. Isu komunikasi dua hala yang baik juga telah diberi penekanan dalam kajian ini. Peranan kemahiran dan teknik komunikasi yang lemah juga akan memburukkan perselisihan dalam rumah tangga [12]. Sebagai contoh, gagal mendengar dengan baik, cepat menghukum dan membuat kesimpulan, mengamalkan komunikasi satu hala, tidak berterus terang dan telus serta mengelak daripada perbincangan. Berdasarkan dapatan ini saya berpendapat bahawa komunikasi dua hala yang telus menjadi kunci utama dalam sesebuah perkahwinan dalam mengelakkan konflik yang berterusan.

Pasangan muda yang mula mencipta kehidupan baharu di alam perkahwinan juga turut menghadapi cabaran dalam mengekalkan hubungan yang utuh. Statistik perceraian mengikut umur pula menunjukkan *trend* yang sama sejak lima tahun kebelakangan ini iaitu bagi umur penengah 30 hingga 34 tahun dan 25 hingga 29 tahun mencatatkan jumlah kes perceraian tertinggi [11]. Tidak dinafikan bahawa golongan muda ini perlu lebih berhati-hati serta mempersiapkan diri dengan pelbagai aspek seperti kematangan dan pola pemikiran yang baik agar rintangan dapat dilalui dengan professional dan rasional. Proses komunikasi pasangan suami isteri yang baru menikah sangatlah penting dengan cara memahami dan menjalani peranan masing masing dalam keluarga, menetapkan prioriti terhadap aktiviti yang menjadi tanggungjawab dalam keluarga dan merangka strategi komunikasi yang disepakati oleh kedua-duanya untuk melakukan apa sahaja yang akan dijalani selama menjalani kehidupan berumah tangga [7].

Di samping itu, keganasan rumah tangga juga turut menyumbang kepada berlakunya perpisahan antara pasangan khususnya apabila berlaku penderaan fizikal, emosi atau psikologi yang berterusan sehingga menjejaskan kesejahteraan serta keselamatan mangsa. Dalam konteks ini, ketidakseimbangan kuasa dalam hubungan dan kegagalan komunikasi berkesan sering menjadi

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pemangkin kepada konflik yang berakhir dengan perceraian. Kajian menunjukkan bahawa individu yang mengalami keganasan domestik cenderung untuk mengambil keputusan berpisah sebagai satu bentuk perlindungan diri dan langkah pemulihan emosi, sejajar dengan prinsip maqasid syariah yang menekankan pemeliharaan nyawa, maruah dan kesejahteraan keluarga [18]. Keganasan rumah tangga turut didefinisikan sebagai satu corak keganasan, penderaan, ugutan yang digunakan untuk mengawal atau mengekalkan kuasa ke atas pasangan sama ada yang sedang atau pernah berada dalam hubungan intim [5]. Islam juga turut melarang perbuatan menzalimi orang lain kerana kezaliman bukan sahaja merosakkan hubungan sesama manusia, malah mengundang kemurkaan Allah SWT serta menghapuskan keberkatan dalam kehidupan. Diantara ayat-ayat tersebut adalah firman Allah: “Siapa di antara kalian yang berbuat zalim, nescaya Kami menimpakan kepadanya azab yang besar”. (QS. Al Furqan : 19).

Kegagalan suami untuk memenuhi keperluan kewangan serta nafkah terhadap keluarga merupakan salah satu punca utama konflik rumah tangga yang membawa kepada tekanan psikologi khususnya kepada isteri. Ketidakseimbangan dalam pembahagian tanggungjawab ekonomi antara pasangan boleh menyebabkan isteri mengalami gejala kemurungan [14]. Ketidakfungsian peranan dalam sistem keluarga juga boleh menjejaskan kestabilan emosi pasangan, terutama apabila salah seorang gagal melaksanakan peranan utama dalam keluarga [14]. Kenyataan ini membuka minda saya bahawa aliran pengurusan kewangan yang baik dan corak gaya hidup dalam pembahagian tanggungjawab amat mempengaruhi status sesebuah keluarga tersebut. Sekiranya ketua keluarga mampu menguruskan kewangan dengan baik nescaya konflik dan bebanan dalam membiayai ahli keluarga dapat dicantas.

Seterusnya, anak-anak yang hadir daripada keluarga yang bercerai pasti mengalami masalah gangguan emosi dan perasaan. Antara emosi-emosi yang sering dikaitkan dengan anak-anak apabila ibu bapa mereka bercerai adalah perasaan sedih, tertekan, malu, marah, benci, bersalah dan sebagainya [19]. Perkara ini juga dapat memberi impak negatif terhadap tindakan anak-anak mereka dalam kehidupan seharian. Seseorang individu yang tertekan emosinya akan menunjukkan gejala seperti agresif, mudah memberontak, marah yang tidak dapat dikawal, kemurungan, penyakit mental dan berpotensi membunuh diri [19]. Isu ini tidak boleh dipandang enteng kerana turut dapat menjejaskan keharmonian sosial masyarakat di negara ini.

Perceraian juga turut memberi reaksi besar terhadap kehidupan seorang ibu tunggal dalam menjalani kehidupan seharian. Isu yang sering kali dikaitkan dengan sebahagian besar ibu tunggal adalah kesempitan hidup yang dialami apabila terpaksa menjadi Ketua Isi Rumah (KIR) yang perlu memenuhi keperluan ahli keluarga lebih-lebih lagi ibu tunggal yang mempunyai anak di bawah tanggungannya [16]. Pada hakikatnya, kebanyakan golongan ibu tunggal mengalami kesukaran menjaga ahli lain dalam keluarga dan membesarkan anak kerana mereka sudah hilang sebahagian besar pendapatan yang sebelum ini yang diberikan oleh suami [16]. Melalui kajian lepas yang telah diteliti amat penting untuk seorang wanita mencari pekerjaan yang stabil sejak awal percintaan bagi mempersiapkan diri dengan segala kemungkinan yang berlaku sekiranya perceraian menjadi solusi terkakhir dalam sesebuah perpisahan keluarga dan tidak hanya mengharapkan sumber daripada pasangan.

Perkahwinan kini turut memakan kos yang banyak hingga menyebabkan pengantin terbeban setelah memulakan kehidupan sebenar setelah alam pernikahan. Dari aspek pelaksanaan syariat Islam, Al-Taysīr merujuk kepada berpegang kepada hukum hakam agama sepertimana yang dikehendaki oleh Allah SWT dan beramal dengannya melalui konsep mempermudahkan . Konsep ini merupakan salah satu ciri atau keistimewaan syariat Islam [9]. Perbelanjaan dan gaya hidup yang keterlaluan tanpa pengawalan juga menyebabkan berlakunya perceraian kerana berlakunya pembaziran serta kurang sumber kewangan. Secara semulajadinya, jiwa manusia lebih cenderung kepada sesuatu yang mudah dan berusaha untuk mengelakkan dari sebarang kesusahan dan kesukaran [9]. Oleh itu, setiap pasangan perlulah merancang perbelanjaan dengan baik sejak awal pernikahan agar tidak menanggung kesusahan setelah memulakan realiti kehidupan berumah tangga yang dapat menyumbang kepada perceraian. Konsep Al- Taysir jelas menggalakkan untuk umat islam hidup dalam kesederhanaan.

Kajian terkini menunjukkan bahawa peningkatan kadar perceraian dalam kalangan pasangan muda berkait rapat dengan faktor komunikasi, tekanan ekonomi dan ketidakmatangan emosi [8]. Hal ini menunjukkan keperluan pendekatan yang lebih sistematik dalam pendidikan kekeluargaan.

Secara keseluruhannya, sorotan literatur ini memperlihatkan bahawa isu perceraian tidak lagi boleh dianggap sebagai masalah individu semata-mata, sebaliknya merupakan fenomena sosial yang memberi kesan menyeluruh terhadap struktur keluarga, perkembangan anak-anak, kestabilan kewangan serta kesejahteraan mental. Oleh itu, dapatan ini menegaskan keperluan intervensi bersepadu dari aspek dasar undang-undang dan sokongan komuniti untuk menangani kesan perceraian secara holistik dan berkesan dalam masyarakat Malaysia.

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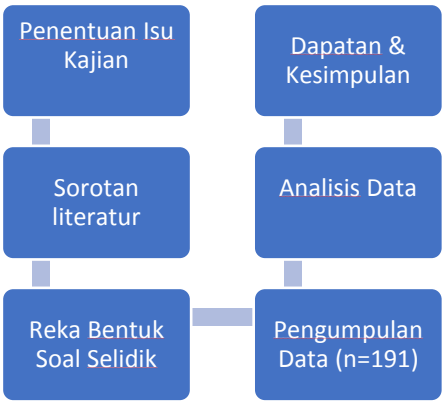
III. METODOLOGI KAJIAN

Kajian ini menggunakan pendekatan campuran (mixed-method) yang menggabungkan analisis kualitatif dan kuantitatif. Pendekatan kualitatif melibatkan analisis kandungan terhadap sumber sekunder seperti artikel jurnal, laporan dan sumber Islam. Pendekatan kuantitatif pula menggunakan kaedah tinjauan melalui soal selidik dalam talian. Sebanyak 203 borang diedarkan dan 191 respons lengkap dianalisis. Instrumen kajian menggunakan skala Likert lima mata bagi menilai tahap kefahaman responden. Data dianalisis menggunakan analisis deskriptif bagi mendapatkan kekerapan dan peratusan.



Rajah 1: Proses Kajian

IV. DAPATAN KAJIAN

Seramai 191 orang pelajar Pegawai Kadet UPNM yang beragama Islam telah menjawab secara sukarela borang kaji selidik yang di edar atas talian dalam tinjauan terhadap kefahaman berkaitan isu-isu perceraian yang berlaku dalam kalangan masyarakat kini.

Bahagian A daripada kajian soalan adalah berkaitan maklumat demografi responden. Kajian ini hanya melibatkan pelajar Pegawai Kadet Tahun 3 dan Tahun 4 daripada UPNM. Jumlah responden adalah seramai 191 orang. Kajian telah menunjukkan sebanyak 81.7% responden yang terdiri daripada Pegawai Kadet lelaki manakala sebanyak 18.3% terdiri daripada Pegawai Kadet wanita. Jumlah responden yang melibatkan pelajar Pegawai Kadet wanita lebih sedikit berbanding lelaki adalah kerana bilangan pengambilan pelajar Pegawai Kadet wanita setiap tahun adalah mengikut ratio 1:4.

Berdasarkan hasil kajian daripada 191 orang responden yang diselidik, Seramai 161 orang (84.3%) terdiri daripada umur 21 tahun dan 10 orang (5.2%) yang berumur 22 tahun. Lingkungan umur ini merupakan pelajar Pegawai Kadet Tahun 3 . Peratusan umur ini adalah merupakan peratusan majoriti kerana Pegawai Kadet Tahun 3 lebih ramai berbanding Pegawai Kadet Tahun 4. Selain itu, pada peringkat umur 23 tahun, adalah memperlihatkan hanya 20 orang (10.5%) sahaja yang memberikan maklum balas kerana mereka ini merupakan pelajar Pegawai Kadet tahun 4 yang mengambil jurusan kejuruteraan. Responden juga terdiri daripada pelbagai fakulti. Berdasarkan hasil kajian daripada 191 orang responden yang diselidik, seramai 96 orang responden bersamaan dengan 50.3% adalah dari FPPP. Responden dari FSTP pula menunjukkan sebanyak 66 orang yang mewakili peratusan sebanyak 34.6%. Data juga menunjukkan seramai 20 orang (10.5%) responden dari FKJ dan 7 orang (3.6%) terdiri daripada pelajar APPI. Selain itu, bagi pelajar AKP adalah seramai 2 orang iaitu hanya mewakili 1% daripada keseluruhan kajian.

Bahagian B dari borang kaji selidik dianalisa bagi mengenalpasti pengetahuan am responden berkaitan konflik perceraian serta solusinya menurut perspektif Islam. hasil kajian daripada 191orang responden yang diselidik seramai 181orang responden (94.8%) mempunyai pengetahuan tentang isu konflik dalam perkahwinan. Seramai 10 orang (5.2%) pula tidak mempunyai pengetahuan tentang konflik yang berlaku dalam perkahwinan dunia kini. Hal ini menunjukkan bahawa ramai responden mempunyai pengetahuan asas dan mengambil cakna tentang isu perkahwinan yang berlaku kini.

A) Punca Utama Konflik Dalam Perkahwinan

Punca Utama Konflik	Peratus
1.Kewangan	42.4%
2.Ketidakserasian	31.9%
3.Keganasan Rumah Tangga	21.5%
4.Perhubungan Jarak Jauh	3.7%
5.Pengkhianatan dalam Rumah Tangga	0.5%

Jadual 1: Punca Utama Konflik

Kajian menunjukkan seramai 81 orang responden (42.4%) menyatakan bahawa masalah kewangan menjadi punca utama terhadap konflik rumah tangga manakala sebanyak 61 orang (31.9%) berpendapat bahawa ketidakserasian menjadi asbab konflik dalam perkahwinan. Peratusan yang menyatakan keganasan rumah tangga sebagai punca utama konflik adalah sebanyak 21.5% yang mewakili

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seramai 41 orang responden. Seramai 7 orang (3.7%) pula berpandangan perhubungan jarak jauh punca tercetusnya konflik dan seramai 1 orang (0.5%) yang memilih pengkhianatan rumah tangga sebagai punca konflik dalam perkahwinan. Data ini menunjukkan bahawa ramai responden menyatakan masalah kewangan atau ekonomi sebagai pencetus kepada konflik antara suami dan isteri. Hal ini amat signifikan dengan keadaan pasangan muda hari ini kerana terdapat situasi dimana pasangan muda gagal untuk melakukan penyesuaian dan perubahan hidup untuk menangani konflik, terutamanya konflik yang tercetus daripada krisis kewangan hingga harus mengorbankan banyak keinginan dan kemahuan mereka untuk memastikan keperluan utama dapat dipenuhi [12].

B) Pengalaman Terhadap Situasi Konflik Perkahwinan Ibu Bapa

Pengalaman Konflik dalam Keluarga	Peratus
1.Ya	42.4%
2.Tidak	31.9%

Jadual 2: Pengalaman Konflik dalam Keluarga

Hasil kajian mendapati seramai 134 orang (70.2%) mempunyai pengalaman terlibat dengan konflik perkahwinan ibu bapa mereka. Seramai 57 orang(29.8%) pula tidak mempunyai pengalaman tersebut. Perkara ini menununjukkan majoriti responden pernah melihat dan menghadapi sendiri konflik yang berlaku dalam keluarga mereka. Jelaslah bahawa konflik ini ialah perkara lazim dalam mendirikan rumah tangga serta merupakan salah satu jalan dalam memupuk kesefahaman yang lebih harmoni. Cara penerimaan dan penyelesaian konflik tersebut adalah penting bagi mengelakkan kesan atau konflik berpanjangan.

C) Pengetahuan Keperluan *Kafaah* Dalam Rumah Tangga

Pengetahuan tentang *Kafaah*	Peratus
1.Ya	42.4%
2.Tidak	31.9%

Jadual 3: Pengetahuan tentang *Kafaah*

Berdasarkan hasil kajian daripada 191 orang responden yang diselidik seramai 160 orang (83.8%) mempunyai pengetahuan tentang keperluan Kafaah menurut Islam dalam perkahwinan manakala sebanyak 31 orang (16.2%) yang tidak mempunyai pendedahan tentang keperluan Kafaah. Hal ini menunjukkan ramai responden mempunyai pengetahuan asas berkenaan tuntutan Kafaah dalam mendirikan rumah tangga. Kafaah amat disarankan oleh Islam dan perlu diambil serius kerana kesilapan memilih pasangan menyebabkan konflik rumah tangga yang boleh menyebabkan perceraian [15].

D) Kefahaman Maksud Kafaah

Tahap Kefahaman Konsep *Kafaah*	Peratus
1.Mempunyai harta yang sama banyak	9.4%
2.Keserasian paras rupa	6.3%
3.Keturunan	3.7%
4.Aliran pemikiran dan pemahaman yang serasi	80.6%

Jadual 4: Tahap kefahaman konsep *Kafaah*

Hasil soal selidik yang dilakukan terhadap 191 orang responden, adalah menunjukkan bahawa para responden mempunyai pemahaman yang berbeza mengenai konsep Kafaah dalam perkahwinan. Bagi kefahaman mengenai Kafaah yang pertama iaitu “mempunyai harta yang sama banyak” adalah menunjukkan sebanyak 9.4% yang menganggap harta sebagai pengukur kepada keserasian. Sememangnya harta bukanlah segala-galanya yang dapat memberi kebahagiaan dalam kehidupan seseorang namun jurang pemilikan harta yang terlalu jauh juga akan menimbulkan lagi masalah kewangan hingga menjadi punca perceraian [15]. Manakala seramai 6.3% yang menilai paras rupa sebagai satu bentuk keserasian dalam perkahwinan atau memilih pasangan. Selain itu, kefahaman responden mengenai Kafaah merupakan sekufu dari segi keturunan adalah sebanyak 3.7% di mana mereka memandang keturunan sebagai satu aspek penting dan hal ini selari dengan tuntutan agama yang juga mementingkan keturunan dalam memastikan kestabilan keluarga. Penekanan harus diberikan pada pemahaman yang terkakhir di mana sebanyak 80.6% responden menafsir konsep Kafaah dalam perkahwinan sebagai satu bentuk aliran pemikiran dan pemahaman yang serasi. Sikap pasangan yang tidak serasi dari sudut budaya dan tidak mempunyai kesefahaman antara satu sama lain turut mempengaruhi punca perceraian ini berlaku dan telah menjadi satu bukti yang signifikan terhadap masalah ini [15].

E) Tanggungjawab dalam Menjamin Keharmonian Rumah Tangga

Pihak yang bertanggungjawab dalam keluarga	Peratus
1. Suami	9.9%
2.Isteri	6.8%
3.Suami dan Isteri	83.2%

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Jadual 5: Pihak yang bertanggungjawab dalam keluarga

Menurut hasil kajian soal selidik terhadap 191 responden yang dilakukan, seramai 19 orang (9.9%) yang menyatakan bahawa tanggungjawab sesebuah keluarga hanya terletak pada suami sahaja manakala seramai 13 orang (6.8%) pula menganggap keharmonian rumah tangga itu akan terjamin sekiranya isteri menjalankan peranan dengan baik. Peratusan tertinggi adalah sebanyak 83.2% yang mewakili seramai 159 responden dimana mereka menegaskan bahawa keharmonian sesebuah ruamh tangga memerlukan tanggungjawab bersama antara suami dan isteri. Justifikasi ini amat tepat dimana menurut sebuah kajian lepas yang telah dijalankan dimana responden mengambil keputusan untuk berpisah dengan bekas suami beliau yang bersikap lepas tangan dari aspek nafkah terhadap isteri beliau ekoran dari kemampuan pihak isteri menampung perbelanjaan diri dan anak mereka [14]. Hal ini menunjukkan bahwa ketidakseimbangan pembahagian tanggungjawab dalam rumah tangga menjadi pencetus utama kepada konflik dan tekanan mental dalam kalangan pasangan.

F) Relevansi Konsep Suami sebagai *Provider* dalam Masyarakat Moden

Relevensi suami *provider*	**Peratus**
1. Ya	63.9%
2.Tidak	6.8%

Jadual 6: Relevansi Suami *Provider*

Hasil kajian menunjukkan seramai 122 orang dengan peratusan sebanyak 63.9% menyatakan konsep suami sebagai seorang *provider* masih relevan dalam mendepani dunia kini. Seramai 69 orang (6.8%) pula tidak bersetuju bahawa konsep ini diaplikasikan pada zaman ini. Jika dilihat pada era moden ini, penglibatan wanita dalam pendidikan dan ekonomi mendorong kepada penafsiran peranan gender yang bercanggah. Namun Islam tetap melihat lelaki sebagai pemegang tanggungjawab kepimpinan (*qawwam)* yang seimbang dengan kewajipan melindungi serta memenuhi keperluan keluarga [4]. Islam turut melihat lelaki dan wanita mempunyai peranan yang berbeza tetapi saling melengkapi. Seseorang isteri perlu mempunyai kesedaran dalam menilai tahap kemampuan suami dalam memberi nafkah agar tidak membebankan suami hingga berlakunya konflik. Isteri yang bekerja boleh membantu suami jika ia membawa maslahah kepada keluarga, namun ia tidak sekali-kali mengangkat darjatnya menjadi kewajipan yang mengikat untuk melaksanakannya. Hal ini jelaslah bahawa relevansi konsep suami sebagai *provider* masih relevan dan dapat menajmin kebahagiaan sekiranya suami mempunyai sifat *qawwam* dan isteri mempunyai sifar *qana'ah.*

G) Pengetahuan Konsep *Taysir* Dalam Perkahwinan

Pengetahuan konsep *Taysir*	**Peratus**
1. Ya	91.6%
2.Tidak	8.4%

Jadual 7: Pengetahuan konsep *Taysir*

Kajian menunjukkan bahawa seramai 175 orang (91.6%) mempunyai pengetahuan yang baik berkenaan konsep *Taysir* yang dianjurkan oleh Islam dalam perkahwinan. Namun masih ada segelintir responden yang tidak mempunyai pengetahuan tersebut dengan peratusan sebanyak 8.4% mewakili seramai 16 orang. Hal ini menunjukkan bahawa amalan *Taysir* ini masih tidak difahami dan diaplikasikan secara menyeluruh dalam kalangan masyarakat, meskipun majoriti responden mempunyai tahap pengetahuan yang baik berkenaan konsep tersebut.

H) Persepsi Responden Masyarakat Terhadap Bebanan *Trend* Majlis Perkahwinan Masa Kini

Bebanan terhadap majlis perkahwinan kini	**Peratus**
1. Ya	69.1%
2.Tidak	30.9%

Jadual 8: Bebanan terhadap majlis perkahwinan kini

Hasil kajian menunjukkan majoriti responden dengan peratusan sebanyak 69.1% mengatakan bahawa *trend* majlis perkahwinan kini memberi bebanan terhadap pengantin yang bakal mendirikan rumah tangga. Hal ini kerana secara semulajadinya, jiwa manusia lebih cenderung kepada sesuatu yang mudah dan berusaha untuk mengelakkan dari sebarang kesusahan dan kesukaran sebagaimana dalam perkahwinan [9]. *Trend* majlis perkahwinan hari ini telah memakan kos yang tinggi dengan pelbagai faktor seperti tuntutan adat, pengaruh media sosial, persaingan status sosial serta keperluan majlis yang bersifat mewah hingga memberi bebanan terhadap pengantin. Secara khususnya *al-Taysīr* dalam perkahwinan menurut agama adalah menghilangkan sebarang kesukaran dan halangan-halangan kepada pelaksanaan perkahwinan [9]. Selain itu, terdapat juga segelintir responden dengan peratusan sebanyak 30.9% yang berpandangan bahawa *trend* majlis perkahwinan ini tidak membebankan. Dapat disimpulkan kesemua

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pendangan ini bergantung terhadap kemampuan serta cara pelaksanaan sesuatu majlis perkahwinan tersebut diadakan.

I) Kepentingan *Syura* Dalam Menyelesaikan Konflik Perkahwinan

Kepentingan *Syura*	Peratus
1. Ya	92.1%
2.Tidak	7.9%

Jadual 9**:** Kepentingan *Syura*

Hasil kajian mendapati bahawa majoriti responden dengan peratusan sebanyak 92.1% bersetuju bahawa *syura* (berbincang) meerupakan satu elemen penting dalam menjamin kesejahteraan keluarga. Perkara ini merupakan satu kaedah perbincangan yang memerlukan komunikasi yang baik dalam menyelesaikan sesuatu masalah bagi mengelakkan kepincangan dalam hubungan pasangan. Hubungan interpersonal yang baik seperti komunikasi yang berkesan serta sikap pasangan yang baik akan menjadikan konflik yang melanda pasangan muda dapat diurus dengan lebih profesional [7]. Namun, segelintir responden dengan peratusan sebanyak 7.9% berpendapat *syura* bukanlah satu kaedah utama dalam menyelesaikan konflik. Jelaslah bahawa secara keseluruhan responden bersetuju bahawa *syura* perlu diamalkan dalam sesebuah keluarga. Sebagaimana firman Allah S.W.T dalam kitab agungnya:

Maksdunya: Dan juga (lebih baik dan lebih kekal bagi) orang-orang yang menyahut dan menyambut perintah Tuhannya serta mendirikan sembahyang dengan sempurna; dan urusan mereka dijalankan secara bermesyuarat sesama mereka; dan mereka pula mendermakan sebahagian dari apa yang Kami beri kepadanya (Asy-Syuura 42:38).

Ayat ini telah menegaskan supaya bertukar-tukar pendapat dan fakta agar akhirnya dapat mencapai kepada keputusan yang terbaik dan memenuhi matlamat.

J) Analisis Peranan Komunikasi Berkesan dalam Mencegah Perceraian

Peranan komunikasi berkesan	Peratus
1.Mengurangkan salah faham antara pasangan	38.7%
2.Membantu pasangan mengurus emosi dan tekanan dengan lebih tenang	27.7%
3. Mewujudkan rasa dihargai dan difahami dalam hubungan	21.5%
4.Memudahkan penyelesaian konflik sebelum menjadi lebih serius	12%

Jadual 10: Peranan Komunikasi dalam Mencegah Perceraian

Berdasarkan soal selidik yang dilakukan daripada 191 responden yang diselidik, adalah menunjukkan bahawa para responden mempunyai pendapat yang berbeza dalam menetapkan peranan atau tujuan utama komunikasi berksesan dalam mencegah perceraian. Bagi peranan pertama iaitu "mengurangkan salah faham" adalah menunjukkan peratusan paling tertinggi iaitu sebanyak 38.7% daripada kesuluruhan tujuan utama komunikasi dalam keluarga. Manakala bagi peranan kedua "membantu pasangan mengurus emosi dan tekanan dengan tenang" adalah sebanyak 27.7% responden yang memilih. Selain itu, peranan komunikasi ketiga pula menunjukkan seramai 21.5% responden yang berpendapat bahawa komunikasi penting bagi mewujudkan rasa dihargai dan difahami dalam hubungan. Akhir sekali, bagi peranan keempat "memudahkan penyelesaian konflik yang lebih serius" hanya menunjukkan sebanyak 12% responden sahaja. Dapat disimpulkan secara keseluruhan bahawa peranan utama komunikasi adalah bertujuan menjamin kesefahaman yang baik antara pasangan kerana pasangan yang saling memahami pasti dapat mencatas segala masalah atau anasir buruk yang membawa kepada konflik perceraian.

K) Analisis Cadangan Responden Terhadap Penyelesaian Konflik Rumah Tangga dalam Kalangan Golongan Muda

Cadangan responden	Peratus
1.Sentiasa berkomunikasi dan berbincang dengan matang	52.8%
2.Bertoleransi serta mengekalkan kesefahaman	17.8%
3.Pendekatan ilmu keagaamaan dan kaunseling keluarga	13.6%
4.Mengadakan program pendedahan terhadap perkahwinan	3.7%
5. Melakukan aktiviti sosial bersama	3.7%
6. Memilih pasangan yang serasi	8.4%

Jadual 11: Cadangan Responden

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Hasil kajian telah mendapat pelbagai pandangan dan cadangan yang telah dilontarkan oleh responden dalam menangani isu konflik rumah tangga terutama terhadap golongan muda pada hari ini. Antara cadangan yang telah diberikan adalah dimana setiap pasangan perlulah berkomunikasi serta berbincang dengan matang dan pemikiran yang terbuka agar konflik ini dapat ditangani dengan baik. Pendapat ini telah mendpat peratusan tertinggi sebanyak 52.8% yang mewakili seramai 101 orang responden. Cadangan ini amat bertepatan dengan apa yang dinyatakan dalam kajian lepas bahawa sekiranya kedua-dua pihak suami isteri tidak dapat melakukan komunikasi dengan sempurna dan berkesan, maka perasaan ingin memahami dan difahami tidak wujud dalam diri [8]. Cadangan yang kedua pula iaitu "bertoleransi serta mengekalkan kesefahaman" telah mendapat peratusan sebanyak 17.8% yang mewakili 34 orang responden. Sebagaimana diketahui secara umum, kesefahaman merupakan kunci utama dalam menjernihkan sesuatu keadaan yang buruk. Sikap sebegini dapat membantu pasangan untuk memahami peranan masing-masing dengan sikap keterbukaan dan menerima pasangan dengan ikhlas [2]. Toleransi dalam pasangan juga turut merangkumi sikap, kewangan serta pembahagian tugas dalam sesebuah keluarga.

Selain itu, cadangan ketiga daripada responden adalah menggunakan pendekatan ilmu keagamaan serta melibatkan diri dalam kaunseling keluarga dengan peratusan sebanyak 13.6%. Persediaan ilmu agama amat penting bagi memastikan tujuan perkahwinan sentiasa berpaksikan redha Allah S.W.T. Pegangan agama yang lemah telah menyebabkan para suami menimbulkan pelbagai masalah rumah tangga seperti mengabaikan tanggungjawab nafkah, penderaan dan curang tanpa merasakan ianya sebagai dosa [14]. Cadangan seterusnya ialah "mengadakan program pendedahan terhadap perkahwinan" dan "sentiasa melakukan aktiviti sosial bersama" dengan peratusan yang sama bagi setiap cadangan tersebut sebanyak 3.7%. Pendedahan awal terhadap ilmu pengurusan rumah tangga terutama kepada golongan muda amat mustahak bagi membuka minda mereka agar lebih serius dalam mendirikan rumah tangga. Jika dilihat pada hari ini, ramai anak muda yang terlalu tergopoh-gopoh dalam perkahwinan kerana mengikuti *trend* semasa tanpa persediaan yang rapi. Pasangan yang sudah berkahwin juga amat digalakkan untuk meluangkan masa Bersama dengan melakukan aktiviti sosial bersama seperti beriadah, makan bersama atau melawat tempat-tempat menarik. Hal ini amat penting bagi memastikan ikatan kasih sayang dalam keluarga sentiasa terjalin kerana masa bersama adalah lebih berharga berbanding pemberian harta.

Saranan terkahir terhadap penyelesaian konflik rumah tangga ialah dengan memilih pasangan yang serasi. Pendapat ini telah menerima peratusan sebanyak 8.4%. Pemilihan pasangan yang serasi amat penting bagi memastikan pasangan saling memahami serta mempunyai pola pemikiran yang sama tanpa mementingkan diri. Perkara ini selari dengan kajian lepas yang telah dijalankan yang menyatakan bahawa kualiti perkahwinan mereka semakin meningkat apabila pasangan saling memahami antara satu sama lain dan menerima kelebihan dan kekurangan pasangan masing-masing [2]. Jelaslah bahawa sekufu antara suami isteri ini dilihat sangat penting bagi memastikan keamanan dan kebahagiaan rumah tangga [15]. Lantaran itu, seeloknya bagi setiap pasangan suami isteri itu serasi dan setaraf dalam banyak perkara agar rumah tangga yang diharungi lebih mudah ditempuhi.

V. RUMUSAN

Tuntasnya, kajian ini menunjukkan bahawa konflik rumah tangga dalam kalangan golongan muda merupakan isu yang signifikan dan memerlukan pengurusan yang berkesan bagi memastikan keharmonian serta kelangsungan institusi perkahwinan. Golongan muda merupakan aset yang amat penting bagi menjamin kemajuan dan kekuatan sesebuah masyarakat dan negara [10]. Mereka ini perlu digilap dengan acuan terbaik bagi melahirkan satu model yang terbaik dan berkualiti. Dapatan kajian dari soal selidik mendapati bahawa konflik yang tidak ditangani secara matang dan berhemah berpotensi menjejaskan hubungan suami isteri serta membawa kepada perpecahan rumah tangga. Oleh itu, usaha pencegahan dan penyelesaian konflik perlu diberi perhatian serius khususnya dalam kalangan pasangan muda yang masih dalam proses penyesuaian kehidupan berumah tangga.

Hasil kajian mendapati bahawa komunikasi berkesan merupakan faktor utama dalam mencegah dan menyelesaikan konflik rumah tangga. Majoriti responden menekankan kepentingan perbincangan terbuka dan komunikasi dua hala. Komunikasi yang baik dapat mengurangkan salah faham, mengawal emosi dan membina persefahaman antara suami dan isteri manakala kegagalan berkomunikasi sering menjadi punca kepada pertelingkahan yang berpanjangan. Selain itu, kajian ini turut menunjukkan bahawa nilai toleransi, kesefahaman dan kematangan emosi memainkan peranan penting dalam mengekalkan keharmonian rumah tangga. Sikap saling bertolak ansur, menurunkan ego, bersabar serta menerima kekurangan pasangan dikenal pasti sebagai elemen penting dalam mengurus konflik secara konstruktif. Pasangan muda perlu memiliki kematangan diri agar setiap permasalahan dapat diselesaikan secara rasional tanpa dipengaruhi oleh emosi atau sikap mementingkan diri. Kajian ini juga mendapati

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bahawa pendekatan keagamaan dan amalan syura berfungsi sebagai panduan penting dalam pengurusan konflik rumah tangga. Penghayatan nilai Islam seperti kesabaran, musyawarah, saling menghormati dan keadilan membantu pasangan membuat keputusan secara bijaksana dan berlandaskan prinsip syariah.

Kesimpulannya, kajian ini menegaskan bahawa pencegahan konflik rumah tangga memerlukan pendekatan menyeluruh yang merangkumi aspek komunikasi berkesan, kematangan emosi, penghayatan nilai agama serta sokongan sosial. Pendekatan ini diyakini mampu membantu golongan muda membina rumah tangga yang harmoni, sejahtera dan berkekalan.

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HAK-HAK WANITA DALAM PERKAHWINAN: KAJIAN AWAL KEFAHAMAN DALAM KALANGAN PELAJAR UPNM

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Abstrak

Hak wanita dalam perkahwinan Islam merupakan aspek penting dalam memastikan keadilan, kesejahteraan dan keharmonian institusi kekeluargaan. Islam melalui al-Quran, hadis dan perundangan syariah telah memperuntukkan pelbagai hak kepada wanita sebelum, semasa dan selepas perkahwinan. Kajian ini bertujuan mengenal pasti tahap kefahaman pelajar Universiti Pertahanan Nasional Malaysia (UPNM) terhadap hak-hak wanita dalam perkahwinan menurut perspektif syariah. Kajian ini menggunakan pendekatan kuantitatif berbentuk kajian penerokaan melalui pengedaran soal selidik kepada 287 orang pelajar tahun tiga UPNM yang dipilih menggunakan kaedah persampelan rawak mudah. Data dianalisis secara deskriptif bagi mendapatkan kekerapan dan peratusan. Dapatan menunjukkan bahawa tahap kefahaman pelajar berada pada tahap yang baik, namun pelaksanaan hak wanita masih memerlukan penambahbaikan dari segi pendidikan, kesedaran masyarakat dan sokongan institusi.

Abstract

Women's rights in Islamic marriage constitute an essential aspect in ensuring justice, well-being, and harmony within the family institution. Islam, through the Qur'an, hadith, and Shariah law, has established various rights for women before, during, and after marriage. This study aims to identify the level of understanding among Universiti Pertahanan Nasional Malaysia (UPNM) students regarding women's rights in marriage from the Shariah perspective. A quantitative exploratory approach was employed through the distribution of questionnaires to 287 third-year UPNM students selected using simple random sampling. The data were analysed using descriptive analysis to obtain frequencies and percentages. The findings indicate that although students demonstrate a good level of understanding, the implementation of women's rights still requires improvement in terms of education, public awareness, and institutional support

Keywords **:** *Hak wanita, perkahwinan Islam, syariah, nafkah, mahar, fasakh, Maqasid al-Syariah*

I. PENGENALAN

Perkahwinan dalam Islam merupakan satu kontrak suci yang merangkumi tanggungjawab rohani dan undang-undang bagi memastikan keadilan serta kesejahteraan antara pasangan. Al-Quran melalui Surah Ar-Rum ayat 21 menekanka bahawa hubungan suami isteri dibina atas asas kasih sayang dan rahmah [1]. Dalam konteks syariah, kedudukan wanita dalam perkahwinan bukan bersifat pasif, sebaliknya Islam menetapkan pelbagai hak kepada wanita seperti hak memilih pasangan, hak mahar, hak menetapkan syarat dalam akad nikah serta hak nafkah yang meliputi tempat tinggal, makanan dan pakaian.

Di Malaysia, hak-hak wanita dalam perkahwinan turut diperincikan melalui Enakmen Undang-Undang Keluarga Islam yang menggariskan tanggungjawab suami dan isteri bagi menjamin keharmonian rumah tangga [2]. Walau bagaimanapun, pelaksanaan prinsip syariah dalam konteks semasa berhadapan dengan pelbagai cabaran termasuk isu penderaan, pengabaian nafkah dan salah tafsir terhadap teks agama yang membawa kepada ketidakseimbangan kuasa dalam perkahwinan [3]. Penafsiran yang tidak tepat terhadap ayat-ayat tertentu kadangkala digunakan untuk menghalalkan dominasi suami, sedangkan Islam menekankan Namun demikian, cabaran seperti kekurangan kefahaman masyarakat, budaya patriarki serta tafsiran fiqh yang konservatif masih mempengaruhi pelaksanaan hak wanita dalam

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perkahwinan. Oleh itu, kajian ini bertujuan menilai konsep hak wanita menurut perspektif syariah serta tahap kefahaman terhadap hak tersebut dalam konteks masyarakat Muslim di Malaysia.

II. SOROTAN LITERATUR

Sorotan literatur bertujuan untuk meningkatkan pemahaman kita tentang konsep hak wanita dalam perkahwinan dari sudut pandangan syariah serta peranan, halangan dan kemungkinan pelaksanaannya dalam masyarakat Islam Malaysia. Sebagai sistem hidup yang menyeluruh, Islam telah memberikan pelbagai hak kepada wanita dalam institusi perkahwinan untuk memastikan keluarga makmur dan keadilan dari pihak suami. Menurut kajian [2], menunjukkan bahawa meskipun perundangan syariah telah memperuntukkan pelbagai hak kepada wanita sebelum, semasa dan selepas perkahwinan, pelaksanaannya masih berdepan dengan cabaran seperti ketidakseimbangan kuasa antara suami isteri, kelemahan literasi undang-undang serta isu penguatkuasaan yang tidak menyeluruh di Mahkamah Syariah.

Menurut kajian [4], punca-punca kegagalan rumah tangga sering kali berpunca daripada tekanan kewangan, kekurangan komunikasi dan penderaan emosi atau fizikal terhadap wanita. Keadaan ini menyebabkan pendekatan yang bersifat perundangan dan psikososial diperlukan. Di sinilah pengamal kaunseling keluarga, yang boleh memberikan sokongan emosi dan bimbingan kepada wanita yang terkesan.Kajian turut menyarankan bahawa pendekatan psikopendidikan yang digabungkan dengan nasihat guaman syarie dapat membantu wanita lebih memahami dan mempertahankan hak mereka dalam institusi perkahwinan. Hal ini kerana, dalam perkahwinan Islam adalah penting untuk mewujudkan keharmonian dalam rumah tangga dengan menggunakan hak-hak bersama suami isteri, termasuk hak untuk berinteraksi dengan baik dan menikmati kesenangan bersama (istimta') serta hak berkaitan anak seperti penjagaan dan nasab. Hal ini selaras dengan matlamat perkahwinan dalam Islam iaitu untuk mewujudkan keluarga sakinah, mawaddah wa rahmah [5].

Selain itu, perkembangan undang-undang serta pengaruh konvensyen antarabangsa seperti Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW) turut memberi kesan terhadap perbahasan hak wanita dalam institusi keluarga Islam di Malaysia. Sejarah Islam sendiri menunjukkan wanita memainkan peranan penting dalam masyarakat seperti Saidatina Khadijah RA, Rufaidah al-Aslamiyah dan Asma' binti Abu Bakar RA, sekali gus membuktikan bahawa Islam mengiktiraf kemampuan dan kedudukan wanita secara signifikan.

Selain menjadi akad yang menghalalkan hubungan antara lelaki dan wanita, perkahwinan dalam Islam juga memberikan hak dan tanggungjawab yang mesti dipenuhi oleh kedua-dua pihak. Zakaria et al. membincangkan kewajipan suami isteri dalam perkahwinan Islam iaitu dua kategori utama hak suami isteri terdiri daripada hak berkaitan kewangan seperti nafkah dan mahar dan hak bukan kewangan seperti kasih sayang, perlindungan maruah dan tanggungjawab moral rumah tangga [6]. Kajian [6] menegaskan bahawa pengabaian terhadap hak dan tanggungjawab suami isteri boleh menjadi antara faktor utama berlakunya perceraian dalam rumah tangga termasuk kegagalan memenuhi hak kewangan dan bukan kewangan seperti nafkah serta layanan yang baik.

Selain itu, artikel ini menekankan bahawa banyak pelanggaran hak isteri berlaku akibat kejahilan suami dan ketidakpedulian masyarakat terhadap syariat seperti tanggapan bahawa harta isteri adalah milik suami secara mutlak atau pengabaian terhadap komunikasi dan kasih sayang dalam rumah tangga [7]. Hak-hak batin termasuk nafkah emosi, bimbingan rohani dan layanan yang baik turut ditekankan sebagai aspek penting yang sering diabaikan [7]. Dalam konteks pemerkasaan hak selepas perceraian pula, *mut'ah al- talaq* merupakan salah satu mekanisme penting. *Mut'ah al-talaq* merupakan satu bentuk pemberian saguhati kepada isteri yang diceraikan sebagaimana yang disyariatkan dalam Surah al-Baqarah ayat 236 dan 241. Latif & Abdullah [8] menyatakan bahawa *mut'ah al-talaq* melindungi dan menjamin hak wanita selepas perceraian, terutamanya apabila ia datang kepada tuntutan kewangan dan kesedaran tentang hak selepas perceraian menurut undang-undang keluarga Islam di Malaysia.

Dalam konteks Malaysia, Undang-Undang Keluarga Islam (Negeri Selangor) 2003 memperuntukkan bahawa wanita yang diceraikan tanpa sebab berhak menuntut mut'ah di Mahkamah Syariah [9]. Pendekatan hukum ini berlandaskan mazhab Syafie yang dominan di Malaysia dengan memandang mut'ah sebagai wajib sebagaimana ianya selari dengan maqasid syariah yang menekankan perlindungan terhadap wanita dari aspek emosi dan kewangan. *Mut'ah* dianggap sebagai satu bentuk keadilan yang menjaga kesejahteraan wanita Islam dan pensyariatannya berfungsi sebagai pelaksanaan perlindungan dalam sistem kekeluargaan Islam.

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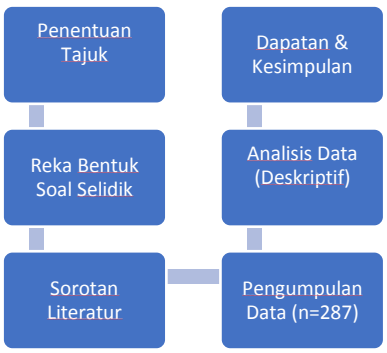
Secara amnya, memperkasakan hak wanita dalam perkahwinan bukanlah hanya tugas pihak berkuasa namun ia adalah usaha kolektif yang memerlukan kerjasama pelbagai lapisan masyarakat. Peranan peguam syarie dan pengamal kaunseling keluarga perlu dipertingkatkan dalam menghadapi realiti sosial yang mencabar melalui strategi pendidikan, bimbingan dan advokasi yang bersepadu. Hanya melalui pendekatan yang holistik dan berteraskan prinsip keadilan Islam, institusi kekeluargaan dapat diperkukuh dan wanita dapat memainkan peranan sebagai rakan kongsi yang setara dan bermaruah dalam kehidupan berumah tangga.

III. METODOLOGI KAJIAN

Kajian ini menggunakan pendekatan kuantitatif berbentuk kajian penerokaan melalui pengedaran soal selidik kepada pelajar tahun tiga Universiti Pertahanan Nasional Malaysia (UPNM). Seramai 287 responden telah dipilih menggunakan kaedah persampelan rawak mudah bagi mendapatkan gambaran awal tahap kefahaman terhadap hak wanita dalam perkahwinan.

Data yang diperoleh dianalisis menggunakan analisis deskriptif bagi menghasilkan kekerapan dan peratusan. Pendekatan ini sesuai digunakan untuk mengenal pasti corak kefahaman responden serta memberikan gambaran awal terhadap isu yang dikaji.

Menurut [10], kajian penerokaan sesuai digunakan apabila sesuatu permasalahan telah dikenal pasti tetapi makumat mengenaninya masih terhad. Pendekatan ini bertujuan untuk mengumpul data dan membina maklumat asas dengan memberikan gambaran awal mengenai isu yang dikaji serta membangunkan bentuk atau metod kajian yang sesuai untuk penyelidikan masa hadapan.



Rajah 1: Proses Kajian

IV. DAPATAN KAJIAN

Bahagian ini melaporkan analisis statistik demografi mengandungi maklumat latar belakang responden setelah diperolehi daripada borang soal selidik di Bahagian A dan telah dianalisis menggunakan kaedah taburan kekerapan dan peratusan.

Kategori	Elemen	Responden (n)	Peratus (%)
Jantina	Lelaki	219	76.3
	Perempuan	68	23.7
	Jumlah	287	100.0
Umur	18-25	257	89.5
	26-35	23	8.0
	36-45	4	1.4
	46 ke atas	3	1.0
	Jumlah	287	100.0
Status Perkahwinan	Bujang	273	95
	Sudah Berkahwin	14	5
	Jumlah	287	100.0

Jadual 1 : Taburan Frekuensi dan Peratusan berdasarksn Profil Responden

Jadual di atas menunjukkan seramai 287 orang responden telah terlibat dalam kajian ini. Dari segi jantina, majoriti responden terdiri daripada lelaki iaitu sebanyak 76.3%, manakala 23.7% lagi adalah perempuan.

Berdasarkan taburan umur, peratusan tertinggi adalah responden dalam lingkungan umur 18 hingga 25 tahun, diikuti oleh responden dalam lingkungan umur 26 hingga 35 tahun iaitu sebanyak 8%. Seterusnya, responden dalam lingkungan umur 36 hingga 45 tahun mencatatkan peratusan sebanyak 4%, manakala responden berumur 45 tahun ke atas merupakan kumpulan paling kecil dengan peratusan hanya 1%. Dari aspek status perkahwinan, dapatan menunjukkan bahawa 95% responden masih bujang manakala 5% adalah berkahwin.

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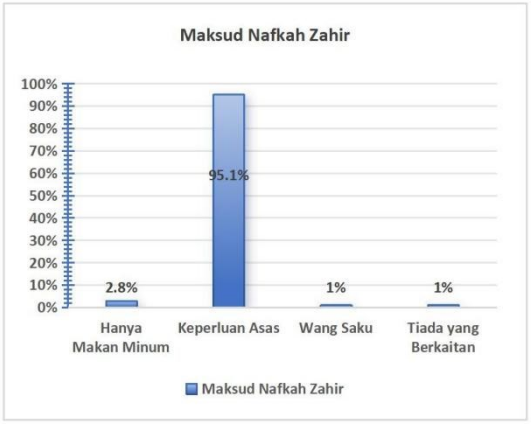
Analisis taburan responden berdasarkan fakulti memperlihatkan penguasaan yang jelas oleh Fakulti Pengajian dan Pengurusan Pertahanan (FPPP), yang mewakili 89.2% daripada keseluruhan responden kajian. Fakulti Sains dan Teknologi Pertahanan (FSTP) pula menyumbang sebanyak 7.7% daripada jumlah responden. Sementara itu, Akademi Pertahanan Pengajian Islam (APPI) mencatatkan peratusan sebanyak 1.4%, manakala Pusat Bahasa (PB) dan Fakulti Kejuruteraan Pertahanan dan Pengurusan (FKPP) masing-masing menyumbang 0.7%.

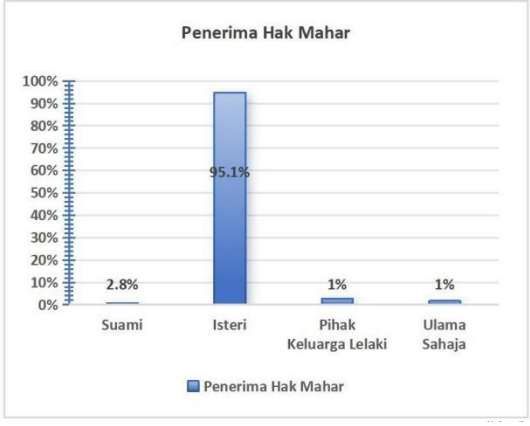
Tahap Pengetahuan dan Kefahaman

Bahagian ini membincangkan dapatan soal selidik berkaitan tahap pengetahuan dan kefahaman responden terhadap topik kajian. Ia merangkumi sejauh mana responden memahami konsep, maklumat dan isu yang dikaji serta menilai perbezaan tahap kefahaman mengikut latar belakang atau kategori tertentu.



Jadual 2 : Kefahaman Tentang Nafkah Zahir

Berdasarkan dapatan soal selidik, tahap kefahaman responden mengenai maksud nafkah zahir menunjukkan bahawa majoriti responden seramai 257 orang (95.1%) memahami bahawa ia merujuk kepada penyediaan keperluan asas. Sebilangan kecil responden pula mengaitkannya hanya dengan makanan dan minuman (2.8%, 8 orang) atau wang saku (1.0%, 3 orang), manakala seramai 3 orang (1.0%) tidak memberikan jawapan y



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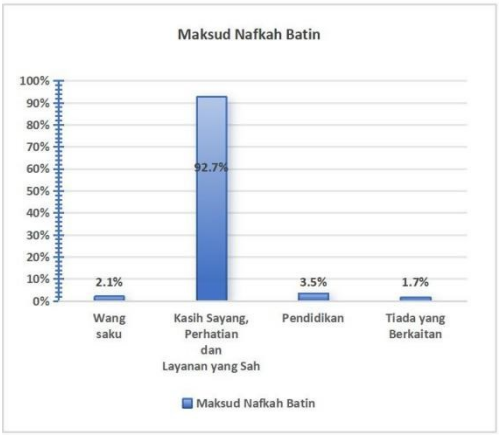
mengikut kemampuan suami dan uruf setempat [11].



Jadual 3: Kefahaman Tentang Nafkah Batin

Carta bar berikut memaparkan tahap kefahaman responden mengenai nafkah batin berdasarkan soal selidik. Daripada 287 responden, majoriti iaitu 266 orang (92.7%) memahami nafkah batin sebagai pemberian kasih sayang, perhatian dan layanan yang sah. Sebanyak 10 orang (3.5%) pula mengaitkannya dengan pemberian pendidikan kepada isteri, manakala 6 orang (2.1%) melihatnya sebagai memberi wang saku bulanan. Seramai 5 orang (1.7%) tidak memberikan jawapan yang berkaitan. Dapatan ini menunjukkan bahawa pemahaman responden lebih menekankan aspek emosi dan layanan yang sah dalam konteks nafkah batin, selari dengan perbincangan [12] yang menegaskan bahawa hubungan suami isteri dalam Islam hendaklah berasaskan layanan yang baik, kasih sayang dan pemenuhan hak batin isteri menurut prinsip *mu'āsharah bi al-ma'rūf. Mu'āsyarah bil ma'rūf* bermaksud layanan yang baik terhadap pasangan melalui keadilan dalam nafkah dan tempat tinggal serta tutur kata yang lembut. Menurut Wahbah az-Zuhaili, konsep ini merangkumi pertuturan yang baik, tingkah laku yang terpuji dan keadilan dalam aspek kehidupan sekali gus menekankan prinsip kesalingan antara suami dan isteri [13].

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Jadual 4 : Penerima Hak Mahar (mas kahwin)

Berdasarkan carta bar, majoriti responden (94.8% iaitu 272 orang) menyatakan bahawa isteri merupakan penerima hak mahar dalam perkahwinan Islam. Dapatan ini menunjukkan tahap kefahaman yang tinggi dalam kalangan pelajar UPNM terhadap ketetapan syarak berkaitan mahar. Hanya sebilangan kecil responden beranggapan bahawa mahar diberikan kepada pihak keluarga lelaki (2.8%), ulama (1.7%) dan suami (0.7%), menunjukkan masih wujud kekeliruan kecil dalam kalangan responden. Dapatan ini selaras dengan [11] yang menegaskan bahawa mahar merupakan hak isteri dan pemilikan mutlaknya tidak boleh dipindah atau diberikan kepada pihak lain tanpa keizinan isteri.

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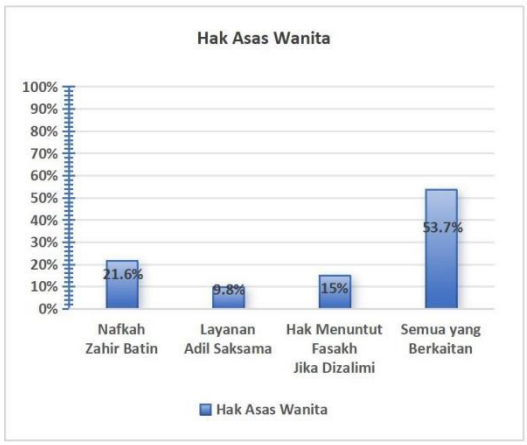
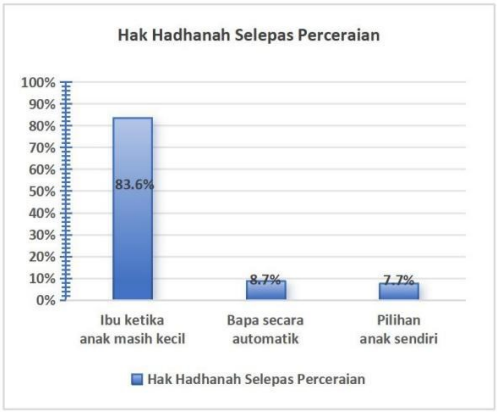
dan perceraian yang tidak sah (3.1%), menandakan





bahawa salah faham masih berlaku namun pada tahap minimum. Dapatan ini bertepatan dengan perbincangan [14] yang menjelaskan bahawa fasakh merupakan mekanisme pembubaran perkahwinan yang dibenarkan syarak apabila berlaku kemudaratan atau kegagalan suami menunaikan hak isteri.

Jadual 6: Hak Hadhanah Selepas Perceraian

Majoriti responden, iaitu 83.6% (240 orang) berpendapat bahawa ibu berhak mendapat hak *hadhanah* selagi anak masih kecil, selari dengan prinsip syariah. Sebahagian kecil responden menyatakan hak penjagaan diberikan secara automatik kepada bapa (8.7%) atau anak memilih sendiri (7.7%), menunjukkan terdapat perbezaan pandangan dalam kalangan responden. Dapatan ini selari dengan perbincangan [8] yang menjelaskan bahawa hukum dan amalan undang-undang keluarga Islam mengutamakan ibu sebagai pihak yang paling layak memegang hak hadhanah anak kecil demi menjaga kebajikan dan maslahah kanak- kanak.

Jadual 7: Hak Asas Wanita

Dapatan kajian menunjukkan lebih separuh responden (53.7% atau 154 orang) bersetuju bahawa hak asas wanita merangkumi semua aspek seperti nafkah zahir dan batin, layanan adil serta hak menuntut *fasakh*. Hal ini menggambarkan tahap pemahaman yang menyeluruh terhadap hak wanita dalam perkahwinan Islam. Walau bagaimanapun, selebihnya responden memilih hak secara berasingan seperti nafkah (21.6%), hak *fasakh* (15%) dan layanan adil (9.8%), yang menunjukkan bahawa sebahagian responden masih melihat hak wanita dalam bentuk yang terpisah. Dapatan ini bertepatan dengan perbincangan [15] yang menegaskan bahawa hak dan kewajipan dalam perkahwinan Islam perlu difahami secara holistik

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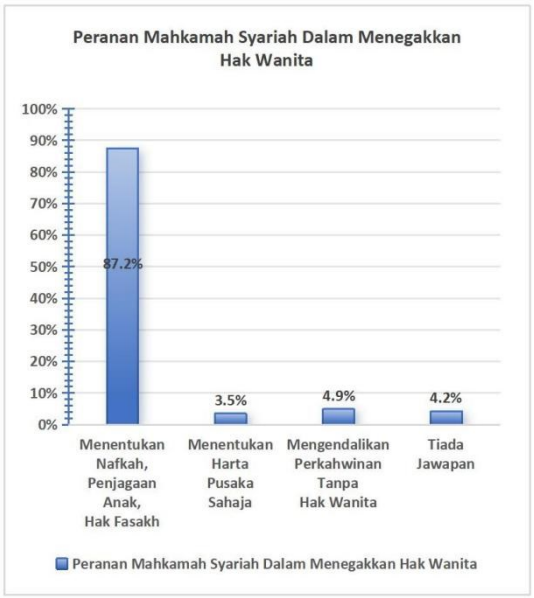
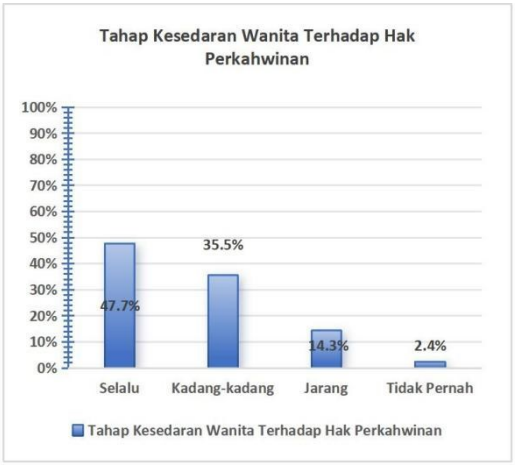
bagi menjamin keadilan dan keharmonian rumah tangga.





Jadual 8: Peranan Mahkamah Syariah Dalam Menegakkan Hak Wanita

Carta bar menunjukkan bahawa majoriti responden, iaitu 87.5% (251 orang), memahami bahawa peranan Mahkamah Syariah dalam konteks hak wanita merangkumi penentuan nafkah, penjagaan anak serta hak *fasakh*. Hanya sebilangan kecil responden, iaitu 3.5% (10 orang), mengaitkan Mahkamah Syariah dengan penentuan harta pusaka sahaja, manakala ada juga yang beranggapan bahawa mahkamah mengendalikan perkahwinan tanpa mengambil kira hak wanita atau tidak memberikan jawapan yang tepat. Dapatan ini menandakan bahawa kefahaman pelajar terhadap fungsi Mahkamah Syariah dalam menegakkan hak wanita adalah tinggi, tetapi masih terdapat kekeliruan pada sebahagian kecil responden, selari dengan penemuan [16] mengenai perlaksanaan hak wanita di Mahkamah Syariah.

Jadual 9: Hak Wanita Untuk Mendapat Keselamatan Diri Daripada Keganasan Rumah Tangga

Dapatan menunjukkan bahawa majoriti responden, iaitu 91.6% (263 orang), bersetuju bahawa wanita mempunyai hak untuk mendapat keselamatan diri daripada keganasan rumah tangga. Hanya sebilangan kecil responden berpendapat sebaliknya (1.4%, 4 orang), kadang- kadang (2.4%, 7 orang), atau bergantung kepada keluarga (4.5%, 13 orang). Ini menunjukkan kesedaran yang tinggi dalam kalangan pelajar terhadap hak wanita bagi perlindungan daripada keganasan, sejajar dengan pandangan [17] yang menekankan respons undang-undang Islam terhadap mangsa keganasan rumah tangga.

Jadual 10: Tahap Kesedaran Wanita Terhadap Hak Perkahwinan

Dapatan kajian menunjukkan bahawa 47.7% (137 orang) responden selalu menyedari hak mereka dalam perkahwinan, manakala 35.5% (102 orang) kadang-kadang, 14.3% (41 orang) jarang, dan 2.4% (7 orang) tidak pernah menyedari hak mereka. Ini menandakan tahap kesedaran wanita terhadap hak perkahwinan adalah sederhana hingga tinggi, tetapi masih terdapat ruang untuk penambahbaikan, sejajar dengan dapatan [18] mengenai kesedaran wanita terhadap hak dan tanggungjawab dalam perkahwinan.

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Jadual 11: Peranan Keluarga dan Komuniti Dalam Menjamin Hak Wanita

Dapatan menunjukkan bahawa 85.7% responden sangat setuju bahawa keluarga dan komuniti memainkan peranan penting dalam menjamin hak wanita. Sebanyak 9.4% bersetuju, manakala 1.4% (4 orang) tidak setuju dan 3.5% (10 orang) tidak pasti. Ini menegaskan bahawa sokongan sosial dan peranan komuniti merupakan faktor penting dalam memastikan hak wanita dilaksanakan dengan berkesan [19].

Cara Terbaik Meningkatkan Kesedaran Pelajar IPT Tentang Hak-hak Wanita Dalam Perkahwinan Menurut Syariah

Berdasarkan analisis maklum balas keseluruhan responden kajian, majoriti pelajar mencadangkan bahawa pendekatan pendidikan dan pendedahan aktif merupakan kaedah paling berkesan untuk meningkatkan kesedaran pelajar 3 Universiti Pertahanan Malaysia (UPNM) mengenai hak-hak wanita dalam perkahwinan menurut syariah. Dapatan kajian menunjukkan bahawa lebih daripada 80% daripada jumlah responden mengemukakan cadangan yang hampir sama, khususnya melalui penganjuran ceramah, seminar, kursus serta program kesedaran yang bersifat berstruktur. Penemuan ini sejajar berdasarkan kajian [20] menyatakan bahawa institusi pengajian tinggi pengajian tinggi mempunyai peranan penting dalam membentuk kesedaran sosial pelajar melalui persekitaran pendidikan, aktiviti kokurikulum, budaya kampus serta sokongan perkhidmatan lain.

Seterusnya, responden berpandangan bahawa penganjuran ceramah dan seminar membolehkan penyampaian maklumat secara langsung serta menyediakan ruang interaksi dua hala melalui sesi soal jawab bersama pihak berautoriti seperti pensyarah, pegawai Mahkamah Syariah dan tokoh agama. Pendekatan ini dilihat mampu meningkatkan kefahaman pelajar secara lebih mendalam kerana isu hak-hak wanita dalam perkahwinan dapat dibincangkan secara menyeluruh, merangkumi aspek hukum Syariah, perundangan keluarga Islam serta realiti pelaksanaannya di Malaysia. Dapatan ini selari dengan laporan Jabatan Kemajuan Islam Malaysia {JAKIM) yang menekankan kepentingan pendidikan berasaskan kefahaman hukum serta konteks semasa bagi mengelakkan salah faham terhadap hak dan tanggungjawab dalam institusi perkahwinan Islam[21].

Selain itu, sebanyak 72% daripada jumlah responden kajian turut mencadangkan pelaksanaan kempen kesedaran, sama ada secara fizikal di kampus atau melalui platform digital seperti media sosial sebagai medium sokongan yang berkesan bagi menyebarkan maklumat kepada lebih ramai pelajar secara berterusan dan mudah diakses. Peratusan ini merujuk kepada kekerapan cadangan yang dikemukakan oleh responden, memandangkan sebahagian responden memberikan lebih daripada satu cadangan. Dapatan ini menunjukkan bahawa penggunaan platform digital semakin relevan dalam menyampaikan maklumat berkaitan isu syariah kepada golongan muda, selaras dengan corak komunikasi dan pembelajaran generasi masa kini [22] Oleh itu, gabungan pendekatan formal dan informal dilihat paling sesuai bagi meningkatkan tahap kesedaran pelajar tahun 3 UPNM terhadap hak- hak wanita dalam perkahwinan menurut syariah.

Pelaksanaan Hak-hak Wanita Dalam Perkahwinan di Malaysia

Dapatan kajian memperlihatkan bahawa persepsi pelajar Universiti Pertahanan Nasional Malaysia (UPNM) tahun 3 terhadap pelaksanaan hak- hak wanita dalam perkahwinan di Malaysia adalah bercampur dan tidak seimbang dengan kecenderungan yang lebih kritikal terhadap tahap pelaksanaannya. Hasil analisis menunjukkan bahawa sekitar 39% daripada keseluruhan 287 responden berpendapat bahawa hak- hak wanita dalam perkahwinan belum dilaksanakan dengan adil. Golongan ini mengaitkan pandangan mereka dengan isu- isu seperti kegagalan pemberian nafkah, keganasan rumah tangga, diskriminasi budaya serta sikap sebahagian suami yang mengabaikan tanggungjawab. Faktor kurangnya pengetahuan wanita tentang hak mereka dan kekangan kewangan untuk membawa kes ke mahkamah turut dikenal pasti sebagai punca utama ketidakadilan dalam pelaksanaan hak wanita. Dapatan ini sejajar dengan kajian yang mendapati terdapat cabaran pelaksanaan undang- undang keluarga Islam di Malaysia terutamanya berkaitan perlindungan hak wanita dan keberkesanan penguatkuasaan, meskipun peruntukan undang- undang telah tersedia [23].

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Dalam masa yang sama, sekitar 30% responden berpandangan bahawa hak- hak wanita telah dilaksanakan dengan adil di Malaysia. Pandangan ini disandarkan kepada kewujudan Mahkamah Syariah, peruntukan undang- undang yang berlandaskan syariah Islam serta kejayaan penyelesaian pelbagai kes berkaitan nafkah, *fasakh* dan hak penjagaan anak. Responden dalam kategori ini melihat sistem perundangan syariah sebagai satu mekanisme penting dalam melindungi hak wanita dan memastikan keadilan ditegakkan dalam institusi perkahwinan. Dapatan ini turut konsisten dengan rujukan [2] yang menunjukkan bahawa undang-undang keluarga Islam di Malaysia telah dirangka untuk memperincikan hak- hak pasangan termasuk hak nafkah dan hak penjagaan, meskipun terdapat perdebatan mengenai pelaksanaannya dalam konteks realiti sosial.

Walau bagaimanapun, sekitar 26% responden mengambil pendirian sederhana dengan menyatakan bahawa pelaksanaan hak- hak wanita adalah adil dari sudut peruntukan undang- undang tetapi belum sepenuhnya adil dari segi pelaksanaan dan penguatkuasaan. Responden dalam kumpulan ini menekankan bahawa kelemahan birokrasi, tempoh perbicaraan yang panjang serta penguatkuasaan perintah mahkamah yang kurang efektif menyebabkan sebahagian wanita gagal menikmati hak mereka secara menyeluruh. Pandangan ini selaras dengan rujukan [4] yang menyatakan adanya jurang antara peruntukan undang- undang dan realiti pelaksanaan di peringkat masyarakat menjadi sorotan dalam kajian semasa mengenai cabaran pelaksanaan undang- undang keluarga Islam di Malaysia.

Seterusnya sekitar 5% responden pula berada dalam kategori tidak pasti atau tidak memberikan jawapan yang jelas mencerminkan kemungkinan kekurangan pendedahan atau kefahaman mendalam berkaitan pelaksanaan hak- hak wanita dalam perkahwinan di Malaysia. Secara keseluruhan, dapatan ini menunjukkan bahawa walaupun peruntukan undang-undang keluarga Islam di Malaysia menyediakan asas perlindungan terhadap hak-hak wanita, persepsi pelajar UPNM tahun 3 mencerminkan bahawa keberkesanan pelaksanaan-nya masih memerlukan penambahbaikan dari aspek kefahaman undang-undang, kesedaran masyarakat serta kecekapan intistusi pelaksana. Hal ini selaras dengan kajian [2] yang menekankan bahawa perlindungan hak wanita memerlukan gabungan antara peruntukan undang-undang dan usaha pendidikan serta kesedaran masyarakat

V. KESIMPULAN

Kesimpulannya, kajian ini menunjukkan bahawa hak-hak wanita dalam perkahwinan menurut syariah Islam telah ditetapkan secara jelas bagi menjamin keadilan dan kesejahteraan institusi kekeluargaan. Tahap kefahaman pelajar UPNM terhadap hak-hak tersebut berada pada tahap yang baik, namun masih memerlukan pengukuhan melalui pendidikan dan kesedaran berterusan. Oleh itu, usaha memperkasa kefahaman terhadap hak wanita perlu melibatkan semua pihak termasuk lelaki, keluarga dan masyarakat secara menyeluruh. Pendekatan yang holistik berasaskan pendidikan, kesedaran dan sokongan institusi amat penting bagi memastikan hak-hak wanita dapat difahami dan dilaksanakan selaras dengan prinsip syariah Islam.

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Innovation Trends Among Students Based on Final Year Project Competition Winners: A Case Study of Politeknik Kuching Sarawak

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Abstract

Final Year Project (FYP) competitions serve as a vital platform for students to demonstrate innovation, technical proficiency, and problem-solving capabilities, yet long-term trends in these achievements are often underutilized for academic planning. This study analyzes the trends among overall winners at Politeknik Kuching Sarawak (PKS) over six semesters to identify departmental contributions and innovation trajectories using a quantitative descriptive approach where frequency counts and trend visualizations were applied to institutional records. The results reveal a significant dominance by the Information and Communication Technology (ICT) department, which secured four (4) overall wins (66.7%), followed by Electrical and Mechanical Engineering with one (1) win each (16.7%), while notably, the Internet of Things (IoT) emerged as the most frequent winning category representing 50.0% of total wins. Conversely, a persistent innovation gap was identified in the Civil Engineering, Petrochemical, and Commerce departments, suggesting that while technical software-based innovations are thriving, there is a critical need for more inclusive evaluation criteria. Ultimately, this research provides actionable institutional intelligence to inform curriculum enhancement and strategic resource allocation, fostering a more balanced innovation ecosystem within polytechnic education.

Keywords **:** *Final Year Project; Innovation Trends, Institutional Intelligence; IoT; Polytechnic Education; Student Innovation*

1. INTRODUCTION

The Final Year Project (FYP) serves as a fundamental platform for students to integrate technical knowledge, problem-solving skills, and innovation competencies developed throughout their academic journey. This capstone experience provides a comprehensive demonstration of a student's ability to conduct independent research and execute complex design tasks. Winarno et al. [1] highlight that the Final Year Project reflects an institution's commitment to practical problem-solving. Consequently, many institutions host project competitions to reward outstanding innovation and ensure student solutions align with both industry needs and societal demands. At Politeknik Kuching Sarawak, FYP competitions are conducted regularly across multiple academic departments. Each event features several categories, resulting in the selection of an overall winner representing the most outstanding project. Participation in innovation competitions does more than prove technical ability, it actively enhances teamwork and problem-solving skills [2]. In a vocational context, these experiences are essential for preparing students to meet the demands of a fast-evolving technological landscape. To align academic theory with real-world and market-driven capabilities, long-term analysis of student creativity is needed [3]. This study aims to analyze trends among FYP competition winners over a three-year period to provide a data-driven foundation for institutional planning. By examining departmental patterns and the characteristics of winning projects, this research seeks to identify the

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current direction of student innovation. This study offers a thorough case study of how project-based learning in a polytechnic environment encourages practical creativity among graduates. Ultimately, this introduction establishes the necessity of moving beyond simple recognition to a more analytical understanding of student achievement.

Final Year Project (FYP) competitions are established platforms for showcasing student innovation. These competitions play an essential role in demonstrating the technical capabilities and creative output. The outcomes from category winners potentially reflect emerging innovation strengths across various academic departments. However, competition results are frequently archived merely as historical records of achievement rather than being utilized to support evidence-based academic planning. According to Xinming [4], this lack of rigorous analysis hinders the ability of institutions to identify creativity trends, evaluate the efficacy of current curricula, and adapt educational practices to meet evolving industrial demands. At Politeknik Kuching Sarawak, while FYP competitions are conducted regularly across multiple departments, there has been limited academic effort to examine long-term patterns regarding departmental contributions or innovation paths. Consequently, valuable insights that could guide curriculum refinement and strategic resource allocation remain underutilized. Handayani and Haeruddin [5] and Husin et al. [6] argue that a comprehensive analysis of competition winners provides a robust framework for identifying innovation trends and assessing the development of transferable skills required by the modern workforce. Therefore, this study seeks to bridge the existing gap by examining FYP competition winners over a three-year period to provide evidence-based insights for institutional improvement. By analyzing the specific types of recognized projects and their departmental origins, this research will evaluate how these outputs align with the polytechnic's goals for graduate competency and industry relevance. Ultimately, this analysis will transform stagnant historical records into a dynamic roadmap for future innovation planning and curriculum excellence.

The primary goal of this research is to transform archived competition data into actionable institutional intelligence. To achieve this, the following objectives have been established:

1. To identify departments that consistently produce overall winners.
2. To analyze trends of winning projects across departments over six semesters.
3. To identify innovation directions reflected in winning projects.
4. To examine patterns of departmental dominance in project competitions.

To address the identified research gap, this study will seek to answer the following questions:

1. Which department most frequently produces overall winners?
2. Is there a changing trend in departmental dominance across semesters?
3. What innovation focus can be observed from winning projects?
4. Are certain departments consistently leading in project competitions?

The significance of this study lies in its shift toward a data-driven approach to evaluating student success, transforming competition outcomes from ceremonial recognition into reliable source for academic improvement. Final Year Project competitions form as platforms for awarding excellence. By examining competition winners across multiple semesters, this study generates empirical insights that support evidence-based academic planning and the strategic development of innovation for Politeknik Kuching Sarawak, the findings of this research provide a diagnostic tool to identify departmental strengths and track the evolution of student innovation. This

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information empowers institutional management to refine curriculum design, strengthen the internal innovation culture, and enhance the overall quality of student projects. By identifying the key variables that contribute to success, this study facilitates the development of targeted support mechanisms. Furthermore, this research contributes to the broader academic debate by establishing a framework for utilizing competition data to monitor innovation trends within technical institutions. This methodology encourages structured documentation, allowing for more balanced participation across diverse academic departments. The insights derived from this analysis can inform critical curriculum adjustments, particularly by enhancing student-centered project allocation and the application of design thinking to solve real-world problems [7]. As noted by Quintero and Maldonado [8], this approach ensures that students develop both the core technical proficiency and the transversal soft skills required to navigate the complex challenges of the Industry 4.0 era. This study provides a scalable model for technical institutions to align their academic outputs with the rapidly changing demands of the global industrial landscape.

II. LITERATURE REVIEW

Final Year Projects (FYP) serve as a fundamental capstone in higher education, functioning as the primary vehicle for transitioning students from theoretical learners to autonomous practitioners. Academic research consistently identifies the FYP as a crucial component that enhances technical proficiency, independent problem-solving, and critical professional skills. by integrating specialized knowledge with essential competencies such as project management, technical reporting, and formal presentation, these projects prepare students for the rigors of postgraduate research or direct entry into the workforce. As Razali [9] notes, the FYP serves as a vital benchmark for evaluating a student's ability to apply design thinking methodologies, particularly in industrial design programs where innovative problem-solving is a core requirement. The FYP also fosters multidisciplinary collaboration and creativity within polytechnic environments, preparing students for the demands of modern industry. This integration of practical application and academic rigor is especially significant in fields like automation engineering, where effective teaching models are required to nurture emerging talent. According to Yuan [10], student-centered project models are essential for developing academic resilience, enabling learners to adapt to unpredictable real-world contexts while ensuring successful project completion. To further enhance this resilience, institutions often adopt a comprehensive industry-integrated feedback loop. This approach ensures that student innovation is continuously refined through mentor evaluations and industry standards, effectively bridging the gap between classroom theory and workplace expectations. At Politeknik Kuching Sarawak, FYP competitions provide a high-visibility platform for students to demonstrate their applied skills across diverse departments. These events offer students the opportunity to address authentic engineering issues through interdisciplinary teamwork, a necessity highlighted by Kulturel-Konak [11]. Such exposure encourages students to align their work with industry norms while benefiting from feedback mechanisms that sharpen their design and engineering capabilities. FYP remains the most effective bridge for ensuring that polytechnic graduates possess both the creative confidence and the practical skills demanded by the global economy.

Student competitions are recognized as effective instruments for academic and professional growth, as they provide the necessary recognition and motivation to foster high-quality output. Expanding on this, Hasan et al. [12] highlight that student

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competitions serve as significant indicators of future industry developments. Because winning entries are required to address contemporary socio-technical challenges, these projects frequently reveal the next generation of innovative solutions and emerging technological shifts. This alignment ensures that the academic output remains relevant to the rapidly evolving industrial landscape, effectively acting as a bridge between classroom innovation and market needs. Li et al. [13] further observe that these events facilitate a critical transition, moving students from theoretical academic exercises toward the development of commercially viable prototypes. This incubation process effectively prepares students for the workforce by teaching them to refine high-value projects according to industry standards. Regarding the innovative process, Blust and Myszka [14] explain that competitions offer an environment where students can pursue unconventional solutions without the typical risks associated with failure. This allows for comprehensive exploration from the initial conceptual phase to the final presentation, helping students learn to navigate real-world technical constraints. This development is reinforced by the involvement of industry experts as Zaher et al. [15] note, these professionals provide objective feedback on the technical and commercial viability of student designs, offering a level of inquiry that traditional academic grading may not provide. The success of student-centric model depends on how competition outcomes are recorded and analyzed. When these results are treated as more than just a celebratory milestone, they reveal critical data regarding which departments are successfully fostering interdisciplinary skills. Tracking these performance trends over multiple semesters allows the institution to identify gaps in the current curriculum and reallocate resources toward emerging technology areas that students are naturally gravitating toward.

Institutional innovation varies by department, with performance advantages often tied to specific areas of expertise. Research indicates that departments with specialized resources, faculty expertise, and tailored curriculum consistently produce more award-winning projects [16]. Engineering departments, for example, typically dominate technical categories, while commerce departments excel in entrepreneurship-based competitions. At Politeknik Kuching Sarawak, preliminary observations show that the Civil Engineering, Mechanical Engineering, and ICT departments are the most frequent contributors to overall winning projects, indicating distinct departmental trends in student innovation. For instance, engineering departments typically dominate technical project categories, whereas business-related departments tend to excel in entrepreneurship-focused competitions. These variations in performance are often attributed to specific pedagogical strategies, such as the implementation of multi-level subject competitions. The effectiveness of these departmental initiatives is further reinforced by the adoption of an integrated industry-academic feedback model. As noted by Liu et al. [17], this model incorporates enterprise engineers as mentors and judges, ensuring that student project outcomes align with the rigorous technical and sustainability standards of the modern software and manufacturing industries. By identifying these departmental strengths and formalizing industry-integrated training, institutions can develop a more robust framework for fostering high-level student innovation across all disciplines.

Trend analysis is used to track how project themes and innovation priorities change over time. García-Peñalvo [18] demonstrates that analyzing past competition data can reveal distinct patterns in student creativity and emerging areas of technological interest. In similar studies, observing the distribution of winners across

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various departments and categories over several semesters has provided critical insights into the evolution of student innovation priorities. Applying such trend analysis to the Politeknik Kuching Sarawak Final Year Project competitions may help identify which departments are consistently producing innovative outputs and how research focuses shift across different academic cycles. This evolution in research focus is increasingly driven by a transition toward student-defined topics that allows them to prototype products based on personal interest and feasibility discussions with lecturer, rather than relying solely on predefined industry suggestion. This shift not only boosts student engagement but also ensures that the resulting innovations are both personally meaningful and technically grounded. Furthermore, participation in these organized exhibitions offers students significant networking advantages. These events allow students to connect with potential employers and industry sponsors who provide informal mentorship. This external engagement encourages students to move beyond pure technical specifications; as noted by Liu et al. [17], it facilitates the integration of empathy-driven design principles. Consequently, technical solutions are refined to address both the functional requirements and the emotional needs of the end-users.

Despite the documented benefits of student competitions and trend analysis, a significant disconnect remains in how these elements are studied within specific institutional contexts. While numerous studies explore Final Year Project outcomes and student competitions as separate entities, there is a lack of research on departmental innovation and long-term trends within individual polytechnic institutions. Most existing literature focuses either on isolated single-year results or broad comparisons across multiple institutions, leaving a gap in the understanding of intra-institutional evolution. This study addresses this deficiency by examining competition winners over six semesters at Politeknik Kuching Sarawak, providing a systematic analysis of departmental performance and shifting innovation trajectories. By evaluating the specific characteristics of winning entries, this research investigates the extent to which polytechnic lecturers act as catalysts for these trends. Yuan et al. [10] notes that specific investigation is still required to determine how the institutional allocation of student-centered projects impacts the overall performance and professional skill development of graduates transitioning into specialized technical roles. Furthermore, Okoye and Edokpolor [19] emphasize that ensuring institutional training tools serve as exact replicas of workplace equipment is a critical factor in fostering the self-reliance necessary for graduates to maintain an innovative edge. When students train on industry-standard infrastructure, they develop the practical confidence required to transition seamlessly into professional roles, ensuring their creative outputs are grounded in current technical realities. The transition toward modern pedagogical structures also presents unresolved questions. This research seeks to address the ambiguity surrounding how interdisciplinary models which prioritize flexible collaborative structures over traditional academic silos are integrated into the technical curriculum of Malaysian polytechnics [20]. Additionally, it is still unclear how the Industry 4.0 paradigm has affected the difference between the skill sets provided by higher education and the practical skills needed by local industry. To address this divide, Khan et al. [21] emphasize investigating interdisciplinary design frameworks that can better integrate theoretical student concepts with real-world technological requirements. Consequently, this study aims to fill these identified gaps by providing a localized, data-driven perspective on the future of technical education in Malaysia.

III. METHODOLOGY

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This study employs a quantitative descriptive design to systematically examine the distribution of innovation excellence at Politeknik Kuching Sarawak. A descriptive approach is appropriate for this research as it facilitates the objective identification of patterns and trends within an existing dataset without the need for variable manipulation [22]. By analyzing the outcomes of Final Year Project competitions, this study provides an empirical foundation for understanding how various academic disciplines contribute to the institutional innovation landscape over a specific timeframe. The study utilizes secondary data obtained from official records of Final Year Project (FYP) competition winners, which include information such as project categories, departments, and winning frequencies. As the research relies on documented institutional records rather than primary data collection methods such as questionnaires or interviews, the analysis focuses on identifying observable patterns within the dataset.

The data were retrieved from the Politeknik Kuching Sarawak competition archives, which document the official results of Final Year Project competitions. Secondary data analysis is recognized as a reliable research approach that enables scholars to extract new insights and longitudinal perspectives from existing administrative records [23]. The dataset spans six consecutive semesters, providing an adequate timeframe to observe shifts in innovation focus and the consistency of departmental performance. The specific data points collected include:

i. Performance Metrics: Records of overall winners and category-specific winners in each competition.
ii. Organizational Units: Information was collected from the following departments: Civil Engineering (JKA), Electrical Engineering (JKE), Mechanical Engineering (JKM), Petrochemical Engineering (JKPK), Commerce (JP), and Information and Communication Technology (JTMK).
iii. Project Characteristics: Categorical details such as project titles and the type of innovation within the seven standard competition categories conducted each semester. For data analysis, descriptive statistical techniques were applied using Microsoft Excel. The study focuses on three analytical components: frequency analysis of overall winners by department, trend analysis across six semesters, and innovation direction analysis to identify the distribution of projects across innovation fields.

To ensure a comprehensive evaluation of the findings, the study utilizes three distinct analytical techniques. First, Frequency Analysis is applied to determine the total count of overall winners per department. This provides a clear quantitative measure of which academic units consistently produce high-value innovations. Second, Trend Analysis is conducted using time-series visualization to map departmental performance across the six-semester duration. Observing these patterns over an extended period is essential for identifying whether innovation is growing in specific technical fields. Finally, Innovation Direction Analysis is performed by classifying project titles into specific technological domains, such as Software Development, Structural Engineering, or Sustainable Business Models. This classification bridges the gap between technical output and industry requirements**.** All data are processed using statistical software to generate tables and graphical representations, ensuring that the results are presented with the precision required for institutional decision-making. Ultimately, this approach ensures that the study's conclusions are supported by actual institutional data rather than subjective impressions. It is important to acknowledge that this study is specifically based on the

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"Overall Winners" of the competitions, resulting in a relatively small sample size (n = 6). Despite this numerical constraint, the longitudinal nature of the dataset, which spans six consecutive semesters, adds significant depth to the analysis. This extended timeframe allows for the identification of persistent departmental trends and innovation development that provide a more comprehensive institutional perspective than a single-semester study.

A. Results

This section presents the analysis of overall winners in the Final Year Project (FYP) competitions conducted at Politeknik Kuching Sarawak over six semesters. The analysis focuses on identifying departmental contributions and examining patterns in student innovation outcomes.

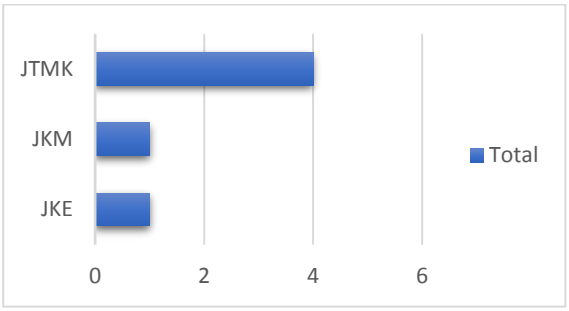
Table 1 summarizes the distribution of overall winners across the six-semester study period. The data indicates a clear disparity in winning frequencies among the various departments.

Table 1: Frequency of Overall Winners per Department

Department	Session II 2022/2023	Session I 2023/2024	Session II 2023/2024	Session I 2024/2025	Session II 2024/2025	Session I 2025/2026	Total
JKA	-	-	-	-	-	-	0
JKE	-	-	-	-	1	-	1
JKM	-	1	-	-	-	-	1
JKPK	-	-	-	-	-	-	0
JP	-	-	-	-	-	-	0
JTMK	1	-	1	1	-	1	4

Note: JKA: Civil Engineering; JKE: Electrical Engineering; JKM: Mechanical Engineering; JKPK: Petrochemical Engineering; JP: Commerce; JTMK: Information and Communication Technology

Figure 1: Frequency of Overall Winners per Department



As illustrated in Table 1 and Figure 1, the Information and Communication Technology Department (JTMK) emerged as the most dominant contributor, securing four overall wins across the six semesters. This represents approximately 66.7% of the total overall wins recorded during the study period. In contrast, the Electrical Engineering (JKE) and Mechanical Engineering (JKM) departments recorded one win each, reflecting an intermittent success rate. Notably, no overall winners were recorded from the Civil Engineering (JKA), Petrochemical Engineering (JKPK), and Commerce (JP) departments. This suggests a significant concentration of "overall winning" quality within technical-software fields, while other core engineering and social science departments face challenges in securing the top spot.

Figure 2 illustrates the longitudinal trend of competition winners, focusing on the continuity of success over time.

Figure 2: Trend Analysis of Overall Winners

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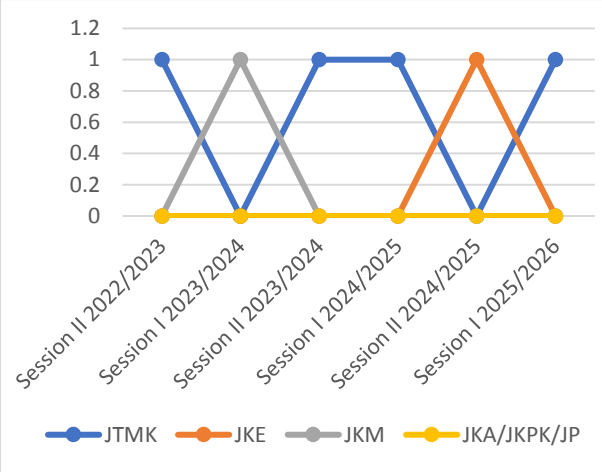

Figure 2 illustrates the longitudinal trend of competition winners over six semesters. The Department of Information and Communication Technology (JTMK) demonstrates a dominant yet cyclical trend, successfully capturing the top spot in four out of six sessions. The graph clearly shows that while other departments like Mechanical Engineering (JKM) and Electrical Engineering (JKE) managed to break JTMK's streak at specific points (Session I 2023/2024 and Session II 2024/2025), they were unable to sustain that momentum in subsequent semesters. Meanwhile, the combined line for JKA, JKPK, and JP remains stagnant at the zero-axis, highlighting a persistent gap in achieving the overall winner status throughout the three-year study period.

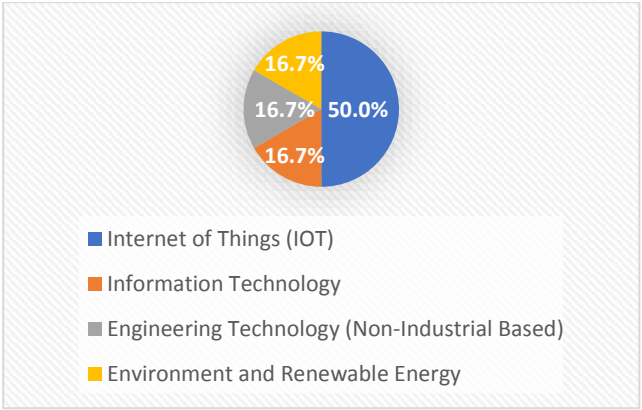

Figure 3: Distribution of Overall Winners by Project Field (Six Semesters)

The analysis reveals a clear dominance of the Internet of Things (IoT), accounting for 50.0% of total wins. The success of IoT in both JTMK and JKE suggests an institutional preference for interdisciplinary projects that combine hardware with digital connectivity. Other fields like *Environment and Renewable Energy* and *Engineering Technology* represent smaller shares (16.7% each).

The analysis reveals several critical patterns that warrant institutional reflection, particularly regarding the significant performance gap where the Department of Civil Engineering (JKA), Department of Commerce (JP), and Department of Petrochemical Engineering (JKPK) have yet to secure an overall win. JTMK's sustained dominance, accounting for 66.7% of total wins, likely reflects a well-established framework for faculty guidance and rapid prototyping that aligns effectively with current competition standards and Industry 4.0 requirements. In contrast, for departments such as JKA and JKPK, innovation often involves heavy complex technical process, high material costs, and extensive lab-based testing, which makes it challenging to produce a market-ready prototype within the limited FYP timeline compared to software-based ICT projects. Furthermore, a distinction in innovation types is observed for the Department of Commerce, where the current judging criteria tend to favor physical or mechanical products over service models or marketing strategies. Without a dedicated category that recognizes the value of management-

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based innovation, high-quality projects from JP find it difficult to compete against the tangible technical sophistication of engineering prototypes. Consequently, the stability of winning trends around IoT-based and intelligent systems suggests that departments that do not integrate such features remain at a disadvantage, highlighting a persistent gap in achieving overall winner status across over the three-year study period.

B. Discussion

The analysis reveals several clear patterns regarding the innovation landscape at Politeknik Kuching Sarawak. Firstly, the data highlights a significant departmental dominance by the ICT department (JTMK), which secured 66.7% of the wins, suggesting that JTMK may have a more established framework for faculty guidance or better access to resources that align with current competition standards. This performance advantage is often tied to specialized resources and tailored curricula that consistently produce award-winning projects [16]. While the Mechanical Engineering (JKM) and Electrical Engineering (JKE) departments managed to secure wins in specific sessions, their success remains intermittent compared to the sustained momentum of JTMK. Winning projects tend to align with departmental expertise, where JTMK focuses on software and JKE on electronics, indicating that student innovation is heavily influenced by departmental strengths. The stability of these winning patterns, particularly the dominance of the Internet of Things (IoT), suggests that the institutional environment and industry-aligned mentorship play a crucial role in maintaining project quality [15]. This trend is consistent with recent studies by [24], which emphasize the necessity of integrating Industrial IoT elements into engineering curricula to meet modern industrial demands. However, the persistent lack of wins for the Petrochemical (JKPK), Civil Engineering (JKA), and Commerce (JP) departments highlights a critical performance gap that warrants further institutional reflection. For departments like JKA and JKPK, the high technical complexity and material costs may hinder the production of visually impactful prototypes within the tight FYP timeline, as compared to the "wow factor" often achieved by software-based projects. These findings serve as a strategic roadmap for policy enhancement, where tracking winners over time can inform curriculum adjustment [25] and ensure that future innovation is more balanced across all academic disciplines.

IV. CONCLUSION

This study provides a systematic analysis of student innovation patterns at Politeknik Kuching Sarawak over a six-semester period. The results conclude that the Department of Information and Communication Technology (JTMK) is the primary driver of innovation excellence, securing 66.7% of the total overall wins. A significant trend identified is the dominance of the Internet of Things (IoT), which emerged as the winning project field in 50.0% of the competitions, proving its high relevance in the current technical education landscape. However, a persistent innovation gap exists, as the Civil Engineering (JKA), Petrochemical Engineering (JKPK), and Commerce (JP) departments have yet to record an overall win. This disparity is attributed to the high technical complexity and material costs in engineering fields, as well as the challenges faced by the Commerce department in competing against "Hard Innovation" prototypes. Ultimately, while innovation is thriving in digital-based sectors, there is an urgent need for institutional support to ensure a more balanced development across all academic disciplines.

V. RECOMMENDATIONS

To foster a more inclusive and competitive innovation ecosystem at Politeknik

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Kuching Sarawak, it is recommended that the institution establishes a cross-departmental mentorship framework where JTMK and JKE collaborate with JKA and JKPK to integrate IoT elements such as smart sensors and automated monitoring into traditional engineering projects. Furthermore, a strategic review of the competition's judging criteria is necessary to provide a fairer platform for "Soft Innovation" from the Commerce Department, potentially through the introduction of specialized categories for service-based or social innovation. The institution should also prioritize targeted resource allocation and funding for departments facing high material costs, such as JKA and JKPK, to enable the production of more polished and visually impactful prototypes within the FYP timeline. Finally, organizing capacity-building workshops focused on Industry 4.0 technologies for students and supervisors in non-ICT departments will be crucial in bridging the technical knowledge gap and ensuring future project outcomes are aligned with current global innovation trends.

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Psychological Capital and Career Advancement of Hospitality and Tourism Industry in Sabah

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Abstract

Psychological capital is a constructive psychological state characterized by four synergistic resources: hope, involving goal-oriented determination; efficacy, reflecting confidence in task mastery; resilience, the capacity to recover from setbacks; and optimism, maintaining a positive outlook for future success. Within the hospitality and tourism industry in Sabah a vital pillar of the regional economy these internal resources are increasingly recognized as essential drivers for professional sustainability in a rapidly evolving business landscape. However, despite the industry's economic importance, there remains a significant gap in empirical evidence exploring how these psychological dimensions specifically influence the career advancement of local employees. This study adopted a quantitative approach, utilizing proportionate stratified random sampling to gather data from 287 employees across five key divisions in Sabah. Data analysis performed via SmartPLS 4.0 using Partial Least Squares-Structural Equation Modeling (PLS-SEM) revealed that hope, efficacy, resilience, and optimism all maintain a significant positive relationship with career advancement, with optimism emerging as the most influential predictor. These findings underscore the critical need to integrate psychological resource development into human capital strategies to reshape the global knowledge economy and ensure the long-term competitiveness of Sabah's hospitality and tourism workforce.

Keywords: *Psychological capital; Career advancement; Hospitality and tourism industry*

I. INTRODUCTION

Sabah's hospitality and tourism industry plays a vital and significant role as a major contributor to the overall economy of the state, shaping not only the financial landscape but also influencing social interactions and cultural exchanges within the region [1]. Despite its critical importance, however, there are relatively limited studies available that thoroughly examine the various factors that affect the career advancement of employees working within this key and essential industry. Recognizing the challenges faced, it is essential to delve deeper into the nuances of employee progression to ensure a robust workforce. To address this noticeable gap in the literature, the present study draws on the broaden-and-build theory of positive emotions, which suggests that positive emotional experiences can lead to a wider range of cognitive and behavioral capacities, to investigate the intricate relationship between psychological capital and career advancement.

Embracing a quantitative research methodology, data are meticulously collected through an extensive cross-sectional survey that targets employees currently engaged in the vibrant hospitality and tourism industry located in Sabah. This process captures a broad spectrum of perspectives, insights, and experiences that reflect the diverse nature of the industry [2]. The insightful and compelling results derived from this research have the potential to significantly inform managers and decision-makers about effective strategies to support the career advancement of their employees. This progress not only fosters individual development but also cultivates a more engaged and motivated workforce, ultimately boosting the overall performance and sustainability of the industry in this vibrant region [3].

Increasingly, the hospitality and tourism industry has emerged as a pivotal focus of economic growth and development in numerous regions around the globe. This vital sector plays an essential and increasingly prominent role in contributing significantly to income generation, job creation, and foreign exchange earnings that bolster local economies. By attracting visitors from different places, it enhances the overall quality of life for individuals residing in those areas, while also opening new avenues for cultural exchange and interaction. As communities invest in this sector,

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they often see increased infrastructure development, which further supports a vibrant and sustainable environment for both locals and tourists alike [4]. The career advancement of employees in any organization within the hospitality and tourism realm is fundamentally important to ensure the achievement of its overarching organizational goals and objectives. However, despite the critical significance of employee progression and development opportunities, limited research exists that specifically attempts to link the concept of psychological capital to career advancement within the hospitality and tourism industry, which presents a notable gap in the academic literature [5].

The current study makes a noteworthy contribution to the existing body of literature by developing a comprehensive research model that thoroughly examines the intricate relationships that exist among the various dimensions of psychological capital. These dimensions include the four constructs of hope, efficacy, resilience, and optimism, each of which plays an essential role in influencing career advancement and personal growth in the hospitality and tourism industry [6]. This approach provides deeper insights into how organizational environments can substantially impact employee growth and development trajectories within this vital sector, ultimately aiming to enhance the overall effectiveness and success of organizations operating in the ever-evolving landscape of hospitality and tourism industry [7]. By addressing these critical factors, the research sheds light on potential pathways for fostering employee engagement and motivation, which are key to a thriving hospitality and tourism workforce [8].

Nevertheless, the market prices for crude oil and natural gas have exhibited remarkable volatility over the years, with a particularly notable downturn occurring in 2015. This downturn culminated in the lowest recorded prices in 2016, which sent shockwaves throughout the global energy markets and caused significant concerns among stakeholders, investors, and local businesses alike. As a direct consequence of these fluctuating prices impacting crucial revenue streams, Sabah is actively seeking viable alternatives to generate sustainable income for the enhancement of the state's economy and to reduce dependency on the increasingly erratic oil market.

This strategic shift in direction has led to a renewed and reinvigorated focus on the vast potential that tourism offers as an industry, which, if harnessed and managed effectively, could invigorate the local economy, create ample job opportunities for its citizens, and provide long-lasting benefits that would contribute significantly to the overall well-being and quality of life within the community in Sabah [9]. By investing in and promoting tourism, Sabah is not only aiming to diversify its economic foundations but also looking to showcase and elevate its rich cultural heritage and breathtaking natural beauty, thereby attracting both local and international visitors who seek unique experiences and adventures.

Research indicates that psychological capital can serve as a significant and impactful driver of several positive individual and organizational outcomes. Extending upon this foundational insight, it is noteworthy and somewhat alarming that a comprehensive review of existing academic literature reveals a conspicuous absence of empirical studies exploring the intricate relationship between psychological capital and career advancement specifically within the context of the hospitality and tourism industry in Sabah [8].

This considerable gap in knowledge suggests that there exists a significant lack of insight into how various forms of organizational support may impact and influence the intricate and often challenging relationship between psychological capital and career advancement. This is particularly relevant in terms of mitigating the motivation-hygiene issue that frequently arises in such dynamic and fast-paced environments, which can greatly affect employee morale and progression [10].

Furthermore, businesses and organizations have a vital opportunity to assist in the progressive advancement of their employees by proactively implementing their own financial support mechanisms and strategies. By doing so, they can provide individuals who are genuinely on the path to professional progress with satisfactory and meaningful financial rewards and benefits that genuinely acknowledge their hard work, efforts, and contributions to the company.

Given these significant gaps in current research and understanding, the present study aims to thoroughly investigate and illuminate the association between psychological capital and career advancement specifically within the hospitality and tourism industry in Sabah. Additionally, the analysis will be extended and enriched by determining whether perceived organizational support serves to meaningfully modify the hypothesized relationship between these critical factors, thereby contributing valuable insights to the existing body of knowledge in this important area of study and paving the way for future research initiatives.

The primary objective of this study is to determine the relationship between psychological capital and career advancement in the hospitality tourism industry in Sabah. This relationship has received little research attention in relatively developed economies, especially in Malaysia, where a theoretical framework is absent.

The purpose also informs the proposed hypotheses, supported by a literature review. Career advancement is the dependent variable, with empirical evidence indicating a positive association with psychological capital. Hope, efficacy,

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resilience, and optimism are the independent variables.

Human capital takes centre stage in the realm of organizational success, especially when one examines it through the intricate lens of psychological capital. This concept plays a vital role in determining not just the individual growth of employees but also the collective advancement of organizations themselves. Psychological capital is a multifaceted construct that encompasses several pivotal components: hope, efficacy, resilience, and optimism. Each of these elements plays a foundational role in cultivating a positive perspective regarding work, personal life, and the challenges that inevitably arise [11].

Employees who showcase elevated levels of psychological capital are often seen to exhibit remarkable communication skills, which enhance their interactions with both superiors and peers. This improved engagement not only paves the way for better career opportunities but also significantly boosts collaborative efforts across diverse teams within the work environment [12]. Focusing specifically on the vibrant and dynamic sectors of the hospitality and tourism industry, one can identify a wealth of opportunities for upward mobility and substantive career progression.

Tourism stands as the second most significant pillar of Sabah's economy, contributing substantially to job creation and foreign exchange. As the state seeks sustainable alternatives to the volatile oil and gas markets, the growth of this sector is paramount. However, the 'Skills Revolution' necessary for this growth depends heavily on the career progression of the local workforce. While technical skills are often highlighted, the underlying psychological drivers of this advancement remain under-researched in the local context [13].

II. LITERATURE REVIEW

Career advancement serves as a primary motivator for professional growth, acting as a critical mechanism to reduce high turnover rates and enhance organizational commitment. In the dynamic context of Sabah's hospitality industry, tangible progression pathways are essential for maintaining workforce morale. Recent studies emphasize that in the post-pandemic service economy, career trajectories are increasingly influenced by an individual's internal psychological resources rather than traditional organizational structures alone. [14].

Employees who feel that they have attained tangible career advancement are much more likely to devote considerable time and effort to their employer's objectives and overall growth. Furthermore, psychological capital plays an indispensable role in facilitating career advancement, as it empowers individuals to confront challenges with a positive mindset, enhances their resilience in the face of adversity, and fosters a strong determination to achieve both personal and professional goals [8].

Previous studies have clearly revealed that a high level of psychological capital can positively influence employees' likelihood of experiencing career advancement across diverse sectors. Despite this, very little attention has been directed towards examining the moderation effect on the relationship between psychological capital and career advancement specifically within the hospitality and tourism industry [15]. Thus, based on the notable gaps identified in the existing literature, it is crucial and necessary to study the intricate relationship between psychological capital and career advancement. Addressing these elements will not only enhance our understanding but also improve practices and strategies within this critical sector [16].

Career advancement is widely recognized as one of the most significant incentives for professional growth within the hospitality and tourism industry because it effectively reduces high employee turnover while simultaneously enhancing the level of support that employees demonstrate toward the broader organizational impact [17]. An increasing number of research studies have systematically explored the intricate link between psychological capital and the pathways of employees' career advancement across various industrial sectors, consistently demonstrating a positive correlation between the facets of psychological capital and employees' attitudes and behaviours regarding career advancement opportunities [18].

Psychological capital is a multidimensional construct comprising four positive psychological resources: hope, efficacy, resilience, and optimism. Hope involves the agentic determination to pursue goals while identifying alternative pathways to achieve them. Efficacy refers to the self-confidence required to execute master challenging tasks. Resilience is the capacity to bounce back from professional setbacks, while optimism reflects a positive attribution regarding future success. Recent methodological advancements in PLS-SEM suggest that these dimensions function synergistically to enhance employee performance and well-being. [19].

This dynamic interaction significantly influences the likelihood that the actual behaviour will either be executed or not executed. Consider three distinct types of constructs namely, independent constructs, and a dependent construct within the scope of hotel frontline employees, career advancement within the hotel industry emerges as the dependent construct that influences their professional trajectories [20]. Psychological capital serves as the independent constructs in this context, distinctly manifesting in various forms such as hope, efficacy, resilience, and optimism.

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Career-related behaviors and outcomes are intricately guided by psychological capital, which plays a significant role in influencing various dimensions of one's professional journey both directly and indirectly. In an insightful and comprehensive study that robustly supports these intricate relationships through the well-established framework of conservation of resources theory, meaningful and positive connections that exist between all four critical components of psychological capital hope, efficacy, resilience, and optimism and the overall process of career advancement [21]. Empirical evidence consistently demonstrates a positive correlation between high levels of psychological capital and proactive career behaviours. For instance, recent research on service sector employees indicates that those with robust psychological resources are more likely to seek out upward mobility and master the "Skills Revolution" required for modern industry demands. This relationship is often explained through the Conservation of Resources (COR) Theory, which posits that individuals with a rich "caravan" of psychological resources are better positioned to acquire further professional gains and navigate career obstacles [22].

The present study integrates Broaden-and-Build Theory and COR Theory to investigate how internal states drive professional outcomes. While previous studies have examined these variables in diverse global sectors such as a large-scale study of 1,225 managers in China there remains a critical research gap regarding these dynamics in the specific socio-economic environment of East Malaysia. Consequently, the following hypotheses are proposed:

Hypothesis$_{1a}$: The hope dimension of psychological capital has a significant relationship with career advancement.

Hypothesis$_{1b}$: The efficacy dimension of psychological capital has a significant relationship with career advancement.

Hypothesis$_{1c}$: The resilience dimension of psychological capital has a significant relationship with career advancement.

Hypothesis$_{1d}$: The optimism dimension of psychological capital has a significant relationship with career advancement.

Based on the literature and the discussion, the conceptual framework for this study is illustrated in Figure 1.

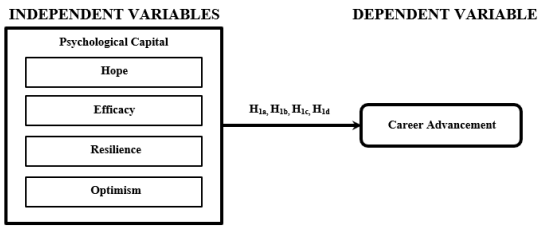

Figure 1: Conceptual Framework

The rationale behind the combination of the independent variables and the dependent variable is that the integration of these variables would facilitate that enables psychological capital dimensions to influence career advancement. The various variables had been adapted from the following previous studies [11] [23].

III. RESEARCH METHODOLOGY

For this study, the research instrument was developed by applying measurement scales recognized from previous studies. Modifications were done to the substances to ascertain that it applied into the framework of this study. Moreover, the validity and the reliability of the instrument were determined with the information obtained from focus group, translation process, pre-test, and a pilot test study performed and conducted. The real and the actual information gathering or data collection had been initiated after accomplishment (in terms of validity and reliability) of the research instrument was attained or achieved. The systematic execution of this study followed a structured six-phase research process flow, as illustrated in Figure 2.

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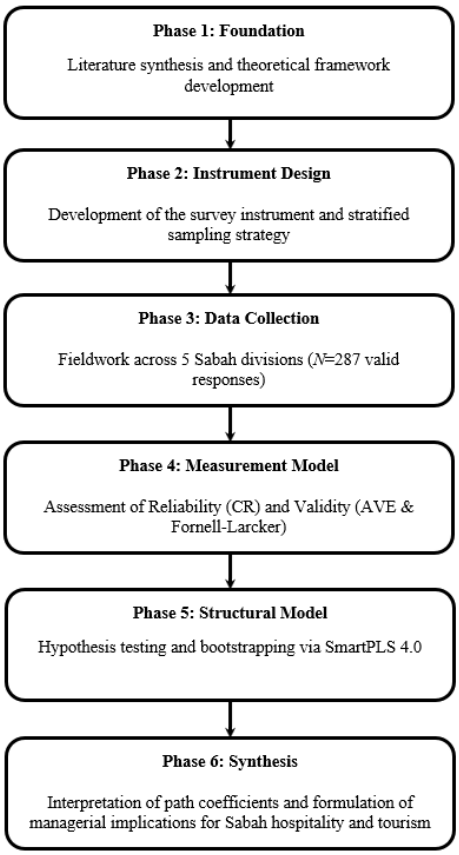

Figure 2: Research Process Flow

Moreover, the information for this study was gathered through the application of the drop-off and collect technique. The sample for this study was selected by applying the proportionate stratified random sampling method. Using Statistical Package for Social Sciences (SPSS) version 31.0 and Partial Least Squares-Structural Equation Modeling (PLS-SEM) method, the data were assessed.

This analysis applied a correlation research plan using the quantitative research strategy to investigate the relationship between the independent variables and the dependent variable. This analysis of correlation was directed to the population of 1,567 hospitality and tourism industry in the State of Sabah. In getting the primary data, self-administered questionnaire was the selected method for this analysis, in addition to the quantitative responses from the respondents based upon a 5-point Likert-type scale reply. Moreover, in collecting the views from the selected groups, a proportionate stratified random sampling method was applied. This study employed the drop-off and collect technique, where all the data were collected once, within a period of seven months to gather rhythmic responses from the respondents.

Emphasized that the decision of sampling design is an essential aspect of research design, including both sampling strategy and sample size determination. Sampling design can be comprehensive into a major type (i.e. probability sampling). The probability sampling is one type of sample in which the components in the population are designated by some known facts [24]. In this analysis, the sampling strategy applied in the investigation was the probability sampling. In probability sampling process, every member of the population has a known non-zero probability of being nominated [25].

In choosing the respondents, stratified random sampling was used because all the members of the population are equally qualified and chances of getting selected are also equal. Since all of them met the criterion in the hospitality and tourism field and can be the representation of their industries, the respondents were selected blindly.

Table 1

List of Population of Hospitality and Tourism Industry in Sabah

No.	Division	Number of Hospitality and Tourism Industry
1.	Kudat Division	68
2.	West Coast Division	842
3.	Interior Division	114
4.	Sandakan Division	228
5.	Tawau Division	315
	Total	**1,567**

Source: Department of Industrial Development and Research (DIDR), Sabah (2024)

Based on Table 1, this analysis concentrated only on hospitality and tourism industry in Sabah, which comprised of Kudat Division, West Coast Division, Interior Division, Sandakan Division, and Tawau Division. This is because; the State of Sabah is comprised of 5 divisions. In this study, the respondents were the employees of hospitality and tourism industry in Sabah.

Table 2 represents the proportionate stratified random sampling conferring to different divisions of hospitality and tourism industry in Sabah. This proportional sample size was measured based on 20 percent for each division. The researcher used proportionate stratified random sampling for the population, which was divided into strata, and the researcher included the stratum when selecting the sample. Based on the population, the researcher uses 20 percent as the stratum because the percentage chosen was applicable to make the stratum fit for the purpose of the study based on the requirement of the sample size.

The stratified sample needed about 313 hospitality and tourism industry for specific survey. Thus, the researcher included in the sample 20 percent from the population of hospitality and tourism industry from each division. However, with continuous action of following up, the progress which the respondents had made in answering the questionnaires and having face-to-face meetings with them, the rate of response for the distributed questionnaires were 92 percent, equivalent to 287 responses.

Table 2

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Proportionate Stratified Random Sampling According to Divisions of Hospitality and Tourism Industry in Sabah

No.	Division	Population	Number of Subjects in the Sample *Proportionate Sampling (20 percent of the population)*
1.	Kudat Division	68	14
2.	West Coast Division	842	168
3.	Interior Division	114	23
4.	Sandakan Division	228	45
5.	Tawau Division	315	63
	Total	**1,567**	**313**

IV. RESULT AND DISCUSSION

A measurement model contains a satisfactory internal consistency reliability if the Composite Reliability (CR) of each component is more than the required value of 0.7. Table 3 indicates that the CR for each construct in this study ranged between 0.773 and 0.852 and the value exceeds the required threshold value that stands at 0.7. In view of this, the outcomes showed that the components utilized in representing the constructs contained satisfactory internal consistency reliability.

Table 3

Descriptive and Reliability Statistics

Constructs	Item	Mean	Std. Dev.	Loadings	T-value
Hope	HO1	3.91	0.832	0.739	7.412
HO = 0.792	HO2	3.65	0.917	0.788	8.006
	HO3	3.29	0.740	0.716	6.453
Efficacy	EF1	3.54	0.937	0.752	8.095
EF = 0.804	EF2	3.64	0.841	0.884	12.227
	EF3	3.72	0.856	0.878	13.212
Resilience	RE1	3.95	0.793	0.672	10.413
RE = 0.773	RE2	3.79	0.891	0.768	12.525
	RE3	3.73	0.947	0.746	10.529
Optimism	OP1	3.88	0.901	0.694	8.387
OP = 0.782	OP2	3.77	0.771	0.722	9.746
	OP3	3.90	0.881	0.796	11.571
Career Advancement	CA1	3.69	0.899	0.721	13.881
CA = 0.852	CA2	3.73	0.833	0.685	13.442
	CA3	3.73	0.831	0.731	14.289
	CA4	3.76	0.859	0.746	15.779
	CA5	3.93	0.866	0.777	17.539
	CA6	3.94	0.870	0.782	17.602

In this study, the convergent validity of the measurement model was evaluated through the examination of its Average Variance Extracted (AVE) value. Convergent validity is adequate if the constructs contain an AVE that ranges between 0.508 and 0.674, which is more than the required threshold value of about 0.5. As illustrated in Table 4, the outcome demonstrated that the measurement model of this study indicated abundant convergent validity.

Table 4

Average Variance Extracted Value

Constructs	Average Variance Extracted (AVE)
Hope	0.560
Efficacy	0.674
Resilience	0.537
Optimism	0.508
Career Advancement	0.533

Within this study, the discriminant validity of the measurement model was evaluated with the help of two measures, namely criterion and cross-loading. A measurement model is considered to have discriminant validity if the AVE square root is more than the correlations involving the measure, alongside all the remaining measures. Additionally, the same situation can prevail if the loadings of the indicators exceed against their specific constructs than other constructs [26].

Therefore, for determination of the initial evaluation of the discriminant validity of the measurement model, the AVE value had been generated for each construct through the PLS-SEM algorithm function. This was followed by the manual calculation of AVE square roots. Going by the outcomes, all the values of AVE square roots were more than the off-diagonal elements within their corresponding columns, as well as rows. The elements in bold in Table 5 represent the AVE square roots, along with the unbolded values that represent the intercorrelated values between the constructs. As illustrated in Table 5, all off-diagonal elements had been less than the AVE square roots (bolded on the diagonal). Thus, the outcomes proved that the criterion used by Fornell and Larker was fulfilled.

Table 5

Inter-Correlation Matrix

Constructs	HO	EF	RE	OP	CA
Hope	**0.748**				
Efficacy	0.460	**0.721**			
Resilience	0.380	0.416	**0.732**		
Optimism	0.344	0.342	0.629	**0.713**	
Career Advancement	0.461	0.391	0.561	0.511	**0.730**

Note: Diagonals (bolded) represent the square root of the AVE, while the off-diagonals represent the correlations

The evaluation of the discriminant validity entailed assessing the loadings of the indicators regarding all correlated constructs. The cross-loading output was generated by using the function of the PLS-SEM algorithm. The cross-loading output between the indicators and the constructs is illustrated in Table 6. Additionally, all measurement components with higher loadings against the required latent variable than other variables are indicated in Table 6. Furthermore, the table indicated that the loading for each block was higher compared to other blocks within the same columns, as well as rows. The loading provides a clear separation of all latent variables, as explained within the conceptual model. Therefore, the output of the cross-loading revealed that the second evaluation for the discriminant validity in the measurement model had been fulfilled.

Table 6

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Cross-Loading

	HO	EF	RE	OP	CA
HO1	**0.739**	0.301	0.297	0.355	0.329
HO2	**0.788**	0.317	0.271	0.256	0.327
HO3	**0.716**	0.413	0.283	0.155	0.377
EF1	0.334	**0.752**	0.278	0.186	0.250
EF2	0.415	**0.884**	0.393	0.353	0.378
EF3	0.314	**0.721**	0.307	0.422	0.449
RE1	0.247	0.294	**0.685**	0.383	0.401
RE2	0.203	0.306	**0.731**	0.465	0.417
RE3	0.289	0.238	**0.746**	0.469	0.363
OP1	0.334	0.368	0.550	**0.777**	0.423
OP2	0.313	0.222	0.405	**0.682**	0.363
OP3	0.261	0.244	0.481	**0.769**	0.392
CA1	0.288	0.293	0.490	0.437	**0.735**
CA2	0.194	0.189	0.456	0.376	**0.717**
CA3	0.208	0.198	0.401	0.264	**0.685**
CA4	0.238	0.334	0.459	0.317	**0.712**
CA5	0.215	0.217	0.434	0.385	**0.684**
CA6	0.343	0.261	0.393	0.456	**0.672**

The outcome given in Table 7 showed that a significant relationship was been identified between hope and the career advancement (β = 0.162, t = 2.620 $p < 0.01$). The existence of a significant relationship between efficacy and the career advancement ($\beta = 0.110$, $t = 2.454$, $p < 0.05$). A significant relationship between resilience and career advancement ($\beta = 0.163$, $t = 2.645$, $p < 0.01$). Lastly, optimism displayed a positive influence on the career advancement of hospitality and tourism industry in Sabah ($\beta = 0.172$, $t = 2.598$, $p < 0.01$).

Table 7

Path Coefficients, T-value, and Significant Level for All Hypothesized Paths

Hypothesis	Relationship	Coefficient	T-value	Significance Level
$Hypothesis_{1a}$	Hope -> Career Advancement	0.162	2.620**	0.01
$Hypothesis_{1b}$	Efficacy -> Career Advancement	0.110	2.454*	0.05
$Hypothesis_{1c}$	Resilience -> Career Advancement	0.163	2.645**	0.01
$Hypothesis_{1d}$	Optimism -> Career Advancement	0.172	2.598**	0.01

**$p < 0.01$, *$p < 0.05$

Table 8

Summary of Hypotheses

	Hypothesis Statement	Results
$Hypothesis_{1a}$	The hope dimension of psychological capital has a significant relationship with the career advancement of hospitality and tourism industry in Sabah.	**Supported**
$Hypothesis_{1b}$	The efficacy dimension of psychological capital has a significant relationship with the career advancement of hospitality and tourism industry in Sabah.	**Supported**
$Hypothesis_{1c}$	The resilience dimension of psychological capital has a significant relationship with the career advancement of hospitality and tourism industry in Sabah.	**Supported**
$Hypothesis_{1d}$	The optimism dimension of psychological capital has a significant relationship with the career advancement of hospitality and tourism industry in Sabah.	**Supported**

The path coefficients statistics presented in Table 7 and summary of hypotheses in Table 8 indicated that hope, efficacy, resilience, and optimism did have influence upon career advancement. In this study, the results from the hypotheses have been deemed as significant. The significant results were identified, thus implying that the psychological capital dimensions played a positive role in career advancement of hospitality and tourism industry in Sabah.

V. CONCLUSION

In an era characterized by an intensely fierce level of competition, organizations must prioritize the crucial task of actively cultivating individuals who possess a robust and formidable level of psychological capital. This strategic focus is not merely an option but an essential requirement to ensure that employees are well-equipped to navigate and successfully surmount the various barriers they may encounter while striving to achieve the set objectives. This necessity is particularly pronounced within the dynamic and rapidly evolving hospitality and tourism industry, where adaptability is key. Employees who consistently exhibit high psychological capital not only possess a strong belief in their own abilities but also demonstrate elevated levels of hope, efficacy, resilience, and optimism.

These exceptional qualities empower them to confront challenges head-on, ultimately enabling them to overcome obstacles that may otherwise hinder their progress. By actively fostering and diligently developing these essential traits within their workforce, companies can effectively motivate employees to embrace more demanding and challenging responsibilities. This, in turn, leads to enhanced opportunities for significant career advancement that can contribute to personal and professional growth in a myriad of ways. However, existing research indicates that the intrinsic qualities of workers alone are insufficient to drive meaningful career progression; rather, it is crucial to acknowledge that the presence and provision of adequate support from the organization itself play a vital role in shaping this important relationship between personal attributes and career growth.

Indeed, the absence or loss of social support can significantly weaken the connections between an employee's personal characteristics and their overall career trajectory, making it even more difficult for individuals to truly flourish and thrive in their roles. This reinforces the point that fostering strong psychological capital in employees must be complemented by effective and supportive organizational support systems.

Consequently, it is imperative for organizations to strategically invest in providing substantial levels of social support to employees, thereby facilitating career development that aligns seamlessly with the enhancement of psychological capital. Such initiatives not only empower individuals with the confidence to pursue their aspirations and goals but also contribute to building a more robust and resilient workforce that feels genuinely valued and supported.

This collaborative and supportive approach ultimately drives the organization toward greater success and sustainability in an increasingly competitive market, positioning it to thrive in the face of various adversities, while nurturing talented individuals who will drive future innovation and

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lasting progress in both their careers and the organization.

The hospitality and tourism industry occupy an essential and significant place in the overall economy of Sabah, a region that is truly endowed with a rich cultural heritage and stunning natural beauty. This vibrant area is characterized by a diverse and wide-ranging selection of remarkable tourism products and experiences that attract an array of visitors from all corners of the globe, each eager to explore its unique offerings. Nevertheless, despite the multitude of opportunities available within this dynamic and flourishing sector, there exists a conspicuous lack of useful information regarding crucial staff career considerations and potential pathways for advancement.

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LAST MILE DELIVERY QUALITY AND EXPERIENCE: KEY DETERMINANTS OF E-COMMERCE CUSTOMER LOYALTY OF GEN Z

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Abstract

With the e-commerce revolution reforming the retailing business environment of Malaysia, customer loyalty is the endgame of the businesses that intend to remain competitive. The paper explores the role of the last stage of the process last-mile delivery (LMD) in fact determining the loyalty of Generation Z consumers. Our structured survey and quantitative analysis of the results of the application of the SERVQUAL model to measure speed, reliability, communication, and professionalism made us understand what, in fact, determines repeat purchases among this young target audience. The results proved to be instructive: whereas the research model explained almost half of the variation in customer loyalty, only the delivery speed and rider professionalism proved to be significant. Interestingly, the statistical weight of reliability and communication was not of a comparable level, which indicates that in the case of Gen Z, the need to receive instant gratification and a respectful human contact usually prevails over technical accuracy. As it is evident in the preference to the TikTok platform and Shopee and a preferred courier in J&T, the study shows that e-commerce requires more than mere logistics to flourish. Instead, they will have to adopt a customer experience that is more customer-centric by focusing on shorter delivery times and enhanced rider training to establish a seamless, reliable experience.

Keywords **:** *Last Mile Delivery, Customer Loyalty, Gen Z,e-commerce, servqual,speed, professionalism*

I. INTRODUCTION

In the highly competitive e-commerce landscape of Malaysia, customer loyalty has emerged as a key driver of profitability and market leadership. Last-mile delivery (LMD) plays a fundamental role in cultivating this loyalty (Chuyen, 2025), as its quality and the customer's experience are no longer just logistical considerations but critical brand differentiators. Our analysis identifies three core factors that determine LMD quality: the importance of speed and reliability, the power of transparency and proactive communication, and the significance of human and experiential factors. (Mohd Yusoff & Mohammad, 2023). Previous research proved that speed matters only if reliability accompanies it (Pavlovich, 2025)The Malaysian market, with its rapid digital adoption and a mobile-first consumer base, presents a unique set of challenges, including high operational costs and a significant technology gap. (Zainuddin, 2022) However, these challenges can be transformed into opportunities through strategic investments in technology and sustainable practices.

II. LITERATURE REVIEW

A. The Service Quality (SERVQUAL) model, developed by Parasuraman, Zeithaml, and Berry (1988), is a cornerstone for measuring service quality by identifying the gap between customer expectations and perceptions across five dimensions. Academic literature consistently applies this model to logistics and delivery services, including the complex final stage of the supply chain, the last mile. Researchers have found that these dimensions are highly relevant to how customers evaluate their LMD experience. (Stevic, 2023)

B. Reliability is consistently identified as the most critical dimension. In LMD, this means performing the promised service dependably and accurately. Studies emphasize the importance of on-time delivery, order accuracy, and ensuring the package arrives in good condition as core components of reliability. A reliable delivery service reduces customer uncertainty and builds trust, which is a

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strong predictor of loyalty. (Cai, Liu, Lai, Zhu, & Yuen, 2024)

C. Responsiveness refers to the willingness to help customers and provide prompt service. This is vital in the LMD context. Proactive and clear communication about delivery status, real-time tracking, and the ability to handle delivery exceptions or customer complaints quickly are key elements of responsiveness. A responsive delivery service makes customers feel valued and in control of their purchase. (Matong, 2020)

D. Assurance involves the knowledge, courtesy, and trustworthiness of employees. This dimension is especially relevant to the LMD, where the delivery rider is often the only human touchpoint between the e-commerce store and the customer. A professional, polite, and knowledgeable rider inspires confidence and reflects positively on the brand. (Cai, Liu, Lai,)

III. RESEARCH METHODOLOGY

The most suitable method to collect data for this study is by distributing questionnaires to the respondents. This approach allows researchers to obtain reliable and accurate information directly from the participants. In this research design, a single cross-sectional design is used, where data is collected from a specific sample of the population at one point in time. Only one group of respondents is selected from the target population, and the necessary information is gathered from this group to represent the study. The population is defined by their location and their specific experience with e-commerce, as the research focuses on how LMD quality in this geographic area affects customer loyalty. Due to the specific and contained nature of the target population, a non-probability sampling method is most appropriate. Specifically, Convenience Sampling is a practical and widely used approach for this type of research.

The survey questionnaire will be the main instrument for data collection. It will be designed based on the theoretical framework, using established scales to measure the key variables. The questionnaire will be divided into the following sections:

Section A: Demographics: Questions about the respondent's age, gender, family income, and preferred courier service.

Section B: Independent Variable: Questions about the speed of last-mile delivery, reliability of last-mile delivery, communication and professionalism of delivery personnel. This section will use a 5-point Likert scale to measure LMDQ based on the SERVQUAL dimensions.

Section C: Dependent Variable: Question that will focus on customer loyalty on e-commerce among the Gen Z.

ANOVA (Analysis of Variance) is a suitable statistical test for this topic, but it addresses a different type of question than multiple regression. While multiple regression is used to determine the influence of continuous variables, ANOVA is primarily used to compare the means of two or more groups to see if there is a statistically significant difference between them. Using multiple regression analysis is crucial for this research topic because it allows to analyse how several different factors of last-mile delivery simultaneously influence customer loyalty. This method goes beyond simple correlation to determine the unique contribution of each factor. Multiple regression used to isolate the specific effect of each independent variable on the dependent variable. In this case, it has several dimensions of LMD quality (e.g., speed, reliability, communication, professionalism) that all likely impact customer loyalty.

IV. RESULT AND DISCUSSION

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.704[a]	.496	.481	.52627

a. Predictors: (Constant), IV4, IV1, IV3, IV2

The regression model showed a strong relationship between the independent variables (IV1–IV4) and the dependent variable, with R = .704. The predictors explained 49.6% of the variance in the dependent variable (R^2 = .496, Adjusted R^2 = .481). The standard error of .52627 indicates that the model fits the data reasonably well, confirming that the selected predictors play a significant role in influencing customer satisfaction and loyalty among Gen Z.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	37.049	4	9.262	33.443	.000[b]
	Residual	37.666	136	.277		
	Total	74.715	140			

a. Dependent Variable: CL

b. Predictors: (Constant), IV4, IV1, IV3, IV2

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The ANOVA results confirmed that the regression model was statistically significant, $F(4, 136) = 33.44$, $p < .001$. This indicates that the independent variables (IV1–IV4) collectively explained a significant proportion of the variance in customer loyalty. The findings suggest that factors such as speed, reliability, communication, and professionalism play an important role in shaping loyalty among Gen Z.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Sta
		B	Std. Error	Beta			Tolerance
1	(Constant)	1.082	.283		3.817	.000	
	IV1	.241	.104	.252	2.312	.022	.312
	IV2	.074	.136	.068	.549	.584	.242
	IV3	.202	.111	.202	1.824	.070	.301
	IV4	.245	.112	.249	2.194	.030	.288

a. Dependent Variable: CL

The results of the regression analysis indicate that Speed and Professionalism have a significant positive influence on Customer Loyalty, while Reliability and Communication do not show a statistically significant effect in this study. Speed ($B = 0.241$, $p = 0.022$) significantly affects Customer Loyalty, meaning that when the Speed score increases by one point, the Customer Loyalty score is expected to increase by 0.241 points, assuming other variables remain constant. Similarly, Professionalism ($B = 0.245$, $p = 0.030$) also shows a significant positive relationship with Customer Loyalty, indicating that higher professionalism leads to higher customer loyalty. In contrast, Reliability ($B = 0.074$, $p = 0.584$) does not significantly influence Customer Loyalty because the p-value is greater than 0.05, suggesting that the relationship may occur by chance. Communication ($B = 0.202$, $p = 0.070$) also does not significantly affect Customer Loyalty, although its p-value is relatively close to the significance level. Overall, these findings suggest that Speed and Professionalism are more important factors in influencing Customer Loyalty compared to Reliability and Communication in this model.

V. CONCLUSION

The data shows that speed and professionalism are the most influential factors in shaping customer loyalty. Students want their parcels delivered quickly, and they value respectful, well-groomed delivery personnel who handle packages with care. These preferences reflect Gen Z's broader expectations: they are used to instant gratification and seamless digital experiences, and they expect the same from their physical interactions with brands.Interestingly, reliability and communication, while still important, did not show a statistically significant impact in this study. This could suggest that Gen Z consumers are more focused on the overall experience rather than technical precision. For example, they may tolerate minor delays if the delivery is handled professionally and with a positive attitude.

From a marketing perspective, these findings are crucial. Brands that want to win the loyalty of Gen Z must go beyond just selling products they must deliver experiences. This includes fast, smooth delivery and human interaction that feels respectful and trustworthy. E-commerce platforms and courier services that fail to meet these expectations risk losing repeat business and damaging their reputation among this highly connected and vocal demographic. The dominance of platforms like TikTok and Shopee, and the preference for J&T as a courier, further highlight how Gen Z gravitates toward brands that are familiar, fast, and socially engaging. These platforms have successfully built trust by aligning with Gen Z's lifestyle and communication style, making them ideal case studies for future marketing strategies.

For E-Commerce Platforms, it is crucial to offer faster delivery options and clearly communicate expected delivery timelines. This helps manage customer expectations and enhances satisfaction. Collaborating with reliable courier services known for professionalism such as J&T can further improve the delivery experience. Additionally, investing in customer service training for delivery personnel ensures that interactions are respectful, courteous, and helpful, which Gen Z values highly. To build stronger brand loyalty, e-commerce platforms should also leverage social media platforms like TikTok. By creating relatable content and engaging with influencers, brands can connect more effectively with younger audiences and foster long-term relationships.

For Courier Services, the final delivery experience plays a vital role in shaping customer perceptions. Therefore, courier companies should prioritize training their riders to be polite, professional, and responsive. Maintaining delivery speed is especially important for younger consumers who expect efficiency and reliability. Furthermore, enhancing communication tools such as real-time tracking and proactive updates—can reduce customer anxiety and build trust in the service.

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Project-Based Learning through the Documentation of Measured Drawings of Heritage Buildings in TVET Education: An Implementation Study of Selected Terengganu Heritage Houses

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Abstract

Technical drawing is one of the fundamental skills that students need to master in Technical and Vocational Education and Training (TVET), particularly in the construction field. However, some students still face difficulties in interpreting technical drawings meaningfully when learning relies heavily on classroom-based explanation, studio exercises, and examples that are not closely connected to real site conditions. In response to this issue, this study examines the implementation of Project-Based Learning (PBL) through heritage building documentation and measured drawing as a more contextual learning approach in TVET education. The study focuses on two selected Terengganu heritage houses, namely Rumah Limas Belanda and Rumah Bujang Berserambi Berselasar. A qualitative approach was employed through observation of project implementation, analysis of students' work, and supporting project documents. The findings show that students' direct involvement in fieldwork helped them develop a clearer understanding of structural systems, spatial organisation, and the relationship between technical drawings and actual building conditions. The project also improved their ability to produce more systematic technical documentation and exposed them to the educational value of local built heritage. Overall, the study suggests that heritage building documentation and measured drawing have strong potential to serve as a practical and meaningful learning model in TVET education.

Keywords: *Heritage buildings; measured drawing; Project-Based Learning; technical drawing; TVET education*

I. INTRODUCTION

Technical drawing is one of the fundamental skills in Technical and Vocational Education and Training (TVET), particularly in the construction field. It is essential not only for producing drawings, but also for understanding how a building is planned, organised, and constructed. Through technical drawing, students are expected to interpret dimensions, forms, spatial relationships, and the functions of building components. However, in actual teaching and learning practice, some students still face difficulties in interpreting technical drawings meaningfully, especially when learning is heavily based on classroom explanation, studio exercises, and sample drawings that are not closely connected to real site conditions.

This issue suggests that procedural drawing ability does not always lead to deeper technical understanding. Students may be able to reproduce plans, elevations, and sections, yet still struggle to relate drawings to actual structural systems, spatial organisation, and the functional relationships between building elements. In TVET, this limitation is important because technical learning should prepare students to read, interpret, and apply knowledge in real contexts rather than in simulated settings alone.

In response to this issue, Project-Based Learning (PBL) has become increasingly relevant in technical and vocational education because it promotes active learning through structured tasks, real situations, and applied problem-solving. Recent studies have shown that PBL can support stronger student engagement and better connections between theory and practice in technical learning environments [1]–[4]. At the same time, research on heritage documentation suggests that heritage buildings offer rich structural and spatial information that can support observation, analysis, and technical interpretation [5]–[8].

Based on this context, this study examines the implementation of PBL through the documentation and measured drawing of two selected Terengganu heritage houses, namely Rumah Limas Belanda and Rumah Bujang Berserambi Berselasar. The study focuses on how students' involvement in fieldwork, documentation, and measured drawing activities supported their understanding of structural systems, spatial

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organisation, and technical documentation in the context of TVET education.

The objectives of this study are as follows:

1) to identify the implementation of Project-Based Learning through the documentation and measured drawing of heritage buildings in TVET education;
2) to analyse how students' involvement in fieldwork and technical documentation supported their understanding of structural systems and building elements; and
3) to evaluate the potential of this approach as a learning model for technical courses in TVET education.

II. LITERATURE REVIEW

A. Introduction

This section reviews the literature related to three main areas: technical drawing competency in TVET education, the implementation of Project-Based Learning (PBL) in technical and vocational education, and the potential of heritage building documentation as a more contextual medium for technical learning. This review is important because it positions the present study within the current body of knowledge, highlights issues that still remain in teaching practice, and identifies the gap that this study intends to address.

B. Technical Drawing in TVET Education

In construction-based TVET education, technical drawing is a fundamental component that supports students' understanding of structural systems, spatial organisation, and the relationships between building elements. Although students are commonly introduced to the preparation of plans, elevations, and sections, true mastery does not depend solely on the ability to draw. Students must also be able to interpret technical information accurately and relate it to the actual condition of a building.

In teaching practice, one common challenge is that students may be able to produce drawings by following examples, yet still struggle to understand real building structures in a more comprehensive way. This often occurs when learning relies too heavily on simulated exercises, ready-made drawing samples, and classroom-based explanations. Under such conditions, some students begin to see technical drawing as a document-preparation procedure rather than as a tool for understanding structural logic and building function.

In the context of TVET, this issue has important implications because learning that is disconnected from real situations may limit students' ability to understand how different building elements work together as part of a complete system. For this reason, technical drawing instruction requires a learning approach that is closer to real experience, allowing students to directly observe the relationship between drawings, structures, and spaces.

C. Project-Based Learning in Technical and Vocational Education

Over the past five years, Project-Based Learning has continued to receive attention as one of the more suitable approaches in technical and vocational education. In general, PBL enables students to learn through tasks that involve a clear work process, problem-solving, teamwork, task management, and the production of assessable outputs.

In the Malaysian context, Mustapha *et al.* [1] found that the implementation of PBL in a polytechnic setting helped create a more active learning environment and encouraged students to become more directly involved in technical learning processes. Their findings suggest that this approach can shift learning away from an overly lecturer-centred mode towards one that gives students greater room to explore, make decisions, and produce their own work.

However, the effectiveness of PBL does not occur automatically. Adnan and Abdul Rahman [2] reported that the implementation of PBL in Malaysian vocational colleges still faces several challenges, particularly in terms of time management, limited resources, and the need for close supervision during project activities. This indicates that PBL requires appropriate project design and a supportive implementation environment if the intended learning experience is to be meaningful.

From a broader perspective, Martini *et al.* [3] showed through a comparative study involving Malaysia and Indonesia that PBL helps bridge the gap between theoretical knowledge and practical skills in TVET education. Their study also suggests that projects based on real contexts provide more meaningful learning experiences because students are required to deal with situations that are closer to actual workplace demands.

In addition, Wahab and Husnin [4] emphasised that teachers' perceptions and readiness also play an important role in the successful implementation of PBL. Their findings show that factors such as the learning environment, curriculum, and institutional support influence how effectively PBL can be carried out. In other words, the value of PBL lies not only in the concept itself, but also in how it is planned, supported, and implemented in practice.

D. Heritage Building Documentation as a Technical Learning Medium

Heritage building documentation involves systematic processes such as physical measurement, observation of structural elements, analysis of spatial organisation, and the preparation of technical records. From a learning perspective, this process

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has strong educational value because students are required to engage directly with real buildings. They do not simply observe the physical form of a structure, but also need to understand the function of each element and the relationship between structural components that make up the building as a whole.

Abdullah *et al.* [5] demonstrated that the documentation of Malay heritage building structures is important for understanding traditional building characteristics in a more systematic manner. Although their study focused more on structural analysis in the heritage context, it remains relevant to education because it shows that heritage buildings can serve as a rich technical reference for observation, analysis, and interpretation.

In the present study, heritage buildings are not viewed solely as cultural objects to be recorded, but as learning media that can help students develop deeper technical understanding. When students are involved in real measurement work, they are required to read spaces, understand structures, assess the connections between building elements, and then translate this information into technical drawings. This makes learning more dynamic because students learn from real conditions rather than relying only on examples presented on paper.

Recent international studies also show that heritage documentation is increasingly linked to digital representation, modelling workflows, and educational interpretation, suggesting that documentation activities can function not only as conservation tools but also as meaningful learning media for technical and spatial understanding [6]–[8].

E. Research Gap

While recent studies have discussed project-based learning in technical and vocational education, others have examined heritage documentation from conservation and digital representation perspectives. However, limited attention has been given to how measured drawing documentation of heritage buildings can function as a project-based learning medium in TVET education. This gap is especially relevant in contexts where students need to connect field observation, structural interpretation, and technical drawing in a more meaningful way [3], [5]–[8].

Based on this gap, the present study was conducted to examine more closely how the implementation of PBL through the documentation of Terengganu heritage houses can help students understand building structures, spatial organisation, and the relationship between theory and practice in a real learning context.

III. RESEARCH METHODOLOGY

A. Introduction

This section explains the research methods used to examine the implementation of a heritage building documentation and measured drawing project in the context of TVET education. It covers the research design, study context, student groups involved, project implementation procedures, data collection methods, data analysis, and the steps taken to strengthen the credibility of the findings. For the purpose of this paper, the study focuses only on two Terengganu heritage houses, namely Rumah Limas Belanda and Rumah Bujang Berserambi Berselasar.

B. Research Design

This study employed a qualitative approach in the form of an implementation study. This approach was selected because the study focuses on the learning process that took place during the project rather than on measuring students' achievement statistically. In this study, the project was viewed as a form of project-based learning that allowed students to learn through real field experience.

A qualitative approach was considered appropriate because the study aimed to understand how students' involvement in measuring, observing, analysing, and documenting real buildings helped them develop clearer technical understanding. The focus of the study was not limited to the final products alone, but also included the learning experience that took place throughout the project. This is consistent with studies highlighting the value of project-based and context-rich learning environments in technical and vocational education [1], [3], as well as heritage-based educational projects that integrate documentation activities into student learning [6].

C. Study Context

This study was carried out within the course DCA50233 Measured Drawing, attended by Semester 5 Diploma in Architecture students from Politeknik Port Dickson, Malaysia. The project was conducted through field activities at Perkampungan Budaya, Muzium Negeri Terengganu, Kuala Terengganu, Malaysia. Although the original programme involved several Terengganu heritage houses, this paper focuses only on two houses under the researcher's supervision, namely Rumah Limas Belanda and Rumah Bujang Berserambi Berselasar.

These two houses were selected because they offer suitable construction characteristics for technical learning, particularly in terms of structural systems, spatial organisation, and traditional architectural elements. In the context of this study, the houses were not treated merely as documentation objects, but as learning media that allowed students to observe, measure, and interpret real building structures directly.

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D. Students Involved in the Study

The programme report shows that the DCA50233 course involved a total of 42 students. However, this paper focuses only on two groups that were directly involved with the two selected houses. For Rumah Limas Belanda, the project involved 8 students, while for Rumah Bujang Berserambi Berselasar, another 8 students were involved. Therefore, this study focuses on 16 students who carried out the documentation and measured drawing of the two heritage houses.

This narrower focus was chosen to ensure that the analysis remained more directed and consistent with the purpose of the study, which is to examine more closely how heritage building documentation was implemented as a technical learning experience within the context of these two specific houses.

E. Project Implementation Procedure

The project was carried out in several stages. Based on the programme report, the activities began with an initial briefing at the study site, followed by preparation of equipment and task allocation before the measurement work began. Students then proceeded with fieldwork, organised the data obtained, and produced technical documentation based on the recorded information.

In general, the project implementation can be described in five stages.

1) Orientation and Planning

At the initial stage, students were briefed on the project objectives, scope of work, the buildings to be documented, and the expected learning outcomes. Group task allocation was also carried out so that each student had a clear role. This phase was important because it helped students develop an initial understanding of the task and organise their group work more systematically.

2) Fieldwork

Fieldwork was the core component of the project. At this stage, students conducted physical measurements of the buildings on site, observed structural elements, and recorded information related to dimensions, spatial arrangement, and construction features. Through this activity, students were directly exposed to real building structures and had to understand what they observed rather than simply relying on drawing examples in the classroom.

In this study, fieldwork was particularly important because it exposed students to actual building conditions and required them to interpret what they observed rather than depend solely on classroom-based examples. This reflects the strength of structured project implementation in technical learning environments, where direct engagement with tasks and context supports deeper understanding [2], [4].

3) Data Analysis and Interpretation

After the field data had been collected, students reorganised the information and examined the accuracy of measurements, the position of structural elements, and the relationships between spaces. At this stage, students had to translate physical observations into more organised technical information. This process was important because it helped them understand how an actual building could be converted from a real physical form into technical documentation.

4) Preparation of Documentation and Measured Drawings

The measurement data were then translated into technical documentation, including site plans, floor plans, structural plans, elevations, sections, and selected construction and decorative details. The programme report also indicates that the project outputs included documentation of the history and background of the houses, measured drawings, as well as architectural and material analysis of Terengganu houses.

The translation of field data into drawings and technical records also reflects broader documentation practices in heritage-related work, where measurement, interpretation, and visual representation form an integrated process. Recent studies on heritage documentation and HBIM-related workflows further support the relevance of this approach in building interpretation and structured representation [6], [8].

5) Learning Reflection

At the end of the process, students reflected on their experience throughout the project, including challenges encountered during measurement, group work management, and the accuracy of the documentation produced. Although these reflections were not formally presented in the programme report, they remained an important part of the learning experience because they helped students reconsider what they had learned through the fieldwork and documentation activities.

F. Data Collection Methods

Data for this study were collected from three main sources.

First, observation during project implementation. This involved observing how students carried out fieldwork, interacted with the study buildings, divided tasks within their groups, and completed the assigned technical work.

Second, analysis of students' work. In this study, the data included the documentation and measured drawings produced by the students, such as plans, elevations, sections, and construction

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details. These outputs were used to examine the extent to which students were able to interpret and document real buildings in a technical and systematic manner.

Third, analysis of supporting documents, particularly the official programme report, which was used to confirm the implementation context, the houses involved, the student groups assigned to the project, and the forms of output produced in the original programme.

In addition to observations, students' work, and supporting documents, available measured drawing assessment records were also referred to as supplementary data. These records were used to provide basic descriptive support for the implementation study, particularly in relation to the students' measured drawing performance.

G. Data Analysis Methods

The data were analysed primarily using a descriptive qualitative approach by identifying themes and patterns emerging from observations, students' work, and supporting documents. In addition, basic descriptive results from the measured drawing assessment rubric were considered to provide limited quantitative support for the implementation study. The analysis focused on three main aspects:

1) how the project was implemented in the context of technical learning;
2) how students understood structural systems and spatial organisation through fieldwork; and
3) how the documentation and measured drawings reflected students' technical competency.

This approach was adopted because it allowed the findings to be explained more closely in relation to students' actual learning experience throughout the project, while the descriptive assessment results served only as supplementary support rather than as the basis for a full quantitative analysis.

H. Data Validity

To strengthen the validity of the findings, this study applied source triangulation. The findings were not based on a single source of information, but were supported through a combination of observations during the project, analysis of students' work, and reference to the official programme report. This helped ensure that the interpretations made were more balanced and supported by multiple forms of evidence.

In addition, the clear focus on two heritage houses and specific student groups also helped maintain consistency between the analysis and the defined scope of the study.

I. Project Implementation Framework

Based on the implementation of this project, a project framework can be outlined to illustrate the students' learning flow throughout the activities. The framework began with orientation and planning, followed by fieldwork, then data analysis and interpretation, followed by preparation of documentation and measured drawings, and finally learning reflection.

This framework shows that the measured drawing project was not simply about producing final drawings, but involved a staged learning process. Through this process, students not only acquired technical skills, but also developed a clearer understanding of how real structures can be translated into systematic technical documentation.

IV. RESULTS AND DISCUSSION

A. Introduction

This section presents and discusses the findings of the study based on the implementation of the documentation and measured drawing project involving two Terengganu heritage houses, namely Rumah Limas Belanda and Rumah Bujang Berserambi Berselasar. The discussion focuses on how the project helped students develop a clearer understanding of building structures, spatial organisation, and architectural elements through field-based learning. The findings are also examined through the documentation and measured drawings produced by the students, which reflect how technical learning was translated into more systematic and meaningful work.

B. Project Implementation as a Technical Learning Experience

One of the main findings of this study is that the heritage building documentation project provided a learning experience that was much closer to real situations than classroom-based learning alone. Through this project, students were not merely exposed to drawing examples, but were directly involved in the process of measuring, observing, recording, and interpreting actual buildings. In the context of technical education, this kind of experience is important because it helps students understand that drawings are not simply final outputs, but are produced through a careful reading of structure and space.

For Rumah Limas Belanda, students were exposed to a traditional elevated house with a high raised floor, layered spatial arrangement, and clearly identifiable structural elements such as columns, stairs, doors, windows, and roof systems. The house documentation shows that the project was carried out through fieldwork involving measurement, recording, background study, and analysis of the building before the information was reorganised into technical documentation.

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For Rumah Bujang Berserambi Berselasar, students worked with a traditional house characterised by a more linear and open spatial arrangement, with emphasis on the *serambi*, *rumah ibu*, and *dapur* spaces. Observation and project documentation show that the house presents a clearer spatial division that is closely related to its social and domestic functions, thus allowing students to understand how spatial arrangement influences the overall form of a building.

In general, the project made learning more active because students had to engage directly with actual dimensions, materials, spaces, and the arrangement of building elements. This made the learning process more dynamic and less confined to theory alone. This finding is in line with previous studies showing that project-based learning becomes more meaningful when students are actively involved in authentic and applied tasks rather than only classroom-based exercises [1], [3].

C. Students' Understanding of Structural Systems and Building Elements

The findings also indicate that students' involvement in the project helped strengthen their understanding of building structural systems in a more concrete way. This can be seen from the information they were able to identify and document in both heritage house projects.

For Rumah Limas Belanda, students were able to identify several major structural elements clearly. Among these was the column system, which consists of 40 columns measuring 220mm × 220mm and functions as the main structural support that transfers the building load downward. The house also has 12 steps, comprising 10 timber steps and 2 stone steps, showing a combination of material and function in the main access element. In addition, students documented the *cengal* timber floor, which contains small gaps between the timber boards for ventilation and practical purposes, as well as the roof system consisting of five ridges with *singgora* roof tiles.

For Rumah Bujang Berserambi Berselasar, students demonstrated their understanding through their ability to identify the relationship between the form of the house and its structural system. The house documentation indicates that the structure is supported by 39 timber columns, uses *cengal* timber as the main building material, and has timber flooring arranged with small gaps for ventilation and cleanliness purposes. Students were also able to identify features such as timber panel walls, outward-opening windows, and the elongated roof form that characterises the house.

What matters here is not simply the identification of numbers or building elements, but how students came to understand the function of each component within the overall building system. Through fieldwork, students were able to see more clearly that columns are not just objects shown in drawings, but primary support elements; stairs are not only access components, but also part of the functional design of the house; and spatial arrangement is not merely a plan, but something closely connected to lifestyle, culture, and patterns of use.

The ability to identify and interpret real structural elements in this study also supports the view that documentation-based heritage learning can strengthen students' understanding of building systems and technical representation [6], [8].

D. Understanding of Spatial Organisation and House Function

Another important finding of this study is the improvement in students' understanding of spatial organisation and its relationship to building function. This is especially evident in the documentation of Rumah Bujang Berserambi Berselasar, which describes the house as having three main spaces: the *serambi*, *rumah ibu*, and *dapur*. The floor plan presented in the documentation clearly shows how each space is arranged and how social and domestic functions are reflected in the layout. For instance, the *serambi* functions as a social and reception space, the *rumah ibu* serves as the main family area, and the *dapur* functions as the food preparation and domestic work area.

In Rumah Limas Belanda, spatial understanding can be seen through the division of the house into three main sections: the front space for guests, the second space for sleeping and dining, and the third space, or *surung*, which functions as an area for meetings, gatherings, and specific ceremonies. This information helped students realise that the spatial arrangement of traditional houses was not random, but closely related to function, culture, and the social order of the community.

Through observation and documentation, students were not only learning how to read floor plans, but were also learning why certain spaces existed, how they were used, and how the structure of the house supported those functions. This shows that the heritage house documentation project gave students the opportunity to understand spatial organisation in a deeper way than drawing exercises based only on reference examples.

E. Documentation and Measured Drawings as Learning Outcomes

The findings show that the documentation and measured drawings produced by the students can be regarded as clear evidence of their technical learning achievement. In technical drawing education, the ability to transform field observation into structured visual and technical representation is closely related to students' spatial interpretation and understanding. This has also been highlighted in

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recent studies on drawing and visualisation-based learning, which emphasise the role of representation in strengthening technical comprehension [9], [10]. The project documentation produced by both groups was not limited to descriptive writing, but was supported by floor plans, structural layouts, building element drawings, and visual documentation that reflected careful data collection and systematic organisation of information.

In addition to the qualitative findings, basic descriptive results from the measured drawing assessment rubric provided further support for the implementation study. The Rumah Limas Belanda group obtained 92/100, while the Rumah Bujang Berserambi Berselasar group obtained 90/100, giving an overall mean score of 91/100. Both groups achieved strong performance in key measured drawing components, particularly the title block, layout sheet, floor plan, roof plan, elevations, scale, and general technical organisation. Slightly lower scores were recorded in components requiring more detailed interpretation and representation, such as the site plan, sections, detail drawings, and schedule-related elements. This suggests that while students were generally able to produce strong measured drawing outputs, more complex forms of graphic and technical translation remained comparatively more challenging.

For Rumah Limas Belanda, the students' documentation demonstrates their ability to record elements such as flooring, columns, stairs, doors, windows, roofs, and carved decorative details in a structured way. This indicates that students were not only able to collect data in the field, but were also capable of transforming that information into technical documentation that could be read and understood clearly.

For Rumah Bujang Berserambi Berselasar, the students' documentation also shows strengths in the clarity of floor plans, spatial division, details of flooring, columns, walls, and windows, as well as explanations of the function of each space within the house. Such outputs suggest that students were not merely producing drawings, but were developing a complete learning product that combined observation, analysis, and technical understanding.

In addition, the project outcomes were not limited to course-based assessment. The measured drawing projects for Rumah Limas Belanda and Rumah Bujang Berserambi Berselasar both received Gold Medal recognition at the 8th Regional Educators, Students Product's Exhibition (RESPEX), indicating that the students' work was recognised beyond ordinary classroom assessment.

To provide a clearer summary of the main findings, Table 1 presents the key learning aspects identified through the two heritage house projects.

Table 1: Summary of Findings Based on the Two Heritage Houses

Findings Aspect	**Rumah Limas Belanda**	**Rumah Bujang Berserambi Berselasar**	**Learning Implication**
Structural system	Students identified the column system, stairs, floor, openings, and roof	Students identified the column system, floor, walls, windows, and roof	Students developed a clearer understanding of the function of structural elements in real buildings
Spatial organisation	Students understood the division of the front space, second space, and *surung*	Students understood the *serambi*, *rumah ibu*, and *dapur* spaces	Students were able to relate spatial arrangement to house function
Technical documentation	Students produced plans, sections, elevations, and detailed building elements	Students produced floor plans, spatial documentation, and building element details	Students were able to translate field data into technical documentation more systematically
Learning value	Learning was closely linked to a raised-floor house structure and detailed building elements	Learning was closely linked to spatial relationships and the functions of a traditional house	Field experience helped connect theory with practice
Recognition of outcomes	Received Gold Medal recognition at RESPEX	Received Gold Medal recognition at RESPEX	Learning outcomes extended beyond ordinary coursework

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To further illustrate the relationship between project implementation and the identified learning impact, Figure 1 shows the learning flow experienced by students through the heritage house documentation and measured drawing activities.

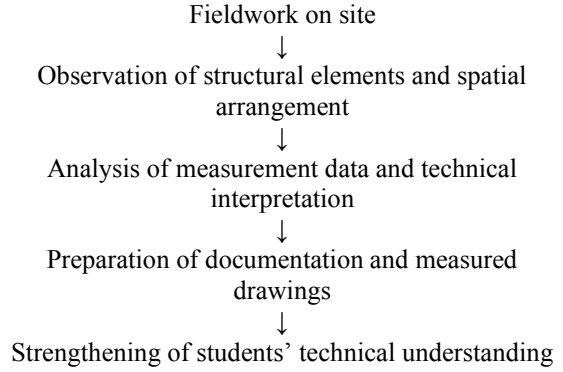

Figure 1: Student learning flow through the heritage house documentation and measured drawing project

Figure 1 shows that students' technical understanding did not develop instantly, but grew progressively through field experience, observation of real structures, analysis of collected data, and the preparation of systematic technical documentation.

F. Discussion

Overall, the findings show that the heritage house documentation and measured drawing project had a positive effect on students' technical learning. Field experience helped them see more clearly the relationship between theory, actual building structures, and technical documentation. Rather than relying solely on drawing examples, students learned to understand buildings through direct observation, measurement, and analysis.

The findings also suggest that the use of heritage houses as learning media has distinct value. In addition to strengthening students' understanding of structure and space, the project also exposed them to traditional architecture, building materials, carved motifs, and the cultural values embedded in the buildings. In this sense, the project not only developed technical skills, but also fostered students' sensitivity towards local built heritage. These findings also support earlier work suggesting that effective project-based learning depends not only on the project itself, but also on how well the task structure, learning environment, and implementation process support student engagement and understanding [2], [4].

From a pedagogical perspective, these findings reinforce the view that project-based learning becomes more meaningful when it is implemented through tasks that are genuinely grounded in real situations. In this study, heritage buildings served as a context that enabled students to learn actively, develop understanding in stages, and produce clear documentation as evidence of learning. Therefore, this approach has the potential to serve as a practical implementation model for technical courses in TVET, particularly those that require a combination of field observation, structural analysis, and technical documentation.

V. CONCLUSION

This study examined the implementation of a heritage building documentation and measured drawing project in TVET education, focusing on Rumah Limas Belanda and Rumah Bujang Berserambi Berselasar. The findings show that students' direct involvement in fieldwork helped them develop a clearer understanding of structural systems, spatial organisation, and the relationship between technical drawings and actual building conditions. Through measuring, observing, analysing, and documenting real buildings, students were able to move beyond classroom-based drawing exercises and engage with technical knowledge in a more meaningful way.

The study also found that the documentation and measured drawings produced by the students can be regarded as clear evidence of technical learning. These outputs show that students were able not only to record building information, but also to interpret field observations and translate them into systematic technical documentation. External recognition received through competition further suggests that the learning outcomes extended beyond ordinary classroom assessment.

Overall, this study indicates that heritage house documentation has strong potential as a contextual learning medium in TVET education. It contributes to the discussion on how project-based learning can be implemented more meaningfully in technical courses, while also highlighting the educational value of local built heritage.

While this study focused primarily on qualitative evidence, the inclusion of basic descriptive assessment results provided additional support for the implementation findings. Future research may incorporate broader quantitative measures to complement this approach.

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Inclusive Board Game Design Using Universal Design for Learning to Support Diverse Deaf and Hearing Students

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Abstract

Universal Design for Learning (UDL) offers a framework to make educational activities accessible to all learners, including deaf/hard-of-hearing (DHH) students. This research explores adapting an educational board game (originally for teaching art elements) using UDL principles. We survey recent literature on UDL and DHH education, conduct participatory co-design workshops with deaf students and instructors, and prototype multiple game variants that employ UDL strategies (e.g. visual symbols, sign-language support, multi-sensory cues). Usability testing and expert accessibility reviews evaluate each variant. Finally, we compare learning outcomes (knowledge gains and engagement) across adapted and original versions. This UDL-driven approach aims to ensure that deaf learners of varied language and sensory profiles can fully access and benefit from the game.

Keywords **:** *Inclusive Design; Universal Design for Learning; Deaf Education; Board Games; Accessibility.*

I. INTRODUCTION

Deaf and hard-of-hearing (DHH) students often face barriers in traditional learning environments, especially when instruction relies on auditory or complex textual content. Educational researchers recommend using visual aids and interactive tools to support DHH learners. Board games have been shown to enhance engagement and learning in many subjects, but typical games may inadvertently exclude DHH players (e.g. reliance on spoken clues or small text). Universal Design for Learning (UDL) is a pedagogical framework that prescribes *multiple means of representation, engagement, and expression* so that all learners can participate fully. Applying UDL to game design means providing information in varied formats (visual, textual, signed) and allowing different modes of interaction. This study focuses on an existing art-education board game for deaf students and investigates how to adapt it using UDL. The goal is to create game versions that accommodate diverse deaf/hearing profiles – for example, learners with varying sign language proficiency or additional disabilities and to empirically evaluate whether the UDL adaptations improve accessibility and learning outcomes.

II. LITERATURE REVIEW

UDL emphasizes that there is no single "average" learner; lessons should include *multiple means of engagement, representation, and action/expression*. For DHH students, UDL suggests specific strategies: captioned media, graphic organizers, and inclusion of sign language or interpreters. In practice, UDL has been applied to board games: Kaletski-Maisel notes that UDL's three core principles can guide accessible game design, such as offering different ways to play or access content. For instance, a game might include both competitive and cooperative modes to engage different students, and use rich visuals to replace or augment text.. Studies on participatory design with Deaf users emphasize co-design: involving deaf students throughout development leads to artifacts with a *"stronger visual presence"* and better fit with Deaf culture. This underlines that inclusive design is not just about adding features, but about fundamentally shaping the game with input from its target users. Taken together, the literature suggests that adapting games for DHH learners requires (1) identifying UDL-aligned features (e.g. visual symbols, sign supports, choice of interaction), and (2) engaging DHH users and experts in the design process[6][3].

III. RESEARCH METHODOLOGY

We followed a mixed-methods design spanning literature, participatory design, prototyping, and evaluation. Key steps were:

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- **Literature Survey:** We reviewed recent research on UDL in DHH education and accessible game design. This included pedagogical guidelines and case studies on inclusive classroom strategies as well as game-specific accessibility frameworks. The goal was to compile best practices (e.g. captioning, visuals, multi-sensory cues) to inform our game adaptations.

Method	Respondent	Data Analysis
Interview	Lecturer	Audio → Text Analysis
Observation	Lecturer and deaf student	Observation → Text Analysis
Contextual	Literature Review	Contextual Analysis → Text Analysis

Table 1. Method and Data Analysis from Visual Communication Department, Polytechnique of Ibrahim Sultan

- **Co-design Workshops:** Three co-design sessions were held with groups of 4–6 deaf/polytechnic students (using sign language) and DHH educators. Each workshop focused on one game aspect (e.g. instructions, question design, physical components). We presented the original game, gathered feedback on barriers, and brainstormed solutions. Using "paper prototyping", participants sketched and role-played variants. For example, students suggested adding image-only answer cards and including ASL reference cards. These sessions align with participatory design principles, ensuring the game's adaptations reflect actual user needs[6].

- **Prototyping UDL Variants:** Guided by the workshops, we developed three adapted game versions in addition to the original: **"Symbolic" variant** with pictorial question/answer cards and color-coded categories; **"Sign & Text" variant** combining written prompts with companion ASL video clips (via QR codes); **"Multi-Sensory" variant** adding haptic (vibration) and visual light cues for special moves. Each version was documented with rule changes. All prototypes maintained the core educational content but altered presentation and interaction modes to provide multiple means of representation and action/expression.

Usability and Accessibility Testing: Each game version underwent heuristic and user testing. Accessibility experts (sign language instructors and special-education specialists) evaluated the components against guidelines (e.g. clear visuals, minimal text, alternate input options). Concurrently, we observed playtests with new DHH students (n=15, not in design workshops) rotating through each game version. We noted comprehension issues (e.g. misinterpreted symbols) and reliance on the instructor. Participants also rated each version on ease of understanding and engagement (using adapted visual scales). The goal was to verify that UDL adaptations reduced barriers: for example, that students could answer questions using the provided symbols and signs without extra help.

- **Learning Outcome Comparison:** Finally, we compared educational impact across versions. Before playing, each student took a short quiz on art-element concepts (pre- test). They then played the game and took a similar post-test. We computed learning gain for each variant. We also conducted quick interviews (using ASL) about their confidence and enjoyment. We specifically looked at whether the UDL-adapted versions resulted in higher gains or more positive attitudes compared to the original game, and whether students with lower English proficiency benefited more from the adaptations.

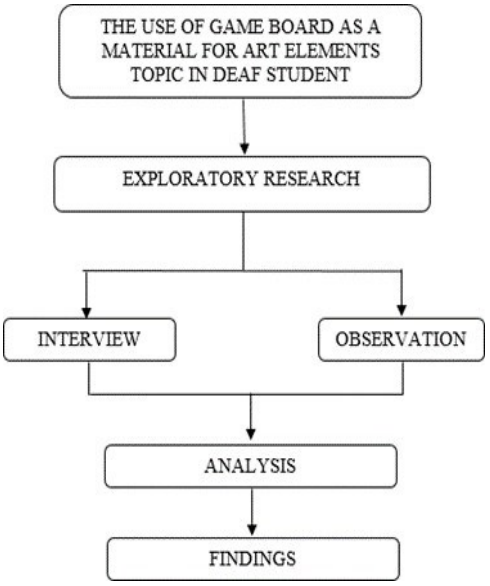

Fig 1. Research Design Process for Learning Aid Game Board by researcher

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IV. EXPECTED FINDINGS AND DISCUSSION

Based on UDL theory and prior work, we anticipate that the adapted versions will improve accessibility and engagement for DHH learners. For instance, adding explicit visual cues and sign language is expected to help students with limited reading skills or less English proficiency. If the "Symbolic" variant shows higher post-test scores than the original, this would indicate that graphical representation aided learning. The "Sign & Text" version may particularly benefit those comfortable with ASL, while "multi-sensory" cues could increase sexcitement and help maintain attention. We will analyze which adaptations correlate with the greatest improvements. It is also possible that too many options (e.g. simultaneous visual and sensory feedback) might overwhelm some players; qualitative feedback will identify any such issues. The first phase of ideation in order to create the product shaping shied. This stage involves the practical shape towards user daily usage. The idea development (Figure 2) is creating different parts of product segments. The main compartment ideation to build a card slot area to compile all the cards inside the product design. The arrow is showing the hidden part to keep the main layout surface. The plan in this stage is to develop the main surface to become slightly smaller so that the user can use this product as a portable aid. In this stage of design, the idea of material and colours has been pointed out as well. The idea development of the main surface involves the buttons function to point the task, lane to slide the buttons to move around the board. The flip concept has been finalized through this phase of design development. The detailing aspect on the cards compartments and lane was done in order to harmonize the design system. In this phase, sizing is the most critical discussion to seek for better practicality for the end-user. This phase shows the upper outlook of the design and cardholder area. It is to ensure that the user can easily understand the usability of the product design.

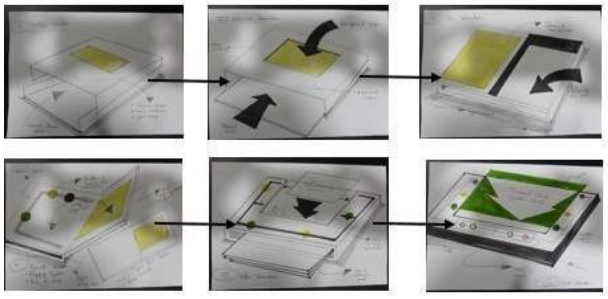

Fig 2. Idea sketches development Learning Aid Game Board by researcher.

Fig 3: Prototype Learning Aid Game Board by researcher

The sample of the actual product design is in Figure 3. Using a lightweight material, attractive colours and practical size button to deliver the learning objective. This is a sample to be tested by the deaf students; to determine its functional aspect and improvise were its necessary. The making of this teaching aid is not difficult and does not need power supply. Moreover, the aspect of fun, interactive and user-friendly features need to be considered as the signature of this teaching aid. In order to achieve the students' performance in class, lecturers need to consider teach the deaf students in several method including the way of presentation, improving the students approach like during an actual project and even using a different medium of explanation rather than lecturing verbally in front of the students. Collaboration among deaf students and the community could help them to be a better industry player in the art community.

V. CONCLUSION

This research applies an inclusive design lens to an educational board game for deaf students by leveraging UDL principles and co-design methods. By systematically incorporating multiple modes of communication and involving Deaf users, the adapted game should allow a wider range of learners to participate fully. The multi-step approach from literature- informed design to iterative testing exemplifies how to make learning games equitable. Board games don't have to be the main part in the syllabus of our nation, but they might provide a unique and fun opportunity to increase the possibility of learning cognitive that our normal academic studies may not. Consider how it might encourage the students to play more board games on their own, or how you could potentially bring these games into your classroom and help students dive into these fun and competitive learning opportunities. This type of learning method using a board game can build up the culture of different learning style. However, the research finding is expected to contribute new

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knowledge to establish understanding elements of art from visual communication concept in 3D perspective to a deaf student. The skills that would enable graphic deaf student can prepare them to become better and effective design graphic and contributors to the information graphic industry. By understanding the elements of art, a deaf student can produce the creative and innovation of artwork or design to be competitive with other normal students. The study also expected to produce graduates who are knowledgeable

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Faktor Pemilihan Program Pelancongan Dalam Kalangan Pelajar Semester Satu di Kolej Komuniti Malaysia

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Abstrak

Industri pelancongan dikenal pasti sebagai salah satu pemacu utama ekonomi negara, di samping menawarkan pelbagai prospek kerjaya kepada graduan. Perkembangan ini menuntut institusi Pendidikan dan Latihan Teknikal dan Vokasional (TVET), khususnya Kolej Komuniti, untuk melahirkan tenaga kerja berkemahiran dalam bidang pelancongan. Namun begitu, kajian yang memfokuskan kepada faktor pemilihan bidang pelancongan dalam kalangan pelajar Kolej Komuniti masih terhad. Sehubungan itu, kertas konsep ini mencadangkan satu kajian tinjauan kuantitatif berbentuk deskriptif bagi mengenal pasti faktor-faktor yang mempengaruhi pemilihan program pelancongan dalam kalangan pelajar Semester Satu di 13 Kolej Komuniti seluruh Malaysia bagi Sesi I:2026/2027. Data dicadangkan untuk dikumpul melalui soal selidik berstruktur secara dalam talian dan dianalisis menggunakan perisian SPSS bagi memperoleh skor min, sisihan piawai, kekerapan dan peratusan. Dapatan kajian ini dijangka memberi implikasi kepada pihak pengurusan kolej dalam merangka strategi promosi dan pengambilan pelajar yang lebih berfokus, di samping menyumbang kepada pemantapan program pelancongan dalam konteks TVET, khususnya Kolej Komuniti di Malaysia.

Kata kunci: *Pemilihan program pelancongan; Kolej Komuniti; Pendidikan pelancongan; Pelancongan; TVET*

Abstract

The tourism industry is recognised as one of the key drivers of the national economy, while also offering diverse career prospects for graduates. This development requires Technical and Vocational Education and Training (TVET) institutions, particularly Community Colleges, to produce skilled manpower in the tourism field. However, studies focusing on the factors influencing the selection of tourism programs among Community College students remain limited. Accordingly, this conceptual paper proposes a descriptive quantitative survey to identify the factors influencing the selection of tourism programs among first-semester students from 13 Community Colleges across Malaysia for Session I:2026/2027. Data are proposed to be collected through a structured online questionnaire and analyzed using SPSS software to obtain mean scores, standard deviations, frequencies, and percentages. The findings of this study are expected to have implications for college management in formulating more focused student recruitment and promotional strategies, while also contributing to the strengthening of tourism programs within the TVET context, particularly Community Colleges in Malaysia.

Keywords **:** *Tourism program selection; Community college; Tourism education; Tourism; TVET*

I. PENGENALAN

Industri pelancongan dilihat sebagai sektor utama yang memacu kemajuan ekonomi negara serta menyediakan pelbagai prospek kerjaya dalam bidang seperti hospitaliti, pengangkutan, rekreasi dan perkhidmatan pelancongan [1]. Namun begitu, pandemik COVID-19 telah memberikan impak yang signifikan terhadap sektor ini, apabila jumlah ketibaan pelancong antarabangsa mencatatkan penurunan mendadak daripada 26.1 juta pada tahun 2019 kepada 4.33 juta pada tahun 2020 [2], sekali gus menjejaskan keseluruhan ekosistem industri pelancongan. Perubahan drastik ini bukan sahaja menjejaskan kestabilan industri, malah berpotensi mempengaruhi persepsi pelajar terhadap bidang pelancongan sebagai salah satu pilihan pengajian.

Dalam konteks ini, institusi Pendidikan dan Latihan Teknikal dan Vokasional (TVET) memainkan peranan penting dalam menawarkan laluan pendidikan yang berorientasikan kemahiran dan menyokong kebolehpasaran graduan. Sebagai komponen penting dalam institusi TVET, Kolej Komuniti berperanan sebagai platform strategik dalam melahirkan tenaga kerja separa profesional yang sejajar dengan keperluan dinamik industri

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semasa. Program pelancongan yang ditawarkan memberi penekanan kepada kemahiran praktikal serta pengalaman pembelajaran yang dibentuk berdasarkan keperluan industri, sekali gus membentuk kefahaman pelajar dalam bidang yang diceburi.

Walaupun program pelancongan ditawarkan di Kolej komuniti, jumlah kemasukan pelajar bagi program ini didapati tidak seragam antara kolej dan sesi pengajian. Situasi ini mencerminkan ketidakseimbanganpemilihan program oleh pelajar. Sehubungan itu, hal ini menimbulkan persoalan tentang faktor sebenar yang mempengaruhi keputusan tersebut. Senario ini turut disokong oleh pemerhatian di peringkat institusi yang menunjukkan wujudnya variasi kecenderungan pelajar dalam memilih program pelancongan di Kolej Komuniti.

Pemilihan program pengajian merupakan satu keputusan penting yang memberi kesan jangka panjang terhadap laluan pendidikan dan kerjaya pelajar. Keputusan ini merupakan hasil daripada pelbagai faktor dalaman dan luaran, termasuklah minat pelajar, pengaruh ibu bapa dan keluarga, rakan sebaya, serta persepsi terhadap peluang kerjaya [3]. Dalam konteks pasca pandemik, perubahan dalam landskap industri pelancongan turut berpotensi mempengaruhi pertimbangan pelajar dalam membuat keputusan pemilihan program.

Walaupun pelbagai kajian berkaitan pemilihan program pengajian telah dijalankan, kebanyakannya tertumpu kepada konteks pendidikan universiti. Kajian yang memfokuskan kepada pelajar institusi TVET khususnya Kolej Komuniti di peringkat sijil masih terhad, sedangkan kumpulan ini mempnyai latar belakang, orientasi pembelajaran serta keutamaan yang berbeza. Tambahan pula, pelajar Semester Satu merupakan kumpulan yang signifikan untuk dikaji kerana mereka berada pada peringkat awal pengajian dan keputusan pemilihan program masih relevan.

Justeru, kekurangan bukti empirikal yang memfokuskan kepada fakor pemilihan program pelancongan dalam konteks pelajar kolej komuniti di Malaysia menunjukkan keperluan kepada kajian yang lebih terarah bagi memahami corak dan kecenderungan pemilihan pelajar. Sehubungan itu, kajian ini dicadangkan bagi mengenal pasti faktor yang mempengaruhi pemilihan program pelancongan dalam kalangan pelajar Semester Satu di Kolej Komuniti Malaysia.

II. KAJIAN LITERATUR

Bab ini membincangkan kajian terdahulu mengenai faktor yang mempengaruhi pemilihan kursus oleh pelajar, khususnya dalam bidang pelancongan. Pemilihan program pengajian melibatkan proses yang kompleks serta dipengaruhi oleh pelbagai faktor yang saling berkait. Kajian ini memberi fokus kepada empat konstruk utama, merangkumi minat pelajar, pengaruh ibu bapa dan keluarga, pengaruh rakan sebaya serta peluang kerjaya. Dalam konteks program Sijil Pengembaraan Pelancongan di Kolej Komuniti, pemahaman terhadap faktor ini amat penting dalam membantu institusi merangka strategi pengambilan pelajar yang lebih berkesan.

A. Aspek Minat Pelajar

Minat pelajar sering dikenal pasti sebagai faktor utama yang mempengaruhi kecenderungan terhadap pemilihan sesuatu bidang pengajian. Dalam konteks Malaysia, pelajar didapati lebih cenderung untuk menyambung pengajian dalam bidang pelancongan apabila kurikulum menekankan kepada elemen praktikal, penguasaan bahasa Inggeris serta pembangunan kemahiran insaniah, di samping menyediakan peluang laluan pengajian yang jelas bermula daripada sijil, diikuti diploma dan seterusnya ke peringkat ijazah. Kajian terdahulu menunjukkan bahawa kejelasan laluan pengajian serta kewujudan peluang perkembangan akademik mampu meningkatkan kecenderungan pelajar bagi meneruskan pengajian ke peringkat lebih tinggi dalam bidang pelancongan dan perhotelan, berbanding menamatkan pengajian hanya di peringkat sijil sahaja [4], [5]. Selain itu, pelajar yang memilih bidang berdasarkan minat didapati cenderung menunjukkan prestasi akademik yang lebih baik dan seterusnya mencapai tahap kepuasan pembelajaran yang lebih tinggi [6]. Kajian terdahulu menegaskan bahawa faktor dalaman seperti minat mempunyai pengaruh yang signifikan terhadap pemilihan program pengajian, manakala faktor luaran pula berupaya mempengaruhi pencapaian akademik pelajar [7]. Minat yang tinggi dapat meningkatkan motivasi pembelajaran, malah turut mempengaruhi tahap penglibatan pelajar dalam aktiviti akademik [8].

B. Aspek Pengaruh Ibu Bapa dan Keluarga

Pengaruh ibu bapa dan keluarga kekal sebagai faktor penting dalam proses membuat keputusan pelajar. Keluarga sering menjadi sumber sokongan utama serta rujukan dalam pemilihan program pengajian [8]. Lazimnya, keluarga akan mempertimbangkan peluang melanjutkan pengajian ke peringkat lebih tinggi serta pulangan jangka panjang daripada pelaburan pendidikan sebelum menyokong keputusan anak-anak. Dalam konteks ini, status sosioekonomi turut mempengaruhi cara keluarga mengakses maklumat dan membuat keputusan. Keluarga banyak bergantung kepada maklumat berkaitan laluan sambungan pengajian, pemindahan

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kredit serta peluang biasiswa dalam menilai sesuatu program [9], [10]. Bagi keluarga daripada latar belakang sosioekonomi yang rendah, penyebaran maklumat yang jelas dan bersasar amat penting bagi membantu mereka memahami potensi dalam bidang pelancongan. Dalam sesetengah keadaan, keputusan pelajar turut dipengaruhi oleh harapan keluarga yang mengutamakan kestabilan kerjaya serta jaminan masa depan [6]. Seiring dengan itu, ibu bapa berperanan penting dalam membentuk aspirasi kerjaya, pilihan pengajian serta hala tuju pendidikan anak-anak [11].

C. Aspek Pengaruh Rakan Sebaya

Pengaruh rakan sebaya merupakan faktor sosial yang signifikan dalam pemilihan program pengajian dalam kalangan pelajar. Rakan sebaya berperanan sebagai sumber maklumat, motivasi dan sokongan emosi. Interaksi sosial dalam kalangan pelajar, khususnya melalui pengaruh rakan sebaya secara tidak langsung membentuk sikap, tingkah laku, motivasi pelajar, serta persepsi pelajar terhadap bidang pengajian [12]. Dalam konteks pelajar lepasan sekolah, pengaruh ini menjadi lebih ketara kerana mereka berada dalam fasa peralihan ke alam pendidikan tinggi. Pada tahap ini, pengaruh bapa dilihat semakin berkurangan, manakala rakan sebaya lebih dominan dalam membentuk nilai serta gaya hidup individu [13]. Seseorang pelajar cenderung untuk menyambung pengajian apabila rakan rapatnya mempunyai perancangan yang sama. Kajian turut menunjukkan bahawa rakan sebaya boleh mengukuhkan atau mencabar niat pelajar bergantung kepada pengalaman yang diperhatikan, termasuk kejayaan pemindahan kredit dan persepsi terhadap program lanjutan [4], [14].

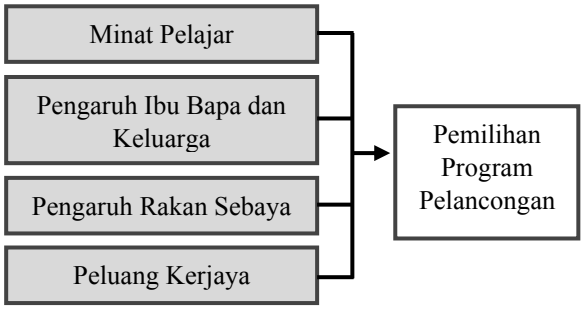
D. Aspek Peluang Kerjaya

Di samping itu, persepsi terhadap peluang kerjaya juga dikenal pasti sebagai faktor yang mempengaruhi pemilihan program pengajian oleh pelajar. Pelajar lazimnya mempertimbangkan kebolehpasaran graduan, kestabilan pekerjaan serta potensi perkembangan kerjaya sebelum membuat keputusan [15]. Dalam konteks TVET, khususnya bidang pelancongan, program yang ditawarkan sering dilihat sebagai laluan awal ke alam pekerjaan, terutamanya apabila disokong oleh latihan industri dan pengalaman kerja sebenar [16], [17]. Selain itu, kejelasan laluan kerjaya seperti kesinambungan daripada peringkat sijil ke tahap lebih tinggi turut meningkatkan kecenderungan pelajar untuk memilih bidang ini [16], [18]. Penglibatan industri melalui latihan praktikal serta hubungan dengan majikan juga membantu membentuk jangkaan pekerjaan dan meningkatkan keyakinan pelajar terhadap masa depan kerjaya mereka. Pendedahan awal kepada persepsi terhadap realiti pekerjaan bukan sahaja meningkatkan kefahaman pelajar terhadap bidang yang dipilih, malah membantu mengurangkan ketidakpastian terhadap masa depan kerjaya mereka [19], [20]. Oleh itu, peluang kerjaya bukan sahaja mempengaruhi pemilihan program, malah turut membentuk tahap komitmen pelajar terhadap pembelajaran.

III. KERANGKA KONSEPTUAL KAJIAN

Kajian ini mengetengahkan satu kerangka konseptual yang mencadangkan bahawa pemilihan program pelancongan dipengaruhi oleh empat faktor utama iaitu minat pelajar, pengaruh ibu bapa dan keluarga, pengaruh rakan sebaya serta persepsi terhadap peluang kerjaya. Keempat-empat faktor ini bertindak sebagai pembolehubah bebas yang mempengaruhi pembolehubah bersandar iaitu pemilihan program pelancongan. Kerangka konseptual ini memberikan gambaran jelas tentang hubungan antara pembolehubah yang dikaji serta menjadi asas dalam pembinaan instrumen kajian. Selain itu, kerangka ini turut membantu pengkaji bagi mengenal pasti faktor dominan yang mempengaruhi keputusan pelajar secara sistematik.

Rajah 1: Kerangka Konseptual Kajian



Rajah 1 memperlihatkan hubungan antara pembolehubah bebas dan pembolehubah bersandar dalam konteks pemilihan program pelancongan.

IV. METODOLOGI KAJIAN

Kajian ini mencadangkan penggunaan pendekatan kuantitatif deskriptif bagi mengenal pasti faktor yang mempengaruhi pemilihan program pelancongan dalam kalangan pelajar. Pendekatan ini sesuai digunakan untuk menggambarkan fenomena semasa serta memberikan gambaran awal tentang kecenderungan pelajar dalam membuat keputusan. Populasi kajian melibatkan pelajar Semester Satu daripada 13 Kolej Komuniti di Malaysia yang menawarkan program pelancongan bagi Sesi I:2026/2027. Pemilihan sampel dicadangkan melaluikaedah persampelan rawak mudah bagi memastikan responden mewakili populasi kajian.

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Instrumen kajian yang akan digunakan terdiri daripada soal selidik berstruktur yang dibangunkan berdasarkan empat konstruk utama iaitu minat pelajar, pengaruh ibu bapa dan keluarga, pengaruh rakan sebaya dan persepsi terhadap peluang kerjaya. Setiap item akan dinilai menggunakan skala Likert lima mata bagi mengukur tahap persetujuan responden. Bagi menjamin kesahan dan kebolehpercayaan instrumen, kajian rintis akan dijalankan sebelum pengumpulan data sebenar. Data yang diperoleh akan dianalisis menggunakan perisian SPSS melalui statistik deskriptif seperti min, sisihan piawai, kekerapan dan peratusan bagi mengenal pasti pola pemilihan program dalam kalangan pelajar. Interpretasi skor min akan dirujuk berdasarkan skala yang dicadangkan oleh Landell [21], iaitu tahap rendah (1.0 hingga 2.33), tahap sederhana (2.34 hingga 3.67), dan tahap tinggi (3.68 hingga 5.00).

V. KESIMPULAN

Secara keseluruhannya, kertas konsep ini mengemukakan cadangan kajian bagi mengenal pasti faktor utama yang mempengaruhi pemilihan program pelancongan dalam kalangan pelajar Semester Satu di Kolej Komuniti yang terdapat di Malaysia. Kajian ini signifikan dan relevan bagi memperkukuh kefahaman terhadap proses pembuatan keputusan bagi memilih program pengajian bidang pelancongan dalam konteks Pendidikan TVET. Dapatan kajian ini dijangka bukan sahaja menyumbang kepada pengayaan literatur sedia ada, malah menawarkan perspektif yang lebih kontekstual terhadap faktor pemilihan program program di peringkat sijil. Dari sudut praktikal, hasil kajian ini berpotensi menjadi asas kepada pembangunan strategi pengambilan pelajar yang lebih berfokus dan selari dengan kecenderungan sebenar pelajar. Selain itu, kajian ini berupaya mengukuhkan penawaran program pelancongan agar menjadi pilihan pelajar di samping menepati keperluan industri.

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PRODUCING AN ORGANIC ANTI-FOGGING BAR FOR CLEANING GOGGLE SURFACE

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Abstract

Water recreation such as scuba diving is very popular with tourists and locals. Diving activities that use goggles and gas tanks to see coral and marine life. However, fogging goggles can cause accidents in the water. Because of that, the researcher decided to make an anti-fogging bar works to remove the vapour produced on the surface of the goggles when entering the water. Therefore, this innovation is to produce an anti-fogging bar using organic ingredients, to determine vitamin A content in the anti-fogging bar and to determine the level of acceptance of the anti-fogging bar. The anti-fogging bars were sent to biotech to determine vitamin A content. The result found that this anti-fogging bar contains vitamin A which is retinal at a dose of 15.3 mg/100 g. Vitamin A supports the skin's immune system, speeds up healing, prevents breakouts and encourages natural moisturizing, which means it effectively hydrates the skin. The result of the questionnaire found that all respondents agreed that the anti-fogging bar can remove fog on the goggle surface, the overall mean score is 4.15 which is at a high level. The quantitative method was used, where Google form questionnaires were distributed to 30 respondents from students Diploma in Tourism Management from semester 2 until semester 5. From the questionnaires, the researcher used Statistical Packages for Social Science (SPSS) version 25 to analyse the data to obtain the percentage value and also the mean score. In conclusion, this innovative product which is an anti-fogging bar was well received by users in terms of smell, texture and packaging. This anti-fogging bar also helps divers from having a foggy mask and blocking their vision while diving

.

Keywords: *Anti-Fogging, Goggle, Recreational, Vitamin A,*

I. INTRODUCTION

Several item that can be used on goggles have been introduced to the market to prevent vaporized water from getting on mirrors. Preventing fogging on goggle surfaces is crucial, particularly keeping clear vision while engaging in activities like skiing, swimming, or other situations where goggles are required [1] (Eldridge, 2020). Traditional anti-fogging remedies, however, frequently contain chemicals that could not be beneficial to the environment or could irritate the skin [2]. As a result, this organic anti-fogging bar was created to offer a natural, efficient and eco-friendly way to stop fogging on goggle surfaces. Because it is long-lasting, contains no hazardous chemicals, and can extend protection, organic anti-fogging bars are also regarded as environmentally beneficial products. In addition to being cost-effective because it is potentially cheaper than the commercial alternative and can be customizable. Fogging on goggle surfaces is a significant issue for a variety of activities, from industrial applications to sports. Conventional anti-fogging products on the market frequently contain artificial chemicals that could be harmful to the environment and irritate the skin. Certain anti-fogging products on the market include irritants that, when used repeatedly, could result in irritation or pain. It might be difficult for people with sensitive skin to find a good, non-irritating way to stop goggle from fogging.

II. LITERATURE REVIEW

Due to rising demand from some industries, including healthcare, the hotel sector and water recreation, the market for anti-fogging devices has been growing rapidly. Customers are looking for alternatives more and more to reflect their beliefs. This is an opportunity for a creative, sustainable and natural solution such as the anti-fogging bar. There are existing anti-fogging products in the market.

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1) Sprays and Liquid solutions

Many anti-fogging solutions on the market come in liquid form, applied by spraying directly onto the goggle surface. These products often contain chemical compounds designed to reduce surface tension and prevent fogging.

2) Wipes and towelettes pre-moistened wipes

Commonly used to clean and apply anti-fogging agents to goggle surfaces. Some wipes are disposable, while others are designed for multiple uses.

3) Anti-Fogging Coatings

Some goggle manufacturers offer anti-fogging coating on their lenses, either applied during the manufacturing process or available as aftermarket treatments. These coatings typically involve chemical formulations for effective fog prevention.

Due to the lack of fillers and irritants [2], stated that many natural products function better than their standard equivalents. The harmful ingredients that made your skin feel healthier or your hair feel smoother might have caused short-term harm, despite the fact that specific artificial treatments may work better on the first attempt. Natural goods' prices vary depending on their content and the ingredients they include, thus sometimes they might be more pricey than their regular equivalents. Essential oils and extracts are used in natural goods, which are pricey to make. But, over the long run, taking into account the skin advantages natural goods provide, they are more affordable than conventional cosmetics, which are unhealthy for your skin. As organic products don't contain dangerous chemicals, they are always safer for the environment. Chemicals and synthetic ingredients are used in traditional 7 items, throughout the production process, these ingredients are emitted into the air and water along with other pollutants. Use organic items to save the environment.

B. **Ingredients**

1) Beeswax.

Common natural ingredient that may be used to seal a variety of objects. Beeswax has long lasting protection. Due to its creamy, durable nature, beeswax provides lasting protection on surface like diving masks or bathrooms mirrors. Other research has formulated a beeswax emulsion for all waterproofing applications. Since beeswax is hydrophobic, or water-resistant, it works extremely well as a natural anti-fog agent, especially when applied to glasses, goggles and windscreens. Inhibits condensation by forming a barrier that keeps moisture from sticking to the surface. [4]

2) Papaya Extract

Papayas are a good source of vital antioxidant vitamins A, C, and E. Diets rich in antioxidants may reduce the risk of heart disease. The antioxidants reduce the oxidation of cholesterol. Cardiovascular disease is caused by blockages, which are made more likely by oxidizing cholesterol. Papaya also contains vitamin A, another vitamin necessary for a robust immune system. Lycopene, a natural pigment, is found in red or orange foods. The fruits papaya, watermelon, and tomatoes are rich in lycopene. [3]

Table 1: Vitamin A content in fruit

FRUIT	VITAMIN A (mg/100g
Cantaloupe	814g
Passion Fruit	263g
Grapefruit	230g
Mango	165g
Apricot	155g
Watermelon	154g
Orange	151g
Peach	147g
Papaya	145g
Olives	134g
Nectarine	129g
Plums	66g

Table 1 shows Papaya contains 145 mg of Vitamin A per 100 g**,** indicating that it is a moderate source of Vitamin A among the listed fruits**.** This nutrient mainly comes from beta-carotene**,** which contributes to maintaining good vision, immune function, and healthy skin**.**

Benefit Vitamin A

i. Eyes

Lowering the risk of macular degeneration and vision loss is one of the most significant benefits vitamin A provides for our eyes. Also, it improves the immune system, which aids in reducing eye irritation and our risk of contracting eye infections. [5]

ii. Skin

By assisting in the removal of damaged elastin fibers and boosting angiogenesis, or the development of new blood vessels, retinoids like retinal can help reduce skin suppleness and sagging.

iii. Reducing hyperpigmentation and other sun damage

A diet rich in carotenoids, such as beta carotene, can aid in the prevention of skin disorders, ageing skin, and cell damage. In addition, carotenoids can defend the skin from UV rays and several environmental

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factors that may damage the condition and look of the skin.

3) Olive Oil

Olive oil contains antioxidants that may help defend the body against cellular deterioration, which can result in a variety of illnesses and ailments. Due to its little processing, extra virgin olive oil has a bitter flavour but contains more antioxidants than other varieties. Some individuals use it medicinally by taking a teaspoon of it. Benefit of Olive Oil are:

i. Reduce inflammation

Antioxidants contained in olive oil include vitamin E. Antioxidants assist in reducing inflammation and redness brought on by psoriasis or acne. Also, they defend the skin from free radicals, which can cause wrinkles and premature skin ageing.

ii. Protects against the sun's UV rays

Olive oil has a natural SPF of 6, which helps in preventing sunburn. This is better than a lot of sunscreens that are sold commercially. The best course of action is to apply sunscreen on top of olive oil because it might make the skin more susceptible to the sun.

iii. Moisturizers and fights bacteria

By reducing the bacteria that cause acne, using an olive oil-based soap can help reduce acne in those who are prone to it. Olive oil is also renowned for hydrating and moisturizing the skin.

III. RESEARCH METHODOLOGY

This research was carried out **FOUR (4)** stages (methods) as follow:

Stage 1: Planning and requirement analysis

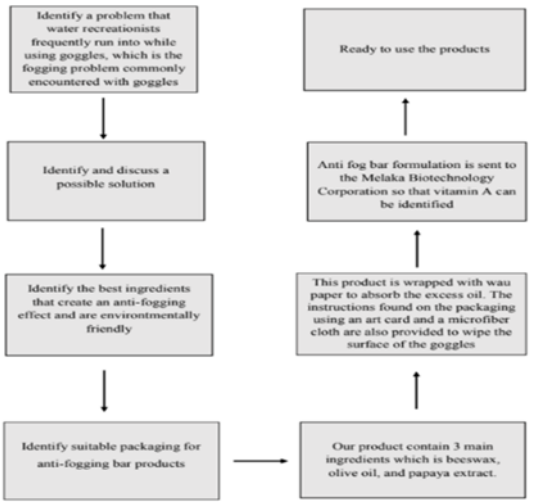
Conduct a literature review to determine whether the materials and processes applied in the creation of an organic anti-fogging bar are appropriate. The cost of many natural products varies depending to their components and content. The potentially harmful chemical that improved skin's sensation may have had short-term negative effects. Because they don't contain hazardous chemicals, organic products are always better for the environment.

Stage 2: Designing Project (Formulation)

Table 2: Ingredients

NO.	INGREDIENTS
1	Beeswax
2	Olive Oil
3	Papaya Extract

Stage 3: Product Development



Stage 4: Testing and Deployment

laboratory tests at Biotech (Melaka Biotechnology Corporation) to identify vitamin A content which is good for the skin and has no chemical substances.

Stage 5: Deployment and Maintenance

The formulations will be improved until the product developed has complied with the required standards from an aspect of cost-effectiveness and environmentally friendly. At this stage, researchers make improvements to packing, product size, pricing and market differentiation.

Stage 6: User Acceptance, Testing and Analysis

Based on objectives

i. To produce an organic anti-fogging bar for cleaning goggles surfaces.

Make laboratory tests at BioTech (Melaka Biotechnology Corporation) to identify vitamin A content which is good for skin and has no chemical substances.

ii. To identify the acceptance of anti-fogging bars among respondents.

Collaboration with REDTMA Recreation Sports Centre (Pantai Siring) to distribute questionnaires to respondents to identify their acceptance of the product.

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IV. RESULT AN DISCUSSION

1) *RESULT*

A. *Designing Project (Formulation)*

Table 3: Product Formulation

NO.	INGREDIENTS	MEASUREMENT
1	Beeswax	50g/bar
2	Olive Oil	10ml/bar
3	Papaya Extract	2.5mk/bar

From the test results, the ingredients of anti-fogging bar are Beeswax (50g bar), Olive Oil (10ml/bar) and Papaya Extract (2.5ml/bar).

B. *Lab test result for Vitamin A content.*

Table 4: Vitamin A content

DATE OF TESTING	TEST PARAMETER	UNIT	TEST METHOD	RESULT	LIMIT
10/May/23	*Vitamin A (as Retinol)	mg/100g	MY/STP/218 based on USP 30-NF25 page 214	15.3	NA

From the test results, vitamin A was found in the anti-fogging bar and the type is retinol. From the sample sent, 15.3 mg of vitamin A is present in 100g of the anti-fogging bar.

C. *The acceptance of anti-fogging bars among respondents*

Table 5 shows the mean score of the perception level of acceptance towards the anti-fogging bar. The overall mean obtained for this section is 4.14, this table shows that the anti-fogging bar product itself and the packaging innovation products are at a high level. The question that showed the highest mean score was 'I will recommend to others who experience fog or condensation on surfaces of their goggles while doing water recreation' with a mean score of 4.30, while the lowest mean was 3.37 with the question 'Is this product beneficial to the skin'. For the question "this bar offers long-lasting on goggles surface and this bar protect on goggle surface because of resilient characters is in high level, 4.13 and 4.27 in mean score

Table 5: Score Mean
acceptance level of anti-fogging

NO	QUESTIONS	MEAN SCORE	LEVEL
1	I like anti-fogging bar that have a natural smell	4.23	High
2	Anti-fogging bar has a pleasant smell	3.72	Medium
3	This product beneficial to the skin	3.37	Medium
4	The bar has a light texture	4.20	High
5	The bar has a non-sticky texture	4.30	High
6	Anti-fogging bar is effective quickly for cleaning goggle surface	4.27	High
7	Anti-fogging bar is helpful for cleaning the google surface	4.37	High
8	I will purchase an anti-fogging bar product in the future	4.20	High
9	This bar offers long-lasting on goggle surface	4.13	High
10	This bar can protect on goggle surface because of resilient character.	4.27	high
11	I will recommend to others who experience fog or condemnation on surface of their goggles while during water recreation	4.30	High
12	The size of the packaging appropriate for the size of the anti-fogging bar	4.23	High
13	The packaging includes clear instruction on how to use the anti-fogging bar.	4.27	High
14	I like to use the anti-fogging bar based on the packaging.	4.13	High
15	The packaging seal the anti-fogging bar to prevent it contact with bacteria.	4.10	High
	TOTAL	**4.14**	**High**

2) *DISCUSSION*

i. Anti-Fog

The analysis found pure beeswax can be used to treat lenses or masks. Long-lasting protection is provided by beeswax. Beeswax offers long-lasting protection on surfaces like bathroom mirrors and diving masks because of its creamy, resilient character.

ii. The anti-fogging bar has a pleasant smell

The analysis of the study found that the question about whether anti-fogging bars have a pleasant smell got a medium because some respondents found that the neutral smell was pleasant but some respondents found that the neutral smell was not pleasant.

iii. Beneficial to the skin

The study found that the question about whether this product is beneficial to the skin got medium because some respondents have sensitive skin problems and feel that this product is not beneficial to their skin, but some respondents feel that this product is beneficial for the eyes because the vitamin A content is higher in the eyes compared to the skin.

3) *SUGGESTION*

i. Various smells

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This product will be improved in terms of its smell for example by adding essential oil or other organic materials that can be used as a fragrance. Everyone has their taste in smell and this may benefit water recreational users while wearing goggles because some people may like that their goggles have a pleasant smell and feel comfortable using them.

ii. Beneficial for skin

This anti-fogging bar product will be added with ingredients that focus more on vitamin C which is a vitamin for the skin, so not only water recreational users can use it but ordinary people can also use it on their skin

iii. Adding ingredients that are rich Vitamin C

Will be added with ingredients that focus more on vitamin C which is a vitamin for the skin so not only recreational users can use it but ordinary people can also use it in their daily lives.

V. CONCLUSION

This organic anti-fogging bar's special blend of components offers a novel solution to fogging problems. Since beeswax is hydrophobic, or water-resistant, it works extremely well as a natural anti-fog agent, especially when applied to glasses, goggles and windscreens The increasing need for environmentally friendly and organic products is in the line with customer preferences. The innovation is in offering a workable solution to a prevent issue while satisfying the demands of customers who care about the environment. of. the organic anti-fogging products bar will be formulated with biodegradable and sustainably sourced ingredients, minimizing its impact on the environment. (SDG12 Responsible Consumption and Production) and the organic composition of the anti-fogging bar ensures that it is gentle on the skin, has Vitamin A and is good for the skin. (SDG 3 Goof Health and Well-being)

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Digital Workforce Readiness in Supply Chain Management Determinants: Evidence of a Malaysian TVET Institution.

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Abstract

Industry 4.0 is causing a significant change in the global supply chain sector, creating an urgent need for a workforce that is both technologically competent and dynamic enough to meet the demands of the upcoming digital transformation. This study examines whether the Malaysian Technical and Vocational Education and Training (TVET) students are ready to support the digital transformation of the logistics and supply chain sector. Specifically, it evaluates the student's digital literacy level, investigates the relationship between digital literacy, training development and curriculum alignment with workforce readiness, and compares readiness across students' cohorts. Using a purposive sampling approach, data were collected using a structured questionnaire administered to 169 students enrolled in the Diploma in Logistics and Supply Chain Management at Polytechnic Seberang Perai. Descriptive results revealed that the respondents demonstrate a high level of digital competency. Pearson correlation analysis indicated a strong positive correlation between all independent variables and workforce readiness, with curriculum alignment emerging as the most significant predictor ($r = .755$, $p < .001$). A one-way ANOVA also showed no statistically significant differences in preparedness across semesters ($p = .162$) suggesting consistent competency levels among the student groups. These findings highlight the need for TVET institutions to implement real-time simulations of the supply chain into learning and evaluation. Comprehensively, this study provides empirical evidence to support the development of a resilient, technology-oriented supply chain workforce in alignment with the National TVET Policy 2030.

Keywords: Curriculum Alignment; Digital Literacy Skills; Future Workforce Readiness; SCM;

I. INTRODUCTION

A. Background of study

With technological changes in the world, global industries have undergone a digital revolution that demands a workforce capable of operating in more complex digital environments. Developing the skills needed for the transformation to digital and automated economic systems relies heavily on Technical and Vocational Education and Training (TVET). Polytechnics in Malaysia play a crucial role in the TVET system. They are responsible for preparing students to work in a technology-driven economy. Despite this responsibility, concerns still arise on how well these institutions can prepare graduates for the changing digital industrial landscape.

Limitations on supply have become a major challenge as global value chains are increasingly operating in an environment that faces persistent disruption and systemic constraints. As a result, supply chains are no longer confined to back office support functions but have taken on a strategic role at the national level. This places a greater emphasis on the need for a resilient workforce that can coordinate and respond to uncertainty through decentralized decision making and adaptive capabilities [39]. The digital transformation in the Supply Chain Management (SCM) industry is facilitated by the use of intelligent technologies, including Big Data analytics, Blockchain, and the Internet of Things (IoT). Emerging technologies reinforce predictive analytics, automation as well as real-time monitoring. These are the core pillars of resilience and competitive advantage in the global market [8]. Along with the basic requirements of Industry 4.0, the requirements of a digitally capable workforce have increased dramatically in order to facilitate the successful implementation of these technologies [2].

Malaysia's manufacturing and supply chain services are essential to the country's economy, and technological integration is both timely and necessary. National Policy on Industry 4.0 (

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Industry4WRD) provides the strategic vision of the enhancement of the digital preparedness in the industries [20]. However, challenges remain. Information and Communication Technology (ICT) 2025 data shows that 7.9% of the graduates are underemployed. They are employed in jobs that fail to exploit their qualifications even when the national unemployment rate is only 3.0% [10]. The skills gap is particularly high in SCM; around 83 percent of professionals working within the biopharma and manufacturing industries indicate the need to undergo intensive training in digital skills [9], and 53 percent of organizations cite lack of digitally skilled talent as the reason behind the stalled digital transformation processes [35].

Despite the National TVET Policy 2030 targeting the empowerment of digital skills of the graduates in future [23], the barriers that persisted to undermine the readiness of the graduates include the use of obsolete curriculum, inadequate digital infrastructure, and inefficient instructional resources [14]. Similar to other countries, Malaysia has tried to incorporate international digital literacy models, such as the Digital Literacy Skills Framework (DLSF) in Australia and the European standards of DigCompEdu [38]. However, loopholes still exist between the policymaking process and actual implementation, and institutional reforms are not as rapid as expected [30].

B. Problem Statement

The supply chain industry all over the world is experiencing a rapid transition of the conventional operational methods to Industry 4.0 technologies. Despite the large-scale investments of the Malaysian government such as the RM6.8 billion of the MADANI Budget 2024 to increase the pace of digital transformation, the outcomes of these efforts have not yet been reflected in better workforce readiness [5]. The skills produced by TVET institutions and industry demands continue to diverge, especially when it comes to exposure to essential technologies like blockchain, real-time inventory management systems, and predictive analytics [32].

The available literature is also a reflection of the inability to focus on SCM-specific needs. As an example, [33] analyzed digital literacy programs in TVET but failed to discuss the technical aspect peculiar to SCM. Similarly, [17] examined the issue of curriculum alignment, but they failed to contextualize their results to the world of logistics. Consequently, it remains unclear whether the obstacles linked to the process of digital literacy acquisition do really deter student readiness in the Malaysian TVET context.

To fill this gap, this research paper will focus on the digital literacy competency of SCM students at Polytechnic Seberang Perai (PSP), Penang, Malaysia, and analyse the discrepancy between the TVET curriculum and industry requirements as well as the training related constraints that could hamper the acquisition of the needed skills.

C. Research Objectives and Questions

The main objective of this research is to address the relevance of digital literacy in future workforce preparation in students of PSP, Diploma in Logistics and Supply Chain Management (DLS). Particularly, the study will aim to:

1. Analyze the level of digital literacy skills development in the students of DLS.
2. Establish the correlations among the digital literacy skills, training development, and curriculum alignment with the future workforce preparedness.
3. Identify significant variances of readiness among different student groups.

Within the framework of these objectives, the following questions will be answered in the research: (a) What is the current state of the digital literacy proficiency of DLS students? (b) Does the future readiness of workforce have significant relationship with digital literacy skills, training development, and curriculum alignment? (c) Do the levels of readiness noticeably different among the various student groups?

D. Significance and Scope

This paper fills a significant research gap as it investigates the supply chain specific competencies through the Malaysia Qualifications Framework (MQF). It suggests that there is a systematic research model that relates digital literacy and curriculum effectiveness with a practical implication for TVET institutions, policy makers and other stakeholders in the industry. The findings, which specifically address the Diploma in Logistics and Supply Chain Management (DLS) students of Polytechnic Seberang Perai (PSP), can be useful in benchmarking the improvement of vocational training to align with the aspirations of the National TVET Policy 2030. Finally, the research will lead to the creation of a more competitive and future ready Malaysian workforce, which can adapt to the growing number of digital complexities in the global economy.

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II. LITERATURE REVIEW

A. Digital Transformation in the Supply Chain

IR4.0 has significantly changed the dynamics of the global market. Digital transformation has become a critical factor in the organizational competitiveness. Strategic application of digital technologies and data-driven processes that are used to improve operational efficiency is known as digital transformation. This continues to impact almost all areas of industry. In the next decade 90 percent of the jobs in the worldwide will require digital literacy as [40] noted that, there is an increasing relevance of digital literacy. The integration of new technologies in the logistics and supply chain industry has increased innovation, enhanced productivity, and real-time decision-making. Yet, the digital talent shortage has been increasing across the industries posing a challenge to the growth of the economy as well as graduate employability.

In 2025, agility, sustainability, and the important role of artificial intelligence are universally described as successful in transforming supply chains. Almost 72 percent of those organizations that report clear objectives of intelligent and end to end supply chain ecosystems. The adoption of technology is however not enough by itself. The workforce readiness is also one of the issues that is listed critical success factors. Most organizations need to balance between high-tech digital systems and human skills that will enable them to predict the change instead of responding to it [7].

The modern smart warehouses rely more on human-robot cooperation where Autonomous Mobile Robots (AMRs) are used to address the standard transportation and storage operations. Meanwhile, the human workforce manages the monitoring and decision-making process as well as optimization of the system. Within these settings, it is not manual handling skills that define workforce readiness but rather it depends on digital capability and systems thinking and flexibility. Education and training institutions are therefore very crucial in preparing graduates with skills necessary to effectively operate with intelligent automation technologies [36].

B. Digital Literacy Skills

In the contemporary digital economy, digital proficiency is directly related to the academic performance and employability of a student. In the SCM context, digital literacy includes the capacity to apply technological tools that can help streamline supply chains, evidence-based decision-making, and address the changing demands of digital-driven business conditions [3]. The demands for digital skills is on the rise all over the world, yet there is a shortage of skilled talent. According to [1] 32 percent of employees are lack of the digital skills needed to perform most middle-skill jobs.

The increasing gap between the abilities of graduates and the requirements of the industry has increased the anxieties surrounding digital skill shortages. Given that the progress in Industry 4.0 has been accelerating significantly in a disproportion to the training of the workforce. In the Malaysian digital economy, data literacy, creating digital content and technical problem solving are also being perceived as relevant competencies by employers as reflections of graduate employability [24]. TVET students, especially, digital literacy can serve as an intermediary between the theoretical and industry-specific practice [32]. The research significantly emphasizes that SCM graduates in terms of high digital competencies are highly demanded, and employers are more willing to hire individuals who can work digitally, using the tools of automation and data-based systems [22], [19].

C. Training Development Barriers

Although TVET institutions are making efforts to strengthen digital capacity, the students have been found to face issues that hinder them in achieving digital competency. Among the most notable constraints is the resource gap in which lack of access to the contemporary software, devices, and other digital settings restricts the possibilities of practical study [19]. Without practical experience of being exposed to analytics tools such as Enterprise Resource Planning (ERP) system, students have problems with applying the knowledge they learned in the classroom into practice [32].

The technological skills of the teachers are also highly imperative. Many teachers of TVET are not computer literate to support the rapid growth of SCM technologies [16]. According to [28] the lack of IT-savvy teachers directly influences the quality of teaching that involves ICT. Moreover, the act of institutions that neglect to revise the curriculum to correspond with the recent technology only worsens the skills gap [22].

D. Curriculum Alignment

Curriculum alignment is known as the degree of alignment between the educational programs and the national standards and industry expectations [33]. Digital literacy is defined as the ability to use digital technologies to responsibly retrieve, understand, process, and communicate information by Malaysia's national curriculum guidelines [31], [29]. By aligning appropriately, TVET graduates will acquire the competencies needed to match the requirements of technologically advanced industries [16].

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Industry 4.0 workforce readiness is strongly influenced by the degree of alignment between vocational curricula and evolving technological work environments. Digital readiness cannot be achieved through isolated technical skills alone; rather, it requires capability-oriented curricula that prepare learners to function in modular, reconfigurable, and data driven production systems. This perspective highlights the need for vocational education to move beyond task-based instruction toward system level competence development, enabling graduates to supervise, adapt, and optimise automated technologies in response to changing market conditions [34].

Moreover, the majority of programs are yet to keep up with the relevance of their curriculum. [17] observe that not all institutions are finding it easy to integrate the new technologies such as blockchain and artificial intelligence into their learning outputs. Such a lag in adapting to modernization in the curriculum has induced a bottle neck effect in regard to capabilities of students to acquire high-level digital skills that will enable them to work in a rapidly digitalizing SCM ecosystem.

There is continuous concern as to whether Malaysian TVET institutions have adequate curricular flexibility and technological ability to create workforce capability to respond to Industry 4.0 needs. Organizational issues like poor governance and irregular involvement in the industry still act as barriers to sustaining curriculum significance and adjustment to technological advancement [4].

E. Research Gaps

Although there has been a wide discussion on the issue of digital literacy in the past literature the necessity to define specifically the issue of digital skills required by Supply Chain Management (SCM) students within the Malaysian TVET system remains largely unexplored. Existing literature is inclined to refer to the situation in case of general education or any other industry [33], and the practical application of curriculum alignment in the logistics industry is one of the least studied sectors.

Likewise, although barriers associated with training have been recognized in the broader educational framework, other concerns, like the lack of updated infrastructure, insufficient digital facilities, and inadequate instructor skills, have not been addressed within SCM programs in Malaysian TVET institutions in detail [19]. The presence of these gaps renders it particularly challenging to consider potential gaps in the existing TVET ecosystem regarding its capacity to equip students with the digital competencies that they need in the contemporary supply chain setting.

To overcome these limitations, the current study examines the effect of digital literacy, training development and curriculum alignment among SCM students in determining their future workforce readiness. According to the reviewed literature, it is evident that these three constructs are the most important factors that determine digitalized supply chain job readiness. The relationship between them is presented in the research structure depicted in Figure 1 shows the direction of this study's analysis.

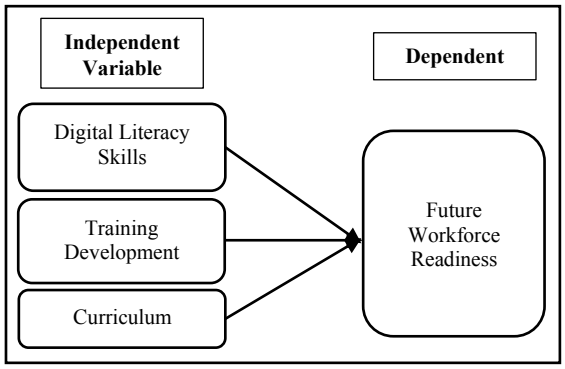

Figure 1

III. RESEARCH METHODOLOGY

A. Research Design and Hypotheses Development

The research design is quantitative and correlational with a cross-sectional time frame since this study aims to identify the factors that determine workforce preparedness in the future. The design is appropriate to study the interaction of more than two variables in a natural setting where relationships between constructs could be determined without researchers interference in the study [12]. The study is designed with three hypotheses based on the literature, each of which hypothesizes a strong positive correlation between an independent variable and future workforce preparedness:

- H1: There is a substantial relationship between an individual's digital literacy skills and future workforce readiness.
- H2: There is a substantial relationship between an individual's training development and future workforce readiness.
- H3: There is a substantial relationship between an institutions curriculum and future workforce readiness.

These hypotheses are combined to create the foundation of evaluating the impact of educational preparation on the readiness of a student towards an industry of a digitalized supply chain.

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B. Target Population, Sample Determination, and Unit of Analysis

The sample population consisted of 559 students who are pursuing Diploma in Logistics and Supply Chain Management (DLS) at Polytechnic Seberang Perai (PSP) [11]. Purposive sampling was applied to target students in Semester 4 and Semester 5 and students undergoing internship training (N = 270) to ensure the relevance with regard to the study objectives since they are well exposed to the curriculum and related learning in the industry. According to [26] sample size determination table, in order to reach a 95 percent confidence level and statistical reliability, a minimum sample size of 159 was required [27]. Proportional sampling guaranteed equal representation of every level of study. This study will focus on the individual DLS student as the unit of analysis because the perceptions, competencies, and readiness levels are measured on the individual level.

C. Instrumentation and Measurement Scale

The data were gathered using an electronic structured questionnaire based on the adjustment of an already proven instrument to suit the Malaysian TVET setting. The questionnaire utilized a five point Likert scale where Strongly Disagree to Strongly Agree was used so as to enhance clarity in the response and reduce fatigue of the respondent [6]. The tool was divided into three major parts: (1) Demographic Profile, (2) Independent Variables (Digital Literacy Skills, Training Development Barriers, and Curriculum Alignment), and (3) Dependent Variable (Future Workforce Readiness). This design provided a full coverage of the constructs analyzed in the research and efficiency and consistency of responses.

D. Validity, Reliability, and Data Analysis Strategy

In order to ascertain the goodness of measure of the research tool, the study has put in place a strict pre testing and pilot testing process. Content validity was initially determined by consulting two academicians and a practitioner in the industry, and it was later verified by a pilot test (n = 30) that established the language clarity, relevance, and structural integrity of the content. Cronbach's Alpha was then used to measure internal consistency of every construct, and all values met or exceeded the 0.70 as the acceptable threshold [15].

The SPSS Version 29.0 was used in the analysis of data. The descriptive statistics were used to summarize the characteristics of the respondents and Pearson Correlation Coefficient (r) was used to establish the direction and strength of associations between the two variables of the study based on the methodological recommendation [25]. Normality test was done to ensure that the data fell within the acceptable range of ±1.96 standard deviation, which will enable the collection of parametric tests [21].

Figure 2 shows the general methodological procedure of development of the instruments and expert validation, as well as the pilot testing process and statistical analysis of sampling.

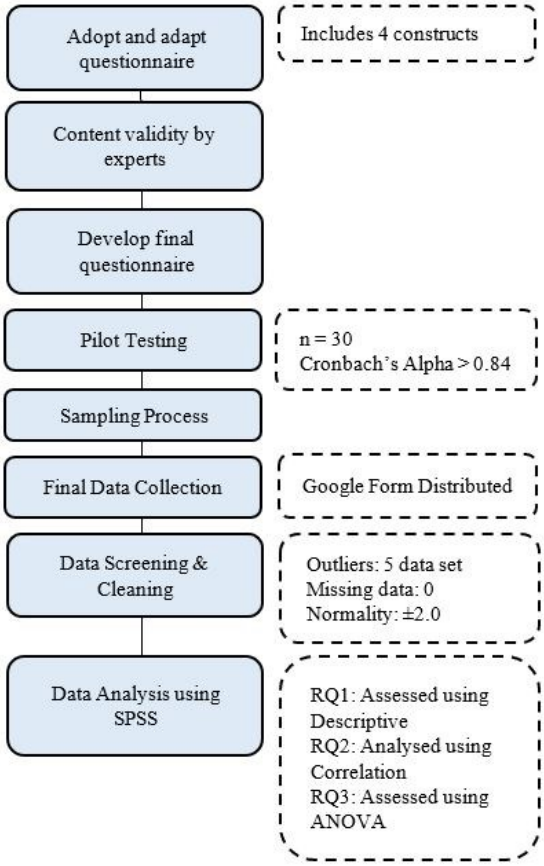

Figure 2

IV. RESULTS AND DISCUSSION

A. Preliminary Analysis and Instrumentation Quality

Prior to the actual analysis, a pilot study (n = 30) was conducted to assess the psychometric validity of the research instrument. A reliability test resulted in Cronbach Alpha values between .759 and .923 (Table 1), with all of them above the recommended minimum of .70 in social science research [37]. Construct validity was also supported by Exploratory Factor Analysis (EFA) with all Kaiser Meyer Olkin (KMO) values being ≥ 0.70 and Bartlett's Test of Sphericity being significant (p less than 0.001). These findings support that the constructs are multidimensional and suitable to further analysis with statistical appropriateness.

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Altogether, reliability and validity of each construct were adequately determined, which are presented in Table 1.

Table 1
Construct Reliability and Validity Measures

Variable	Items	Cronbach's alpha	KMO
Digital Literacy	10	.844	.722
Training Development	3	.759	.689
Curriculum	6	.891	.830
Workforce Readiness	8	.923	.816

B. Demographic and Descriptive Analysis

The total sample size (N = 169) was balanced in terms of its gender distribution, as the proportion of female and male respondents was 53.3 and 46.7 respectively. The proportion of students who own personal digital devices was high at 95.9% and the proportion of students with moderate to high internet access was high at 98.8%. This degree of digital access offers a solid base to the creation of the Industry 4.0 competencies.

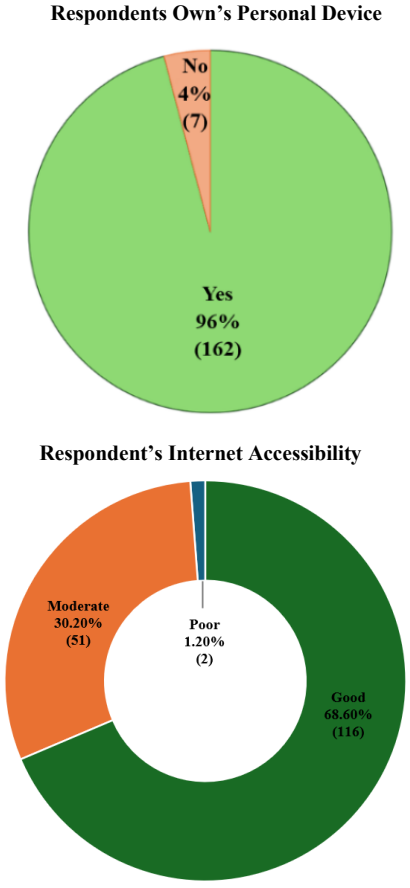

Figure 3

Figure 3 shows that majority of the respondents own personal devices and have access to quality internet connectivity that indicates a good digital preparedness level. This preparedness is further supported by the descriptive statistics of all the four constructs where the mean scores are recorded high especially in curriculum alignment, as indicated in Table 2. Curriculum Alignment had the largest mean ($\bar{x}$ = 4.46, SD = .48) which shows that the students in the DLS program feel that the program is closely aligned with industry expectations. TVET students also exhibited high self-assessment of technological competence in Digital Literacy Skills ($\bar{x}$ = 4.23, SD =.55).

Table 2
Descriptive Analysis for Constructs

	N	Min.	Max.	$\bar{x}$	SD
Digital Literacy	169	2.70	5.00	4.236	.5538
Training Development	169	2.33	5.00	4.132	.6270
Curriculum	169	3.00	5.00	4.462	.4800
Workforce Readiness	169	3.00	5.00	4.395	.4824
Valid N (listwise)	169				

C. Hypothesis Testing and Correlation Analysis

The tested hypotheses of the relationships between the study variables were evaluated using Pearson Correlation analysis (Table 3).

Table 3
Correlation Matrix and Hypothesis Testing

Relationship	*r*-value	*p*-value	Result
H1:DL ⟶FW	.658**	< .001	Supported
H2:TD ⟶FW	.597**	< .001	Supported
H3:C ⟶FW	.755**	< .001	Supported

Digital Literacy (DL), Training Development. (TD), Curriculum (C), Workforce Readiness (FW)
*Note: ***Correlation is significant at the 0.01 level (2-tailed).*

Table 3 indicates that all independent variables had significant positive correlations with future workforce readiness, which support hypothesis H1, H2, and H3. The findings show that Curriculum Alignment (H3) is the most positively correlated with the workforce readiness (r =.755). This implies that the student confidence depends mainly on the structural design of the TVET program. There was also a strong significant relationship between Digital Literacy (H1) which strengthens the point of argument that technical proficiency is a key determinant of employability in a digitalized SCM industry [3], [22].

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D. Comparative Analysis (ANOVA)

One-way ANOVA was used to test the hypothesis of whether the levels of readiness were different among semester groups (Semester 4, Semester 5, and Internship). The results showed no statistically significant differences in the readiness of the future workforce between the three groups, $F(2,166) = 1.84$, $p=.162$. This observation contradicts a widely held belief according to which internship experience significantly increases perceived readiness. Rather, it indicates that the DLS curriculum at PSP can be systematically designed in such a manner to develop digital competence since previous semesters and onwards [13]. The outcomes of ANOVA which summarize these findings are in Table 4.

Table 4
ANOVA Comparison Across Semester Groups

	Sum of Squares	df	Mean Square	F	Sig.
Intergroup	0.85	2	.42	1.84	.162
Intragroup	38.26	166	.23		
Total	39.10	168			

V. CONCLUSION AND IMPLICATIONS

A. Discussion

The study offers empirical evidence on the use of the "Competency Based Whole Institution framework" in the Malaysian TVET situation. Contemporary industrial discourse increasingly emphasises that automation is not intended to replace human roles, but to enhance them through collaborative interaction between humans and intelligent systems. In this context, human roles are progressively shifting toward technical supervision, adaptability, and exception handling within integrated digital ecosystems, underscoring the importance of advanced workforce competencies in automated environments [18]. The results indicate that in spite of the fact that digital literacy is an essential condition, Curriculum Alignment proves to be the strongest variable in reducing the existing skills-technology gap. This finding is in line with the international views that successful digital integration should not be only the mandate of the individual learners but a system-wide institutional obligation [41]. The findings are also consistent with [32] who indicated that curriculum relevance is one of the major predictors of student preparedness. Nevertheless, unlike those findings, the current study indicates that the training barriers demonstrate a moderate correlation to readiness. This implies that PSP could also be addressing some of the digital infrastructure and training resources challenges through institutional structures and support mechanisms.

B. Recommendations

1. **To TVET Institutions:** The educators are suggested to go beyond the mere software education and integrate real-time SCM simulation applications like ERP products and AI powered demand analysis systems into the teaching and evaluation processes. Such strategies can enhance the practical exposure of students and it can represent the reality of the contemporary supply chain settings.

2. **To Policymakers:** The Ministry of Higher Education (MOHE) should think about institutionalizing digital equity audits to be able to maintain uniform access to digital access on all polytechnics. These audits are especially essential to the semi urban institutions because the disparity in infrastructure may occur in spite of high connectivity rates in this research.

3. **To Industry:** The stakeholders in industry should enhance their cooperation with TVET institutions using systematic train the trainer programs. These alliances can assist in making sure that academic educators are not behind in the fast technological progress, such as blockchain usage and the implementation of the Internet of Things (IoT) in the logistics process.

C. Limitations and Future Research

The use of self-reported data in this study presents the risk of social desirability bias because it is possible that the results would depend on the expectation of the students and not the real competencies. Further studies would be enhanced by longitudinal techniques or objective technical measures to confirm the consistency of digital literacy and preparedness with time. Moreover, it would be beneficial to increase the sample size by incorporating the private vocational institutions or other sectors of the TVET to contribute to the overall generalizability of the results and provide a wider perspective on the digital readiness in the vocational education field in Malaysia.

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The Effectiveness of Using BMCExpert on Computational Thinking among Students of the DFT30033 Cyberpreneurship Course

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Abstract

This study investigates the effectiveness of integrating computational thinking specifically decomposition, through BMCExpert in enhancing student performance in the DFT30033 Cyberpreneurship course. A quasi-experimental design was employed involving 40 Semester 3 students divided into a control group (n = 20) receiving conventional instruction and a treatment group (n = 20) exposed to BMCExpert embedded with computational thinking elements. Student performance was measured using pre- and post-tests, and the data were analyzed using paired-sample and independent-sample t-tests. The findings indicate statistically significant improvements in both groups; however, the treatment group exhibited a substantially greater mean gain (21.85) compared to the control group (11.15). Moreover, the independent t-test revealed a significant difference in post-test scores between groups ($t = -5.506$, $p < .05$), demonstrating the superior effectiveness of the intervention. These results underscore the pedagogical value of integrating computational thinking with digital tools such as BMCExpert in fostering higher-order analytical skills and enhancing students' capability to systematically develop business models. The study contributes to emerging evidence supporting technology-enhanced learning approaches in cyberpreneurship education.

Keywords **:** *Computational Thinking; Decomposition,; Business Model Canvas; Digital Learning Tools*

I. INTRODUCTION

The rapid advancement of digital technologies and the emergence of Industry 4.0 have significantly transformed the landscape of entrepreneurship education. In the digital economy, entrepreneurs are not only required to generate innovative business ideas but also to apply structured and logical thinking in developing sustainable business models. Computational thinking which involves skills such as decomposition, pattern recognition, abstraction and algorithmic thinking has become increasingly important beyond the field of computer science and is now recognized as a fundamental cognitive skill in various disciplines including business and entrepreneurship education [1].

In the context of the DFT30033 Cyberpreneurship course, students are required to design and develop a Business Model Canvas (BMC) as part of their learning activities. However, many students experience difficulties in systematically analyzing business components, identifying relationships between elements and structuring their ideas logically. These challenges indicate a gap in computational thinking skills, which are essential for effective business model development in digital entrepreneurship. In the DFT30033 Cyberpreneurship course, students are required to construct a Business Model Canvas (BMC), which consists of multiple interrelated segments such as customer segments, value propositions, channels, revenue streams, and cost structures. Developing a complete business model requires students to understand each segment individually while recognizing how these components contribute to the overall business structure. However, many students struggle to systematically analyze and organize business elements into appropriate categories. This challenge suggests a weakness in decomposition skills as students may find it difficult to break down a business idea into structured components.

To address this issue, BMCExpert was developed as a digital learning tool to support structured learning and guide students in developing their Business Model Canvas systematically and

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also incorporating a drag-and-drop activity that allows students to match business elements with the correct BMC segments. Through this interactive approach, students are guided to identify, classify and organize business information into smaller structured components. This process directly supports the development of decomposition skills by encouraging students to analyze complex business ideas and divide them into meaningful parts. Decomposition refers to the ability to break down a complex problem into smaller, manageable components to facilitate better understanding and solution development [2]. Although widely associated with computer science, decomposition is increasingly recognized as a crucial cognitive skill in various disciplines, including business and entrepreneurship education.

In today's digital economy, entrepreneurs are expected not only to generate innovative ideas but also to apply structured and logical thinking in developing sustainable and scalable business models [3]. As digital business environments become increasingly complex, higher-order cognitive skills are required to support systematic decision-making and problem-solving processes. Recent studies highlight that computational thinking has expanded beyond computer science and is now regarded as a foundational competency across disciplines, including business and entrepreneurship education. The study has demonstrated that integrating computational thinking within problem based learning contexts can foster students' higher order thinking and creative problem solving [4].

Computational thinking encompasses several core skills, namely decomposition, pattern recognition, abstraction and algorithmic thinking. Among these, decomposition plays a crucial role in enabling learners to break down complex problems into smaller, manageable components for clearer understanding and effective solution development. In entrepreneurial contexts, decomposition supports the analysis of business structures, value creation mechanisms and operational elements. Scholars have emphasized the growing importance of integrating computational thinking skills into non-technical disciplines to enhance analytical and strategic capabilities among students.

In the context of the DFT30033 Cyberpreneurship course, students are required to design and develop a Business Model Canvas (BMC) as part of their core learning activities. The BMC consists of multiple interrelated segments, including customer segments, value propositions, channels, customer relationships, revenue streams, key activities, key resources, key partners and cost structures. Developing a comprehensive business model requires students to understand each component individually while recognizing the interconnections among these elements. Additionally, comprehensive analyses of computational thinking in educational contexts emphasize the importance of decomposition alongside other cognitive processes, highlighting its relevance across various instructional settings and learning activities [5]. However, observations from classroom practice indicate that many students encounter difficulties in systematically analyzing business components, identifying logical relationships between segments, and organizing ideas into appropriate categories. These challenges suggest a gap in decomposition skills, as students struggle to break down a complex business idea into structured and meaningful components.

To address this issue, [6] state that interactive and digital learning environments can enhance student engagement and improve academic performance by facilitating active involvement with learning content. Therefore, BMCExpert was developed as a digital learning tool designed to support structured learning in business model development. The tool incorporates an interactive drag-and-drop activity that allows students to match business elements with the correct BMC segments. Through this guided digital interaction, students are encouraged to analyze, classify and organize business information into smaller structured components. This structured matching process directly supports the development of decomposition skills by training students to systematically break down complex entrepreneurial concepts into manageable parts.

Therefore, this study aims to evaluate the effectiveness of BMCExpert in enhancing decomposition skills among students enrolled in the DFT30033 Cyberpreneurship course. The findings are expected to contribute to the integration of computational thinking elements within entrepreneurship education and to provide empirical evidence on the role of interactive digital learning tools in strengthening analytical and structured thinking skills among future digital entrepreneurs.

The study proposes three hypotheses to evaluate the effectiveness of BMCExpert in enhancing student performance. Hypothesis 1 posits that there is a difference in student performance before and after the application of the conventional learning method within the control group. Hypothesis 2 suggests that applying computational thinking, specifically decomposition, through BMCExpert will result in a measurable difference in

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student performance in the treatment group. Finally, Hypothesis 3 asserts that there is a significant difference in post-test performance between the control group and the treatment group, indicating the impact of BMCExpert and computational thinking-based learning on students' ability to analyze and structure business models.

II. LITERATURE REVIEW

Table 1 shows the research findings from previous studies that are related to computational thinking, digital tools, and the Business Model Canvas (BMC). Previous studies have emphasized the growing importance of computational thinking in education, particularly in developing structured problem-solving and analytical skills across disciplines [10][13]. Computational thinking is not limited to technical fields but encompasses cognitive processes that support meaningful problem solving, including decomposition, abstraction, and pattern recognition [14].

Decomposition in particular, plays a significant role in helping learners break down complex problems into manageable components. In entrepreneurship education, this skill enables students to analyze business structures systematically and understand the relationships between different elements of a business model. Studies have shown that integrating decomposition into learning activities improves students' ability to organize information, make decisions and develop structured solutions [11][12].

The use of digital learning tools has also been widely recognized for enhancing student engagement and learning effectiveness. Interactive platforms provide opportunities for active learning, allowing students to manipulate, classify, and organize information in a structured manner [7]. In this context, BMCExpert serves as a digital tool that facilitates the application of decomposition through guided activities such as drag-and-drop matching of business elements to BMC segments. This interactive approach encourages students to plan, monitor, and evaluate their understanding, thereby supporting metacognitive development and strategic thinking [9].

Table 1: *Findings by Previous Researchers*

Researcher(s)	Research Findings
Zou and Chen (2025)	Digital learning enhances accessibility and student engagement, with future directions emphasizing AI integration and online learning platforms.
Assaf et al. (2024)	Computational thinking in the learning process helps students improve their decomposition skills.
Markandan and Osman. (2022)	The implementation of computational thinking improves students' metacognitive awareness and problem-framing abilities.
Tatpuje et al. (2025)	The integration of computational thinking in entrepreneurship education enhances structured problem-solving and business opportunity framing, highlighting its value beyond computing domains.
Jyrwa et al. (2025)	Cognitive processes such as decomposition, abstraction, and pattern recognition improve problem-solving skills when embedded within the curriculum.
Adorni et al. (2024)	Computational thinking positively influences students' cognitive skills and promotes deeper conceptual understanding.
Oliveira et al. (2025)	Computational thinking has emerged as a critical component in modern education, equipping students with essential skills to thrive in a technology-driven world.
Liu et al. (2024)	Computational thinking is not limited to the use of technological tools; rather, it emphasizes cognitive competencies essential for meaningful problem-solving.
Zou et al. (2025)	Digital learning enhances accessibility and engagement, supporting the integration of AI and online platforms in education.
Kang et al. (2023)	Computational thinking assessment tools can effectively distinguish computational thinking skills across different student groups.
Middleton and Suwannatthachote (2021)	Enhancing problem-solving skills requires supporting activities and instructional tools that integrate computational thinking into the learning process.

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Furthermore, integrating computational thinking within digital learning environments has been shown to improve students' academic performance and problem-solving abilities [8][15]. Assessment methods such as pre-test and post-test evaluations are commonly used to measure the effectiveness of such interventions in enhancing cognitive skills [16].

Overall, the literature indicates that the integration of computational thinking, particularly decomposition, with interactive digital tools like BMCExpert can significantly enhance students' ability to analyze and structure complex business models. This approach not only strengthens problem-solving skills but also prepares students for the demands of the modern digital business environment.

III. RESEARCH METHODOLOGY

This study employed a quantitative research approach to examine the effectiveness of BMCExpert in enhancing students' decomposition skills. Research methodology refers to a systematic framework of methods and principles used to conduct a study and ensure reliable and valid results [17]. Selecting an appropriate methodology is essential to ensure that data collection effectively addresses the research questions and objectives [18]. A quasi-experimental design was employed. The quasi-experimental design involved two groups, the control group and the treatment group, with data collected from pre-tests and post-tests to examine differences in performance. As noted by [17] quasi experiments manipulate the independent variable and observe its effect on the dependent variable.

In this study, the quasi-experimental design was implemented to address three research objectives. Both the control and treatment groups initially studied the Business Model Canvas (BMC) subtopic using conventional teaching methods and completed a Pre-Test BMC. Following this, the treatment group received instruction using BMCExpert, which integrates computational thinking with a focus on decomposition skills, while the control group continued with conventional methods. After the intervention, both groups completed the Post-Test BMC, which contained identical assessment items to ensure comparability. Each test consisted of 50 marks and was completed within 30 minutes.

Table 2: *Comparison of Pre-Test and Post-Test Scores by Learning Approach for Different Groups*

Group	Pre-Test (BMC Pre)	Learning Approach	Post-Test (BMC Post)
Control	01	Conventional Learning Method	02
Treatment	03	BMCExpert Learning Method	04

Indicator:
Control group: 01, 02 *X1 – Conventional Learning Method*
Treatment group: 03, 04 *X2 – BMCExpert Learning Method*

Table 2 shows the comparison of Pre-Test and Post-Test Scores by Learning Approach for Different Groups. Three research instruments were used are Pre-Test BMC, the Post-Test BMC, and the BMCExpert Test were almost similar but different to type of business to Continuous Assessment materials for the DFT30033 Cyberpreneurship course, developed by the course instructor. To ensure content validity, all assessment items were developed by the course instructor and aligned with the Test Specification Table (Jadual Spesifikasi Ujian, JSU), which was designed based on the syllabus and validated by the Head of Program.

Sampling was conducted using purposive to select students with specific characteristics, namely those enrolled in the DFT30033 Cyberpreneurship course. Based on the Krejcie and Morgan table, a total of 40 students were selected, divided equally into a control group (n = 20) and a treatment group (n = 20). Research in educational and simulation based studies suggests that, while larger samples are often preferred, meaningful statistical analysis can still be achieved with relatively small group sizes when effect sizes are considered and study design is appropriate. A rapid review of sample sizes in educational research found that the median sample size in simulation based educational studies was about 30 participants per study, indicating that student groups of 8–15 in each group can still yield meaningful results depending on context and research design [19]

Data analysis involved both descriptive and inferential statistics. Descriptive statistics were used to calculate percentages and mean scores, while inferential statistics employed independent sample t-tests to compare the control and treatment groups and paired sample t-tests to assess differences within the same group over time. This approach allowed for a rigorous evaluation of the intervention's effectiveness based on pre-test and post-test results.

IV. RESULT AND DISCUSSION

A. Research Demographics

The study involved 40 students enrolled in the DFT30033 Cyberpreneurship course, all of whom were in Semester 3. These 40 students were then divided into two groups: 20 students were assigned to the control group and the remaining 20 to the treatment group.

The intervention for the control group employed the conventional method, which is the traditional approach commonly used in teaching.

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Meanwhile, the intervention for the treatment group involved the application of computational thinking, specifically decomposition, through BMCExpert.

Table 3: *Gender Distribution of Students in the DFT30033 Cyberpreneurship Course*

	Male	Female	Total
Control Group	13	7	20
Treatment Group	6	14	20

The table 3 shows the gender distribution of students in the control and treatment groups. The control group consisted of 13 males and 7 females, while the treatment group included 6 males and 14 females. Although the gender ratios differed, the sample size for both groups was equal (20 students each), ensuring that comparisons of performance between the groups remain valid.

B. Data Normality

In a study, a data normality test must be conducted prior to statistical analysis to ensure that the data are normally distributed and that the results obtained are accurate. Non-normal data can compromise the validity of the analysis.

According to [20], Skewness indicates the direction of the distribution's asymmetry, whether positive or negative. Kurtosis describes the height or flatness of the distribution curve, indicating whether it is leptokurtic (high) or platykurtic (low). Data can be considered normally distributed if Skewness values fall within ±2 and Kurtosis values within ±3 [21].

Table 4: *Normality Test of Student Achievement for the Control and Treatment Groups*

Student Group	Pre test		Post Test	
	Skewness	***Kurtosis***	***Skewness***	***Kurtosis***
Control Group	.063	-.523	.228	-.972
Treatment Group	.188	-1.149	.272	-1.429

Table 4 presents the results of the normality test for student achievement in the control and treatment groups for both the pre-test and post-test. For the control group, the Skewness values were 0.063 for the pre-test and 0.228 for the post-test, while the Kurtosis values were -0.523 and -0.972, respectively. For the treatment group, the Skewness values were 0.188 for the pre-test and 0.272 for the post-test, with Kurtosis values of -1.149 and -1.429.

All Skewness values fall within the ±2 range, and all Kurtosis values are within the ±3 range, which is considered acceptable. Therefore, it can be concluded that the data for both groups in the pre-test and post-test are normally distributed. Consequently, parametric statistical analyses, such as the t-test, are appropriate for use in this study.

C. Inferential Analysis Results

For hypothesis testing, which there is a difference in student performance before and after the application of the conventional learning method within the control group, a paired-sample t-test was employed. The purpose of this analysis was to examine the difference in the performance of students enrolled in the course DFT30033 Cyberpreneurship before and after the teaching sessions using the conventional learning method.

Table 5: *T-Test for the Comparison of Pre-Test and Post-Test Means for the Control Group Using the Conventional Method*

	Paired-sample t-test			
	Mean Difference	**t**	**df**	**Sig.**
Pre test and Post test	11.150000	-9.401	19	.000

Table 5 presents the results of the paired-sample t-test comparing the pre-test and post-test means in the control group using the conventional method. The analysis yielded a t-value of -9.401 with degrees of freedom (df) = 19 and a significance value of $p = .000$ ($p < .05$). The significance value below 0.05 indicates that there is a significant difference between the pre-test and post-test scores for the control group. This means that the conventional method used had an effect on student achievement. Therefore, the null hypothesis, which states that there is no significant difference between the pre-test and post-test is rejected.

Similarly, for the second hypothesis that applying computational thinking, specifically decomposition, through BMCExpert will result in a measurable difference in student performance in the treatment group, a paired-sample t-test was also used.The analysis was conducted to compare the difference in the performance of students enrolled in the course DFT30033 Cyberpreneurship after the implementation of computational thinking, specifically applying decomposition, using BMCExpert.

Table 6: *T-Test for the Comparison of Pre-Test and Post-Test Means for the Treatment Group Using BMCExpert*

	Paired-sample t-test			
	Mean Difference	**t**	**df**	**Sig.**
Pre test and Post test	21.85000	-11.625	19	.000

The table presents the results of the paired-sample t-test comparing pre-test and post-test scores for the treatment group. The analysis showed a t-value of -11.625 with degrees of freedom (df) = 19 and a significance value of $p = .000$ ($p < .05$). This

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indicates a significant difference between the pre-test and post-test scores, demonstrating that student performance improved after the intervention. Therefore, the null hypothesis, which states that there is no significant difference between the two tests, is rejected.

Although student performance in both groups improved after the intervention, the control group used the conventional method, which is the traditional approach often applied, while the treatment group received an intervention applying computational thinking, specifically decomposition, through BMCExpert. When examining the improvement in performance before and after the intervention, it is evident that the treatment group showed a more substantial increase, with an average improvement of approximately 21.85 compared to the control group's average improvement of around 11.15.

This difference is further tested through the third hypothesis, which examines the significant difference in post-test performance between the control and treatment groups, indicating the impact of BMCExpert and computational thinking-based learning on students' ability to analyze and structure business models. The third hypothesis was tested using an independent-sample t-test to compare post-test results between the control and treatment groups after the intervention.

Table 7: *T-Test for the Comparison of Post-Test Means for the Control and Treatment Groups*

	Levene test		Independent-Sample T-Test		
	F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**
Equal Variances Assumed	.610	.440	-5.506	38	.000
Equal Variances Not Assumed			-5.506	36.196	.000

Table 7 shows the results of the independent-sample t-test comparing the post-test means between the control and treatment groups. The Levene's test results indicated $F = 0.610$ with a significance value of $p = 0.440$ ($p > 0.05$), showing that the variances for both groups are homogeneous. Therefore, the results from the equal variances assumed row were referred to.

Based on the analysis, the t-value was -5.506 with $df = 38$ and a two-tailed significance value of $p = .000$ ($p < 0.05$). This indicates that there is a significant difference between the post-test means of the control and treatment groups. Hence, the null hypothesis stating no significant difference between the two groups is rejected. These findings show that the method applied in the treatment group produced a significantly different impact compared to the conventional method.

Overall, the study findings clearly indicate that both teaching methods, whether conventional or intervention-based, succeeded in improving student performance. This is evidenced by the paired-sample t-test results showing a significant difference between pre-test and post-test scores for both groups ($p < .05$).

However, further analysis reveals that the level of improvement in the treatment group was substantially greater than in the control group. The control group using the conventional method recorded a mean improvement of 11.150, while the treatment group receiving the intervention showed a mean improvement of 21.850, nearly double that of the control group. This difference clearly demonstrates a more significant and meaningful impact resulting from the intervention method.

These findings are further reinforced by the independent-sample t-test comparing post-test means between the two groups. The t-value of -5.506 with $p = .000$ ($p < 0.05$) confirms a significant difference between the control and treatment groups after the intervention, indicating that student achievement in the treatment group was statistically higher than in the control group.

Consequently, the null hypotheses for all three tests are rejected. The results provide strong empirical justification that the intervention method introduced was not only effective but also more efficient than the conventional method in enhancing student performance in the course.

In summary, this study demonstrates that innovations in teaching approaches can produce significant improvements in student achievement and have important implications for current pedagogical practices. The intervention method used has the potential to be expanded as a more dynamic, effective, and high-impact teaching approach.

V. CONCLUSION

The study found that the integration of computational thinking, specifically decomposition, through BMCExpert significantly enhances students' performance in analyzing and structuring business models. While both conventional and intervention-based teaching methods improved student achievement, the intervention using BMCExpert with computational thinking decomposition resulted in almost twice the improvement compared to the conventional approach. Independent t-test results further confirmed that the post-test performance of the treatment group was significantly higher than that of the control group. These findings indicate that computational thinking and digital learning tools can effectively improve learning outcomes, promote

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critical thinking, and strengthen students' entrepreneurial skills. The results also suggest that incorporating innovative, technology-driven pedagogical approaches like BMCExpert into entrepreneurship courses can create a more engaging, effective, and impactful learning experience.

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A Conceptual Review: Transformation of English Language Teaching with AI Chatbots

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Abstract

Technological developments have opened a path to innovation and integration of various pedagogical tools within the ELT field. Among these emerging tools that are beginning to take a strong hold in ELT domain is Artificial Intelligent (AI) chatbots. The aim of this conceptual paper is to examine pedagogical implications of AI chatbots in English Language Teaching (ELT) context. The discussion is grounded in frameworks including Constructivist theory, Self-determination theory (SDT), Interaction hypothesis, and Communicative language teaching (CLT) that serve as theoretical support for implementing AI chatbots in ELT settings. As per the findings, use of AI chatbots in ELT can improve learners' core language abilities, particularly speaking and writing. There are limited empirical data to support benefit of AI chatbot implementation on other language skills such as reading, listening, and vocabulary development. In addition, learners' engagement level and motivation toward language learning increased while language anxiety reduces when English language teachers integrate AI chatbots in their classroom. Other than that, the ease of AI chatbots accessibility promotes learner autonomy through self-paced and independent practice sessions. Despite the benefits AI chatbots have on English language learning, the findings emphasise the need for careful pedagogical integration to prevent overreliance on the support provided by AI chatbots and at the same time preserve critical thinking. Overall, this study systematically positions AI chatbots as an important pedagogical tool in ELT context that could transform ELT practices when implemented within structured and theory-driven instructional designs.

Keywords: *Artificial Intelligent (AI); chatbots; English; English Language Teaching (ELT)*

I. INTRODUCTION

Technological advancements, changing times and individual needs make education a dynamic lifelong process. One of the technological advancements that is blooming at an impressive rate is Artificial Intelligent (AI). Conversational agents, commonly referred to as chatbots, are one of the notable developments in AI and are massively popular in various fields [1]. AI chatbots are conveniently used across diverse contexts including in education. AI chatbots function as conversational systems that allow users to interact with computer programs through Natural Language Processing (NLP) and Machine Learning (ML) to produce conversational interactions like humans. They are conversational agents designed to analyse user input and produce responses that are appropriate to the conversational context [2]. In education, AI chatbots are integrated as a contemporary pedagogical tool and English Language Teaching (ELT) context is slowly emerging as one of the most productive domains for AI chatbots. AI-driven chatbots which were once experimental tools have evolved as significant educational resources over the past five years by transforming how learners acquire and practise English as a Second Language (ESL) or English as Foreign Language (EFL) learning environments [3][4][5]. Widely available conversational AI platforms such as ChatGPT plays a significant role in this transformation [6][7][8]. AI chatbots in ELT context is not just technical novelty but it is beyond that. Pedagogical challenges such as scarce authentic language practice opportunities and individualized feedback, learner anxiety when communicating in real life and limitations in traditional instruction are appropriately addressed by AI chatbots in language education [1]. AI chatbots adequately open possibilities to have language exposure, skill development and practice that help to enhance traditional classroom instruction.

The present study synthesizes recent literature on AI chatbots applications in ELT settings published from 2020 to 2025. The timeline saw a rapid technological advancement leading to an increased attention to the use of AI chatbots in education, particularly in ELT. Empirical and theoretical contributions of highly relevant studies are synthesized to address three key objectives. First, investigating pedagogical frameworks and theoretical concepts serving as the foundation of pedagogical integration of AI chatbots in English language classrooms. Second, evaluating how AI chatbots strengthen learners' language skills such as

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vocabulary, grammar, speaking, writing, and reading. Third, examining the relationship between AI chatbot use and learners' motivational and affective factors.

II. LITERATURE REVIEW

The increasing presence of AI chatbots brings noticeable changes within educational practices. Educators are beginning to adopt AI chatbots to facilitate learning activities in both ESL and EFL settings. The theoretical foundations that align with the use of AI chatbots in English classrooms as well as the positive outcomes learners receive when AI chatbots are incorporated as a pedagogical tool must be properly addressed.

A. Theoretical Perspectives Supporting AI Chatbot in ELT

There are several theoretical perspectives that provide valuable insights on how AI chatbots can be integrated to support English language learning. These frameworks provide strong pedagogical foundation to ensure that AI chatbots integration aligns with the way learners acquire language and remain meaningfully participative in the learning process.

1. Constructivist learning theory

The implementation of AI chatbots in ELT is supported through several relevant theoretical perspectives. One of the key frameworks is constructivist learning theory, which suggests that learners need to engage with their environment and reflect on their experiences before they can construct their knowledge rather than simply receive information [9]. Social interaction must be present for the learners to relate prior knowledge to newly acquired information or ideas rather than passively absorb it. This perspective asserts that teachers function primarily as the facilitators of the learning process while learning environments should promote learner autonomy and encourage active participation. Concurrently, AI chatbots provide interactive conversational context for learners to experiment with language and receive feedback immediately [10]. This makes the integration of AI in the English classroom aligned with principles of constructivist theory. Learners could negotiate meaning, test linguistic hypotheses, and refine their language use in context through ongoing dialogue with chatbots. Such interaction allows ESL and EFL learners to practise language in meaningful communicative situations, thereby supporting the gradual development of linguistic competence.

2. Self-determination theory (SDT)

Another important theoretical perspective is Ryan and Deci's Self-determination theory (SDT) [11] According to the theory, human motivation will be elevated if basic human psychological needs comprising learner autonomy, competence, and relatedness are fulfilled. Learners are more likely to experience intrinsic motivation and sustained engagement in learning activities when these needs are met. In language learning environments, students are motivated when they are able to make choices about their learning, develop confidence in their abilities, and feel connected to others throughout the learning. AI chatbots in ESL or EFL context can support these motivational needs [12] [13]. Independent learning and flexible learning schedules that are enabled by AI chatbots support learner autonomy. Meanwhile, immediate feedback that is provided by AI chatbots during language practice increases learners' competency in English. The interactive nature of conversational exchanges can also foster a sense of relatedness by creating a responsive learning environment. Therefore, learners stay motivated and highly engaged in language learning when these psychological needs are supported.

3. Interaction hypothesis

Long's Interaction hypothesis [14] emphasises meaningful communication in second language acquisition (SLA). As defined by the interaction hypothesis, language development occurs when learners participate in communicative exchanges that allow them to clarify meaning, request clarification, and receive feedback from their interlocutors. The interaction should be two-directional where the learners query, paraphrase and recycle the language input they received. This will enhance the comprehensibility and the target input will function as intended on the learning and developmental needs of each individual learner. Therefore, communicative exchanges that include meaning negotiation and respond to feedback helps learners acquire the language. Pedagogical role of AI chatbots in ELT environment is associated with interaction hypothesis in second language learning. They serve as a platform for learners to participate in continuous communicative practice beyond the limitations of traditional classrooms [7]. When learners interact with AI chatbots, they could ask questions, receive clarification, and adjust their responses based on feedback generated by the system. The ongoing interaction enables learners to experiment with language and refine their linguistic knowledge. As a result, AI chatbots can promote gradual improvement of English proficiency among ESL and EFL learners.

4. Communicative Language Teaching (CLT)

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Communicative Language Teaching (CLT) is widely recognised as a learner-centred approach that prioritises the practical use of language in meaningful communicative situations [15]. The approach encourages learners to actively engage in interaction using the target language to promote communicative competence and functional language [15][16]. AI chatbots are valuable tools to facilitate interactive language use and it is through this they conformed to the CLT approach. Learners are provided with opportunities to participate in simulated conversations by AI chatbots where they can practise different language functions in realistic situations. According to [17] roles as interlocutor, simulator, information transmitter, and recommendation provider in language learning environments are performed by AI chatbots. AI chatbots assist learners practising the language in a manner that resembles authentic communication through these interactive exchanges.

B. AI Chatbots Across Language Skills and Learning contexts

Language learners achieve language proficiency when they master four fundamental skills which are listening, speaking, reading and writing. These skills are further classified into two main categories which are productive and receptive skills. Speaking and writing are known as productive skills because learners actively produce or express language through them. In contrast, reading and listening are recognised as receptive skills because they involve receiving, understanding, and interpreting language that others have produced [18]. Essentially, learners must develop both sets of skills to become competent and independent language users. In addition, to be effectively engaged in spoken communication, it is crucial to master pronunciation whereas vocabulary knowledge serves as a fundamental element that supports both comprehension and language production. Learners may experience difficulties in both understanding and expressing meaning in the target language where there is an inadequate range of vocabulary.

1.Speaking

Studies that investigated the incorporation of AI chatbots in ELT suggests that these technologies could contribute positively to learners' speaking development. AI chatbots promote improvements on various oral skill aspects of the learners [7][19][20]. These include improvements in pronunciation accuracy, intonation patterns, stress placement, and overall speaking fluency. However, the benefits appear to be particularly noticeable when voice-enabled AI chatbots are used rather than text-based conversational agents. Learners who interacted with voice-based AI chatbots demonstrated higher speaking performance compared with those who used conventional chatbot systems. Correspondingly, another research found that participants who engaged with AI chatbot-supported learning activities achieved better pronunciation outcomes than learners in the control group [1][21][22]. Enhanced phonetic accuracy is prevalent when there is intervention of AI chatbots with speech recognition technology. Learners could have repeated practice without being judged or embarrassed when mistakes are made which eventually led to better speaking skill. The repeated practice accompanied by continuous immediate feedback is feasible by AI chatbots.

Apart from phonological development, AI chatbots may also contribute to learners' pragmatic competence and sociolinguistic awareness. Study reported that learners have opportunity to practise selecting appropriate expressions, tones, and speech acts in simulated conversational scenarios that is facilitated by AI chatbots [23]. Learners develop an improved comprehension of the ways language operates within authentic social contexts through these interactions and become more informed about the cultural norms rooted in English communication. However, the effectiveness of AI chatbot integration in ELT varies depending on learners' proficiency levels [3]. Intermediate learners with sufficient linguistic knowledge to engage meaningfully in AI chatbot interactions tend to benefit more from AI chatbot-assisted speaking practice compared to elementary learners. In contrast, advanced learners sometimes report dissatisfaction with the limitations of chatbot responses, because they may be limited and unable to support deeper or more natural conversational exchanges. The results suggest that the value of AI chatbots as pedagogical tools is influenced by learner characteristics, the instructional design of learning activities and the technology itself. Consequently, the success rate of AI chatbots incorporation in ELT needs careful planning in terms of the type of AI chatbot employed and the proficiency level of the learners to maximise their potential benefits.

2. Writing

AI chatbots play a supportive role in improving the writing proficiency of ESL or EFL learners. Related studies have documented improvisation in learners' grammatical accuracy, coherence and cohesion, essay organisation, and the overall quality of argumentative writing when AI chatbots are incorporated into writing instruction [21][24]. One possible explanation for these improvements is the immediate and personalised feedback that AI chatbots provide, which contrasts with the delayed feedback typically encountered in traditional ESL or EFL classrooms. In many classroom contexts, teachers are responsible for reviewing large numbers of student assignments, which may limit their ability to provide timely and repeated feedback on students' writing. As an alternative to teachers, AI chatbots can offer automated suggestions and corrective

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feedback during the writing process. Learners can revise and refine their compositions multiple times through iterative feedback cycles, which may contribute to the gradual development of writing competence. Apart from that, AI chatbots can assist learners to plan, monitor and evaluate their written work, thereby supporting the development of metacognitive writing strategies. Previous studies conducted also highlight that writing environments assisted by AI chatbot can provide guidance on grammar, vocabulary use, textual organisation, and stylistic choices, all of which contribute to improved writing quality [10][24][25]. Nevertheless, despite these potential benefits, blending AI chatbots into ESL or EFL writing instruction should be approached with caution [26]. Excessive reliance on feedback generated by AI chatbots may hinder development of independent critical thinking and creativity in the process of writing. Therefore, it is necessary to carefully plan the pedagogical path to ascertain AI chatbots' role as supportive learning instruments that complement, instead of replacing teachers' role in developing learners' writing abilities.

3. Listening

Listening comprehension shows improvement when incorporating AI chatbots in English language learning settings. Learners are exposed to interactive conversational exchanges that combine both listening and speaking practice when they interact with AI chatbots that come with audio-based technologies. These kinds of interactions may simultaneously support the development of learners' receptive and productive language skills [7]. Learners encounter a variety of authentic speech patterns, discourse markers, and sentence structures that are commonly used in natural communication through conversation mediated by AI chatbot. Exposure to these linguistic features can help learners become more familiar with the rhythm, pronunciation, and structure of spoken English, which may gradually enhance their listening proficiency. In addition, repeated interaction with audio input generated by AI chatbot allows learners to practise listening at their own pace and revisit conversations when necessary, thereby reinforcing comprehension.

Although AI chatbots offer accessible opportunities to practise listening, the quality of listening input largely depends on the way the AI chatbot system is designed and how advanced its speech generation technology is. Therefore, the effectiveness of AI chatbot-assisted listening activities largely depends on how well these technologies are integrated into pedagogically meaningful learning tasks.

4. Reading

Through interactive conversations and automated support, AI chatbots help learners to understand texts and respond to comprehension tasks [27]. In English language classrooms, the contribution of AI chatbots is in the development of several reading-related abilities, including strengthening learners' ability to understand text, ensuring reading accuracy, encouraging critical thinking, and applying pre-reading strategies. By offering prompts, explanations, and follow-up questions, chatbots encourage learners to engage more actively with reading materials and think about the meaning of the text. For example, AI chatbot-assisted activities may include tasks such as close passages and comprehension questions that require learners to examine the context of a passage and construct meaning from the information provided [25].

5. Vocabulary and grammar

AI chatbot interventions in ELT have also supported learners in fostering vocabulary knowledge. Findings from recent studies indicate a significant difference in learners' acquisition of familiar and unfamiliar words when AI chatbots are used as learning tools [28]. Chatbots facilitate vocabulary learning through several mechanisms, including creating authentic contexts for word usage, enabling interactive practice, providing immediate definitions and contextual examples, and generating personalised word lists based on learners' needs [28][29].

In addition to vocabulary learning, learners get guidance in expanding their knowledge on grammar from AI chatbots. Through targeted explanations, error corrections, and adaptive practice opportunities, AI chatbots are able to address individual learners' difficulties related to grammar [10][30]. Their ability to provide instant feedback during interaction also supports the development of grammatical accuracy and metalinguistic awareness among learners**.**

C. Affective and Motivational influence of AI chatbots

1. Affective factors

Affective factors play a crucial role in Second Language Acquisition (SLA) and teaching. Emotional and psychological perspectives such as motivation, anxiety, self-esteem, attitude and emotion towards language learning can impact second language acquisition in a positive or negative way. Language anxiety is one of the recurring obstacles in language education and learners are said to have language anxiety when they associate learning, using or understanding language to negative emotional responses [31][32]. AI chatbots in ELT context demonstrate positive effects in addressing language anxiety of ESL and EFL learners. Consistent reports identified that speaking anxiety is reduced when AI chatbots are used in the classrooms [7][12][33]. This happens when AI chatbots provide a non-judgemental and non-

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pressure environment for learners to practise. The conducive environment for language practice eliminates fear of embarrassment and negative evaluation. Anxiety and fear of learning or using language minimizes when learners interact with chatbots compared to human interlocutors. Consequently, psychological safety is created and it lowers the affective filter that hinders language development. Apart from this, studies documented that AI chatbots increase learners confident and decrease inhibition related to language learning leading to the sustainment of language use [12][33].

2. Motivation and engagement level

Motivation is the drive or reason that pushes someone to do something to achieve their perceived goal. Learner motivation increases when AI chatbots are present in ELT environments [34]. Validated motivational scales employed during studies demonstrated that AI chatbot intervention improved intrinsic and extrinsic motivation of the learners [12][35]. When chatbots provide feedback immediately, learners' need for competence is fulfilled. Learners feel happy when their language needs are satisfied. This motivates them to further develop their language competency. Integration of AI chatbots provides interactive experience and enables learning that is paced according to individual preferences which eventually increases learners' engagement level. Engagement refers to active participation and interest show by someone in doing task. Existing research suggests that incorporating chatbots into language learning environments can positively influence student engagement. Learners tend to participate more actively, maintain attention for longer periods, and demonstrate greater involvement in learning tasks when chatbot-supported activities are used [12][36]. Many learners report that interacting with chatbots feels more engaging than completing traditional exercises, mainly because the exchanges resemble real conversations and provide immediate responses [12]. In addition, chatbot-supported learning environments may help create conditions like "flow," a state in which learners become deeply focused while working on tasks that offer an appropriate level of challenge. Such experiences can contribute to higher engagement as well as greater satisfaction with the learning process.

3. Autonomous learning

Research suggests that AI chatbots integration in ESL or EFL classrooms can promote learner autonomy and self-directed learning. Learners could practise independently, set and monitor progress of their personal learning goals as well as make informed decisions on their learning strategies when AI chatbots are employed as a pedagogical tool [12]. The biggest advantage in using AI chatbots is it allows learners to practice language without time or place constraints. The accessibility freedom permits learners to engage in language practice beyond classroom limitations. In addition, chatbot interactions promote metacognitive awareness and self-regulatory skills, name setting learning goals, monitoring their own progress, and evaluating their performance, all of which are important elements for successful independent learning [12] [19].

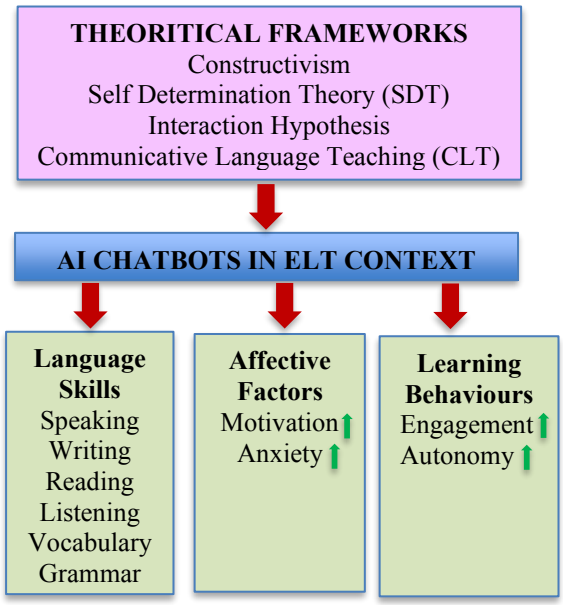

Figure 1 Conceptual framework of AI chatbot integration in ELT

III. METHODOLOGY

This study is a conceptual review that aims to explore theoretical concepts and pedagogical frameworks that serves as fundamental principles on the integration of AI chatbots in English language classroom. Apart from that, it is also important to examine pedagogical and motivational implications it serves on English language learners. Therefore, a structured and transparent literature exploration is employed for that purpose.

1. Literature search strategy

Google Scholar was the main search engine used whereas established academic publishers, including Elsevier, Taylor & Francis, Springer, Wiley and Emerald Publishing were manually explored to identify relevant literature. Boolean operators (AND, OR) were used to combine and refine the literature based on the keyword combinations such as "AI chatbots," "ESL," "EFL," and "English language teaching." The publication year was set from 2020-2025 as this is the period where educational context saw increasing integration of AI technologies due to their rapid advancement leading to the emergence of generative AI tools.

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2. Inclusion and exclusion criteria

The literature was selected based on the relevance to the topic and academic quality. Studies were only included if they:
(i) examine use of AI chatbots within ESL or EFL contexts,
(ii) study implications on language skills and affective factors
(iii) publish in peer-reviewed journals and has high impacts
The literature was excluded if they were published before the year 2020 or after 2025. In addition to empirical studies, important theoretical works relevant to the study were incorporated to provide a strong conceptual foundation for interpreting the role of AI chatbots in ELT.

3. Data Analysis and Synthesis

The literature was analysed using thematic synthesis approach. Key themes that align with the objectives of this paper are:
(i) theoretical perspectives supporting AI chatbot integration,
(ii) contributions to language skills and learning contexts,
(iii) affective and motivational influence

4. Scope and Limitations

As a conceptual review, the purpose of this study is not to provide an exhaustive or systematic account of all available literature. The selection of studies was focused on the relevance to the research objectives and accessibility of sources. While efforts were made to include high-quality and impactful studies, the possibility of omission cannot be entirely excluded. Nevertheless, the structured approach adopted in this study ensures a coherent and meaningful synthesis of current study to inform pedagogical understanding of AI chatbot integration in ELT.

IV. ANALYSIS

The conceptual review show that AI chatbots are not just a technological development instead they are becoming valuable pedagogical tool in ELT context. They support English language learners in terms of language skills development, affective factors and learner autonomy. AI chatbots provide platform for learners to practise speaking and writing effectively by providing instant feedback and continuous interaction. Other than that, AI chatbots provide meaningful and contextualised language exposure to support reading, listening, vocabulary and grammar skills development. However, learners' proficiency and the way activities designed affect the level of improvement. On the other hand, low pressure learning environment created by AI chatbots make learners feel less anxious and use English more confidently. This leads to active engagement and higher motivation when learning feels interactive and personalised. In addition, AI chatbots promote learner autonomy as they allow flexible self-paced practice. Learners have control of their progress and learning strategies which eventually supports more independent learning routine

V. CONCLUSION

Over the past years, AI chatbots have been taking pivotal roles in our lives. Within ELT domains, chatbots are fundamentally transitioning from experimental tools to mainstream pedagogical tools. However, thoughtful considerations are required before integrating AI chatbots in ESL or EFL classrooms to ensure the desired outcomes are achieved. Teachers must be equipped with proper knowledge on pedagogical integration of chatbots to avoid over-reliance on chatbots. The integration of AI chatbots into ELT setting in rural educational settings especially in community college where learners face challenges in accessing quality language learning support needs further investigation. In conclusion, AI chatbots should be incorporated into structured learning activities that promote reflection, encourage problem-solving, and facilitate meaningful communication in the target language.

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Assessing Users' Satisfaction in Using NDCLearnHub for the Network and Data Communication Course at Politeknik Balik Pulau

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Abstract

The integration of digital technologies in higher education has transformed teaching and learning by enabling flexible, interactive and student-centered learning environments. In response to this development, NDCLearnHub was developed as an online learning platform to support students in understanding the Network and Data Communication course at Politeknik Balik Pulau. This study aims to assess students' satisfaction with the use of NDCLearnHub in terms of usefulness, ease of use, ease of learning and overall satisfaction. A quantitative research approach was employed using a questionnaire distributed to Diploma in Information Technology students enrolled in the DFC20293 Network and Data Communication course for Session II: 2025/2026. A total of 191 students participated in the study. The instrument utilized a five-point Likert scale and was validated through a pilot study involving 30 students, achieving Cronbach's Alpha values ranging from 0.835 to 0.887, indicating good reliability. The analysis revealed high mean scores for usefulness (4.1110), ease of use (4.1034), ease of learning (4.2644), and overall satisfaction (4.2072). These findings indicate that NDCLearnHub is an effective digital learning tool that enhances students' learning experience and supports the implementation of technology-driven education.

Keywords **:** *Digital learning; NDCLearnHub; Online learning platform; Students' satisfaction*

I. INTRODUCTION

In recent years, digitalization and rapid technological advancements have fundamentally reshaped how learner access, interpret and interact with information within educational settings. Digital technologies have extended learning beyond the traditional classroom, enabling students to engage with content anytime, anywhere and through diverse formats such as video, simulation and interactive modules. Such technologies act not merely as tools but as integral components of modern pedagogical design, shifting the focus towards learner centered and constructivist approaches that emphasize learner agency, self-regulation and interconnected knowledge networks such as Learning Management Systems, collaborative platforms and educational applications [1].

Aligned with these transformations, online learning has emerged as an innovative instructional approach that transcends the limitations of conventional face to face classroom models [2]. Unlike traditional instruction, online learning leverages digital platforms to facilitate flexible, interactive, and personalized learning experiences. Online environments can enhance learner autonomy and adaptability by enabling students to engage with content at an individualized pace, fostering self-directed and self-regulated learning behaviors that are essential in contemporary digital education [3]. Online platforms also support differentiated instruction by offering multiple pathways for engagement and assessment, thus accommodating diverse student preferences and learning styles [4]. For instance, multimedia content and interactive discussion forums.

Within this evolving educational landscape, an online learning tool NDCLearnHub specifically developed to support students in grasping the concepts of Network and Data Communication. Given the course's inherent challenges such as understanding layered models,

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network protocols, data transmission and communication models during the early stages of learning, online platforms like NDCLearnHub are positioned to support learning by offering interactive, flexible and contextually relevant digital resources that support students' conceptual development and engagement. By facilitating continuous access to course materials and interactive activities, the platform designed to enhance students' cognitive processing and motivation, addressing the limitations associated with traditional lecture - based instruction and aligning with broader trends in digital pedagogy and networked learning [5].

Therefore, this study focuses on evaluation of students' satisfaction in using NDCLearnHub as the online learning tool in Network and Data Communication course at Politeknik Balik Pulau. The findings of this study are indicated that the use of NDCLearnHub contributes positively to students' learning experiences by providing accessible learning materials, interactive content and structured resources that support understanding of networking concepts. In addition, the results show that factors such as perceived usefulness, ease of use, ease of learning and overall satisfaction play important roles in influencing students' acceptance of the platform.

H_1: There is a significant level of user satisfaction in using the NDCLearnHub application for the Network and Data Communication course at Politeknik Balik Pulau.

II. LITERATURE REVIEW

Table 1: Research Findings by previous researchers

Researcher(s)	Research Findings
Mamdouh Alenezi [6]	Digital learning platforms improve students' engagement and access to learning resources.
Emma Clark, Olivia Davis, Sara Al-Jabri [7]	Online learning platforms can increase student engagement, autonomy and motivation.
Novi Risnawati, Muhamad Taufik, Sinta Dewi, Prayash Sharma [8]	Positive perceptions of mobile app in vocabulary learning.
Patrick Brugliera [9]	Features of digital learning platforms influence students' learning experiences.

Table 1 summarizes relevant findings from previous studies on the role of digital learning platform and their impact on users' engagement and satisfaction with online learning platforms. These studies provide a foundation for understanding how tools like NDCLearnHub can influence students' learning experiences. NDCLearnHub integrates various learning elements such as lecture notes, multimedia materials and interactive content that help students better understand theoretical and practical aspects of network and data communication.

Digital learning tools can enhance understanding by providing simulations, structured notes and practice exercises that support complex concepts. Integrating digital learning tools into the courses improves students' comprehension and encourages independent learning, particularly when the system provides organized resources and easy navigation. A study by [6] examined the role of digital learning and digital transformation in higher education institutions. The study found that digital technologies and learning platforms provide flexible and interactive learning environments that enhance students' motivation, independent learning skills and access to educational resources. Digital learning tools allow students to access materials anytime and anywhere, while also supporting collaboration and communication between students and instructors. In a similar context, the present research focuses on assessing users' satisfaction with NDCLearnHub, an online learning platform designed for the Network and Data Communication course at Politeknik Balik Pulau. The current research specifically evaluates students' perceptions of the system in terms of usefulness, ease of use, ease of learning and satisfaction. Both studies emphasize the importance of digital learning platforms in improving the learning environment and supporting flexible access to course materials.

Previous studies have demonstrated that online learning platforms can positively influence students' learning experiences and motivation. Authors [7] investigated the impact of online learning platforms on student motivation using a quantitative survey involving 300 students from various educational institutions. The study found a significant positive correlation between the frequency of platform usage and students' intrinsic and extrinsic motivation. Students who interacted more frequently with the platform reported higher engagement, autonomy and participation in learning activities. Additionally, the study revealed that platform usage explained 38% of the variance in intrinsic motivation and 32% in extrinsic motivation, indicating that consistent interaction with digital learning platforms can enhance students' motivation and engagement in learning. These findings support the importance of evaluating

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users' satisfaction with platforms such as NDCLearnHub in improving the learning experience for the Network and Data Communication course.

The findings of [8] further support the notion that mobile learning applications positively influence students' perceptions and engagement in learning. For example, a study on EFL students' perceptions of a mobile vocabulary application reported that learners found the application helpful, enjoyable and easy to use, which increased their motivation and vocabulary acquisition. However, students also indicated that the application should function as a complementary learning tool rather than a replacement for classroom instruction. These findings suggest that perceived usefulness and ease of use significantly contribute to user satisfaction in digital learning environments. Similarly, the present study investigates whether NDCLearnHub enhances students' satisfaction in learning Network and Data Communication by providing accessible, interactive and user-friendly learning support.

A study by [9] in The Effectiveness of Digital Learning Platforms in Enhancing Student Engagement and Academic Performance reported that digital learning tools significantly enhance student engagement and academic performance in higher education. The study found that interactive features such as quizzes, discussion forums and simulations increase students' motivation and participation in learning activities. In addition, personalized learning paths and immediate feedback provided by digital platforms help improve students' understanding and overall learning outcomes. These findings support the relevance of examining students' satisfaction in using digital learning platforms, such as NDCLearnHub, in supporting the learning process for the Network and Data Communication course at Politeknik Balik Pulau.

III. RESEARCH METHODOLOGY

The researcher employed a quantitative approach using questionnaires to collect data from students who had utilized NDCLearnHub as part of their learning process. This study was conducted at Politeknik Balik Pulau, targeting students of Diploma in Information Technology who were enrolled in the course DFC20293 Network and Data Communication for Session II: 2025/2026.

Based on the guidelines by Krejcie and Morgan in 1970, a sample size of 175 to 181 is recommended for a population of 340 to 360. Considering the total population of 391 students, all students were included in the study sample. A random sampling method was applied, selecting respondents based on their enrollment in the course.

The questionnaire, developed using a 5-point Likert scale, measured students' perceptions of NDCLearnHub across four constructs: usefulness, ease of use, ease of learning, and satisfaction. A pilot study involving 30 students was conducted prior to the main study to assess the reliability of the instrument, with all constructs demonstrating acceptable reliability as indicated by Cronbach's Alpha values.

Data analysis was conducted using SPSS software, employing descriptive statistics (mean, standard deviation) to examine the level of agreement among respondents for each construct. In addition, data normality tests were performed using skewness and kurtosis values to ensure the suitability of the data for analysis. The results provided insights into the overall effectiveness of NDCLearnHub as a digital learning platform.

Table 2 shows the interpretation of Cronbach's Alpha scores as proposed by [10] in 2015.

Table 2: Interpretation of Cronbach's Alpha Scores

Cronbach's Alpha Score	Reliability Interpretation
0.91 to 1.0	Excellent and effective with high consistency
0.71 to 0.90	Good and acceptable
0.61 to 0.70	Acceptable
0.51 to 0.60	Items need improvement
< 0.5	Items should be discarded

The following are the results of the pilot study analysis conducted with 30 students. This pilot study was carried out prior to the actual study to assess the reliability of the items used in the questionnaire.

Table 3: Cronbach's Alpha (α) Values for the Study Variables

	Number of Item	*Alpha Cronbach* (α)	Interpretation
Usefulness	5	.835	Very good
Ease of Use	8	.887	Very good
Ease of Learning	4	.861	Good and acceptable
Satisfaction	7	.874	Very good

Table 3 presents the Cronbach's Alpha (α) values for the study variables, indicating the internal consistency and reliability of the measurement items. The Usefulness variable, with 5 items, has a Cronbach's Alpha (α) values 0.835, interpreted as very good, suggesting high consistency among the

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items. Ease of Use, consisting of 8 items, obtained the Cronbach's Alpha (α) values 0.887, also rated as very good, reflecting a reliable measurement scale. The Ease of Learning variable, with 4 items, has the Cronbach's Alpha (α) values 0.861, interpreted as good and acceptable, indicating satisfactory reliability. Finally, Satisfaction, measured with 7 items, shows the Cronbach's Alpha (α) values 0.874, again rated as very good, confirming that the items are consistent and reliable for further analysis.

Table 4: Level of Agreement Based on Mean Score

Mean Score	Interpretation of Mean Score
1.00 – 2.00	Low
2.01 – 3.00	Moderately Low
3.01 – 4.00	Moderately High
4.01 – 5.00	High

Source: Adapted from [11]

IV. RESEARCH METHODOLOGY

1) Student Demographics

This study involved 391 male and female students who were enrolled in the Network and Data Communication course at Politeknik Balik Pulau.

Table 5: Student Demographic Distribution

		Frequency	Percent
Gender	Male	96	50.3
	Female	95	49.7
	Total	191	100.0
Age	18-21 years old	179	93.7
	22-25 years old	12	6.3
	Total	191	100.0

Based on the table, the majority of respondents were males (96 students; 50.3%), while females comprised 95 (49.7%) out of the total of 191 students. The age distribution shows a participation between two categories, namely 18–21 years (179 students; 93.7%), whereas students aged 22-25 years represented the smallest group, with 12 students (6.3%). This demographic composition indicates that the study perspectives are nearly balanced between genders and encompass the experiences of both younger and adult learners.

2) Data Normality

Before conducting statistical analysis, a data normality test was performed to determine whether the data distribution was normal or skewed [12-13]. Normality was assessed using Skewness and Kurtosis values, where a range of ±2 is considered normal [14].

Table 6: Normality of Data

	Skewness	Kurtosis
Usefulness	.175	-.581
Ease of Use	.219	-.552
Ease of Learning	-.151	-.959
Satisfaction	-.069	-.890

Based on Table 6, all study variables exhibit a normal distribution. The Skewness values for Usefulness (0.175), Ease of Use (0.219), Ease of Learning (-0.151), and Satisfaction (-0.069) fall within the ±2 range, while the Kurtosis values (-0.581, -0.552, -0.959, -0.890) are also within the ±2 range [13-14]. This indicates that none of the variables display skewness or kurtosis beyond the normal thresholds, and therefore, the data are considered normally distributed and suitable for subsequent statistical analysis.

3) Mean Score Level Analysis

Descriptive analysis of values mean and Std. Deviation is used to see the level usefulness, ease of use, ease of learning and satisfaction using NDCLearnHub among students that enrolled Network and Data Communication in Politeknik Balik Pulau.

Table 7 is the result of a descriptive analysis of usefulness using NDCLearnHub among the students involved.

Table 7: Analysis of Mean Value for Usefulness Using NDCLearnHub

No. Item	Item	Mean	Std. Deviation	Inter-pretation
U1	It helps me be more productive	3.9529	.69803	Medium High
U2	It is useful	4.0052	.65291	High
U3	It saves me time when I use it	4.1361	.61755	High
U4	It meets my needs	4.2094	.63917	High
U5	It does everything I would expect it to do	4.2513	.64047	High
	Total	4.1110	.51241	High

Based on the mean score analysis for the use of NDCLearnHub, the item with the highest mean score was item U5 – "It does everything I would expect it to do," with a mean = 4.2513 (SD = 0.64047). This indicates that users feel the platform fully meets their expectations and reflects a high level of agreement according to the [11] scale.

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Conversely, the item with the lowest mean score was item U1 – "It helps me be more productive," with a mean = 3.9529 (SD = 0.69803). Although this value is slightly lower, the level of agreement is still in the moderately high category, suggesting that users perceive the platform as slightly less impactful on their productivity compared to other aspects.

Overall, the mean score obtained for the usefulness of NDCLearnHub was mean = 4.1110 (SD = 0.51241), indicating that NDCLearnHub is considered highly useful, with user agreement at a high level, thus confirming the platform's effectiveness in meeting users' needs and expectations.

Table 8 presents the results of a descriptive analysis of the ease of use of NDCLearnHub among students that enrolled Network and Data Communication course.

Table 8: Analysis of Mean Value for Ease of Use NDCLearnHub

No. Item	Item	Mean	Std. Deviation	Interpretation
EU1	It is easy to use	4.0262	.66834	High
EU2	It is simple to use	4.1990	.62593	High
EU3	It is user friendly	3.9686	.67204	Medium High
EU4	Using it is effortless	3.8168	.69049	Medium High
EU5	It is flexible	4.1990	.66665	High
EU6	I can use it without written instructions	4.1309	.68721	High
EU7	Both occasional and regular users would like it	4.2094	.62249	High
EU8	I can use it successfully every time	4.2775	.64193	High
	Total	4.1034	.45553	High

Next, referring to the mean score analysis for the Ease of Use aspect of NDCLearnHub, the item with the highest score was item EU8 – "I can use it successfully every time," with a mean = 4.2775 (SD = 0.64193), reflecting the highest level of agreement. This result indicates that users feel they can use the platform successfully on every occasion.

Conversely, the item with the lowest score was item EU4 – "Using it is effortless," with a mean = 3.8168 (SD = 0.69049), suggesting that although the platform is relatively easy to use, users still feel that some effort is required, placing the agreement level in the moderately high category.

Overall, the mean score for all items was mean = 4.1034 (SD = 0.45553), indicating that NDCLearnHub is generally considered easy to use, with user agreement at a high level. This confirms that the platform is user-friendly and suitable for a wide range of users.

Table 9 is the result of a descriptive analysis of ease of learning NDCLearnHub among students that enrolled Network and Data Communication course.

Table 9: Analysis of Mean Value for Ease of Learning NDCLearnHub

No. Item	Item	Mean	Std. Deviation	Interpretation
EL1	I learned to use it quickly	4.1885	.70043	High
EL2	I easily remember how to use it	4.2199	.65198	High
EL3	It is easy to learn to use it	4.2304	.70287	High
EL4	I quickly became skillful with it	4.4188	.60911	High
	Total	4.2644	.57364	High

Next, based on the mean score analysis for the Ease of Learning aspect of NDCLearnHub, the item with the highest score was item EL4 – "I quickly became skillful with it," with a mean = 4.4188 (SD = 0.70043), indicating that users can master the platform quickly and reflecting a high level of agreement.

The item with the lowest score was item EL1 – "I learned to use it quickly," with a mean = 4.1885 (SD = 0.70043). Although slightly lower, the finding for this item still reflects a high level of agreement, suggesting that users are able to learn how to use the platform easily.

Overall, the mean score for all items was mean = 4.2644, indicating that NDCLearnHub is generally considered easy to learn, with user agreement at a high level. This confirms the platform's effectiveness in enabling users to learn and master the system quickly.

Table 10 is the result of a descriptive analysis of Satisfaction using NDCLearnHub among students that enrolled Network and Data Communication course.

Table 10: Analysis of Mean Value for Satisfaction Using NDCLearnHub

No. Item	Item	Mean	Std. Deviation	Interpretation
S1	I am satisfied with it	4.0314	.71012	High
S2	It is fun to use	4.2461	.67056	High

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S3	It works the way I want to learn	4.2042	.65308	High
S4	It is visually appealing and well-designed	4.2199	.70623	High
S5	I feel I need to have it	4.1414	.69276	High
S6	It is pleasant to use	4.2984	.65690	High
S7	I would recommend it to a friend	4.3089	.65202	High
	Total	4.2072	.54834	High

Finally, the mean score analysis for the Satisfaction aspect of using NDCLearnHub shows that the item with the highest score was item S7 – "I would recommend it to a friend," with a mean = 4.3089 (SD = 0.65202). This indicates that users are highly satisfied with the platform and are willing to recommend it to others, reflecting a high level of agreement.

Conversely, the item with the lowest score was item S1 – "I am satisfied with it," with a mean = 4.0314 (SD = 0.71012). Although the mean score is slightly lower than other items, it still reflects a high level of agreement, suggesting that users are generally satisfied with their experience using NDCLearnHub.

Overall, the mean score for all items was mean = 4.2072 (SD = 0.54834), indicating that NDCLearnHub is evaluated overall as a platform that provides high user satisfaction. This confirms that the design, functionality, and user experience of the platform successfully meet user expectations.

These findings demonstrate that NDCLearnHub consistently meets user expectations across all major aspects of digital learning use, including usefulness, ease of use, ease of learning, and satisfaction. The high mean values for all aspects (all above 4.0000) indicate that the platform is effective as a digital learning tool and can serve as an engaging and efficient medium for student learning.

Table 11 shows the results of the descriptive analysis, highlighting the average mean scores of research items assessing users' satisfaction of the NDCLearnHub application in the Network and Data Communication course.

Table 11: Analysis of Average Score for Research Items

Item	**Mean**	**Std. Deviation**	**Interpretation**
Usefulness	4.1110	.51241	High
Ease of use	4.1034	.45553	High
Ease of learning	4.2644	.57364	High
Satisfaction	4.2072	.54834	High
Total	4.1715	.52243	High

The findings revealed an overall mean score of 4.1715 for all items, closely aligning with the mean score of 4.16 reported in prior research [15]. This correspondence indicates that students' perceptions of the usefulness of NDCLearnHub are consistent with earlier studies. Such alignment strengthens the reliability of the present results and suggests that the platform demonstrates a stable and dependable level of effectiveness in enhancing students' learning experience.

CONCLUSION

This study evaluated students' satisfaction in using NDCLearnHub for the Network and Data Communication course at Politeknik Balik Pulau. The findings indicate that the platform effectively supports students' learning experiences. All four evaluated constructs which were usefulness, ease of use, ease of learning and satisfaction recorded high mean scores above 4.00, demonstrating strong positive perceptions among users. The results show that students consider NDCLearnHub helpful in accessing learning materials, understanding networking concepts and engaging with course content more efficiently. In addition, the platform was perceived as user-friendly and easy to learn, allowing students to quickly adapt to the system. Overall, the high level of satisfaction suggests that integrating digital learning platforms such as NDCLearnHub can enhance teaching and learning processes and serve as an effective complementary tool in educational environments.

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The Implementation of Brain Breaks in ESL Classrooms: A Study among Diploma Students at Politeknik Ungku Omar

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Abstract

Maintaining students' attention during prolonged classroom sessions remains a challenge in higher education, particularly in English as a Second Language (ESL) contexts where learners engage in multiple cognitive tasks simultaneously. This study investigates the implementation of brain breaks in Technical English classrooms among diploma students at Politeknik Ungku Omar (PUO), Malaysia, and examines their effects on students' focus, engagement, and overall classroom experience. A quantitative research design was employed, involving 60 diploma students who completed a Likert-scale questionnaire at the end of the semester. The data were analysed using descriptive statistics, including mean, variance, and standard deviation, alongside reliability testing using Cronbach's Alpha. The findings reveal that students generally perceive brain breaks as beneficial, with high mean scores indicating improved concentration, reduced cognitive fatigue, and enhanced engagement during lessons. The study concludes that structured brain break activities serve as an effective pedagogical strategy for sustaining attention and promoting active learning in extended ESL classroom sessions.

Keywords: *brain breaks; ESL classroom; student engagement, attention; Technical English*

II. INTRODUCTION

One of the biggest challenges in higher education is keeping students interested during long class periods. Grammar structures, vocabulary, listening comprehension, and spoken interaction are just a few of the linguistic components that students in English as a Second Language (ESL) classes must simultaneously comprehend. Long-term educational periods may lead to mental exhaustion and reduced attention due to the ongoing cognitive effort required for certain learning processes.

Recent studies have highlighted the significance of techniques that promote attention management in educational settings. Teachers often struggle to keep students' attention during lengthy classes, especially in contemporary classrooms with multiple distractions [4]. According to their findings, students may be better able to control their attention and maintain cognitive engagement throughout learning tasks if instructional tactics include short pauses.

The use of brain breaks, also known as active breaks, is a teaching strategy that is receiving increasing attention in educational research. Brain breaks are brief exercises that break up academic work and give students a chance to refocus. These activities may include physical movement, brief discussions, or reflective tasks to refocus students' attention [10].

Activity breaks in the classroom may positively impact students' engagement and cognitive functioning, according to an empirical study. Students' on-task behaviour and attentiveness in classroom settings were much enhanced by the inclusion of brief active breaks throughout courses [8]. Similarly, students' executive functioning and cognitive performance improved due to physically demanding classes and activity breaks [7].

Most of the study has focused on primary and secondary school environments, despite growing interest in brain break techniques. The use of brain breaks in tertiary ESL classes, especially in technical and vocational education environments, has been the subject of a few studies.

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Technical English classes at Politeknik Ungku Omar (PUO) usually last three hours. Students participate in a variety of communicative activities throughout these classes, including report writing, group discussions, technical reading, and presentations. These tasks require sustained focus and, if done nonstop, may lead to cognitive exhaustion.

Thus, the purpose of this study is to investigate how brain breaks are used in PUO's Technical English classrooms and how they affect students' focus, involvement, and engagement throughout lengthy ESL classes.

III. LITERATURE REVIEW

A. Attention Regulation in Classroom Learning

A key component of learning is paying attention [6]. Students are more likely to successfully understand and remember material when they pay close attention during instruction. But it's still difficult to stay focused throughout lengthy classes.

Teachers regularly notice changes in pupils' focus during class. According to their research, prolonged teaching durations, external distractions, and cognitive tiredness may all contribute to attention deficits [4].

Short activity breaks may help control attention and enhance classroom participation, according to research on classroom interventions. Students showed improved on-task behaviour after brief activity breaks, according to experimental research on the effects of active breaks on classroom behaviour [8].

However, breaks are not the only way to regulate attention. Engagement levels are also influenced by student motivation, classroom interaction, and instructional design. To improve classroom learning, brain breaks should be used alongside other interactive teaching techniques.

B. Active Breaks and Cognitive Function

The connection between physical activity in the classroom and cognitive functioning has been studied recently. Movement-based activities may improve cognitive function and activate brain functions, according to studies.

Students who engaged in planned activity breaks showed gains in executive functioning and attention, investigation of the impact of physically demanding lessons and activity breaks on students' cognitive performance [7].

In a similar vein, it is observed that curriculum-based active breaks enhanced students' cognitive flexibility and executive functioning [3].

Despite these results, some studies warn that the effectiveness of activity breaks in the classroom may vary depending on how they are used. Lesson flow may be disrupted by break activities unrelated to the learning objectives. Therefore, educators should carefully design brain break activities to support instructional goals.

C. Brain Breaks and Classroom Engagement

Brain breaks may enhance student motivation and classroom engagement in addition to their cognitive advantages. Activity breaks can foster more dynamic learning settings and boost student engagement, according to studies.

Video-guided activity breaks enhanced student well-being and the classroom environment [10]. Other studies have found that active breaks improved students' participation in class activities and lessened mental tiredness [2].

However, if poorly planned break activities are used without a clear pedagogical goal, they may shorten teaching time. Implementing brain breaks effectively requires careful planning to ensure that break activities enhance rather than disrupt learning [5].

IV. RESEARCH METHODOLOGY

This study employed a survey method as a qualitative method to gather reliable data. A Likert scale questionnaire was used as a research instrument. A total of 60 respondents participated in this study, comprising Diploma-level semester-one students undertaking the compulsory Technical English 1 course. The module is designed to provide technical students with the language input and skills required for technical workplace communication, including presentation and writing skills relevant to

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their respective engineering disciplines. The implementation of Brain Breaks in a classroom occurred throughout the semester, during which the researcher introduced a variety of activities, including physical or movement breaks, rapid-fire questioning breaks, and simple recess breaks. At the end of the course, all students involved in this activity were asked to complete a Google Forms questionnaire to share their insights on implementing the brain break activity in their ESL classrooms.

The questionnaire comprised 10 items, adapted from previous research [1]. The questions were designed to gather input on students' attitudes toward implementing brain breaks in their study.

For data collection, a five- point Likert scale was used with the following interpretations:

5: Strongly agree

4: Agree

3: Not sure

2: Disagree

1: Strongly disagree

Furthermore, the Cronbach's Alpha coefficient was computed using the Statistical Package for the Social Sciences (SPSS) to assess the reliability of the research instrument. The interpretation of the Cronbach's Alpha reliability coefficient score is as in Table 1.

Table 1: Cronbach's Alpha Score Interpretation

Reliability Coefficient	Interpretation of Reliability
0.90 - 1.0	Very good and effective
0.70 - 0.89	Good and acceptable
0.60 - 0.70	Acceptable
< 0.60	Items need to be fixed
< 0.50	Items should be dropped

The data gathered were analysed using the Statistical Package for the Social Sciences (SPSS). The following table interprets the mean score.

Table 2: Mean Score Interpretation

Mean Scale	Level
1.00 - 1.50	Disagree
1.51 - 2.50	Slightly agree
2.51 - 3.50	Moderately agree
3.51 - 4.50	Agree
4.51 - 5.00	Strongly agree

Source: [9]

V. RESULT AND DISCUSSION

A. Reliability Test

The reliability of the brain breaks questionnaire was assessed using Cronbach's Alpha. The analysis produced a Cronbach's Alpha coefficient of 0.928, indicating excellent internal consistency among the 10 questionnaire items. This suggests that the instrument is highly reliable for measuring students' perceptions of brain break activities.

B. Students' Perception of brain breaks in the ESL Classroom

Table 3 presents the overall mean, variance and standard deviation scores of learners' perceptions of brain breaks in the ESL Classroom.

For each item in the brain breaks questionnaire, descriptive statistics were computed to examine central tendency and response dispersion. The mean, variance, and standard deviation of the 10 Likert-scale items collected from 60 respondents were included in the analysis.

The results show that respondents generally agreed or strongly agreed with the benefits of brain break activities during Technical English lessons, with mean values ranging from 4.25 to 4.55. With the highest mean score (M = 4.55, SD = 0.723) among the items, Item 2 ("*Getting a break in the middle of a class helps me to concentrate more on the lesson*") showed that students strongly agreed that mid-class breaks enhance concentration.

Item 4 *("Short breaks during the lesson make me feel better, happier, and more relaxed")* also displayed a high mean value (M = 4.517, SD = 0.813), indicating that brief breaks improve students' mental health by making them feel happier and more at ease throughout class.

Item 9 *("Getting a chance to get up from my seat and move around for 2-3 minutes during a long lesson/ lecture refreshes me")* showed the

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greatest variance (1.380) and standard deviation (SD = 1.175), indicating that responses were more widely dispersed. This implies that students' perspectives on the advantages of moving around during brief breaks were more diverse.

Overall, students typically view brain break exercises as helpful for sustaining focus, boosting motivation, and increasing engagement during Technical English sessions, as indicated by the comparatively high mean scores and moderate standard deviation across all items.

Table 3: Descriptive Statistics (Mean, Variance, Standard Deviation)

Item	Mean	Variance	Standard Deviation
1	4.250	0.936	0.968
2	4.550	0.523	0.723
3	4.367	0.745	0.863
4	4.517	0.661	0.813
5	4.433	0.690	0.831
6	4.433	0.656	0.810
7	4.250	0.787	0.887
8	4.367	0.745	0.863
9	4.250	1.380	1.175
10	4.400	0.719	08.48

VI. CONCLUSION

This study investigated the use of brain breaks in Politeknik Ungku Omar's Technical English classrooms and their possible contribution to maintaining student interest throughout lengthy classes. According to the results, students may be able to focus better, experience less mental fatigue, and engage more fully in class activities if brief breaks are incorporated into lengthy educational sessions.

These results are consistent with recent studies indicating that activity breaks in the classroom can enhance on-task behaviour and promote cognitive engagement [8] [7]. Such tactics may offer useful advantages for sustaining classroom engagement in language-learning environments, where sustained attention is necessary for complex cognitive processing.

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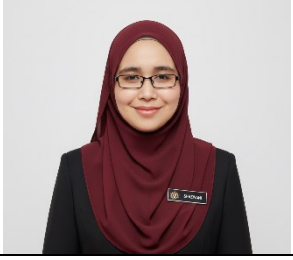
First Author: **NUR SHAZWANI SHUHAMI** 	General Studies Department, Politeknik Ungku Omar Jalan Raja Musa Mahadi, Politeknik Ungku Omar, 31400 Ipoh, Perak, Malaysia E-mail: nurshazwani@puo.edu.my
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Tahap Pengetahuan Konsep dan Peranan Keusahawanan Sosial serta Hubungannya dengan Minat Penglibatan Pelajar Kolej Komuniti Sandakan

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Abstract

Social entrepreneurship is increasingly being recognised as an innovative approach to addressing social issues through sustainable business-based solutions, but the level of student knowledge in this field has not been extensively studied, particularly in community colleges. Therefore, this study aims to assess students' knowledge regarding the concept and role of social entrepreneurship and analyse its relationship with students' interest in participation. This study employs a quantitative approach through a survey design involving 87 students from Sandakan Community College, using a five-point Likert scale questionnaire instrument. The data were analysed using descriptive statistics and Cronbach's alpha reliability test, as well as inferential analysis, namely Pearson correlation and multiple regression. The results of the study show that the level of students' knowledge of the concept (mean = 3.87) and the role of social entrepreneurship (mean = 3.92) is high, while the interest in involvement is at a moderately high level (mean = 3.75). Correlation analysis found a significant positive relationship between conceptual knowledge ($r = 0.56$, $p < 0.01$) and role knowledge ($r = 0.61$, $p < 0.01$) with student interest. Furthermore, regression analysis shows that both dimensions of knowledge significantly contribute to students' interest, with role knowledge being the more dominant predictor. In conclusion, the study findings demonstrate that knowledge of social entrepreneurship plays an important role in increasing students' interest in engaging in socially impactful activities, thereby supporting sustainable community development efforts in line with the global agenda.

Keywords: *social entrepreneurship; higher education; student knowledge; interest; community development*

Abstrak

Keusahawanan sosial semakin mendapat pengiktirafan sebagai pendekatan inovatif dalam menangani isu sosial melalui penyelesaian berasaskan perniagaan yang mampan, namun tahap pengetahuan pelajar dalam bidang ini masih kurang dikaji khususnya di kolej komuniti. Oleh itu, kajian ini bertujuan menilai tahap pengetahuan pelajar terhadap konsep dan peranan keusahawanan sosial serta menganalisis hubungannya dengan minat penglibatan pelajar. Kajian ini menggunakan pendekatan kuantitatif melalui reka bentuk tinjauan yang melibatkan 87 orang pelajar Kolej Komuniti Sandakan, dengan instrumen soal selidik berskala Likert lima mata. Data dianalisis menggunakan statistik deskriptif, ujian kebolehpercayaan Cronbach's Alpha, serta analisis inferensi iaitu korelasi Pearson dan regresi berganda. Hasil kajian menunjukkan bahawa tahap pengetahuan pelajar terhadap konsep (min = 3.87) dan peranan keusahawanan sosial (min = 3.92) adalah tinggi, manakala minat penglibatan berada pada tahap sederhana tinggi (min = 3.75). Analisis korelasi mendapati terdapat hubungan positif yang signifikan antara pengetahuan konsep ($r = 0.56$, $p < 0.01$) dan pengetahuan peranan ($r = 0.61$, $p < 0.01$) dengan minat pelajar. Selain itu, analisis regresi menunjukkan bahawa kedua-dua dimensi pengetahuan memberi sumbangan signifikan terhadap minat pelajar, dengan pengetahuan peranan sebagai peramal yang lebih dominan. Kesimpulannya, dapatan kajian membuktikan bahawa pengetahuan keusahawanan sosial memainkan peranan penting dalam meningkatkan minat pelajar untuk terlibat dalam aktiviti berimpak sosial, sekaligus menyokong usaha pembangunan masyarakat mampan selaras dengan agenda global.

Kata kunci **:** *keusahawanan sosial; pendidikan tinggi; pengetahuan pelajar; minat; pembangunan komuniti*

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I. PENGENALAN

Keusahawanan sosial kini semakin mendapat perhatian sebagai cara yang inovatif untuk menangani pelbagai isu sosial seperti kemiskinan, pengangguran belia, dan pembangunan komuniti. Berbeza dengan keusahawanan tradisional yang memberi penekanan kepada keuntungan semata-mata, keusahawanan sosial menumpukan kepada penciptaan nilai sosial melalui aktiviti perniagaan yang mampan. Dalam kerangka pembangunan ekonomi yang moden, keusahawanan sosial adalah sangat penting kerana ia mengaitkan tujuan sosial dan ekonomi untuk mencipta impak yang baik bagi masyarakat. Peranan institusi pendidikan tinggi dalam menanamkan kesedaran dan pengetahuan tentang keusahawanan sosial kepada pelajar adalah sangat penting. Pendidikan keusahawanan yang efektif bukan hanya meningkatkan kemahiran keusahawanan pelajar, tetapi juga berupaya memupuk pemikiran dan kesedaraan komuniti yang tinggi. Dengan pendedahan kepada konsep keusahawanan sosial, pelajar dapat melihat bagaimana aktiviti perniagaan boleh berfungsi sebagai alat untuk menyelesaikan masalah sosial dalam komuniti.

Walaupun keusahawanan sosial semakin mendapat perhatian dalam agenda pembangunan mampan global, tahap pengetahuan dan kefahaman pelajar institusi pendidikan tinggi terhadap konsep ini masih berada pada tahap yang sederhana, khususnya dalam konteks institusi TVET seperti Kolej Komuniti. Di Kolej Komuniti Sandakan, pendedahan terhadap keusahawanan lebih tertumpu kepada aspek keusahawanan konvensional yang berorientasikan keuntungan, manakala elemen keusahawanan sosial yang menekankan impak kepada komuniti masih kurang diberi penekanan secara sistematik.

Selain itu, pemerhatian awal menunjukkan bahawa penglibatan pelajar dalam aktiviti berasaskan komuniti dan keusahawanan sosial adalah terhad, walaupun peluang untuk melaksanakan projek komuniti sebenarnya wujud melalui kursus dan aktiviti kokurikulum. Kekurangan kefahaman terhadap konsep dan peranan keusahawanan sosial ini berpotensi menjadi faktor yang menyumbang kepada tahap minat penglibatan pelajar yang rendah dalam inisiatif berimpak sosial.

Sehubungan itu, terdapat keperluan untuk mengkaji secara empirikal tahap pengetahuan pelajar terhadap konsep dan peranan keusahawanan sosial serta hubungannya dengan minat penglibatan. Kajian ini penting bagi mengenal pasti jurang pengetahuan yang wujud serta menyokong usaha institusi dalam memperkukuhkan pendidikan keusahawanan sosial selaras dengan aspirasi pembangunan mampan dan agenda *Sustainable Development Goals (SDG)*.

II. KAJIAN LITERATUR

Aktiviti keusahawanan yang bertujuan menyelesaikan masalah sosial dengan pendekatan inovatif dan mampan adalah apa yang disebut sebagai keusahawanan sosial. Menurut [1], keusahawanan sosial melibatkan penggunaan prinsip keusahawanan untuk mencipta nilai sosial yang memberi manfaat kepada masyarakat.

Kajian terdahulu menunjukkan bahawa pendidikan keusahawanan adalah penting untuk meningkatkan kesedaran dan penglibatan pelajar dalam aktiviti keusahawanan sosial [2,3]. Dengan pendedahan kepada konsep keusahawanan sosial, pelajar dapat meningkatkan kemampuan mereka untuk mengenal pasti peluang dalam menyelesaikan masalah sosial di komuniti.

Dalam konteks teori tingkah laku, yang diperkenalkan oleh [4] kajian ini berasaskan *Theory of Planned Behaviour*. Menurut teori ini, sikap, norma subjektif, dan kawalan tingkah laku yang dirasakan mempengaruhi niat seseorang untuk melakukan suatu tingkah laku.

Di samping itu, kajian ini turut dipengaruhi oleh teori [5] yang menekankan peranan faktor kognitif dalam membentuk tingkah laku individu. Pengetahuan dan pengalaman pembelajaran dapat meningkatkan keyakinan individu untuk melibatkan diri dalam sesuatu aktiviti.

Faktor minat pelajar terhadap keusahawanan sosial adalah pengetahuan dan kesedaran sosial, seperti yang ditunjukkan oleh kajian [6]. Oleh itu, tahap pengetahuan pelajar mengenai konsep dan fungsi keusahawanan sosial dijangka mempengaruhi kecenderungan mereka untuk terlibat dalam aktiviti sosial yang memberi impak kepada komuniti.

III. PEMBANGUNAN HIPOTESIS

Pengetahuan Konsep Keusahawanan Sosial dan Minat Penglibatan Pelajar

Pengetahuan adalah komponen penting yang mempengaruhi perasaan dan keinginan seseorang untuk terlibat dalam suatu aktiviti. Menurut *Theory of Planned Behaviour* yang diajukan oleh [4], terdapat elemen kognitif yang mempengaruhi niat seseorang untuk bertindak, seperti sikap dan pandangan terhadap suatu perilaku. Dalam dunia keusahawanan sosial, tahap pengetahuan pelajar tentang konsep keusahawanan sosial itu sendiri adalah kunci untuk mereka menyedari betapa

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pentingnya aktiviti keusahawanan yang memberi impak kepada masyarakat.

Kajian terdahulu juga menunjukkan bahawa pengetahuan mengenai keusahawanan sosial mempunyai hubungan positif dengan minat individu untuk terlibat dalam aktiviti sosial berimpak tinggi [6]. Justeru itu, hipotesis dibawah dicadangkan:

H1: Terdapat hubungan yang signifikan antara pengetahuan konsep keusahawanan sosial dan minat penglibatan pelajar dalam aktiviti keusahawanan sosial.

Pengetahuan Peranan Keusahawanan Sosial dan Minat Penglibatan Pelajar

Mengetahui fungsi keusahawanan sosial dalam mengatasi masalah sosial adalah faktor penting dalam usaha meningkatkan kesedaran sosial di kalangan pelajar. Apabila pelajar menyedari sumbangan keusahawanan sosial kepada pembangunan komuniti, mereka akan lebih cenderung untuk menyertai aktiviti yang memberi manfaat kepada masyarakat.

[5] menjelaskan bahawa pembelajaran kognitif yang diperoleh melalui pendidikan dan pengalaman dapat memperkuat keyakinan individu untuk mengambil bahagian dalam aktiviti tertentu. Menurut [7], pendedahan kepada peranan keusahawanan sosial boleh membantu pelajar menyedari betapa pentingnya inovasi sosial untuk menyelesaikan masalah masyarakat.

Kajian oleh [6,8] turut mendapati bahawa kesedaran terhadap impak sosial dan pemahaman mengenai peranan perusahaan sosial mempunyai hubungan positif dengan minat individu untuk terlibat dalam keusahawanan sosial. Justeru itu, hipotesis berikut dicadangkan:

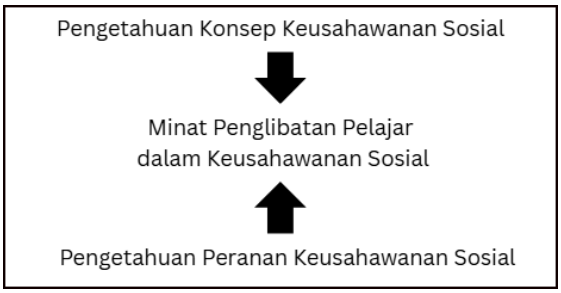
H2: Terdapat hubungan yang ketara antara pengetahuan peranan keusahawanan sosial dan minat penglibatan pelajar dalam aktiviti keusahawanan sosial.

IV. KERANGKA KONSEPTUAL KAJIAN

Bagi menjelaskan hubungan antara pengetahuan yang pelajar perolehi tentang keusahawanan sosial dan minat mereka untuk terlibat dalam aktiviti keusahawanan sosial, kerangka konseptual kajian ini telah dibangunkan berdasarkan teori oleh [4,5].

Kajian lepas juga menekankan bahawa pengetahuan dan kesedaran sosial adalah dua faktor penting yang mempengaruhi minat seseorang untuk terlibat dalam keusahawanan sosial [6]. Oleh itu, kerangka konseptual kajian ini mencadangkan bahawa pengetahuan pelajar terhadap konsep dan peranan keusahawanan sosial mempunyai hubungan yang ketara dengan minat penglibatan pelajar dalam aktiviti keusahawanan sosial.

Rajah 1 : Model Konseptual Kajian



V. METODOLOGI KAJIAN

Reka Bentuk Kajian dan Instrumen

Dengan menggunakan pendekatan kuantitatif dan reka bentuk tinjauan, kajian ini menilai tahap pengetahuan pelajar tentang konsep dan peranan keusahawanan sosial serta bagaimana pengetahuan itu berkaitan dengan minat mereka untuk terlibat dalam aktiviti keusahawanan sosial. Penelitian ini bermatlamat untuk mengukur hubungan antara pemboleh ubah empirikal melalui analisis statistik. Untuk mencapai matlamat ini, pendekatan kuantitatif sesuai digunakan [9].

Penggunaan soal selidik, yang terdiri daripada 30 item, dinilai mengikut skala Likert lima mata, di mana satu mata menunjukkan sangat tidak setuju, manakala lima mata menunjukkan sangat setuju. Kajian ini dikategorikan kepada tiga aspek utama, iaitu:

1. Pengetahuan konsep keusahawanan sosial
2. Pengetahuan peranan keusahawanan sosia
3. Minat penglibatan dalam keusahawanan sosial

Untuk mengukur persepsi dan sikap responden, skala Likert adalah sesuai dalam kajian sosial kerana ia membolehkan pengukuran tahap persetujuan responden terhadap sesuatu pernyataan secara sistematik [10].

Demografi dan Sampel

Pelajar Kolej Komuniti Sandakan dalam dua program pendidikan adalah demografi penyelidikan. Seramai 87 pelajar telah dipilih untuk menjadi sampel kajian ini menggunakan kaedah pensampelan rawak mudah. Pemilihan kaedah kerana ia memberikan setiap anggota populasi memiliki peluang yang sama untuk terpilih sebagai

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responden, sekali gus mengurangkan bias dalam pemilihan sampel [11].

Jumlah sampel ini dianggap mencukupi untuk kajian tinjauan dalam penyelidikan pendidikan dan sains sosial yang menggunakan analisis statistik inferensi [12].

Prosedur Pengumpulan Data

Platform *Google Forms* digunakan untuk mengedarkan soal selidik melalui internet untuk mengumpul data. Kaedah pengumpulan data secara dalam talian semakin digunakan secara meluas dalam penyelidikan sosial kerana ia memudahkan proses pengedaran soal selidik serta meningkatkan kadar respons responden [13, 14].

Responden telah diberi tahu tentang tujuan kajian dan dijamin bahwa semua informasi yang mereka berikan akan dirahsiakan dan hanya digunakan untuk tujuan akademik sebelum mereka menjawab soal selidik.

Analisis Data

Perisian *Statistical Package for the Social Sciences versi 30* telah digunakan untuk menganalisi data kajian bagi mendapatkan maklumat yang berkaitan dengan objektif kajian. Analisis kebolehpercayaan, statistik deskriptif, dan statistik inferensi telah digunakan dalam penyelidikan ini.

Pertama, analisis kebolehpercayaan *Cronbach's Alpha* dijalankan bagi menilai tahap konsistensi dalaman item dalam instrumen soal selidik yang digunakan. Ujian ini penting bagi memastikan setiap item dalam konstruk kajian mengukur konsep yang sama secara konsisten. Menurut [15], julat kebolehpercayaan dalam penyelidikan sains sosial boleh diterima jika *Cronbach's Alpha* melebihi 0.70. Selain itu, kajian oleh [16] turut menyatakan bahawa berdasarkan Jadual 1, tahap kebolehpercayaan instrumen yang baik ditunjukkan dengan nilai alpha antara 0.70 dan 0.90.

Seterusnya, analisis statistik deskriptif digunakan bagi menghuraikan tahap pengetahuan pelajar dan minat penglibatan dalam keusahawanan sosial melalui pengiraan nilai min dan sisihan piawai merujuk kepada Jadual 2. Analisis ini memberikan gambaran umum mengenai taburan data responden. Untuk analisis inferensi, analisis korelasi Pearson digunakan untuk untuk mengenal pasti kaitan antara pengetahuan tentang keusahawanan sosial dan minat pelajar untuk terlibat dalam aktiviti keusahawanan sosial.

Jadual 1. Nilai Pekali Kebolehpercayaan *Cronbach's Alpha* [17]

Julat	Tahap Kebolehpercayaan
> 0.90	Terbaik
0.80-0.89	Sangat Baik
0.70-0.79	Baik
0.60-0.69	Sederhana/Boleh diterima
< 0.60	Lemah/Tidak oleh diterima

Di samping itu, analisis regresi berganda juga dilaksanakan untuk menilai sumbangan relatif setiap dimensi pengetahuan terhadap minat pelajar. Dalam kajian sains sosial, analisis regresi berganda adalah kaedah statistik yang tepat untuk menentukan kekuatan hubungan pemboleh ubah bersandar dan bebas [16].

Jadual 2. Skor Min [18]

Nilai Min	Tahap
1.00 – 1.80	Sangat Rendah
1.81 – 2.60	Rendah
2.61 – 3.20	Sederhana
3.21 – 4.20	Tinggi
4.21 – 5.00	Sangat Tinggi

Penggunaan analisis kebolehpercayaan, statistik deskriptif dan inferensi dalam kajian dapat mengesahkan keputusan yang diperoleh adalah lebih tepat dan kukuh.

VI. HASIL KAJIAN

Latar Belakang Responden :

Latar belakang responden kajian ini terdiri daripada pelbagai ciri demografi, seperti yang ditunjukkan dalam Jadual 3. Data menunjukkan bahawa majoriti responden adalah pelajar lelaki (56.3%) dan perempuan (43.7%). Kebanyakan responden berumur antara 18 hingga 21 tahun (98.8%). Responden mewakili dua program pengajian iaitu Sijil Pengembaraan Pelancongan (50.5%) dan Sijil Teknologi Elektrik (49.4%). Perincian responden mengikut item kajian dapat dilihat dalam Jadual 3.

Ujian Kebolehpercayaan Instrumen

Ujian kebolehpercayaan bertujuan untuk menilai konsistensi item-item dalam instrumen kajian antara satu sama lain menggunakan nilai *Cronbach's Alpha* [15]. Berdasarkan Jadual 4 dapatan setiap konstruk yang mempunyai nilai *Cronbach's Alpha* melebihi 0.80 menunjukkan bahawa kaedah kajian ini sangat boleh dipercayai dan sesuai untuk analisis seterusnya.

Jadual 3. Profil responden

Item Kajian	n	%

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Jantina	Lelaki	49	56.3
	Perempuan	38	43.7
Umur	18 – 19 Tahun	51	58.6
	20 – 21 Tahun	35	40.2
	22 Tahun ke atas	1	1.1
Program Pengajian	Sijil Teknologi Elektrik	43	49.4
	Sijil Pengembaraan Pelancongan	44	50.6
Semester Pengajian	1	23	26.4
	2	34	39.1
	3	18	20.7
	4	12	13.8

Analisis Statistik Deskriptif

Analisis dijalankan untuk menentukan tahap pengetahuan pelajar terhadap konsep dan peranan keusahawanan sosial serta minat mereka untuk terlibat dalam aktiviti keusahawanan sosial. Setiap konstruk yang diukur memiliki tahap interpretasi yang ditentukan oleh nilai min.

Hasil dapatan di Jadual 5 menunjukkan bahawa tahap pengetahuan pelajar terhadap konsep keusahawanan sosial (min = 3.87) dan peranan keusahawanan sosial (min = 3.92) berada pada tahap tinggi. Manakala minat pelajar untuk terlibat dalam aktiviti keusahawanan sosial berada pada tahap sederhana tinggi (min = 3.75).

Jadual 4. Ujian Kebolehpercayaan Instrumen

Konstruk	Bilangan Item	Cronbach's Alpha	Petunjuk
Pengetahuan Konsep Keusahawanan Sosial	10	0.84	Baik
Pengetahuan Peranan Keusahawanan Sosial	10	0.86	Baik
Minat Penglibatan Keusahawanan Sosial	10	0.82	Baik
Keseluruhan Instrumen	30	**0.88**	Sangat Baik

Jadual 5. Tahap Pengetahuan dan Minat Pelajar

Konstruk	Skor Min	Sisihan Piawai	Petunjuk
Pengetahuan Konsep Keusahawanan Sosial	3.87	0.65	Tinggi
Pengetahuan Peranan Keusahawanan Sosial	3.92	0.70	Tinggi
Minat Penglibatan Keusahawanan Sosial	3.75	0.68	Sederhana Tinggi

Analisis Korelasi Pearson

Analisis dijalankan bagi menguji hubungan antara pengetahuan pelajar terhadap keusahawanan sosial dengan minat penglibatan pelajar dalam aktiviti keusahawanan sosial.

Jadual 6. Analisis Korelasi Pearson

Konstruk	r	p	Petunjuk
Pengetahuan Konsep - Minat	0.56	<0.01	Hubungan sederhana positif
Pengetahuan Peranan - Minat	0.61	<0.01	Hubungan sederhana positif

Hasil dapatan Jadual 6 menunjukkan bahawa terdapat hubungan positif yang signifikan antara pengetahuan konsep keusahawanan sosial dan minat pelajar ($r = 0.56$, $p < 0.01$). Selain itu, pengetahuan mengenai peranan keusahawanan sosial juga mempunyai hubungan positif yang signifikan dengan minat pelajar untuk terlibat dalam aktiviti keusahawanan sosial ($r = 0.61$, $p < 0.01$).

Analisis Regresi Berganda

Analisis dijalankan bagi mengenal pasti sumbangan relatif setiap dimensi pengetahuan terhadap minat pelajar untuk terlibat dalam aktiviti keusahawanan sosial.

Hasil analisis regresi membuktikan bahawa kedua-dua dimensi pengetahuan mempunyai pengaruh yang signifikan terhadap minat pelajar untuk terlibat dalam aktiviti keusahawanan sosial. Pengetahuan mengenai peranan keusahawanan sosial ($\beta = 0.41$) didapati mempunyai pengaruh yang lebih kuat berbanding pengetahuan konsep keusahawanan sosial ($\beta = 0.34$). Keputusan ini menunjukkan bahawa pemahaman pelajar terhadap bagaimana keusahawanan sosial dapat memberi impak kepada masyarakat memainkan peranan penting dalam meningkatkan minat mereka untuk terlibat dalam aktiviti keusahawanan sosial.

Jadual 7. Analisis Regresi Berganda

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Konstruk	Beta (β)	t	p
Pengetahuan Konsep	0.34	3.21	<0.01
Pengetahuan Peranan	0.41	3.76	<0.01

Rumusan Pengujian Hipotesis

Jadual 8. Keputusan Pengujian Hipotesis

Hipotesis	Penyataan	Keputusan
H1	Terdapat hubungan signifikan antara pengetahuan konsep keusahawanan sosial dan minat penglibatan pelajar	Disokong
H2	Terdapat hubungan signifikan antara pengetahuan peranan keusahawanan sosial dan minat penglibatan pelajar	Disokong

Secara keseluruhannya, kedua-dua hipotesis kajian disokong kerana terdapat hubungan yang ketara antara pengetahuan keusahawanan sosial dan minat pelajar untuk terbabit secara tidak lansung dalam aktiviti keusahawanan sosial.

VII. PERBINCANGAN DAN IMPLIKASI

Secara keseluruhannya, hasil analisis deskriptif menunjukkan bahawa tahap pengetahuan pelajar terhadap keusahawanan sosial berada pada tahap sederhana hingga tinggi. Min keseluruhan bagi pengetahuan konsep ialah M = 3.84, manakala min bagi pengetahuan peranan ialah M = 3.91. Ini menunjukkan bahawa majoriti pelajar mempunyai kefahaman asas tentang konsep keusahawanan sosial dan peranannya dalam pembangunan masyarakat.

Hasil penemuan ini selari dengan penyelidikan oleh [6], yang menunjukkan bahawa pendedahan awal kepada konsep keusahawanan sosial meningkatkan kesedaran pelajar tentang kepentingan menggunakan pendekatan keusahawanan untuk menangani isu sosial.

Di samping itu, hasil penelitian memaparkan pelajar mempunyai minat yang agak tinggi terhadap keusahawanan sosial, dengan nilai min M = 4.02 yang menunjukkan mereka cenderung untuk menyokong aktiviti yang memberi impak sosial.

Analisis korelasi Pearson menunjukkan terdapat hubungan positif yang signifikan antara pengetahuan konsep dan minat pelajar terhadap keusahawanan sosial ($r = 0.61$, $p < 0.01$). Hubungan positif yang sederhana kuat ini menunjukkan bahawa apabila pelajar mempunyai pemahaman yang lebih baik tentang keusahawanan sosial, mereka lebih cenderung untuk terlibat dalam aktiviti berkaitan. Dapatan ini menyokong prinsip dalam *Theory of Planned Behaviour* oleh [4] yang menyatakan bahawa sikap dan pengetahuan seseorang individu terhadap sesuatu tingkah laku akan mempengaruhi niat dan kecenderungan untuk bertindak.

Di samping itu, analisis regresi berganda menunjukkan bahawa kedua-dua dimensi pengetahuan konsep dan pengetahuan peranan mempunyai sumbangan yang signifikan terhadap minat pelajar. Model regresi yang dihasilkan membuktikan bahawa pemboleh ubah pengetahuan menerangkan sekitar 48% varians dalam minat pelajar ($R^2 = 0.48$). Ini menunjukkan bahawa pengetahuan adalah komponen penting yang mempengaruhi kecenderungan pelajar untuk mengambil bahagian dalam keusahawanan sosial.

Teori pembelajaran sosial dalam *Social Cognitive Theory* yang diperkenalkan oleh [5] juga sejajar dengan penemuan ini. Teori ini berpendapat bahwa pengetahuan dan pengalaman yang diperoleh melalui pembelajaran sangat penting dalam membentuk efikasi kendiri serta perilaku individu. Dalam konteks kajian ini, pendedahan kepada konsep keusahawanan sosial melalui pembelajaran formal mungkin dapat meningkatkan keyakinan pelajar untuk menyertai aktiviti yang berkaitan.

Seterusnya, hasil penelitian ini juga menyokong penyelidikan oleh [2] yang menunjukkan bahawa pendidikan keusahawanan mempunyai hubungan positif dengan niat keusahawanan pelajar. Pendidikan yang mengutamakan penyelesaian masalah sosial dan inovasi dapat mendidik generasi muda tentang pentingnya pembangunan mampan.

Secara keseluruhannya, bukti daripada kajian ini menunjukkan bahawa mengintegrasikan konsep dan peranan keusahawanan sosial di dalam pendidikan boleh meningkatkan minat pelajar untuk menyumbang kepada pembangunan masyarakat. Bukti ini bertepatan dengan kajian [19] yang menyatakan pendidikan dan pengetahuan mempengaruhi minit terhadap keusahawanan sosial. Ini juga sejajar dengan agenda global seperti yang ditetapkan oleh [20] melalui inisiatif *Sustainable Development Goals* yang menyokong penglibatan generasi muda dalam aktiviti ekonomi yang berimpak sosial dan mampan.

Kajian ini membawa beberapa implikasi penting untuk bidang pendidikan serta pembangunan keusahawanan sosial. Dalam pandangan akademik, hasil kajian membuktikan bahawa memasukkan konsep keusahawanan sosial dalam kurikulum pendidikan tinggi mampu meningkatkan

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pengetahuan dan minat pelajar terhadap bidang ini. Oleh itu, institusi pendidikan seperti kolej komuniti disarankan untuk menambah elemen keusahawanan sosial dengan lebih terancang dalam program pengajian mereka.

Dari segi pedagogi, pensyarah boleh mengintegrasikan aktiviti pembelajaran berasaskan projek seperti projek komuniti, simulasi perniagaan sosial atau kajian kes bagi meningkatkan pemahaman pelajar. Pendekatan pembelajaran yang bersifat pengalaman ini dapat membantu pelajar memahami bagaimana keusahawanan sosial dapat digunakan sebagai alat untuk menyelesaikan masalah masyarakat.

Selain itu, hasil kajian ini juga memberi implikasi kepada pembuat keputusan dalam pendidikan. Pendidikan keusahawanan sosial boleh diperkukuhkan oleh Kementerian Pendidikan Tinggi dan institusi latihan kemahiran sebagai sebahagian daripada usaha untuk menghasilkan graduan yang bukan sahaja berorientasikan keuntungan tetapi juga bertanggungjawab sosial.

Dari perspektif pembangunan mampan, keusahawanan sosial boleh menjadi ruang bagi generasi muda untuk menyumbang kepada komuniti dan ekonomi yang lebih inklusif. Oleh itu, pengukuhan pendidikan keusahawanan sosial dapat membantu menyokong agenda pembangunan global seperti *Sustainable Development Goals* yang menekankan kepentingan inovasi sosial dan pembangunan mampan.

VIII. LIMITASI KAJIAN

Walaupun penelitian ini memberikan maklumat penting, terdapat beberapa halangan yang perlu dipertimbangkan. Pertama, responden dalam kajian ini hanya berasal dari satu institusi pendidikan, iaitu Kolej Komuniti Sandakan. Sebagai akibatnya, Hasil kajian ini mungkin tidak boleh digunakan untuk semua pelajar di institusi pendidikan lain di Malaysia.

Kedua, pendekatan kuantitatif digunakan untuk kajian ini dengan melaksanakan soal selidik. Ada kemungkinan bahawa pendekatan ini tidak mampu menjelaskan secara mendalam elemen-elemen yang mempengaruhi minat pelajar dalam keusahawanan sosial. Untuk mendapatkan pemahaman yang lebih menyeluruh, kaedah kualitatif seperti temu bual atau perbincangan kumpulan fokus boleh digunakan.

Ketiga, kajian ini hanya menilai dua dimensi pengetahuan iaitu pengetahuan konsep dan pengetahuan peranan. Faktor lain seperti pengalaman keusahawanan, sokongan institusi atau efikasi kendiri pelajar juga berpotensi mempengaruhi minat pelajar tetapi tidak dianalisis dalam kajian ini.

Bagi kajian masa hadapan, penyelidikan boleh diperluaskan dengan melibatkan perbandingan antara Kolej Komuniti di zon geografi yang berbeza, contohnya antara Sabah dan Semenanjung Malaysia, bagi meningkatkan tahap generalisasi dapatan. Selain itu, pendekatan kajian campuran *(mixed-method)* juga disarankan bagi mendapatkan pemahaman yang lebih 206olistic terhadap faktor yang mempengaruhi keusahawanan sosial dalam kalangan pelajar.

IX. KESIMPULAN

Secara keseluruhannya, kajian ini mendapati bahawa tahap pengetahuan pelajar Kolej Komuniti Sandakan dalam aspek keusahawanan sosial berada di tahap antara sederhana dan tinggi. Pelajar juga menunjukkan minat yang tinggi untuk mengambil bahagian dalam aktiviti keusahawanan sosial.

Analisis inferensi menunjukkan hubungan positif yang tinggi antara pengetahuan dan minat pelajar terhadap keusahawanan sosial. Pengetahuan konsep dan pengetahuan peranan didapati memberikan sumbangan yang signifikan dalam meramalkan minat pelajar. Dapatan ini menunjukkan bahawa pendidikan dan pendedahan kepada konsep keusahawanan sosial mempunyai peranan yang penting dalam membentuk kecenderungan pelajar untuk terlibat dalam aktiviti yang memberi impak kepada masyarakat.

Kajian ini juga menyokong kerangka yang digunakan iaitu *Theory of Planned Behaviour* dan *Social Cognitive Theory* yang menekankan bahawa pengetahuan dan persepsi individu mempengaruhi niat serta tingkah laku mereka.

Secara keseluruhannya, pendidikan keusahawanan sosial berpotensi menjadi platform penting dalam melahirkan generasi muda yang bukan sahaja berorientasikan keusahawanan namum mempunyai kesedaran sosial yang tinggi. Dengan pengukuhan pendidikan dan sokongan institusi, pelajar berpotensi memainkan peranan penting dalam menyumbang kepada pembangunan masyarakat yang lebih mampan selaras dengan agenda global seperti *Sustainable Development Goals.*

X. RUJUKAN

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Pendekatan Gamifikasi Melalui Inovasi Antara Dua Marhalah bagi Kursus Pendidikan Islam: Satu Kajian Tinjauan di Kolej Komuniti Sandakan

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Abstract

The topic of Jamak and Qasar prayers often poses a challenge for students because it involves understanding the laws, conditions, and application in travel situations. This study introduces the innovation "Antara Dua Marhalah" as a gamification approach in teaching and learning (T&L) to enhance the understanding of Islamic Education students, particularly regarding Jamak and Qasar prayers. This quantitative study involved 73 students from Sandakan Community College through a five-point Likert scale questionnaire. Data were analysed using descriptive analysis, an independent t-test, Pearson correlation, and linear regression with SPSS. The findings indicate that the levels of gamification usage, motivation, engagement, understanding, and learning effectiveness are at a high level (mean > 4.60). The independent t-test, on the other hand, showed no significant difference in the level of understanding between students of the Tourism Adventure Certificate Program and the Electrical Technology Certificate Program (t = -0.360, p > 0.05), proving the effectiveness of this approach across fields of study. Correlation analysis shows a significant positive relationship between gamification and learning effectiveness (r = 0.69, p < 0.05), while regression analysis indicates that gamification contributes 48% to learning effectiveness. In conclusion, gamification is an effective approach in enhancing the quality of Islamic education teaching and learning and should be expanded in the field of TVET.

Keywords: *Gamification of Teaching and Learning, Jamak and Qasar prayers, Innovation in Islamic Education.*

Abstrak

Topik Solat Jamak dan Qasar sering menjadi cabaran kepada pelajar kerana melibatkan kefahaman hukum, syarat dan aplikasi dalam situasi musafir. Kajian ini memperkenalkan inovasi "Antara Dua Marhalah" sebagai pendekatan gamifikasi dalam pengajaran dan pembelajaran (PdP) bagi meningkatkan kefahaman pelajar Pendidikan Islam khususnya topik solat jamak dan qasar. Kajian berbentuk kuantitatif ini melibatkan 73 orang pelajar Kolej Komuniti Sandakan melalui soal selidik skala Likert lima mata. Data dianalisis menggunakan analisis deskriptif, ujian-t tidak bersandar, korelasi Pearson dan regresi linear menggunakan SPSS. Dapatan menunjukkan tahap penggunaan gamifikasi, motivasi, penglibatan, kefahaman dan keberkesanan pembelajaran berada pada tahap tinggi (min > 4.60). Ujian-t tidak bersandar pula menunjukkan tiada perbezaan signifikan dalam tahap kefahaman antara pelajar program Sijil Pengembaraan Pelancongan dan Sijil Teknologi Elektrik (t = -0.360, p > 0.05), ini membuktikan keberkesanan pendekatan ini merentas bidang pengajian. Analisis korelasi menunjukkan hubungan positif yang signifikan antara gamifikasi dan keberkesanan pembelajaran (r = 0.69, p < 0.05), manakala analisis regresi menunjukkan gamifikasi menyumbang sebanyak 48% terhadap keberkesanan pembelajaran. Kesimpulannya, gamifikasi merupakan pendekatan berkesan dalam meningkatkan kualiti PdP Pendidikan Islam dan wajar diperluaskan dalam bidang TVET.

Kata kunci **:** *Gamifikasi PdP, Solat Jamak dan Qasar, Inovasi Pendidikan Islam*

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I. PENGENALAN

Dalam era digitalisasi pendidikan, pendekatan pengajaran dan pembelajaran (PdP) perlu berubah daripada kaedah tradisional kepada bentuk yang lebih interaktif, menyeronokkan dan bermakna [1]. Bagi kursus Pendidikan Islam, topik solat jamak dan qasar sering menjadi cabaran kepada pelajar kerana melibatkan kefahaman hukum, syarat serta pelaksanaan dalam situasi sebenar seperti ketika bermusafir.

Berdasarkan pemerhatian penyelidik, pelajar sering keliru dalam menentukan perbezaan antara jamak dan qasar, niat, serta waktu solat yang dibenarkan ketika dalam perjalanan. Tambahan pula, kaedah pengajaran secara tradisional seperti ceramah dan nota bertulis kurang membantu dalam membentuk kefahaman mendalam [2]. Oleh itu, inovasi "Antara Dua Marhalah" dibangunkan sebagai bahan gamifikasi PdP yang membantu pelajar memahami konsep solat musafir melalui pengalaman simulasi sebenar dan pendekatan pembelajaran berasaskan permainan *(game-based learning)*. Gamifikasi yang dibangunkan ini menggabungkan elemen situasi sebenar, peta perjalanan, misi cabaran dan sistem markah, menjadikan pembelajaran lebih aktif dan menarik. Ia juga berfungsi sebagai alat bantu mengajar digital yang selaras dengan keperluan Pembelajaran Abad Ke-21 [3] serta menyokong objektif TVET dalam membangunkan kemahiran insaniah dan profesional pelajar.

Rajah 1: Paparan Antara Muka Inovasi "Antara Dua Marhalah"

Rajah 1 menunjukkan paparan antara muka inovasi gamifikasi "Antara Dua Marhalah" yang mengandungi elemen peta perjalanan, cabaran dan sistem ganjaran. Elemen peta perjalanan dan cabaran yang dibangunkan bagi mensimulasikan situasi musafir untuk meningkatkan kefahaman pelajar terhadap konsep solat jamak dan qasar. Manakala sistem ganjaran pula diwujudkan bagi menjadikan sesi permainan lebih menarik dan menyeronokkan.

Kajian ini dijalankan untuk mengukur tahap penggunaan, kefahaman, motivasi, dan keberkesanan inovasi ini dalam kalangan pelajar.

II. SOROTAN KAJIAN

Pendekatan gamifikasi semakin mendapat perhatian dalam bidang pendidikan kerana keupayaannya meningkatkan motivasi, penglibatan dan kefahaman pelajar melalui elemen permainan seperti cabaran, ganjaran dan simulasi situasi sebenar. Kajian oleh [4] menunjukkan bahawa penggunaan gamifikasi dalam PdP mampu meningkatkan keterlibatan pelajar serta membantu mereka memahami konsep abstrak dengan lebih berkesan. Kajian terdahulu juga menunjukkan bahawa pendekatan gamifikasi mampu meningkatkan keberkesanan pengajaran dan pembelajaran [5,6].

Dalam konteks Pendidikan Islam, inovasi pedagogi amat penting bagi memastikan penyampaian ilmu fiqh tidak terhad kepada hafalan semata-mata, tetapi mampu diaplikasikan dalam kehidupan sebenar [1]. Topik solat musafir, khususnya jamak dan qasar, sering menjadi cabaran kepada pelajar kerana melibatkan pemahaman hukum, syarat serta situasi praktikal yang memerlukan pertimbangan kontekstual. Pendekatan gamifikasi ini amat penting menekankan pengalaman pembelajaran aktif dan menyeronokkan berbanding kaedah tradisional yang bersifat sehala [7,8].

Kajian [9] dalam bidang TVET turut menegaskan bahawa pembelajaran berasaskan permainan dapat meningkatkan pemikiran kritikal dan keyakinan pelajar dalam membuat keputusan. Ini selari dengan aspirasi pendidikan abad ke-21 yang menekankan pembelajaran aktif, kolaboratif dan berpusatkan pelajar. Penggunaan elemen permainan juga menjadikan proses pembelajaran lebih menarik serta mengurangkan kebosanan dalam kelas [10]. Ini menunjukkan bahawa gamifikasi mampu merangsang motivasi intrinsik pelajar untuk terlibat secara aktif dalam pembelajaran.

Selain itu, [11] mendapati bahawa integrasi teknologi dalam Pendidikan Islam mampu meningkatkan minat pelajar serta menjadikan proses pembelajaran lebih relevan dengan realiti semasa. Oleh itu, penggunaan gamifikasi dalam pembelajaran solat musafir dilihat sebagai pendekatan yang sesuai untuk meningkatkan kefahaman pelajar secara praktikal. Kajian [12] menunjukkan pelajar menjadi lebih aktif, responsif dan fokus apabila elemen permainan digunakan dalam pembelajaran. Dalam kajian [13], pendekatan berasaskan permainan membantu pelajar menjadi lebih bermotivasi, serta meningkatkan penyertaan dan prestasi pelajar. Dengan ini pelajar akan dapat memahami konsep dengan lebih jelas serta dapat mengukuhkan penguasaan topik. Kajian oleh [14] turut menunjukkan bahawa pembelajaran berasaskan gamifikasi dapat meningkatkan pencapaian akademik pelajar.

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Secara keseluruhannya, sorotan kajian lepas menunjukkan bahawa pendekatan gamifikasi berpotensi besar dalam meningkatkan kefahaman pelajar serta menjadikan PdP lebih bermakna dan kontekstual melalui pembelajaran interaktif dan pengalaman pembelajaran yang bermakna.

Objektif bagi kajian ini adalah:

1. Mengukur tahap penggunaan gamifikasi dalam proses Pengajaran dan Pembelajaran (PdP).
2. Menilai kefahaman pembelajaran pelajar melalui penggunaan inovasi "Antara Dua Marhalah".
3. Mengenal pasti keberkesanan penggunaan pendekatan gamifikasi terhadap pelajar secara keseluruhan.
4. Mengenal pasti tahap penglibatan pelajar semasa sesi pembelajaran berlangsung menggunakan kaedah tersebut.

Berdasarkan objektif yang telah ditetapkan, kajian ini dijalankan untuk menjawab persoalan-persoalan kajian berikut:

1. Sejauh manakah tahap penggunaan elemen gamifikasi dalam proses Pengajaran dan Pembelajaran (PdP) bagi Kursus Pendidikan Islam di Kolej Komuniti Sandakan?
2. Adakah penggunaan inovasi "Antara Dua Marhalah" dapat meningkatkan kefahaman pelajar terhadap topik Solat Jamak dan Qasar?
3. Apakah tahap keberkesanan keseluruhan inovasi ini dalam meningkatkan motivasi dan kualiti pembelajaran pelajar berbanding kaedah tradisional?

Persoalan-persoalan ini dirangka khusus untuk menangani isu kesukaran pelajar menguasai hukum solat musafir dan masalah kurangnya minat terhadap kaedah pengajaran konvensional.

III. METODOLOGI

Kajian ini menggunakan reka bentuk kajian tinjauan *(survey research design)* yang berasaskan pendekatan kuantitatif. Tinjauan ini dijalan kepada pelajar Kolej Komuniti Sandakan yang mengambil Kursus Pendidikan Islam dan menggunakan inovasi Gamifikasi Antara Dua Marhalah yang telah dibangunkan. Seramai 73 orang responden telah mengambil bahagian menjawab soal selidik iaitu terdiri daripada 58.9% lelaki dan 41.1% perempuan. Kajian ini dijalankan kepada dua kumpulan pelajar yang mengambil Program Sijil Teknologi Elektrik dan Sijil Pengembaraan Pelancongan. Ujian-t tidak bersandar turut dibuat bagi melihat perbezaan tahap kefahaman pelajar terhadap penggunaan gamifikasi yang dibangunkan. Saiz sampel yang diambil memenuhi cadangan minimum untuk analisis korelasi pearson dan regrasi dalam kajian Pendidikan [15]. Menurut [16], teknik pemilihan responden sebegini relevan dengan objektif kajian. Data yang diperoleh dari soal selidik ini akan dianalisis dengan menggunakan perisian statistik SPSS versi 30. Analisis yang dijalankan adalah analisis deskriptif bagi menentukan tahap persepsi responden terhadap setiap item kajian.

Reka bentuk ini dipilih kerana ia membolehkan penyelidik mengumpul data yang bersifat deskriptif dan menganalisis tahap keberkesanan inovasi Antara Dua Marhalah terhadap item yang dikaji secara sistematik.

Kajian ini menggunakan kaedah persampelan bertujuan (*purposive sampling*). Pemilihan ini dibuat kerana hanya pelajar yang telah menggunakan inovasi gamifikasi sahaja relevan untuk menilai keberkesanannya. Instrumen kajian menggunakan borang soal selidik berskala likert 5 mata. Borang soal selidik ini mengandungi lima bahagian utama yang saling berkait bagi memastikan pembangunan dan keberkesanan inovasi dapat dinilai secara menyeluruh, iaitu Bahagian B (Penggunaan Gamifikasi Antara Dua Marhalah dalam Kursus Pendidikan Islam), Bahagian C (Motivasi Pelajar semasa Penggunaan Gamifikasi Antara Dua Marhalah di dalam Kelas), Bahagian D (Penglibatan Pelajar di dalam Kelas ketika Menggunakan Antara Dua Marhalah Gamifikasi), Bahagian E (Kefahaman Pembelajaran dengan Bantuan Gamifikasi Antara Dua Marhalah) dan Bahagian F (Keberkesanan Gamifikasi Antara Dua Marhalah).

Proses pengumpulan data dilaksanakan selepas mendapat kebenaran rasmi daripada pihak pentadbiran kolej bagi memastikan pematuhan terhadap etika penyelidikan. Soal selidik telah diedarkan secara dalam talian menggunakan *Google Form*s bagi memudahkan capaian dan meminimumkan kesilapan input data [17]. Semua responden dimaklumkan bahawa penglibatan mereka adalah secara sukarela dan data yang dikumpul akan dirahsiakan.

Secara keseluruhannya, berdasarkan kajian tinjauan yang dilaksanakan dan metodologi yang digunakan, penyelidik dapat menilai keberkesanan inovasi *Antara Dua Marhalah* sebagai medium pembelajaran yang interaktif. Pelaksanaan kajian ini bukan sahaja membantu mengenal pasti tahap motivasi dan kefahaman pelajar secara kuantitatif,

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malah menyediakan asas kukuh dalam membangunkan model pengajaran Pendidikan Islam yang lebih berkesan, kontekstual dan selaras dengan keperluan abad ke-21.

Jadual 1. Profil Responden

Pemboleh Ubah	Kategori	Frekuensi (f)	Peratus (%)
Jantina	Lelaki	43	58.9
	Perempuan	30	41.1
Program	Sijil Pengembaraan Pelancongan	33	45.2
	Sijil Teknologi Elektrik	40	54.8
Semester	1	5	6.8
	2	29	39.7
	3	19	26.0
	4	20	27.4

IV. HASIL KAJIAN

Latar Belakang Responden

Kajian ini dijalankan untuk meninjau keberkesanan pendekatan gamifikasi Antara Dua Marhalah dalam pembelajaran Pendidikan Islam di Kolej Komuniti Sandakan. Seramai 73 orang pelajar telah terlibat sebagai responden melalui soal selidik skala Likert lima mata. Daripada 73 responden, 58.9 % adalah lelaki 41.1% adalah perempuan. Kesemua responden adalah pelajar yang belajar di Kolej Komuniti Sandakan dan pernah mengambil Kursus Pendidikan Islam serta menggunakan gamifikasi Antara Dua Marhalah. Responden terdiri daripada 2 Program iaitu Sijil Pengembaraan Pelancongan dan Sijil Teknologi Elektrik.

Analisis data dijalankan menggunakan nilai min bagi menilai tahap penggunaan gamifikasi, motivasi pelajar, penglibatan pelajar, kefahaman pembelajaran serta keberkesanan gamifikasi Antara dua Marhalah. Penentuan Skor Minimum adalah berdasarkan kategori nilai seperti Jadual 2.

Jadual 2. Penentuan Skor Minimum berdasarkan Kategori Nilai [18]

Skor Min	Kategori Nilai
1.00-1.99	Lemah
2.00-2.99	Rendah
3.00-3.99	Sederhana
4.00-5.00	Tinggi

Analisis Dapatan Kajian

Dapatan kajian menunjukkan bahawa kefahaman pelajar terhadap pembelajaran khususnya berkaitan Solat Jamak dan Qasar berada pada tahap sangat tinggi dengan skor min 4.66.

Berdasarkan Jadual 3 menunjukkan responden bersetuju gamifikasi telah diintegrasikan secara aktif di dalam PdP. Skor tertinggi bagi bahagian ini ialah PG2 iaitu sebanyak 4.70 dan skor terendah adalah PG3 yang mencatatkan skor (min = 4.58). Ini menunjukkan bahawa pendekatan gamifikasi telah berjaya mewujudkan suasana pembelajaran yang lebih dinamik. Secara keseluruhannya, dapatan ini membuktikan bahawa pensyarah telah mula mengintegrasikan elemen gamifikasi dalam PdP Pendidikan Islam, walaupun tahap penggunaannya masih boleh dipertingkatkan.

Rajah 2: Paparan Antara Muka Aktiviti, Papan Markah dan Simulasi Situasi Inovasi "Antara Dua Marhalah"

Rajah 2 menunjukkan paparan antara muka dalam inovasi gamifikasi "Antara Dua Marhalah" yang mengandungi elemen kuiz interaktif, papan markah dan cabaran berasaskan situasi. Ketiga-tiga elemen ini memainkan peranan penting dalam meningkatkan penglibatan, motivasi dan kefahaman pelajar melalui pendekatan pembelajaran berasaskan pengalaman dan gamifikasi.

Jadual 3. Analisis Penggunaan Gamifikasi Antara dua Marhalah dalam Kursus Pendidikan Islam

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Kod Item	Item	Min (x^-)	Sisihan Piawai (sd)	Kategori Nilai
PG1	Pensyarah menggunakan elemen permainan dalam PdP.	4.68	0.54	Tinggi
PG2	Aktiviti kuiz interaktif digunakan semasa pembelajaran.	4.70	0.52	Tinggi
PG3	Sistem ganjaran (markah/pujian) digunakan dalam kelas.	4.58	0.60	Tinggi
PG4	Aktiviti berbentuk cabaran digunakan semasa PdP.	4.63	0.54	Tinggi
PG5	Penggunaan permainan menjadikan suasana kelas aktif.	4.66	0.53	Tinggi

Berdasarkan Jadual 4 Item MP2 mencatatkan skor min tertinggi iaitu 4.70. Ini menunjukkan bahawa elemen permainan berjaya meningkatkan pengalaman pembelajaran kepada pelajar. Selain itu, item MP3 mencatatkan skor min 4.66 dan item MP1skor min 4.66. Item ini juga berada pada tahap yang sangat tinggi. Ini membuktikan gamifikasi memberi impak yang positif dan berjaya meningkatkan keinginana pelajar untuk lebih aktif. Item berkaitan penglibatan pelajar terhadap pembelajaran turut mencatatkan skor tinggi (min = 4.54). Ini menunjukkan bahawa gamifikasi bukan sahaja meningkatkan keseronokan tetapi juga minat terhadap subjek Pendidikan Islam. Skor tertinggi adalah berkaitan pelajar lebih fokus semasa aktiviti pembelajaran berlangsung (Min: 4.58).

Jadual 4. Analisis Tahap Motivasi Pelajar semasa Penggunaan Gamifikasi Antara Dua Marhalah di dalam Kelas

Kod Item	Item	Min (x^-)	Sisihan Piawai (sd)	Kategori Nilai
MP1	Gamifikasi meningkatkan minat saya terhadap PdP.	4.66	0.53	Tinggi
MP2	Saya lebih bermotivasi untuk mempelajari topik ini.	4.70	0.52	Tinggi
MP3	Gamifikasi menjadikan pembelajaran menyeronokkan.	4.68	0.52	Tinggi
MP4	Saya terdorong menyertai setiap aktiviti yang dijalankan.	4.54	0.54	Tinggi
MP5	Gamifikasi meningkatkan keinginan saya untuk berjaya.	4.57	0.54	Tinggi

Selain itu tahap penglibatan pelajar terhadap gamifikasi Antara Dua Marhalah didapati berada pada tahap yang sangat tinggi berdasarkan Jadual 5. Berdasarkan rajah di bawah, item "saya lebih berani memberi respon dalam kelas" mencatatkan skor sedikit lebih rendah berbanding item lain (min = 4.60), namun ia masih berada pada tahap positif. Ini menunjukkan gamifikasi dapat meningkatkan penyertaan aktif pelajar dalam PdP walaupun PdP berkaitan teori serta berjaya mengubah peranan pelajar daripada pasif kepada lebih aktif dalam proses pembelajaran. Ini menunjukkan gamifikasi yang dibangunkan dan digunakan di dalam kelas menyumbang kepada pembelajaran secara interaktif.

Jadual 5. Analisis Tahap penglibatan Pelajar

Kod Item	Item	Min (x^-)	Sisihan Piawai (sd)	Kategori Nilai
PP1	Saya lebih aktif semasa kelas apabila gamifikasi digunakan.	4.64	0.54	Tinggi
PP2	Saya lebih fokus semasa aktiviti PdP berlangsung.	4.70	0.53	Tinggi
PP3	Saya lebih berani memberi respon dalam kelas.	4.60	0.55	Tinggi
PP4	Saya lebih kerap berinteraksi dengan rakan.	4.63	0.51	Tinggi
PP5	Gamifikasi meningkatkan penglibatan saya dalam PdP.	4.62	0.54	Tinggi

Jadual 6. Analisis Tahap Kefahaman Pembelajaran

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Kod Item	Item	Min (x^-)	Sisihan Piawai (sd)	Kategori Nilai
KP1	Gamifikasi membantu saya memahami topik dengan mudah.	4.70	0.53	Tinggi
KP2	Saya lebih mudah mengingati isi pelajaran.	4.70	0.53	Tinggi
KP3	Gamifikasi membantu saya menguasai konsep solat musafir.	4.64	0.54	Tinggi
KP4	Pembelajaran melalui simulasi menjadikan topik lebih jelas.	4.66	0.53	Tinggi
KP5	Saya lebih faham perbezaan jamak dan qasar.	4.70	0.53	Tinggi

Berdasarkan Jadual 6 skor tertinggi adalah berkaitan "gamifikasi membantu pelajar memahami topik solat musafir dengan lebih mudah" (Min: 4.64). Hasil dapatan mendapati pembelajaran berasaskan pengalaman melalui aktiviti permainan membantu pemprosesan maklumat dengan lebih berkesan. Dapatan ini menunjukkan gamifikasi membantu pemahaman konsep Pendidikan Islam. Responden juga menunjukkan persepsi positif terhadap keberkesanan gamifikasi dalam pembelajaran. Rajah di bawah pula menunjukkan persepsi pelajar terhadap keberkesanan gamifikasi berada pada tahap sangat tinggi.

Jadual 7. Menunjukkan item "Saya berasa pembelajaran ini lebih bermakna" dan item "Saya ingin lebih banyak aktiviti gamifikasi digunakan" masing-masing mencatatkan skor min yang sama iaitu skor min tertinggi 4.70. Dapatan ini menunjukkan penerimaan yang sangat positif terhadap pendekatan gamifikasi Antara Dua Marhalah dalam pembelajaran khususnya topik Solat Jamak dan Qasar. Selain itu, pelajar juga bersetuju bahawa gamifikasi sesuai digunakan dalam Pendidikan Islam (min = 4.64). Dapatan ini mencerminkan kesediaan pelajar untuk menerima pendekatan pembelajaran inovatif dalam subjek agama dan wajar diteruskan pada masa akan datang.

Jadual 7. Analisis Keberkesanan Keseluruhan Inovasi

Kod Item	Item	Min (x^-)	Sisihan Piawai (sd)	Nilai Kategori
KB1	Gamifikasi membantu meningkatkan pencapaian saya.	4.64	0.59	Tinggi
KB2	Gamifikasi sesuai digunakan dalam Pendidikan Islam.	4.64	0.54	Tinggi
KB3	Saya berasa pembelajaran lebih bermakna.	4.70	0.55	Tinggi
KB4	Saya ingin lebih banyak aktiviti gamifikasi digunakan.	4.70	0.50	Tinggi
KB5	Gamifikasi wajar diteruskan dalam PdP masa depan.	4.64	0.56	Tinggi

Dapatan daripada kajian ini selari dengan hasil kajian terdahulu oleh [4] serta [9] yang mendapati bahawa pendekatan gamifikasi dapat meningkatkan motivasi, pemikiran kritikal, serta penglibatan pelajar dalam proses pembelajaran. Selain itu, pendekatan ini juga membantu pelajar mengaplikasikan ilmu dalam situasi sebenar dan mengurangkan kebergantungan kepada kaedah tradisional seperti hafalan atau ceramah semata-mata.

Berdasarkan hasil analisis Jadual 8 keseluruhan kajian mendapati skor min tertinggi adalah berkaitan item "Gamifikasi sesuai digunakan dalam Pendidikan Islam", "Saya ingin lebih banyak aktiviti gamifikasi digunakan" dan "Gamifikasi wajar diteruskan dalam PdP masa depan" dengan skor min 4.66.

Jadual 8: Analisis Keberkesanan Keseluruhan Inovasi

Item	N	Min (x)	Sisihan Piawai (sd)
Tahap Penggunaan Gamifikasi Antara Dua Marhalah dalam Kursus Pendidikan Islam	73	4.65	0.50
Tahap Motivasi Pelajar semasa Penggunaan Gamifikasi Antara Dua Marhalah	73	4.66	0.50
Tahap Penglibatan Pelajar di dalam Kelas ketika Menggunakan Gamifikasi Antara Dua Marhalah	73	4.62	0.49
Tahap Kefahaman Pembelajaran dengan Bantuan Gamifikasi Antara Dua Marhalah	73	4.66	0.50
Tahap Keberkesanan Gamifikasi Antara Dua Marhalah	73	4.66	0.52

Penyelidik turut membuat analisis perbandingan antara Program Sijil Pengembaraan Pelancongan dan Sijil Teknologi Elektrik melalui ujian-t (Independent Sample T-test) seperti yang

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ditunjukkan di Jadual 9 dan 10 bagi menentukan sama ada terdapat perbezaan yang signifikan dalam tahap kefahaman pelajar terhadap penggunaan gamifikasi dalam pembelajaran.

Jadual 9: Statistik Deskriptip mengikut Program

Program	N	Min	Sisihan Piawai
Sijil Pengembaraan Pelancongan	55	4.63	0.31
Sijil Teknologi Elektrik	50	4.67	0.29

Jadual 10: Keputusan Ujian-t Tidak Bersandar

Ujian	Nilai
Nilai T	-0.360
Darjah Kebebasan (df)	103
Nilai Signifikan (p)	0.720

Hasil analisis menunjukkan bahawa tiada perbezaan yang signifikan antara kedua-dua kumpulan tersebut, dengan nilai $t = -0.360$ dan $p = 0.720$ ($p > 0.05$). Ini bermakna hipotesis nol gagal ditolak, iaitu tidak terdapat perbezaan yang signifikan dalam tahap kefahaman antara pelajar daripada kedua-dua program. Berdasarkan jadual 9 nilai min menunjukkan bahawa pelajar dari Program Sijil Teknologi Elektrik (M = 4.67) mempunyai tahap kefahaman yang sedikit lebih tinggi berbanding pelajar Sijil Pengembaraan Pelancongan (M = 4.63). Namun, perbezaan ini adalah kecil dan tidak signifikan secara statistik.

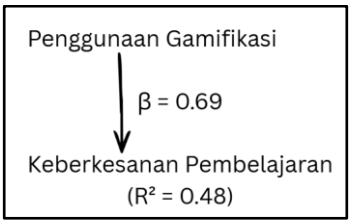
Berdasarkan Jadual 11, analisis korelasi Pearson menunjukkan bahawa terdapat hubungan positif yang signifikan antara penggunaan gamifikasi dengan motivasi pelajar (r = 0.72), dan keberkesanan pembelajaran (r = 0.69). Dapatan ini menunjukkan bahawa semakin tinggi penggunaan gamifikasi dalam pengajaran, semakin tinggi tahap motivasi dan keberkesanan pembelajaran pelajar.

Jadual 11: Analisis Korelasi Pearson antara Pembolehubah Kajian

Pembolehubah	1	2	3
1-Penggunaan Gamifikasi	1	0.72	0.69
2-Motivasi Pelajar	0.72	1	0.93
3-Keberkesanan Pembelajaran	0.69	0.93	1

Rajah 3 menunjukkan bahawa penggunaan gamifikasi memberikan sumbangan yang signifikan terhadap keberkesanan pembelajaran pelajar. Nilai pekali penentuan ($R^2 = 0.48$) menunjukkan bahawa penggunaan gamifikasi menyumbang sebanyak 48% terhadap variasi dalam keberkesanan pembelajaran. Selain itu, nilai pekali regresi menunjukkan bahawa penggunaan gamifikasi mempunyai pengaruh positif yang signifikan terhadap keberkesanan pembelajaran ($\beta = 0.69$, $p < 0.05$) berdasarkan Jadual 12.

Rajah 3: Model Pengaruh Gamifikasi terhadap Pembelajaran.



Jadual 12. Jadual Koefisien Regresi

Pembolehubah	B	Beta	Sig
Konstan	1.28	-	.000
Penggunaan Gamifikasi	0.73	0.69	.000

Secara keseluruhannya, dapatan analisis korelasi Pearson ini menunjukkan bahawa penggunaan gamifikasi mempunyai hubungan yang kuat dan positif dengan motivasi, penglibatan, kefahaman serta keberkesanan pembelajaran pelajar.

V. PERBINCANGAN DAN IMPLIKASI KAJIAN

Dapatan kajian menunjukkan bahawa tahap penggunaan gamifikasi dalam pengajaran Pendidikan Islam berada pada tahap yang tinggi. Hal ini menunjukkan bahawa inovasi yang diperkenalkan berjaya mewujudkan suasana pembelajaran yang lebih menarik, interaktif dan menyeronokkan kepada pelajar. Penggunaan elemen permainan seperti kuiz interaktif, cabaran pembelajaran serta sistem ganjaran mampu meningkatkan minat pelajar terhadap proses pembelajaran.

Dapatan ini selari dengan pandangan [7] yang menyatakan bahawa gamifikasi mampu meningkatkan pengalaman pembelajaran melalui penggunaan elemen permainan seperti markah, cabaran dan ganjaran dalam proses pembelajaran. Pendekatan ini membantu menjadikan pembelajaran lebih aktif dan bermakna kepada pelajar.

Selain itu, dapatan kajian menunjukkan bahawa tahap motivasi pelajar juga berada pada tahap yang tinggi. Hal ini menunjukkan bahawa penggunaan gamifikasi berjaya meningkatkan minat pelajar terhadap pembelajaran Pendidikan Islam. Elemen permainan yang digunakan dalam gamifikasi mampu merangsang motivasi intrinsik pelajar untuk terlibat secara aktif dalam aktiviti pembelajaran. Dapatan ini selari dengan kajian oleh [19,20]

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terhadap pelajar Institusi Pengajian Tinggi (IPT) yang mendapati bahawa penggunaan elemen gamifikasi dalam pembelajaran mampu meningkatkan motivasi serta penglibatan pelajar dalam proses pembelajaran. Elemen seperti cabaran, ganjaran dan maklum balas segera mampu meningkatkan motivasi pelajar serta menjadikan pembelajaran lebih menarik dan interaktif.

Dapatan kajian juga menunjukkan bahawa tahap penglibatan pelajar berada pada tahap yang tinggi. Hal ini menunjukkan bahawa gamifikasi berjaya meningkatkan penglibatan aktif pelajar dalam sesi pengajaran dan pembelajaran. Pelajar didapati lebih fokus, lebih aktif menyertai aktiviti kelas serta lebih berani memberikan respon semasa pembelajaran berlangsung. Dapatan ini selari dengan kajian oleh [5] yang menyatakan bahawa gamifikasi mampu meningkatkan tahap penglibatan pelajar melalui penggunaan elemen permainan dalam konteks pembelajaran. Elemen permainan seperti sistem ganjaran dan cabaran mampu menjadikan pembelajaran lebih interaktif dan menyeronokkan kepada pelajar.

Selain itu, dapatan kajian juga menunjukkan bahawa gamifikasi membantu meningkatkan kefahaman pelajar terhadap kandungan pembelajaran. Aktiviti pembelajaran berbentuk permainan membolehkan pelajar memproses maklumat secara lebih aktif dan bermakna. Kajian literatur menunjukkan bahawa gamifikasi mampu meningkatkan pencapaian akademik, penglibatan serta pengekalan pengetahuan dalam kalangan pelajar.

Berdasarkan ujian-t tidak bersandar yang telah dijalankan, pendekatan gamifikasi yang digunakan adalah berkesan secara konsisten merentasi program yang berbeza, tanpa dipengaruhi oleh latar belakang bidang pengajian pelajar. Ini memberi implikasi bahawa inovasi "Antara Dua Marhalah" mempunyai potensi untuk diaplikasikan secara meluas dalam pelbagai program pengajian di peringkat kolej.

Analisis korelasi Pearson pula menunjukkan bahawa terdapat hubungan yang kuat dan signifikan antara penggunaan gamifikasi dengan keberkesanan pembelajaran pelajar. Hal ini menunjukkan bahawa semakin tinggi penggunaan gamifikasi dalam pengajaran, semakin tinggi tahap keberkesanan pembelajaran pelajar.

Selain itu, analisis regresi linear menunjukkan bahawa penggunaan gamifikasi menyumbang sebanyak 48% terhadap keberkesanan pembelajaran pelajar. Dapatan ini menunjukkan bahawa pendekatan gamifikasi memainkan peranan penting dalam meningkatkan kualiti pengajaran dan pembelajaran Pendidikan Islam.

Secara keseluruhannya, dapatan kajian ini membuktikan bahawa pendekatan gamifikasi merupakan satu inovasi pedagogi yang berkesan dalam meningkatkan motivasi, penglibatan dan kefahaman pelajar dalam pembelajaran. Berdasarkan hasil dapatan tersebut, beberapa implikasi penting dapat dikenal pasti:

Implikasi terhadap Pelajar

- **Peningkatan Kendiri:** pelajar juga lebih berani memberi reaksi dan berinteraksi dalam kelas. Ini mengurangkan kekeliruan mereka mengenai aspek teknikal niat dan waktu solat musafir.
- **Motivasi Intrinsik:** Persaingan sihat yang dipupuk melalui sistem ganjaran dan cabaran dapat meningkatkan keinginan pelajar untuk belajar tanpa merasa terbeban.

Implikasi terhadap Pensyarah dan Pedagogi

- **Transformasi Peranan:** Pensyarah beralih daripada penyampai maklumat sehala kepada pemudah cara (fasilitator) yang lebih kreatif.
- **Kepelbagaian Strategi PdP:** Topik-topik yang bersifat teknikal dan hukum syarak boleh disampaikan dengan lebih dinamik melalui gamifikasi, membolehkan kita meninggalkan kaedah tradisional yang kurang menarik.

Implikasi terhadap Institusi (Kolej Komuniti/TVET)

- **Pemerkasaan Pendidikan Digital:** Pemerkasaan Pendidikan Digital: Di peringkat Kolej Komuniti dan juga di institusi TVET secara keseluruhannya, penggunaan inovasi ini membantu dalam transformasi pendidikan digital.
- **Peningkatan Kualiti Akademik:** Dengan min kefahaman yang tinggi (min}=4.66), institusi harus memastikan bahawa graduan bukan sahaja mahir dalam bidang teknikal (seperti Elektrik atau Pelancongan), tetapi juga mantap dalam pemahaman fardu ain.

Implikasi Sosio-Ekonomi dan Komersial

- **Modul Rujukan Industri:** Inovasi ini berpotensi besar untuk dijadikan sebagai modul digital interaktif yang boleh dimanfaatkan oleh agensi pengurusan umrah/haji dan pusat pelancongan patuh syariah.

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- **Pematuhan Syariah dalam Pelancongan:** Dengan 45.2% responden berasal dari program Pelancongan, penguasaan topik ini secara tidak langsung membantu dalam menyediakan tenaga kerja yang mahir mengendalikan pelancong Muslim yang bermusafir.

Bahan bantu mengajar ini adalah inovasi yang juga berfungsi sebagai alat penilaian alternatif; pensyarah boleh menggunakannya semula untuk topik fiqh lain seperti tayammum, solat ketika sakit, dan ibadah haji. Ia juga memiliki potensi komersial untuk dikembangkan kepada institusi pendidikan dan aplikasi PdP Islamik digital.

VI. KESIMPULAN

Secara keseluruhan, inovasi "Antara Dua Marhalah" telah menunjukkan bahawa pendekatan gamifikasi adalah berkesan dalam meningkatkan kefahaman, minat dan keyakinan pelajar mengenai topik solat musafir. Dengan menggabungkan elemen permainan, simulasi situasi sebenar, dan peta perjalanan, PdP bukan sahaja menjadi lebih menyeronokkan, tetapi juga membantu pelajar mengaplikasikan ilmu fiqh dalam konteks kehidupan dan kerjaya sebenar, terutamanya dalam bidang pelancongan Islam. Dengan pendekatan ini, pelajar tidak hanya mendapatkan ilmu, tetapi juga membangun kemahiran komunikasi, kolaborasi, dan penyelesaian masalah yang sangat penting di dunia pekerjaan masa kini.

Dari sudut pedagogi, inovasi ini menyokong prinsip Pembelajaran Abad Ke-21 (PAK21) dan pendekatan TVET, yang menekankan keseimbangan antara teori dan amali [3]. Ia membuktikan bahawa pengajaran Pendidikan Islam boleh dipersembahkan secara digital dengan cara yang moden, tanpa mengorbankan nilai-nilai spiritual dan keautentikan ilmu Syariah [21]. Di samping itu, keputusan yang diperoleh juga menandakan adanya peningkatan motivasi dalaman pelajar untuk secara aktif dan reflektif mempelajari topik agama [22,23].

Bagi penambahbaikan pada masa hadapan, pengkaji mencadangkan beberapa cadangan penambahbaikan bagi memperkukuh inovasi Antara Dua Marhalah dan meningkatkan kualiti penyelidikan pada masa hadapan iaitu:

Pembangunan Aplikasi Mudah Alih (Mobile App)

- Mengembangkan inovasi ini daripada platform kuiz yang sedia ada kepada aplikasi mudah alih khusus supaya pelajar boleh mengakses nota dan simulasi solat musafir secara kendiri di mana-mana lokasi.
- Memasukkan teknologi Augmented Reality (AR) untuk memperlihatkan visual yang lebih baik tentang jarak antara dua marhalah atau arah kiblat semasa perjalanan.

Perluasan Skop Topik dan Kandungan

- Mengembangkan modul gamifikasi untuk topik fardu ain lainnya, seperti pengurusan jenazah atau zakat, supaya pendekatan ini mencakup lebih dari satu topik.
- Menawarkan pilihan bahasa (seperti Bahasa Inggeris atau Bahasa Arab) untuk meningkatkan peluang perdagangan di peringkat antarabangsa atau untuk kegunaan pelancong asing.

Penambahbaikan Metodologi Penyelidikan

- Melaksanakan kajian kualitatif melalui sesi temu bual dengan pelajar untuk memahami secara lebih mendalam bagaimana elemen gamifikasi tertentu mempengaruhi emosi dan cara berfikir mereka.

Kerjasama Strategik dan Pengkomersialan

- Bekerja sama dengan agensi pelancongan atau pengurusan umrah bagi menguji keberkesanan modul ini dalam situasi sebenar di luar kelas.

Secara keseluruhan, inovasi Antara Dua Marhalah ini tidak hanya memberi kesan pada pemahaman pelajar tentang ibadah solat musafir, tetapi juga menyumbang kepada transformasi pedagogi Islam dalam bentuk pembelajaran berasaskan teknologi yang lebih progresif dan sesuai dengan keperluan masa kini.

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Production Of Paper From Cabbage Waste

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Abstract

The escalating global demand for paper, currently reliant on wood-based pulp, has intensified environmental concerns such as deforestation, high water usage, and chemical pollution. In Malaysia, where the pulp and paper industry is valued at RM6.2 billion, there is a critical need for sustainable alternatives to manage the 1.2 million tons of agricultural waste generated annually, much of which currently contributes to climate change via methane emissions in landfills. This project focuses on producing eco-friendly paper from cabbage waste, aiming to reduce environmental pollution and dependence on wood-based raw materials. The problem addressed in this study arises from the excessive disposal of vegetable waste and the unsustainable nature of traditional paper production, which relies heavily on deforestation and high energy consumption. The scope of the project encompasses the collection of cabbage waste from cafeteria. The methodology involved systematic process of washing, cutting, blending, pulping, and shaping using a 13cm x 18cm deckle. The pulp was treated under three distinct conditions: alkaline using baking soda, neutral using distilled water, and acidic using lemon juice to evaluate the effect of pH modification on the paper's antimicrobial properties and durability. Characterization tests were conducted in controlled environments to observe microbial spoilage and moisture resistance. Results indicated that pH is a primary factor influencing paper functionality. Alkaline-treated paper (pH 8.22) demonstrated superior performance, acting as a natural fungistatic agent that reduced mold growth by at least 60% compared to acidic samples. While neutral paper showed moderate resistance, acidic paper degraded rapidly, losing structural integrity and reaching full mold coverage within five days under high humidity. This study validates that a mild alkaline treatment effectively produces durable, antimicrobial cabbage-based paper, offering a viable, eco-friendly solution for sustainable packaging applications.

Keywords: *Cabbage paper, agricultural waste, antimicrobial properties, pH*

Abstrak

Peningkatan permintaan global terhadap kertas, yang kini bergantung kepada pulpa berasaskan kayu, telah meningkatkan kebimbangan alam sekitar seperti penebangan hutan, penggunaan air yang tinggi, dan pencemaran bahan kimia. Di Malaysia, di mana industri pulpa dan kertas bernilai RM6.2 bilion, terdapat keperluan kritikal untuk mencari alternatif mampan bagi menguruskan 1.2 juta tan sisa pertanian yang dihasilkan setiap tahun. Kebanyakan sisa ini kini menyumbang kepada perubahan iklim melalui pelepasan gas metana di tapak pelupusan sampah. Projek ini memberi tumpuan kepada penghasilan kertas mesra alam daripada sisa kobis, yang bertujuan untuk mengurangkan pencemaran alam sekitar dan kebergantungan kepada bahan mentah berasaskan kayu. Masalah yang ditangani dalam kajian ini timbul daripada pembuangan sisa sayuran yang berlebihan dan sifat pengeluaran kertas tradisional yang tidak mampan dan sangat bergantung kepada penebangan hutan. Skop projek ini merangkumi pengumpulan sisa kobis daripada kafeteria. Metodologi melibatkan proses sistematik iaitu mencuci, memotong, mengisar, menjadikan serat kobis, justeru membentuk menggunakan acuan bersaiz 13cm x 18cm. Serat kobis tersebut dirawat di bawah tiga keadaan berbeza: beralkali menggunakan soda penaik, neutral menggunakan air suling, dan berasid menggunakan jus lemon untuk menilai kesan pengubahsuaian pH terhadap ketahanan dan sifat antimikrob kertas. Ujian pencirian dijalankan dalam persekitaran terkawal untuk memerhatikan kerosakan mikrob dan rintangan kelembapan. Keputusan menunjukkan bahawa pH adalah faktor utama yang mempengaruhi kefungsian kertas. Kertas yang dirawat dengan alkali (pH 8.22) menunjukkan prestasi yang unggul, bertindak sebagai agen pencegah kulat semula jadi yang mengurangkan pertumbuhan kulat sekurang-kurangnya 60% berbanding sampel berasid. Walaupun kertas neutral menunjukkan rintangan sederhana, kertas berasid merosot dengan cepat, kehilangan integriti struktur dan dilitupi kulat sepenuhnya dalam masa lima hari di bawah kelembapan yang tinggi. Kajian ini mengesahkan bahawa rawatan alkali ringan secara berkesan menghasilkan kertas berasaskan kobis yang tahan lama dan antimikrob, menawarkan penyelesaian yang berdaya maju dan mesra alam untuk aplikasi pembungkusan mampan.

Katakunci**:** *Kertas kobis, sisa pertanian, sifat antimikrob, pH*

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I. INTRODUCTION

The global demand for paper continues to rise, driving a heavy reliance on conventional wood-based pulp. In Malaysia, the pulp and paper industry is projected to be valued at RM6.2 billion by 2025, yet it remains highly dependent on this wood pulp. This dependence leads to critical environmental issues, including chemical pollution, excessive water usage, and widespread deforestation. Compounding this issue is the problem of agricultural waste, as Malaysia produces approximately 1.2 million tons of such waste yearly. Large quantities of cabbage waste, specifically discarded leaves and stems, are generated daily from local markets, cafeterias, food processing industries, and households. Currently, poor waste management results in most of this biodegradable waste being disposed of in landfills. The continuous accumulation of this waste creates serious environmental risks, leading to leachate contaminating water sources, pest attraction, and the decomposition process releasing methane gas. Because methane is a major contributor to faster climate change, there is an urgent need for eco-friendly waste management solutions and alternative, sustainable materials.

To address these interconnected problems, this research aims to produce eco-friendly paper by developing an innovative process to convert vegetable waste into paper pulp. The primary objective is to create a biodegradable, durable, and cost-effective paper that promotes sustainable production practices while reducing environmental pollution and deforestation. Specifically, the study seeks to determine the best treatment method for producing high-quality paper from cabbage waste. This involves evaluating how pH-modified cabbage paper responds to microbial spoilage and testing its durability under different controlled humidity conditions.

The scope of this work is carefully defined through specific experimental variables to ensure consistency and a fair comparison across all tests. The constant variable in this study is the paper size, which is strictly fixed at 13cm x18cm for all samples. The manipulated variable is the pH treatment applied to the cabbage paper pulp. Only the pH level is varied while all other conditions remain constant, utilizing lemon juice for an acidic environment, distilled water for a neutral environment, and baking soda for an alkaline environment. Finally, the response variable is the microbial spoilage rate observed on the cabbage paper. This rate is measured through daily visual observations and specific spoilage scoring, which serves as a direct indicator of the paper's antimicrobial effectiveness. By testing under different humidity conditions, the research observes how the manipulated pH treatments affect the response variable of microbial resistance, identifying the most suitable production method for fresh produce packaging.

II. LITERATURE REVIEW

Literature review in this research shown as listed in Table [1] below.

II. LITERATURE REVIEW

Table [1]

No.	Author / Year	Title / Source	Raw Material Used	Methodology / Treatment	Key Findings	Relevance to Present Study
1.	Ahmad et al., 2020	Production of Paper from Banana Peels	Banana peel waste	Alkali pulping with NaOH	Produced strong, biodegradable paper with good fiber bonding	Demonstrates the potential of fruit and vegetable waste as a cellulose source
2.	Lee & Rahman, 2021	Utilization of Sugarcane Bagasse for Sustainable Paper	Sugarcane bagasse	Soda pulping followed by bleaching	Achieved high cellulose yield and smooth texture	Supports use of agricultural by-products for non-wood paper
3.	Nurul et al., 2022	Effects of pH on Fiber Quality in	Mixed vegetable waste	Acidic, neutral, and alkaline soaking	Alkaline treatment improved fiber	Guides pH treatment selection for

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		Agricultural Waste Paper			separation and paper strength	cabbage fiber processing
4.	Chen et al., 2020	Antimicrobial Properties of Plant-Based Paper Coated with Aloe Vera	Recycled paper with Aloe Vera coating	Coating method using plant gel	Improved antimicrobial activity and moisture resistance	Supports adding natural binders like Aloe Vera in cabbage paper
5.	Lim, H. T., & Yusuf, A. R. (2023)	Cabbage Waste as a Renewable Source for Eco-Friendly Paper Production.	Cabbage waste	Alkaline pulping and natural drying process	Cabbage waste can be converted into biodegradable paper with good fiber bonding and moisture resistance.	Supports cabbage waste as a sustainable raw material for paper and packaging production.

III. METHODOLOGY

A. Materials

As illustrated in Figure 3.1, The materials used in this study were carefully selected to support the preparation, processing, and testing of cabbage-based paper. The main raw material was cabbage waste, collected from local cafeterias and markets, consisting of discarded leaves and stems. These materials served as the primary cellulose source for paper production. A knife was used to cut the cabbage waste into smaller pieces to facilitate easier blending and pulping. The blender played a critical role in breaking down the cabbage fibres and water mixture into a smooth and homogeneous pulp. A 500 mL beaker was utilized for measuring liquids, mixing additives, and conducting small-scale tests such as soaking and pH observation during the pulping process.

Tapioca starch was used as a natural binder to improve the strength and flexibility of the paper sheets, ensuring better fibre adhesion. A 25 L storage container was employed to store the prepared pulp mixtures before sheet formation, preventing contamination and moisture loss. The deckle, a handmade wooden frame equipped with a PVC plastic mesh, was used to mold and shape the paper sheets, ensuring consistent thickness and size. A sponge was used to press out excess water from the pulp during sheet formation, while baking paper served as a non-stick drying surface to prevent the sheets from adhering to the oven trays. Finally, an oven was used to dry the paper sheets completely at a controlled temperature, ensuring structural stability and preventing microbial growth.

All materials were selected for their accessibility, cost-effectiveness, and reusability, making the overall process sustainable and suitable for small-scale production.

B. Preparation Techniques

The Process Flow of Production of Cabbage Paper as illustrated in Figure 1.

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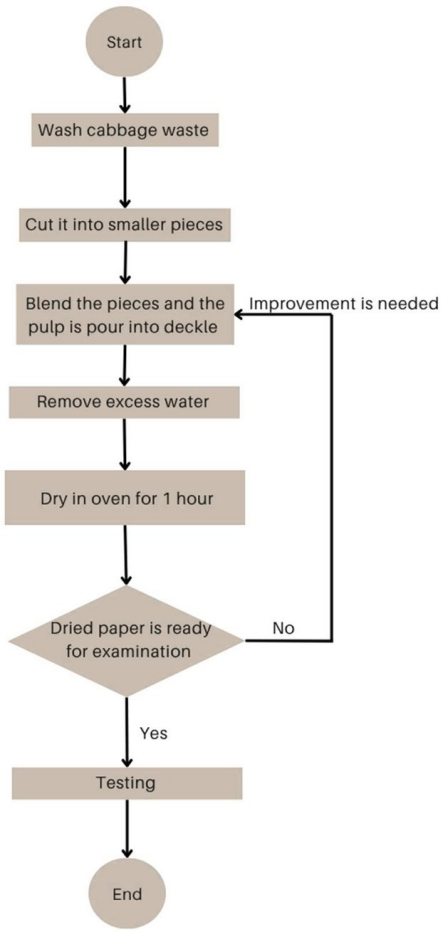

Figure 1: Process Flow of Production of Cabbage Paper

C. Characterization

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Characterization for the pH treatment and antimicrobial activity of the cabbage paper. Figure 2 shows the characterization for the pH treatment and antimicrobial activity testing.

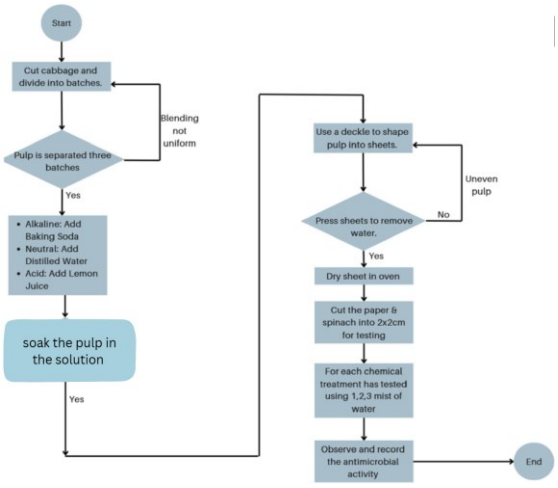

Figure 2: The characterization for the pH treatment and antimicrobial activity testing.

The resulting pulp was then divided into three separate batches for soaking and pH modification using different solutions. For the alkaline treatment, baking soda was applied at a concentration of 0.167 g/mL. For the acidic treatment, lemon juice at a concentration of 50% (v/v) was utilized, while distilled water at 100%(v/v) served as the neutral treatment.

IV. RESULT AND DISCUSSION

A. Average Spoilage Scores of Papers Under Different pH Conditions

Based on Figure 3, the results show that the alkaline-treated cabbage paper was the most effective in maintaining the freshness of produce over the seven days observation period. The produce wrapped in alkaline paper spoiled much slower than those in acidic and neutral conditions, likely because the baking soda created a basic environment that reduced bacterial growth. This finding supports previous studies suggesting that alkaline treatment strengthens fiber bonding and improves paper durability [1]. In contrast, acidic and neutral papers provided little preservation benefit, with the acidic paper showing the fastest deterioration. Overall, the results indicate that adjusting the pH of cabbage-based packaging plays a crucial role in preserving produce freshness, with alkaline conditions offering the best performance for sustainable and biodegradable food packaging applications.

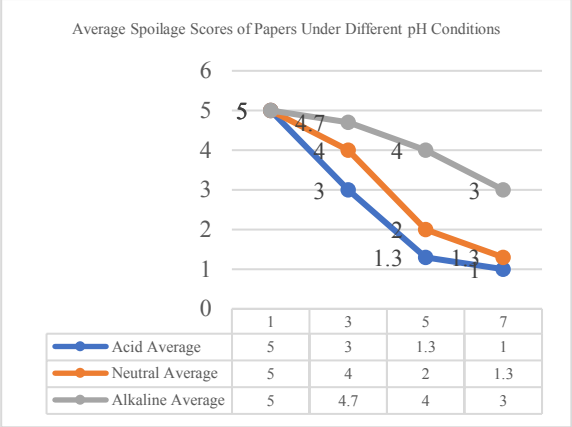

Figure 3: Average Spoilage Scores of Papers Under Different pH Conditions.

B. Average Molding Area of Paper Samples Under Varying Humidity Conditions

Based on Figure 4, the results show that mold growth on cabbage paper was highly affected by the pH condition. The acidic paper developed the most mold throughout the seven days period, while the alkaline paper had the least growth. This indicates that acidic conditions promote faster fungal growth and paper degradation, whereas the alkaline environment helps suppress microbial activity. Similar findings were reported by Chen et al. (2020), who observed that alkaline-treated plant-based papers coated with Aloe Vera showed reduced microbial growth due to higher pH and the presence of bioactive compounds [2]. Overall, the results confirm that pH modification significantly enhances the antimicrobial properties of cabbage paper, with alkaline treatment providing the best protection against mold and ensuring greater durability and hygiene.

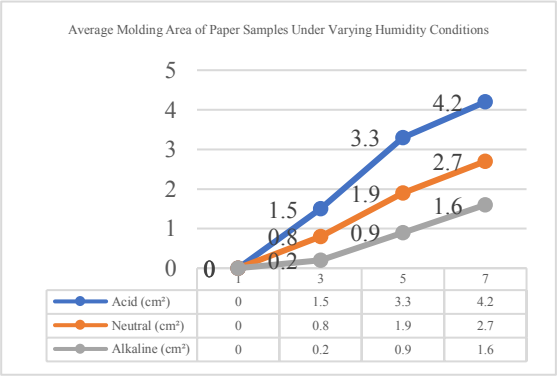

Figure 4: Average Molding Area of Paper Samples Under Varying Humidity Conditions

V. CONCLUSION

This research successfully achieves the primary objective of producing eco-friendly, biodegradable paper from cabbage waste to reduce environmental pollution and decrease reliance on wood-based raw materials. By transforming discarded leaves and stems sourced from local markets and cafeterias into

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a functional product, the study addresses the critical problem of agricultural waste accumulation and the unsustainable nature of traditional paper production. The experimental results directly align with the objective to evaluate the response of pH-modified cabbage paper to microbial spoilage and varied humidity conditions. The study confirms that pH modification is a decisive factor in determining the durability and antimicrobial effectiveness of the paper. Alkaline treatment using baking soda at a pH of 8.22 produced the most favourable results, yielding a material with superior structural integrity and the highest resistance to mold growth. This alkaline-treated paper acted as a natural fungistatic agent, slowing microbial spoilage by at least 60% compared to acidic variants under identical conditions, thereby fulfilling the goal of creating a durable and high-quality alternative to conventional materials. In contrast, the neutral samples treated with distilled water at a pH of 7.31 showed moderate performance, experiencing significant microbial spoilage over time despite performing better than acidic samples. The acidic treatments using lemon juice at a pH of 5.95 showed the weakest performance, suffering from rapid biodegradation and full mold coverage within five days, which renders them unsuitable for practical packaging applications. These findings highlight that a small changes in pH significantly affect paper performance and validate the research hypothesis that an alkaline environment enhances preservation. Ultimately, this study establishes that cabbage waste can be successfully transformed into high-quality biodegradable paper through additive and pH optimization. By integrating natural additives like tapioca starch and implementing precise pH control, this production method supports the circular economy by converting agricultural waste into valuable, environmentally responsible materials. This research offers a sustainable, low-waste alternative to conventional paper while supporting global efforts toward greener material innovation.

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Camera to Classroom: Transforming STEM Learning through Digital Storytelling

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Abstract

This study explores educators' perceptions of digital storytelling as a pedagogical innovation for transforming Science, Technology, Engineering and Mathematics (STEM) learning following their participation in the Digital Storytelling Contest (DISCONT) 2025. As digital technologies reform educational practices, educators require professional learning opportunities that support meaningful pedagogical integration beyond technical exposure. Using an exploratory qualitative research design, data were collected from 19 educators through an open-ended online survey and analysed using thematic analysis. The findings revealed five key themes: pedagogical innovation, enhanced student engagement, professional skill development, implementation challenges and future classroom integration. Educators reported a shift from traditional content delivery to more innovative, student-centred STEM teaching approaches, describing the experience as transformative. Overall, the study highlights digital storytelling as a powerful strategy for bridging technology integration with effective STEM pedagogy and supporting teacher professional development.

Keywords: digital storytelling, pedagogical innovation, STEM education, student engagement, teacher professional development

I. INTRODUCTION

Modern educational practices have been significantly transformed by the rapid advancement of digital technologies, particularly in STEM education. As classrooms increasingly incorporate multimedia tools, digital platforms and interactive technologies, educators are expected not only to adopt these tools but also to integrate them effectively into their pedagogical practices. However, meaningful technology integration requires more than technical familiarity. It also demands professional learning opportunities that enable educators to translate digital tools into purposeful instructional strategies. As digital technologies continue to reshape educational practices, educators require relevant professional development opportunities that extend beyond technical awareness toward meaningful pedagogical application.

Digital storytelling is one such approach that has gained increasing attention in recent years. It combines narrative elements with multimedia to communicate ideas and concepts in engaging, meaningful ways. Research suggests that digital storytelling can enhance student engagement, creativity, and conceptual understanding by encouraging learners to actively construct and communicate knowledge [20]. In STEM education, digital storytelling provides opportunities to contextualise scientific concepts, promote inquiry-based learning, and support students in explaining complex ideas through visual and narrative representations [4].

Recent studies have also highlighted the value of digital storytelling in supporting both student learning and teacher development. Hava and Cakir [7] reported that digital storytelling activities can increase student motivation and participation by allowing learners to express their understanding through multimodal formats. Similarly, Hava [6] found that educators who engage in digital storytelling practices often demonstrate improvements in digital competencies, instructional creativity, and student-centred teaching approaches. These findings suggest that digital storytelling can serve not only as a pedagogical tool but also as a professional learning approach for educators seeking to integrate technology effectively into their teaching practices [20], [4].

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Professional learning programmes that provide opportunities for practice and experience are essential for supporting educators in exploring innovative teaching strategies. In this context, DISCONT 2025 serves as an example, as a regional digital storytelling contest that encourages educators and students to communicate STEM concepts through creative digital narratives. Educators are introduced to innovative approaches to integrating technology, creativity, and subject matter into their teaching through the creation of digital stories.

The purpose of this study is to explore educators' perceptions of digital storytelling as a transformative strategy in STEM education following their participation in DISCONT 2025. Using thematic analysis of post-programme responses from participating educators, the study examines how involvement in the contest influenced educators' professional development, instructional transformation, and implementation considerations. The findings provide insights into how structured innovation initiatives can support significant pedagogical change in STEM education.

II. RESEARCH OBJECTIVES

This study aims to explore educators' perceptions of digital storytelling as a strategy for enhancing STEM education following their participation in the DISCONT 2025 digital storytelling initiative. The objectives of this study are to:

1. Explore educators' perceptions of digital storytelling as an innovative pedagogical method for enhancing STEM learning following their participation in the DISCONT 2025.

2. Identify educators' professional learning experiences and implementation challenges encountered when integrating digital storytelling and their perspectives on its future use in STEM classrooms.

III. LITERATURE REVIEW

Digital Storytelling in STEM Education

Digital storytelling is increasingly recognised as an effective instructional approach that combines narrative techniques with digital media such as images, audio and video to communicate ideas and knowledge. This approach enables learners to construct meaning as they actively express their understanding through multimedia formats. Research has demonstrated that digital storytelling can enhance student motivation and engagement by encouraging learners to actively construct and communicate knowledge instead of passively receiving information [19]. Integrating digital technology with storytelling enables students to organise their ideas, reflect on learning experiences, and explain concepts creatively. Thus, digital storytelling fosters the development of critical 21st-century competencies such as digital literacy, creativity and communication [11].

Digital Storytelling in STEM Learning

Digital storytelling has been identified as a promising approach in STEM education for helping students understand complex scientific concepts. Numerous STEM topics involve abstract concepts that students may find challenging to understand when taught using conventional instructional approaches. Digital storytelling allows learners to represent scientific knowledge through narratives, visual explanations, and multimedia presentations. According to Hung et al. [9], storytelling-based digital learning activities can improve students' motivation, problem-solving abilities, and overall learning achievement. Digital storytelling connects scientific concepts with narrative contexts, enabling students to explain processes, demonstrate understanding, and relate STEM concepts to real-world situations. Such approaches can promote deeper learning and support inquiry-based teaching practices in STEM classrooms. Recent studies have further highlighted the growing importance of digital storytelling in STEM education. Garcia and Ruiz [4] demonstrated its effectiveness in enhancing conceptual understanding and communication skills, while Ho et al. [8] emphasised its role in fostering STEM identity and student engagement.

Digital Storytelling and Teacher Professional Development

In addition to supporting student learning, digital storytelling has also been recognised as a valuable tool for teacher professional development [17], [13]. Through the process of creating digital stories, educators develop both technological competencies and pedagogical strategies for integrating digital tools into their instructional practices. Robin and McNeil [17] emphasised that digital storytelling activities encourage educators to reflect on their instructional practices and to explore innovative ways to communicate subject content. Collaborative storytelling activities can also foster professional learning communities where educators share ideas and pedagogical strategies. These experiences enable educators to experiment with technology-enhanced teaching approaches and build confidence in integrating digital tools into their teaching practices [13]. Digital storytelling enhances pedagogical innovation in STEM education by

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serving as both a teaching technique and a professional learning approach.

Despite increasing attention to digital storytelling in education, limited research evidence remains on how structured initiatives, such as digital storytelling contests, influence educators' pedagogical practices and professional learning in STEM contexts, particularly within the Southeast Asian region. Therefore, this study explores educators' perceptions following their participation in DISCONT 2025.

IV. RESEARCH METHODOLOGY

This study aimed to explore educators' perceptions of digital storytelling as a strategy for promoting STEM education. A qualitative exploratory research design was employed to achieve this objective. A qualitative approach was used to examine educators' experiences, views, and perspectives following their participation in the DISCONT 2025 digital storytelling initiative. Qualitative methods allow researchers to gain deeper insights into educators' perspectives and experiences within specific educational frameworks.

The participants in this study comprised 19 educators who participated in the DISCONT 2025 digital storytelling contest. These educators guided and supported students in developing digital storytelling projects that conveyed STEM concepts through creative narratives and multimedia elements. Therefore, the participants were educators with personal experience implementing digital storytelling activities in their classrooms. Data were collected through an online post-program survey to gather educators' perceptions of their experiences with digital storytelling and its potential influence on STEM education. The overall research process of the study is illustrated in Figure 1.

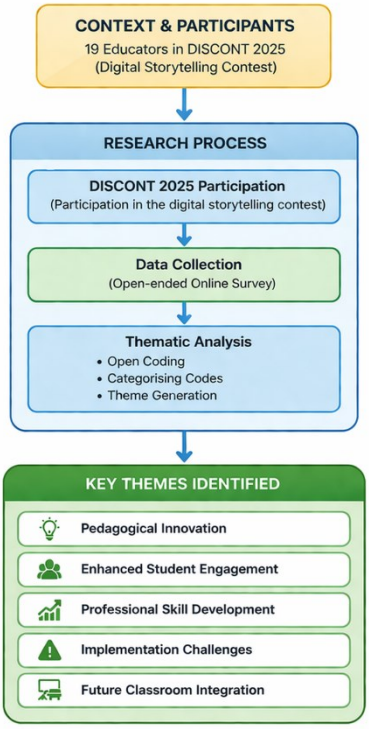

Figure 1: Research Process of the Study

Figure 1 illustrates the research process of the study, beginning with educators' participation in DISCONT 2025, followed by data collection through an open-ended online survey. The responses were analysed using thematic analysis, which involved open coding, categorising codes, and theme generation. This process led to the identification of five key themes related to digital storytelling in STEM education.

Educators' opinions about the advantages of digital storytelling, the skills they gained from the project, and the difficulties they faced during implementation were the main focus of the questions. The responses were analysed using thematic analysis to identify recurring patterns, ideas and themes. The analytical process involved familiarisation with the data, coding salient statements, categorising codes and identifying major themes that reflected educators' perspectives and experiences. This approach enabled the researchers to systematically examine educators' perceptions, professional learning experiences and implementation considerations related to the integration of digital storytelling in STEM education.

To enhance the accuracy of the thematic analysis, the coding process was conducted in several stages. Initially, open coding was performed to identify meaningful units from the responses. These codes were then grouped into categories based on

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similarities and patterns. Subsequently, axial coding was applied to establish relationships between categories, leading to the development of broader themes. The themes were further reviewed and refined to ensure consistency, clarity and alignment with the research objectives.

V. RESULTS AND DISCUSSION

The following presents the findings from the thematic analysis of qualitative responses from 19 educators who participated in DISCONT 2025. The open-ended responses were coded and categorised into key themes that reflect the educators' experiences, perceptions, and reflections on the use of digital storytelling in STEM education. The findings are organised around the five themes identified in the analysis: pedagogical innovation, enhanced student engagement, professional skill development, implementation challenges, and future classroom integration.

Analysis of the 19 educators' responses revealed that the majority perceived DISCONT 2025 as an innovative pedagogical approach in STEM education. Many educators described the sessions as an imaginative teaching approach that allowed them to present STEM ideas in more engaging and expressive ways. Educators reported that they were able to go beyond conventional teaching methods by fusing story elements with multimedia components. For example, one educator shared that "I gained confidence in using digital tools to tell stories and learned how powerful storytelling can be in delivering meaningful messages" (T5). Another educator noted that "the most valuable skill I gained was the ability to effectively combine storytelling elements with digital tools to create engaging educational content" (T12). These answers show that educators can view digital storytelling as a platform for expressing their ideas in a technology-based learning environment and as a great pedagogical approach.

Another prominent theme identified was that using digital storytelling activities indirectly enhances students' engagement in the classroom. Educators noted that students become motivated and show interest and enthusiasm in classroom activities. One educator enlightened that "it helps students stay more engaged by allowing them to express ideas creatively and connect learning with real-life experiences" (T7). Similarly, another educator noted that "digital storytelling helps students visualize something that is still abstract and this really helps them understand the material" (T9). Moreover, the "it helps students express their understanding in a multimodal way, while also encouraging creativity, critical thinking, and collaboration" (T16) suggests that digital storytelling supports deeper comprehension of STEM concepts.

Professional skills development is another theme highlighted through involvement in DISCONT 2025. Numerous educators reported that developing new skills improved their ability to express their STEM ideas, especially in video production, editing and the use of ICT resources for teaching and learning. For example, one educator stated that they gained "ICT skills" and "editing video" skills through the digital storytelling contest (T14). Similarly, another educator stated, "the most valuable skill I gained was the ability to effectively combine storytelling elements with digital tools to create engaging educational content" (T18). These responses suggest that digital storytelling indirectly contributes to educators' professional skills development in areas such as digital literacy, storytelling techniques and creative instructional approaches.

Implementation challenges encountered during the contest were important to consider, although educators also reported several favourable experiences. Time management was the most frequently cited challenge, as educators needed to balance their teaching responsibilities and the contest requirements. For example, one educator shared that "I had a hard time committing to the task but finally managed to finish my video despite a busy schedule" (T3). Similarly, another educator noted that "one of the main challenges was managing time effectively while balancing teaching responsibilities and contest deadlines" (T18). In addition, several DISCONT 2025 educators reported technical challenges. Video recording, production, and editing were some of the difficulties faced by the educators. One educator explained that "the recording is challenging" (T4), while another educator mentioned that "the sound effect, tried many times but couldn't manage to get it done" (T16). These responses indicate that although digital storytelling provides valuable educational opportunities, educators need more time, technical assistance, and direction to carry out these activities effectively.

In summary, despite the challenges encountered, several educators recognised the benefits of using digital storytelling as an instructional strategy to enhance student learning. In addition, educators indicated that they intend to incorporate digital storytelling into their STEM lessons. The storytelling concept, when incorporated with digital tools, helps students express their ideas creatively and effectively. In addition, educators also

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highlighted how digital storytelling may support group learning and help students acquire 21st-century skills. For example, one educator noted that digital storytelling "encourages creativity, critical thinking and collaboration, while also helping students express their understanding in a multimodal way" (T16). These observations suggest that educators recognise the potential of digital storytelling as an effective teaching strategy that can be incorporated into future STEM teaching practices to encourage student participation and active learning.

VI. CONCLUSION

The findings of this study provide important insights into educators' perceptions of digital storytelling as an instructional approach in STEM education following their participation in DISCONT 2025. The thematic analysis revealed five key dimensions: pedagogical innovation, enhanced student engagement, professional skill development, implementation challenges, and the potential for future classroom integration. Taken together, these findings highlight the educational value of digital storytelling as a pedagogical strategy that combines narrative, technology, and creative expression to support more meaningful STEM learning experiences.

Educators see digital storytelling as a means to enhance STEM teaching, especially for abstract ideas that are hard to grasp through traditional methods [2]. Using narratives, visuals, and interactive features makes learning more engaging and helps students relate concepts to real life, boosting understanding and memory. Digital storytelling supports learner-centred, constructivist education by encouraging students and teachers to organise, explain, and share knowledge creatively through tools like video, narration, animation and sound effects [18]. This approach improves comprehension and communication skills essential in STEM and helps incorporate interdisciplinary ideas by contextualising scientific concepts in real-world scenarios, making learning relevant and fostering interest in scientific exploration [10].

This study finds that digital storytelling boosts student engagement by incorporating multimedia such as visuals, narration, and sound, creating a multimodal environment that appeals to diverse learning styles and encourages deeper engagement. It helps students process information via multiple sensory pathways, enhancing understanding and retention. Digital storytelling shifts students from passive recipients of information to active creators of knowledge; they interpret scientific ideas, organise them into stories, and use digital tools, requiring higher-order skills such as analysis, synthesis, and evaluation [3]. Educators see it as a way to improve understanding of abstract STEM concepts, as students visualise ideas through storytelling, making complex processes easier to grasp. For example, phenomena that are difficult to explain with text or equations can be shown through animations, simulations, or narratives, fostering stronger conceptual links. It also boosts creativity and teamwork through group activities such as discussions, brainstorming, and decision-making, thereby promoting collaborative learning [16]. These activities enhance communication, perspective-taking and teamwork, which are essential in STEM.

The findings highlight DISCONT 2025's role in promoting teachers' growth. Many participants found that the digital storytelling contest helped them learn new technical and pedagogical skills, such as digital literacy, video editing, multimedia design and the application of ICT tools in teaching. As digital tech becomes central to education, some teachers lack confidence or experience [14]. Contests like these offer a supportive environment for teachers to experiment with digital tools, gain practical experience, build skills, and find innovative teaching approaches. Developing these skills is vital in 21st-century education, where digital literacy is essential for teachers. Digital storytelling helps educators learn to operate tools and enhance pedagogical goals. This combined knowledge is key to creating effective, tech-rich learning environments. Making digital stories also encourages teachers to consider how they communicate scientific ideas, involving careful planning, engaging storytelling, and clear explanations [5]. This reflection improves students' understanding of STEM concepts and how they present them, promoting ongoing professional growth and better teaching.

The study shows positive views on digital storytelling but also highlights challenges, mainly time management. Educators struggle to balance teaching with creating stories, which involves planning, recording, editing and revising, consuming significant time. Despite recognising its educational benefits, limited time and heavy workloads hinder adoption. Without institutional support, sustaining these practices in daily teaching remains difficult [12]. Several participants reported technical challenges with video recording, sound effects, and editing software, highlighting the need for more technical training and support. Less familiar educators face a steep learning curve, which can discourage the use of digital storytelling in

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classrooms. Successful adoption depends on both individual effort and systemic backing, including professional development, technical assistance, and resources. Overcoming these barriers can foster environments that promote innovative teaching methods [21].

Despite obstacles, many educators remain interested in using digital storytelling in their future teaching, likely influenced by their DISCONT 2025 experience. Digital storytelling enhances 21st-century skills like creativity, critical thinking, teamwork, and communication [15]. Participating in creating digital narratives allows teachers to promote active learning and deeper understanding beyond rote memorisation, supporting educational goals of real-world problem-solving. Integrating storytelling into STEM makes scientific knowledge more human and relatable, connecting lessons with real-world issues and personal experiences [8]. This boosts students' interest and shows the relevance of science and technology in daily life. Digital storytelling can also encourage broader use of technology in education. As teachers become comfortable with multimedia tools and storytelling, they may adopt other digital methods, such as project-based learning, multimedia presentations, and interactive simulations [1]. Therefore, digital storytelling serves as a first step to transforming traditional teaching into more technology-rich environments.

This study proposes that digital storytelling symbolises a promising pedagogical approach for enhancing STEM education. Participants at DISCONT 2025 saw its potential to boost creativity in teaching, increase student engagement, and foster professional growth. However, the study also highlights practical hurdles, such as limited time and technical skills, which must be addressed for successful adoption. Future efforts should include structured training, technical support, and collaborative learning opportunities for teachers. These actions will help educators incorporate storytelling and digital tools more effectively, leading to more enriching and engaging STEM learning experiences for students.

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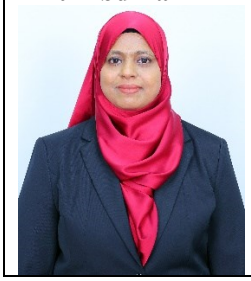

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Penggunaan ChatGPT Dan Hubungannya Dengan Pembelajaran Kendiri Serta Integriti Akademik Dalam Kalangan Pelajar Kolej Komuniti Arau

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Abstrak

Kajian ini dijalankan bagi meneroka hubungan antara penggunaan ChatGPT dalam kalangan pelajar Kolej Komuniti Arau dengan tahap pembelajaran kendiri serta persepsi terhadap integriti akademik dalam konteks penggunaan teknologi kecerdasan buatan generatif dalam pendidikan tinggi. Perkembangan teknologi kecerdasan buatan generatif pada masa kini telah mempengaruhi cara pelajar memperoleh maklumat dan menyelesaikan tugasan akademik melalui bantuan digital yang lebih interaktif. Walau bagaimanapun, penggunaan teknologi ini turut menimbulkan kebimbangan berkaitan aspek etika akademik sekiranya ia digunakan tanpa panduan yang jelas. Kajian ini menggunakan pendekatan kuantitatif melalui reka bentuk tinjauan dengan pengumpulan data menggunakan soal selidik berstruktur yang melibatkan 150 orang pelajar daripada lima program pengajian di Kolej Komuniti Arau. Data kajian menilai tiga (3) konstruk utama iaitu tahap penggunaan ChatGPT, pembelajaran kendiri dan integriti akademik. Data yang diperoleh dianalisis menggunakan statistik deskriptif, ujian-t sampel bebas serta analisis korelasi Pearson bagi mengenal pasti hubungan antara pemboleh ubah yang dikaji. Hasil kajian menunjukkan bahawa tahap penggunaan ChatGPT berada pada tahap sederhana tinggi dengan nilai min 3.62, manakala persepsi terhadap integriti akademik juga berada pada tahap sederhana dengan nilai min 3.21. Analisis ujian-t menunjukkan terdapat perbezaan yang signifikan dalam persepsi integriti akademik antara pelajar yang menggunakan ChatGPT pada tahap tinggi dan rendah. Selain itu, pelajar dengan tahap penggunaan ChatGPT yang lebih tinggi turut menunjukkan tahap pembelajaran kendiri yang lebih baik. Analisis korelasi Pearson turut menunjukkan wujud hubungan positif yang signifikan antara penggunaan ChatGPT dan pembelajaran kendiri ($r = 0.415$), serta hubungan negatif yang signifikan antara penggunaan ChatGPT dan integriti akademik ($r = -0.298$). Dapatan ini menunjukkan bahawa penggunaan teknologi AI generatif dalam pendidikan perlu diimbangi dengan pendekatan pedagogi dan garis panduan etika akademik yang jelas. Secara keseluruhannya, dapatan kajian mencadangkan bahawa penggunaan ChatGPT berpotensi menyokong pembelajaran kendiri pelajar, namun penggunaannya perlu disertai dengan garis panduan etika akademik yang jelas bagi memastikan integriti akademik dapat dipelihara.

Kata kunci *- ChatGPT, Integriti akademik, Kecerdasan buatan generatif, Kolej Komuniti, Pembelajaran kendiri*

Abstract

This study was conducted to explore the relationship between the use of ChatGPT among students at Kolej Komuniti Arau and their level of self-directed learning as well as their perception of academic integrity within the context of generative artificial intelligence technology in higher education. The rapid development of generative artificial intelligence has influenced the way students obtain information and complete academic tasks through more interactive digital assistance. However, the use of this technology also raises concerns regarding academic ethics if it is applied without clear guidelines. This study adopted a quantitative approach using a survey research design, with data collected through a structured questionnaire involving 150 students from five academic programmes at Kolej Komuniti Arau. The study examined three main constructs, namely the level of ChatGPT usage, self-directed learning, and academic integrity. The collected data were analysed using descriptive statistics, an independent samples t-test, and Pearson correlation analysis to determine the relationships among the variables studied. The findings indicate that the level of ChatGPT usage among students is moderately high, with a mean value of 3.62, while the perception of academic integrity is at a moderate level with a mean value of 3.21. The results of the t-test analysis show a significant difference in academic integrity perception between

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students with high and low levels of ChatGPT usage. In addition, students who reported higher levels of ChatGPT usage also demonstrated a higher level of self-directed learning. Pearson correlation analysis further reveals a significant positive relationship between ChatGPT usage and self-directed learning (r = 0.415), as well as a significant negative relationship between ChatGPT usage and academic integrity (r = −0.298). These findings indicate that the use of generative artificial intelligence in education needs to be balanced with appropriate pedagogical approaches and clear academic ethical guidelines. Overall, the results suggest that the use of ChatGPT has the potential to support students' self-directed learning; however, its use should be accompanied by clear academic ethical guidelines to ensure that academic integrity is maintained.

Keywords *- Academic integrity, ChatGPT, Community College, Generative artificial intelligence, Self-directed learning*

I. PENGENALAN

A. Latar Belakang Kajian

Perkembangan teknologi kecerdasan buatan pada masa kini telah membawa perubahan ketara terhadap pendekatan pengajaran dan pembelajaran dalam pendidikan tinggi. Dalam persekitaran pendidikan tinggi masa kini, kemunculan sistem AI generatif seperti ChatGPT telah memperkenalkan kaedah baharu bagi menyokong aktiviti pembelajaran pelajar. ChatGPT ialah model bahasa berasaskan kecerdasan buatan yang mampu menjana teks, menjelaskan konsep serta memberikan respons terhadap soalan pengguna secara automatik melalui pemprosesan bahasa semula jadi [1], [21].

Penggunaan ChatGPT dalam kalangan pelajar institusi pengajian tinggi semakin meningkat kerana teknologi ini dapat membantu pelajar memahami konsep yang kompleks, menjana idea serta menyokong proses penulisan akademik secara lebih sistematik [2], [14], [22]. Perkembangan ini selari dengan keperluan pendidikan masa kini yang menekankan kemahiran pembelajaran kendiri, literasi digital serta keupayaan berfikir secara kritikal.

Namun begitu, penggunaan teknologi ini juga menimbulkan beberapa cabaran berkaitan integriti akademik. Antara isu yang sering dibincangkan termasuk kemungkinan berlakunya plagiarisme, kebergantungan yang tinggi terhadap teknologi serta kekeliruan mengenai had penggunaan AI dalam tugasan akademik [4], [5]. Oleh itu, kajian empirikal yang meneliti penggunaan ChatGPT dalam konteks institusi TVET seperti kolej komuniti amat penting bagi memahami kesannya terhadap pembelajaran pelajar serta implikasinya terhadap pembelajaran kendiri dan integriti akademik.

B. Pernyataan Masalah

Penggunaan ChatGPT dalam kalangan pelajar pendidikan tinggi semakin berkembang dalam beberapa tahun kebelakangan ini. Namun demikian, kajian yang meneliti penggunaan teknologi ini dalam konteks Kolej Komuniti di Malaysia masih kurang dijalankan. Sebaliknya, kebanyakan kajian sedia ada lebih tertumpu kepada universiti penyelidikan atau institusi pendidikan tinggi di negara maju [4], [8].

Selain itu, beberapa penyelidikan terkini melaporkan bahawa ketiadaan garis panduan institusi berkaitan penggunaan AI generatif boleh menimbulkan kekeliruan dalam kalangan pelajar mengenai had penggunaannya dalam tugasan akademik [5], [11]. Keadaan ini berpotensi menjejaskan integriti akademik dan kualiti pembelajaran sekiranya tidak ditangani secara sistematik.

Justeru itu, kajian ini dilaksanakan bagi meneliti tahap penggunaan ChatGPT dalam kalangan pelajar Kolej Komuniti Arau serta menganalisis hubungannya dengan pembelajaran kendiri dan integriti akademik.

C. Objektif Kajian

1. Mengenal pasti tahap penggunaan ChatGPT oleh pelajar Kolej Komuniti Arau dalam proses pengajaran dan pembelajaran.
2. Mengenal pasti bentuk cabaran utama serta persepsi pelajar terhadap kesan penggunaan ChatGPT dari aspek integriti akademik.
3. Mengenal pasti perbezaan persepsi integriti akademik dan pembelajaran kendiri berdasarkan tahap penggunaan ChatGPT.
4. Menganalisis hubungan antara penggunaan ChatGPT dan pembelajaran kendiri pelajar.
5. Menganalisis hubungan antara penggunaan ChatGPT dan integriti akademik.

D. Persoalan Kajian

1. Bagaimanakah tahap penggunaan ChatGPT dalam kalangan pelajar Kolej Komuniti Arau?
2. Apakah bentuk cabaran utama serta persepsi pelajar terhadap penggunaan ChatGPT dari aspek integriti akademik?

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3. Adakah terdapat perbezaan dalam persepsi integriti akademik dan pembelajaran kendiri antara pelajar berdasarkan tahap penggunaan ChatGPT?
4. Adakah terdapat hubungan antara penggunaan ChatGPT dan pembelajaran kendiri pelajar?
5. Adakah penggunaan ChatGPT mempunyai hubungan dengan integriti akademik pelajar?

II. KAJIAN LITERATUR

A. Kecerdasan Buatan Generatif Dalam Pendidikan Tinggi

Dalam konteks teknologi moden, AI generatif merujuk kepada sistem kecerdasan buatan yang direka untuk menghasilkan kandungan digital baharu seperti teks atau imej berdasarkan arahan yang diterima daripada pengguna. Dalam bidang pendidikan tinggi, teknologi ini telah mempengaruhi cara pelajar mengakses maklumat serta menyokong proses pembelajaran mereka melalui persekitaran pembelajaran digital yang lebih interaktif dan responsif [13], [21]. ChatGPT, sebagai salah satu contoh AI generatif, berupaya mensimulasikan perbualan manusia dan memberikan penjelasan akademik secara kontekstual.

Kajian-kajian terkini menunjukkan bahawa AI generatif kini tidak lagi dilihat hanya sebagai alat teknologi semata-mata, sebaliknya telah menjadi sebahagian daripada persekitaran pembelajaran digital yang menyokong pembelajaran yang lebih fleksibel dan berpusatkan pelajar [8], [25]. Perkembangan ini menunjukkan bahawa teknologi AI generatif semakin memainkan peranan penting dalam menyokong pembelajaran kendiri serta pengalaman pembelajaran yang lebih adaptif dalam pendidikan tinggi [22], [23], [25]. Dalam konteks pendidikan, penggunaan ChatGPT memberi peluang kepada pelajar untuk memperoleh sokongan pembelajaran yang lebih fleksibel dan bersifat peribadi, khususnya ketika mereka belajar secara kendiri [8], [22]. Walau bagaimanapun, beberapa kajian terdahulu turut menegaskan bahawa penggunaan AI generatif tanpa pemantauan yang sewajarnya berpotensi mengubah proses pembelajaran daripada aktiviti yang melibatkan pemikiran kognitif kepada pendekatan yang lebih bersifat mekanikal.

Dalam konteks pendidikan TVET, penggunaan AI generatif berpotensi menyokong pembelajaran berasaskan kemahiran dengan menyediakan rujukan segera, penjelasan prosedur dan sokongan dokumentasi teknikal. Namun, potensi ini perlu ditimbang dengan keperluan memastikan pembelajaran kekal berorientasikan kemahiran sebenar dan bukan sekadar penjanaan kandungan [11].

B. Penggunaan ChatGPT Dalam Konteks Akademik

Penggunaan ChatGPT dalam bidang akademik dilaporkan semakin meningkat, khususnya dalam kalangan pelajar di institusi pengajian tinggi. Kajian terdahulu menunjukkan bahawa pelajar memanfaatkan ChatGPT untuk pelbagai tujuan pembelajaran seperti menjana idea, memahami topik yang kompleks serta membantu dalam penyediaan penulisan akademik [4]. Selain itu, keupayaan ChatGPT untuk memberikan maklum balas dengan pantas turut menjadikannya sebagai alat sokongan pembelajaran yang praktikal dan mudah diakses oleh pelajar.

Walaupun ChatGPT mempunyai potensi sebagai alat sokongan pembelajaran, kajian terdahulu menunjukkan bahawa penggunaannya dalam akademik tidak bersifat neutral. Penggunaan sebagai alat sokongan sementara dapat menyokong pembelajaran pelajar, namun kebergantungan berlebihan terhadap teknologi ini berpotensi mengurangkan penglibatan kognitif dan pembelajaran mendalam [2]. Oleh itu, implikasi penggunaan ChatGPT adalah sangat bergantung kepada niat serta strategi penggunaannya dalam konteks akademik.

Dalam konteks kajian ini, penggunaan ChatGPT oleh pelajar Kolej Komuniti Arau perlu difahami sebagai sebahagian daripada strategi pembelajaran harian mereka, terutamanya dalam mengimbangi tuntutan akademik dan kekangan masa. Oleh itu, sorotan literatur ini menegaskan bahawa penggunaan ChatGPT bukan isu “boleh atau tidak”, tetapi isu “bagaimana dan sejauh mana” teknologi ini digunakan dalam pembelajaran akademik.

C. ChatGPT Dan Pembelajaran Kendiri

Pembelajaran kendiri merujuk kepada keupayaan pelajar mengurus proses pembelajaran mereka sendiri, termasuk merancang, melaksanakan dan menilai kemajuan pembelajaran yang dicapai. Dalam era pembelajaran digital, teknologi semakin memainkan peranan penting sebagai sumber sokongan kepada pelajar. Kajian terdahulu menunjukkan bahawa penggunaan AI generatif mampu membantu pelajar meningkatkan pembelajaran kendiri melalui maklum balas segera, sokongan penerokaan pengetahuan serta keupayaan untuk menilai kefahaman sendiri secara berterusan [9], [23].

Dalam konteks ini, ChatGPT boleh berfungsi sebagai alat yang menyokong pembelajaran kendiri dengan membantu pelajar menilai tahap kefahaman

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mereka, mengenal pasti kekurangan dalam pembelajaran serta merancang langkah pembelajaran yang lebih sistematik. Namun demikian, keberkesanan penggunaan teknologi ini juga bergantung kepada tahap literasi digital pelajar serta kemampuan mereka menilai ketepatan maklumat yang dihasilkan oleh AI [10].

Dalam konteks TVET, pembelajaran kendiri adalah elemen penting kerana pelajar perlu menguasai kemahiran secara berdikari. Oleh itu, ChatGPT boleh berfungsi sebagai alat sokongan yang melengkapkan pembelajaran praktikal, selagi penggunaannya tidak menggantikan latihan sebenar dan pengalaman hands-on.

D. Integriti Akademik Dan Cabaran Penggunaan ChatGPT

Integriti akademik merujuk kepada amalan kejujuran, tanggungjawab dan etika dalam pembelajaran dan penilaian akademik. Kemunculan ChatGPT telah menimbulkan cabaran baharu terhadap integriti akademik, khususnya berkaitan plagiarisme, kebergantungan berlebihan dan kekeliruan tentang sempadan penggunaan yang dibenarkan [5].

AI generatif mencabar definisi tradisional plagiarisme kerana kandungan yang dijana tidak disalin secara langsung daripada sumber tertentu [7]. Kajian terkini juga menegaskan bahawa kemunculan teknologi AI generatif memerlukan institusi pendidikan menilai semula dasar integriti akademik serta pendekatan penilaian bagi memastikan ketelusan dalam penggunaan teknologi tersebut dalam tugasan akademik [24]. Keadaan ini menyukarkan penguatkuasaan integriti akademik sekiranya institusi tidak mempunyai dasar dan garis panduan yang jelas. Selain itu, integriti akademik dalam era AI memerlukan pendekatan baharu yang menekankan ketelusan dan literasi AI [6].

Dalam konteks kajian ini, cabaran integriti akademik yang dibincangkan dalam literatur menjadi asas penting untuk mentafsir dapatan hubungan negatif antara penggunaan ChatGPT dan persepsi integriti akademik pelajar Kolej Komuniti Arau.

III. METODOLOGI KAJIAN

A. Reka Bentuk Kajian

Kajian ini dilaksanakan menggunakan reka bentuk kajian kuantitatif berbentuk tinjauan. Pendekatan ini digunakan kerana ia membolehkan data dikumpulkan daripada sejumlah besar responden secara efisien dalam masa yang singkat, di samping sesuai untuk dianalisis menggunakan kaedah statistik [17].

B. Populasi Dan Sampel Kajian

Populasi kajian melibatkan pelajar yang sedang mengikuti lima program pengajian di Kolej Komuniti Arau, iaitu Sijil Teknologi Maklumat (STM), Sijil Fesyen dan Pakaian (SFP), Sijil Teknologi Senibina (STS), Sijil Teknologi Pemprosesan Makanan (SPK) serta Sijil Teknologi Elektrik (SKE). Berdasarkan populasi tersebut, sebanyak 150 orang pelajar dipilih sebagai sampel kajian menggunakan kaedah persampelan berstrata bagi memastikan wakil daripada setiap program pengajian terlibat secara seimbang dalam kajian ini.

C. Instrumen Kajian

Kajian ini menggunakan soal selidik berstruktur sebagai instrumen utama untuk mengumpul data. Instrumen tersebut direka bagi mengukur beberapa pembolehubah penting dalam kajian, iaitu tahap penggunaan ChatGPT, pembelajaran kendiri dan integriti akademik. Konstruk bagi setiap pembolehubah adalah berasaskan kajian terdahulu yang meneliti penggunaan AI generatif dalam pendidikan [2], [6], [9]. Bagi setiap item yang disediakan, responden diminta memberikan penilaian menggunakan skala Likert lima mata, iaitu daripada 1 (Sangat Tidak Setuju) hingga 5 (Sangat Setuju). Pembinaan item soal selidik adalah berasaskan adaptasi daripada kajian terdahulu berkaitan pembelajaran kendiri dan integriti akademik dalam pendidikan tinggi bagi memastikan kesahan kandungan (*content validity*) instrumen kajian.

Bahagian A: Maklumat Demografi

Bahagian ini mengumpulkan maklumat asas responden yang meliputi program pengajian, jantina, semester pengajian, pengalaman menggunakan ChatGPT serta kekerapan penggunaannya dalam aktiviti akademik.

Bahagian B: Tahap Penggunaan ChatGPT

Bahagian ini mengandungi item yang mengukur bentuk dan tahap penggunaan ChatGPT oleh pelajar dalam konteks akademik seperti membantu memahami konsep, menjana idea tugasan dan menyokong penulisan akademik.

Bahagian C: Pembelajaran Kendiri

Bahagian ini mengukur tahap pembelajaran kendiri pelajar apabila menggunakan ChatGPT, termasuk keupayaan merancang pembelajaran, mencari maklumat secara kendiri dan membuat refleksi terhadap pembelajaran.

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Bahagian D: Integriti Akademik

Bahagian ini menilai persepsi pelajar terhadap kesan penggunaan ChatGPT terhadap integriti akademik, termasuk aspek kejujuran, risiko plagiarisme dan tanggungjawab akademik.

Bagi memastikan instrumen kajian yang dibangunkan mempunyai tahap kesahan kandungan yang baik, proses penilaian oleh pakar telah dijalankan. Tiga (3) orang pakar dalam bidang pendidikan dan teknologi pembelajaran telah terlibat dalam menilai kesesuaian konstruk serta kandungan item soal selidik yang dibangunkan. Berdasarkan maklum balas yang diberikan, beberapa pengubahsuaian telah dilakukan terhadap struktur dan susunan item bagi memastikan instrumen tersebut dapat mengukur konstruk kajian dengan lebih tepat.

Selain itu, kajian rintis turut dijalankan dengan melibatkan 30 orang pelajar yang mempunyai ciri yang hampir sama dengan responden kajian sebenar. Tujuan kajian rintis ini adalah untuk menilai kefahaman responden terhadap item soal selidik serta mengenal pasti sebarang kelemahan dalam instrumen kajian. Dapatan kajian rintis menunjukkan bahawa kebanyakan responden dapat memahami item yang disediakan dengan jelas dan hanya sedikit penambahbaikan diperlukan. Justeru, instrumen kajian ini dianggap sesuai untuk digunakan dalam pengumpulan data kajian sebenar.

D. Hipotesis Kajian

Hipotesis nol yang dibentuk dalam kajian ini adalah seperti berikut:

H_{01}
Tiada perbezaan yang signifikan dalam persepsi integriti akademik antara pelajar berdasarkan tahap penggunaan ChatGPT di Kolej Komuniti Arau.

H_{02}
Tiada perbezaan yang signifikan dalam tahap pembelajaran kendiri pelajar berdasarkan tahap penggunaan ChatGPT dalam kalangan pelajar Kolej Komuniti Arau.

H_{03}
Tiada hubungan yang signifikan antara penggunaan ChatGPT dengan tahap pembelajaran kendiri dalam kalangan pelajar Kolej Komuniti Arau.

H_{04}
Tiada hubungan yang signifikan antara penggunaan ChatGPT dengan integriti akademik dalam kalangan pelajar Kolej Komuniti Arau.

IV. DAPATAN DAN PERBINCANGAN

A. Tahap Penggunaan ChatGPT Dalam Pengajaran Dan Pembelajaran

Jadual 1

Tahap Penggunaan	Skor Min	Sisihan Piawai	Interpretasi
Penggunaan ChatGPT dalam PdP	3.62	0.58	Sederhana Tinggi

Berdasarkan Jadual 1, analisis menunjukkan bahawa tahap penggunaan ChatGPT dalam kalangan pelajar Kolej Komuniti Arau berada pada tahap sederhana tinggi dengan skor min 3.62. Keputusan ini menunjukkan bahawa ChatGPT semakin digunakan oleh pelajar sebagai alat sokongan dalam proses pembelajaran, khususnya untuk membantu memahami konsep yang kompleks, menjana idea serta menyokong penyediaan tugasan akademik. Hal ini turut menggambarkan penerimaan yang positif terhadap penggunaan teknologi AI generatif dalam kalangan pelajar.

Dapatan kajian ini juga konsisten dengan beberapa kajian terdahulu yang mendapati bahawa pelajar institusi pengajian tinggi memanfaatkan ChatGPT sebagai alat pembelajaran yang fleksibel serta mudah diakses [2], [14]. Tambahan pula, keupayaan sistem ini untuk memberikan maklum balas secara segera menjadikannya sumber bantuan pembelajaran yang berguna, terutamanya dalam konteks pembelajaran kendiri [14].

Dalam konteks pendidikan TVET, penggunaan ChatGPT pada tahap sederhana tinggi juga boleh dikaitkan dengan keperluan pelajar untuk mendapatkan sokongan pembelajaran yang lebih praktikal dan membantu proses penyelesaian masalah. Oleh itu, dapatan ini mencadangkan bahawa ChatGPT semakin memainkan peranan sebagai sebahagian daripada persekitaran pembelajaran digital dalam kalangan pelajar.

B. Cabaran Utama Penggunaan ChatGPT dalam Kalangan Pelajar

Jadual 2

Item	Pernyataan	Min	SP	Tahap
I5	Penggunaan ChatGPT boleh mendorong kepada isu plagiarisme dalam	3.86	0.72	Sederhana Tinggi

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Item	Pernyataan	Min	SP	Tahap
	tugasan akademik			
I6	Saya keliru tentang had penggunaan ChatGPT yang dibenarkan dalam tugasan akademik	3.74	0.75	Sederhana
I7	Saya merasakan penggunaan ChatGPT memerlukan garis panduan rasmi daripada institusi	3.91	0.69	Sederhana Tinggi
I8	Saya bimbang penggunaan ChatGPT boleh menjejaskan kualiti pembelajaran saya	3.68	0.77	Sederhana

Analisis terhadap Jadual 2 menunjukkan bahawa antara cabaran utama penggunaan ChatGPT dalam kalangan pelajar Kolej Komuniti Arau ialah keperluan kepada garis panduan rasmi daripada pihak institusi (Item I7), kebimbangan terhadap kemungkinan berlakunya plagiarisme (Item I5) serta kekeliruan berkaitan had penggunaan teknologi tersebut dalam tugasan akademik (Item I6). Keputusan ini menggambarkan bahawa pelajar tidak menolak penggunaan ChatGPT, tetapi mereka memerlukan panduan yang jelas bagi memastikan teknologi ini digunakan secara selaras dengan keperluan akademik.

Dapatan ini turut menyokong hasil penyelidikan terdahulu yang menunjukkan bahawa ketidakjelasan dasar institusi sering menjadi faktor utama yang menimbulkan kebimbangan pelajar mengenai integriti akademik dalam penggunaan AI generatif [5], [15]. Tambahan pula, tanpa garis panduan yang jelas, pelajar mungkin menggunakan teknologi tersebut berdasarkan interpretasi sendiri, yang berpotensi membawa kepada kesalahan akademik yang tidak disengajakan [2].

Dalam konteks pendidikan TVET, cabaran ini menjadi lebih signifikan kerana pembelajaran menekankan keseimbangan antara teori dan kemahiran praktikal. Oleh itu, kekeliruan dalam penggunaan ChatGPT boleh menjejaskan keberkesanan pembelajaran sekiranya teknologi ini digunakan sebagai pengganti kepada usaha pembelajaran sebenar.

C. Persepsi Pelajar Terhadap Integriti Akademik

Jadual 3

Item	Pernyataan	Min	SP	Tahap
I1	Saya menyemak semula kandungan yang dijana oleh ChatGPT sebelum digunakan	3.82	0.71	Sederhana Tinggi
I2	Saya tidak menyalin bulat-bulat kandungan daripada ChatGPT dalam tugasan akademik	3.76	0.74	Sederhana
I3	Saya memahami risiko integriti akademik sekiranya menggunakan ChatGPT tanpa rujukan	3.88	0.68	Sederhana Tinggi
I4	Saya menggunakan ChatGPT sebagai alat sokongan, bukan pengganti usaha sendiri	3.84	0.70	Sederhana Tinggi

Analisis terhadap Jadual 3 menunjukkan bahawa pelajar Kolej Komuniti Arau mempunyai persepsi terhadap integriti akademik pada tahap sederhana hingga sederhana tinggi. Nilai min yang tinggi bagi Item I3 dan I4 mencerminkan bahawa pelajar menyedari kepentingan mengekalkan integriti akademik dan cenderung melihat ChatGPT sebagai alat sokongan dalam pembelajaran, bukannya sebagai pengganti kepada usaha pembelajaran mereka sendiri.

Dapatan ini turut seiring dengan hasil penyelidikan terdahulu yang menunjukkan bahawa pelajar

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lazimnya mempunyai tahap kesedaran etika yang baik dalam penggunaan AI generatif, namun masih memerlukan panduan bagi memastikan kesedaran tersebut diterapkan secara konsisten dalam amalan akademik [4]. Tambahan pula, kesedaran terhadap integriti akademik dalam penggunaan AI bukan hanya dipengaruhi oleh sikap individu, tetapi juga berkait rapat dengan sokongan serta dasar yang disediakan oleh institusi pendidikan [6].

Walaupun tahap kesedaran pelajar terhadap integriti akademik adalah baik, keputusan yang berada pada kategori sederhana menunjukkan bahawa pemahaman tersebut masih perlu diperkukuh. Oleh itu, institusi pendidikan perlu mengambil pendekatan yang lebih sistematik dalam meningkatkan literasi AI serta kesedaran terhadap etika akademik dalam kalangan pelajar kolej komuniti.

D. Perbezaan Persepsi Integriti Akademik Berdasarkan Tahap Penggunaan ChatGPT

Jadual 4

Kumpulan	Min	t	df	Sig. (p)	Cohen's d
Penggunaan Rendah	3.42				
Penggunaan Tinggi	3.08	3.03	147.93	0.003*	0.45

*p < 0.05

Hasil ujian-t pada Jadual 4 menunjukkan terdapat perbezaan yang signifikan dalam persepsi integriti akademik antara pelajar dengan tahap penggunaan ChatGPT yang rendah dan tinggi ($p = 0.003$). Saiz kesan analisis ini berada pada tahap sederhana (Cohen's $d \approx 0.45$), menunjukkan bahawa tahap penggunaan ChatGPT memberikan pengaruh yang bermakna terhadap persepsi integriti akademik pelajar. Pelajar yang menggunakan ChatGPT pada tahap tinggi mencatatkan skor integriti akademik yang lebih rendah berbanding pelajar yang menggunakan ChatGPT pada tahap rendah.

Dapatan ini menyokong kajian terdahulu yang menyatakan bahawa penggunaan AI secara intensif tanpa kawalan pedagogi boleh melemahkan kefahaman pelajar terhadap prinsip integriti akademik [18]. Semakin tinggi kebergantungan pelajar terhadap AI generatif, semakin tinggi risiko salah guna akademik sekiranya penilaian masih berfokus kepada produk akhir semata-mata [5].

Dalam konteks kajian ini, dapatan tersebut menunjukkan bahawa penggunaan ChatGPT perlu disertai dengan bimbingan etika dan penilaian berasaskan proses pembelajaran agar integriti akademik dapat dipelihara.

E. Perbezaan Pembelajaran Kendiri Berdasarkan Tahap Penggunaan ChatGPT

Jadual 5

Kumpulan	Min	t	df	Sig. (p)	Cohen's d
Penggunaan Rendah	3.34				
Penggunaan Tinggi	3.89	-4.11	147.97	<0.001*	0.67

Berdasarkan analisis dalam Jadual 5, terdapat perbezaan yang signifikan dalam tahap pembelajaran kendiri antara pelajar yang mempunyai tahap penggunaan ChatGPT yang berbeza. Pelajar yang menggunakan ChatGPT dengan lebih kerap menunjukkan skor min pembelajaran kendiri yang lebih tinggi ($M = 3.89$) berbanding pelajar yang kurang menggunakan teknologi tersebut ($M = 3.34$). Keputusan ujian-t mencatatkan nilai $t = -4.11$ dengan tahap signifikan $p < 0.001$. Selain itu, nilai Cohen's $d = 0.67$ menunjukkan saiz kesan pada tahap sederhana hingga tinggi, yang menggambarkan bahawa penggunaan ChatGPT mempunyai pengaruh yang ketara terhadap tahap pembelajaran kendiri pelajar.

Dapatan kajian ini juga menyokong penemuan kajian terdahulu yang menunjukkan bahawa ChatGPT boleh membantu meningkatkan pembelajaran kendiri melalui penyediaan maklum balas segera, penerangan konsep serta sokongan dalam merancang aktiviti pembelajaran [10], [19]. Teknologi AI generatif berpotensi meningkatkan autonomi pelajar apabila digunakan sebagai alat sokongan pembelajaran, dan bukannya sebagai pengganti kepada usaha pembelajaran mereka sendiri [10].

Secara keseluruhannya, keputusan kajian ini menunjukkan bahawa penggunaan ChatGPT berpotensi membantu memperkukuh pembelajaran kendiri, terutamanya apabila pelajar menggunakan teknologi tersebut secara reflektif dan bertanggungjawab.

F. Hubungan Antara Penggunaan ChatGPT Dan Pembelajaran Kendiri

Jadual 6

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Pembolehubah	r	Sig. (p)	Kekuatan Hubungan
Penggunaan ChatGPT – Pembelajaran Kendiri	0.415	<0.001*	Sederhana Positif

Analisis korelasi pada Jadual 6 menunjukkan terdapat hubungan positif yang signifikan antara penggunaan ChatGPT dan pembelajaran kendiri (r = 0.415). Hubungan ini menunjukkan bahawa peningkatan penggunaan ChatGPT dikaitkan dengan peningkatan tahap pembelajaran kendiri pelajar.

Dapatan ini menyokong kajian terdahulu yang menyatakan bahawa ChatGPT boleh berfungsi sebagai "scaffolding tool" dalam pembelajaran kendiri, khususnya dalam membantu pelajar meneroka idea dan menilai kefahaman mereka sendiri [2]. Namun begitu, dapatan kajian tersebut turut menegaskan bahawa manfaat ini hanya dapat dicapai sekiranya pelajar mempunyai tahap literasi AI yang mencukupi.

G. Hubungan Antara Penggunaan ChatGPT Dan Integriti Akademik

Jadual 7

Pembolehubah	r	Sig. (p)	Kekuatan Hubungan
Penggunaan ChatGPT – Integriti Akademik	-0.298	<0.001*	Lemah–Sederhana Negatif

Merujuk kepada analisis dalam Jadual 7, kajian ini mendapati bahawa terdapat hubungan negatif yang signifikan antara penggunaan ChatGPT dan tahap integriti akademik pelajar (r = −0.298). Keputusan ini menunjukkan bahawa peningkatan penggunaan ChatGPT cenderung dikaitkan dengan penurunan persepsi pelajar terhadap integriti akademik.

Dapatan ini turut menyokong beberapa kajian terdahulu yang menegaskan bahawa penggunaan AI generatif boleh memberi cabaran kepada amalan integriti akademik sekiranya tidak disertai dengan dasar institusi dan kaedah pentaksiran yang sesuai [20], [16]. Oleh itu, hubungan negatif yang diperoleh menekankan keperluan kepada pendekatan yang lebih holistik yang melibatkan pembangunan polisi institusi, latihan berkaitan etika akademik serta inovasi dalam pedagogi.

H. Pengujian Hipotesis Kajian

Jadual 8

Hipotesis Nol	Keputusan Hipotesis
H_{01} - Tiada perbezaan yang signifikan dalam persepsi integriti akademik antara pelajar berdasarkan tahap penggunaan ChatGPT di Kolej Komuniti Arau.	Hipotesis nol (H_{01}) ditolak.
H_{02} - Tiada perbezaan yang signifikan dalam tahap pembelajaran kendiri pelajar berdasarkan tahap penggunaan ChatGPT dalam kalangan pelajar Kolej Komuniti Arau.	Hipotesis nol (H_{02}) ditolak.
H_{03} - Tiada hubungan yang signifikan antara penggunaan ChatGPT dengan tahap pembelajaran kendiri dalam kalangan pelajar Kolej Komuniti Arau.	Hipotesis nol (H_{03}) ditolak.
H_{04} - Tiada hubungan yang signifikan antara penggunaan ChatGPT dengan integriti akademik dalam kalangan pelajar Kolej Komuniti Arau.	Hipotesis nol (H_{04}) ditolak.

Berdasarkan keputusan dalam Jadual 8, Hipotesis Nol 1 (H_{01}) tidak disokong kerana terdapat perbezaan yang signifikan dalam persepsi integriti akademik antara pelajar yang mempunyai tahap penggunaan ChatGPT yang berbeza. Pelajar yang menggunakan ChatGPT dengan lebih kerap menunjukkan skor integriti akademik yang lebih rendah berbanding pelajar yang menggunakan teknologi tersebut secara minimum. Dapatan ini turut menyokong kajian terdahulu yang menegaskan bahawa penggunaan AI generatif secara meluas tanpa garis panduan yang jelas boleh menimbulkan kekeliruan berkaitan batasan etika akademik, khususnya dalam aspek keaslian tugasan dan tanggungjawab pelajar terhadap hasil kerja akademik mereka [5], [6].

Selain itu, AI generatif mencabar definisi tradisional integriti akademik kerana kandungan yang dijana tidak melibatkan penyalinan langsung, sekali gus menyebabkan kekeliruan dalam kalangan pelajar tentang amalan yang dibenarkan [7]. Dalam konteks Kolej Komuniti, pelajar yang masih membina kefahaman akademik mungkin lebih terdedah

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kepada cabaran ini jika penggunaan ChatGPT tidak dipandu secara sistematik.

Tambahan pula, analisis kajian menunjukkan bahawa Hipotesis Nol 2 (H_{02}) tidak disokong kerana terdapat perbezaan yang signifikan dalam tahap pembelajaran kendiri antara pelajar berdasarkan tahap penggunaan ChatGPT. Pelajar yang menggunakan ChatGPT dengan lebih kerap menunjukkan tahap pembelajaran kendiri yang lebih tinggi berbanding pelajar yang kurang menggunakan teknologi tersebut. Dapatan ini selari dengan kajian terdahulu yang menyatakan bahawa AI generatif boleh menyokong pembelajaran kendiri dengan menyediakan maklum balas segera, membantu penerokaan kendiri serta memudahkan pemahaman konsep secara lebih fleksibel [2], [3].

Kajian oleh pengkaji terdahulu juga turut menunjukkan bahawa penggunaan ChatGPT membantu pelajar merancang pembelajaran mereka sendiri, sekali gus meningkatkan autonomi pembelajaran [10]. Dalam konteks TVET dan kolej komuniti, dapatan ini amat relevan kerana pembelajaran kendiri merupakan kemahiran penting dalam membentuk pelajar yang berdikari dan bersedia menghadapi keperluan industri.

Dapatan kajian juga menunjukkan bahawa Hipotesis Nol 3 (H_{03}) turut ditolak, dengan wujudnya hubungan positif yang signifikan antara penggunaan ChatGPT dan pembelajaran kendiri. Hubungan sederhana positif ini menunjukkan bahawa peningkatan penggunaan ChatGPT berkait dengan peningkatan tahap pembelajaran kendiri pelajar. Dapatan ini konsisten dengan kajian terdahulu yang mendapati bahawa ChatGPT menyokong pembelajaran berpusatkan pelajar dengan membolehkan penerokaan pengetahuan secara kendiri [8].

Selain itu, teknologi AI juga dapat memperkukuhkan pembelajaran kendiri apabila digunakan sebagai alat sokongan, bukannya pengganti pemikiran pelajar [9]. Dapatan ini mengukuhkan hujah bahawa ChatGPT berpotensi menjadi pemangkin kepada pembelajaran kendiri sekiranya disepadukan dengan pendekatan pedagogi yang sesuai.

Berdasarkan keputusan analisis, Hipotesis Nol 4 (H_{04}) juga tidak disokong kerana terdapat hubungan negatif yang signifikan antara penggunaan ChatGPT dan tahap integriti akademik pelajar. Walaupun kekuatan hubungan yang diperoleh berada pada tahap lemah hingga sederhana, dapatan ini selari dengan kajian terdahulu yang menunjukkan bahawa kekurangan garis panduan yang jelas boleh meningkatkan kemungkinan berlakunya penyalahgunaan AI generatif dalam aktiviti akademik [6], [12].

Namun, kekuatan hubungan yang sederhana menunjukkan bahawa integriti akademik tidak dipengaruhi oleh penggunaan ChatGPT semata-mata. Faktor lain seperti literasi AI, kefahaman etika akademik dan peranan pensyarah turut mempengaruhi persepsi integriti akademik pelajar [16].

V. KESIMPULAN

Secara keseluruhannya, kajian ini telah mencapai objektif yang ditetapkan dengan meneliti tahap penggunaan ChatGPT dalam kalangan pelajar Kolej Komuniti Arau serta hubungannya dengan pembelajaran kendiri dan integriti akademik. Dapatan kajian menunjukkan bahawa penggunaan ChatGPT berada pada tahap sederhana tinggi dalam kalangan pelajar. Keadaan ini mencerminkan bahawa teknologi AI generatif semakin diterima sebagai salah satu alat sokongan pembelajaran dalam persekitaran pendidikan digital. Perkembangan ini turut menggambarkan perubahan dalam pendekatan pembelajaran pelajar yang semakin memanfaatkan teknologi digital bagi membantu pemahaman konsep, penjanaan idea serta pengurusan pembelajaran secara lebih kendiri.

Walau bagaimanapun, dapatan kajian turut menunjukkan dua implikasi utama berkaitan penggunaan ChatGPT. Di satu pihak, penggunaan teknologi ini didapati berpotensi menyokong serta memperkukuh pembelajaran kendiri pelajar, seperti yang ditunjukkan melalui perbezaan signifikan serta hubungan positif antara penggunaan ChatGPT dan tahap pembelajaran kendiri. Sebaliknya, kajian ini juga menunjukkan kewujudan hubungan negatif yang signifikan antara penggunaan ChatGPT dan persepsi terhadap integriti akademik. Dapatan ini memberi gambaran bahawa penggunaan AI generatif tanpa panduan yang jelas boleh menimbulkan kekeliruan berkaitan etika akademik serta berpotensi mewujudkan cabaran terhadap amalan integriti akademik pelajar, khususnya dalam aspek penilaian akademik.

Dari sudut implikasi praktikal, dapatan kajian ini mencadangkan bahawa pensyarah perlu mempertimbangkan pendekatan pentaksiran yang lebih bersifat “AI-aware” atau “AI-proof”. Antara pendekatan yang boleh dilaksanakan termasuk tugasan refleksi individu, pembentangan lisan, projek berasaskan masalah serta penilaian berasaskan proses pembelajaran. Pendekatan ini dapat membantu memastikan pelajar benar-benar memahami kandungan pembelajaran serta mengurangkan kebergantungan berlebihan terhadap teknologi AI generatif dalam tugasan akademik.

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Sehubungan itu, penggunaan ChatGPT dalam pendidikan tidak wajar dilihat secara ekstrem sama ada sebagai ancaman sepenuhnya atau sebagai penyelesaian mutlak kepada proses pembelajaran. Sebaliknya, teknologi ini perlu dimanfaatkan secara seimbang melalui pembangunan dasar institusi, pendekatan pedagogi yang sesuai serta pengukuhan literasi AI dan etika akademik dalam kalangan pelajar. Pendekatan ini penting bagi memastikan manfaat teknologi AI generatif dapat dimaksimumkan tanpa menjejaskan nilai asas integriti akademik, terutamanya dalam konteks pendidikan TVET dan kolej komuniti.

Walaupun kajian ini memberikan gambaran awal tentang penggunaan ChatGPT dalam kalangan pelajar Kolej Komuniti Arau, beberapa keterbatasan kajian perlu dipertimbangkan dalam mentafsir dapatan yang diperoleh. Pertama, kajian ini hanya melibatkan pelajar daripada satu institusi pendidikan iaitu Kolej Komuniti Arau. Oleh itu, dapatan kajian tidak boleh digeneralisasikan secara menyeluruh kepada semua institusi TVET atau institusi pengajian tinggi yang lain. Selain itu, kajian ini menggunakan pendekatan kuantitatif berbentuk tinjauan yang bergantung kepada persepsi responden melalui soal selidik. Justeru, kemungkinan wujud kecenderungan responden dalam memberikan jawapan yang bersifat subjektif.

Di samping itu, kajian ini dijalankan secara keratan rentas (cross-sectional) yang hanya menggambarkan keadaan penggunaan ChatGPT pada satu tempoh masa tertentu. Oleh itu, kajian pada masa hadapan dicadangkan untuk menggunakan pendekatan longitudinal atau kaedah campuran bagi memperoleh pemahaman yang lebih mendalam tentang kesan penggunaan AI generatif terhadap pembelajaran kendiri pelajar serta integriti akademik, khususnya dalam konteks pendidikan TVET.

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Penulis ingin merakamkan setinggi-tinggi penghargaan dan terima kasih kepada pihak pengurusan Kolej Komuniti Arau atas kebenaran dan sokongan yang diberikan bagi membolehkan kajian ini dilaksanakan dengan jayanya. Penghargaan juga ditujukan kepada semua pelajar Kolej Komuniti Arau yang telah terlibat sebagai responden dan memberikan kerjasama sepenuhnya sepanjang proses pengumpulan data dijalankan.

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The Learning Styles of Polytechnic Students Based on the VARK Model

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Abstract

This study aims to identify the dominant learning styles among Semester 1 students, Session 1 2024/2025 at Politeknik Muadzam Shah based on the VARK Model (Visual, Auditory, Read/Write, Kinesthetic). Given that the transition from secondary education to the Technical and Vocational Education and Training ecosystem often triggers ambiguity in learning preferences. This study applies the Fuzzy Delphi Method to obtain precise consensus and address the uncertainty of subjective data. The research sample consists of 150 respondents selected through purposive sampling. The research instrument is a 5-point Likert scale questionnaire, which was subsequently converted into Triangular Fuzzy Numbers for the defuzzification process. The findings indicate that the Read/Write learning style recorded the highest score (Amax = 0.853), followed by Visual (Amax = 0.797), Aural (Amax = 0.733), while the Kinesthetic style recorded the lowest score (Amax = 0.617). All items achieved the threshold value ($d \leq 0.2$), confirming a strong group consensus. The results summarize new students rely more on written notes and visuals rather than physical activities at the beginning of their studies. The implications suggest that lecturers at Polytechnics should strengthen text-based and graphic-based instructional modules progressively before fully emphasizing workshop practicals to ensure a more effective learning transition.

Keywords **:** *Learning Styles; VARK Model; Fuzzy Delphi Method; Polytechnics*

I. INTRODUCTION

Technical and Vocational Education and Training (TVET) in Malaysia is currently undergoing a phase of digital transformation that demands greater effectiveness in the teaching and learning process (PdP). Politeknik Muadzam Shah (PMS), as one of the leading TVET institutions under the Ministry of Higher Education, continuously strives to ensure that the quality of its graduates aligns with industry requirements. However, one of the main challenges faced by educators is understanding the diversity of students' learning styles, particularly among Semester 1 students of Session 1 2024/2025, who represent a post-pandemic generation with unique cognitive tendencies.

The VARK model introduced by Neil Fleming has become a critical instrument in identifying whether students tend to prefer Visual (V), Auditory (A), Read/Write (R), or Kinesthetic (K) learning styles. At the Polytechnic level, understanding this VARK profile is extremely important because technical syllabi require a balance between theoretical mastery and practical skills. Without accurate data regarding dominant learning styles, there is a high risk of mismatch between lecturers' delivery methods and students' learning reception, which may ultimately affect students' motivation and academic performance at the early stage of their studies.

This study adopts an innovative approach by applying the Fuzzy Delphi Method (FDM) to analyze students' selection of learning styles. The use of FDM in this study aims to address the ambiguity and uncertainty present in students' subjective responses, considering that conventional statistical methods often fail to handle the "grey zone" in human choices. With a sample of 150 Semester 1 students at PMS, the application of the Fuzzy Delphi method enables researchers to obtain a more precise and scientific consensus regarding the most dominant learning styles within this cohort.

Specifically, the introduction of this study highlights that the Read/Write (R) style was identified as the most dominant learning style, followed by Visual (V), Auditory (A), and finally Kinesthetic (K). These findings carry significant implications for instructional design at PMS, where emphasis on textual and graphical literacy should be strengthened before students transition fully into more intensive practical phases. Therefore, this study is expected to serve as a guide for lecturers in designing teaching and learning strategies that are more adaptive and responsive to the actual profiles of today's students.

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II. LITERATURE REVIEW

The analysis of literature from 2020 to 2025 indicates a dynamic trend in students' learning styles within Polytechnic institutions, particularly in addressing the transitional phase of post-pandemic education. Early studies by Rahman et al. [1] and Aziz and Ismail [2] emphasized that technical students traditionally exhibit strong Kinesthetic (K) and Visual (V) tendencies. This is largely due to the nature of the Polytechnic curriculum, which emphasizes psychomotor skills and graphical demonstrations, directly contributing to improved student information retention in engineering and design courses.

However, the shift toward digital learning during the pandemic triggered changes in learning style profiles. Studies by Siti Nor [3] and Tan and Ahmad [4] reported a significant increase in Read/Write (R) preferences through the use of digital notes and platforms such as CIDOS. This phenomenon demonstrates that Polytechnic students, including those at PMS, are capable of adapting their learning styles according to resource availability, where digital textual literacy becomes the primary medium for absorbing academic input before practical skills are applied.

Furthermore, the literature indicates that most students in TVET institutions no longer rely on a single learning style. Yusof and Hashim [5] revealed that more than 60% of students demonstrate Multimodal characteristics, requiring a combination of audio-visual and textual elements simultaneously. These findings are supported by Ariffin et al. [6], who employed the Fuzzy Delphi Method (FDM), where expert consensus showed that the Read/Write (R) style often serves as a foundation or "entry point" for students before they master more complex Kinesthetic (K) skills in workshop settings.

Gender aspects also play a significant role in determining VARK preferences. Studies by Hassan et al. [7] found that male Polytechnic students tend to maintain dominance in the Kinesthetic style, while female students demonstrate higher scores in Read/Write and Aural styles. The implication for PMS students is the need for diverse teaching strategies by lecturers to ensure inclusive engagement between male and female students, particularly in classes with balanced gender compositions.

The integration of emerging technologies such as Artificial Intelligence (AI) and Virtual Reality (VR) has begun to appear prominently in the literature of 2024 and 2025. Rajesh [8] and Ibrahim et al. [9] highlighted that the use of adaptive technologies can automatically match teaching materials with students' VARK profiles. For Semester 1 students at PMS, early exposure to VR could help address gaps in their Visual learning style, thereby facilitating the understanding of abstract concepts without requiring physical presence in potentially risky environments.

Nevertheless, a gap remains in the literature regarding the relationship between learning styles and academic assessment. Abdullah [10] argued that traditional examination systems often favor students with a Read/Write style, while Kinesthetic learners may be disadvantaged. This explains why the present study identified R as the highest scoring style—possibly reflecting the demands of the current Diploma-level assessment system, which still requires strong textual mastery at the early stage of study (Semester 1).

In conclusion, the literature review suggests that the learning styles of Polytechnic students continue to evolve under the influence of technological environments and lecturers' instructional approaches. The use of the Fuzzy Delphi methodology in this study represents a forward-looking step in addressing ambiguity in learning style data. The results of this analysis not only fill gaps in the local literature but also provide a strong foundation for PMS to design more personalized and effective teaching modules for Session 1 2024/2025.

III. RESEARCH METHODOLOGY

This study employed a quantitative survey research design combined with the Fuzzy Delphi Method (FDM) to identify dominant learning styles among students. The application of FDM aims to address elements of uncertainty and fuzziness in subjective data derived from human perceptions. Through this approach, the selection of learning styles based on the VARK model is not measured solely through conventional statistical mean values but is further strengthened by calculating the level of group consensus, ensuring that the findings obtained possess high validity and reliability within the context of technical and vocational education.

The study population consisted of students at Politeknik Muadzam Shah (PMS), with a specific focus on Semester 1 students for Session 1 2024/2025. The study sample was selected using a purposive sampling technique, involving 150 respondents. The selection of first-semester students is critical in understanding their initial learning style profile during the transitional phase from secondary education to the Polytechnic learning ecosystem. This sample size is considered sufficient and significant to meet the requirements of Fuzzy Delphi analysis in identifying consistent patterns of learning style tendencies within a single cohort.

The research instrument used was a questionnaire adapted from the VARK Inventory developed by Neil Fleming. The questionnaire consisted of 16 items covering four main dimensions: Visual (V), Auditory (A), Read/Write (R), and Kinesthetic (K). Each item was evaluated using a 5-point Likert scale, allowing respondents to

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indicate their level of agreement with the given statements. The scale values were subsequently converted into Triangular Fuzzy Numbers (TFN) consisting of a minimum value (m_1), the most plausible value (m_2), and a maximum value (m_3) in order to initiate the mathematical computation process within the Fuzzy Delphi model.

The data analysis procedure was conducted through three main phases within the FDM framework. The first phase involved calculating the Threshold Value (d) to determine the level of consensus for each item, where a value of $d \leq 0.2$ indicates that group agreement has been achieved. The second phase involved determining the percentage of group consensus, which must exceed 75% for each learning style dimension. The final phase involved the Defuzzification process to obtain the final score (Amax). This score was then used to establish the ranking of dominant learning styles, where this study anticipates Read/Write (R) to rank the highest, followed by Visual (V), Aural (A), and Kinesthetic (K).

IV. RESULTS

The findings obtained through the Fuzzy Delphi Method (FDM) indicate that the Read/Write (R) learning style recorded the highest defuzzification score (Amax) of 0.853. This score reflects a very strong tendency among the 150 Semester 1 respondents at Politeknik Muadzam Shah (PMS) toward text-based input and written notes. All items within this dimension achieved the threshold value ($d \leq 0.2$), confirming the existence of a consistent consensus among students regarding their reliance on textual references during the early stage of their studies.

The Visual (V) learning style ranked second with an Amax score of 0.797. Students showed agreement that the use of charts, technical diagrams, and demonstration videos greatly assists them in understanding abstract concepts that are difficult to explain through words alone. These findings indicate that although text remains the primary medium, visual support is a critical element in the cognitive structure of TVET students at PMS for Session 1 2024/2025.

For the Auditory (A) learning style, the recorded score was 0.733, placing it in the third position. This suggests that verbal interaction, face-to-face lectures, and group discussions are well received by students, although they are not as dominant as written or visual inputs. The consensus level for this dimension also met the FDM criteria, indicating that auditory learning patterns exist at a moderate level within the hierarchy of students' learning preferences.

Consistent with the study's projection, the Kinesthetic (K) learning style recorded the lowest score of 0.617. Although Polytechnic institutions are typically associated with hands-on skill-based learning, the FDM data reveals that Semester 1 students have not yet prioritized physical or workshop-based activities as their primary learning preference. This score reflects a relatively low level of psychomotor readiness at the early diploma stage, thereby completing the VARK ranking profile for this study as: R > V > A > K.

V. DISCUSSION

The dominance of the Read/Write (R) learning style among Semester 1 students at PMS reflects a "legacy effect" from the secondary education system, which is heavily oriented toward written examinations. Students who have just enrolled in the Polytechnic tend to carry over their previous study habits that emphasize reading notes and rewriting information for memorization purposes. This discussion aligns with the academic transition theory, which suggests that students tend to rely on the learning methods most familiar to them when facing a new and challenging learning environment.

The Visual (V) learning style ranking in second place indicates significant potential for the use of multimedia technology at PMS. TVET students are naturally attracted to graphical representations due to the nature of technical subjects that require spatial reasoning and visual interpretation. The combination of a high R score and a strong V score suggests that the most effective teaching and learning strategy for this cohort is the provision of printed or digital modules enriched with infographics, flowcharts, technical diagrams, and links to demonstration videos.

Furthermore, the Auditory (A) learning style, which ranked third, indicates that two-way communication in the classroom remains relevant but needs to be supported by structured reference materials. Students may find lectures without written notes difficult to process. Therefore, lecturers should ensure that every lecture session is accompanied by handouts, structured notes, or clear slide presentations in order to accommodate the dominant Read/Write and Visual learning preferences among the respondents.

The most significant finding of this study is the lowest score recorded for the Kinesthetic (K) learning style. This phenomenon can be considered a "TVET paradox", as students who choose Polytechnic education are generally expected to have strong practical inclinations. However, in the context of Semester 1 students, they may experience culture shock or lack of confidence when handling complex workshop equipment. This discussion suggests the need for gradual practical exposure through a scaffolding approach, enabling students' kinesthetic skills to be progressively developed as they advance through subsequent semesters.

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VI. CONCLUSION

This study successfully identified the learning style profile of Semester 1 students at Politeknik Muadzam Shah (PMS) using the Fuzzy Delphi Method (FDM) as a rigorous analytical approach. The findings conclude that the Read/Write (R) learning style is the most dominant, while the Kinesthetic (K) learning style records the lowest level. These findings provide clear implications for academic management and lecturers at PMS to adapt their instructional design in order to meet students' needs during the transitional phase. Greater emphasis should be placed on written materials and visual aids before fully introducing intensive practical activities.

In conclusion, the selection of learning styles should not be viewed as static but rather as an early indicator of the effectiveness of teaching and learning processes (PdP) in TVET institutions. The application of FDM has demonstrated high data validity through the achievement of consistent threshold values across the analysis. Future studies are recommended to examine the evolution of students' learning styles as they progress to higher semesters, in order to determine the extent to which learning preferences shift from theoretical orientation toward practical and hands-on engagement throughout their period of study at the Polytechnic.

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Identifying Students' Learning Styles Using Interpretive Structural Modeling and MICMAC Analysis

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Abstract

Understanding students' learning styles is crucial for designing personalized learning experiences that enhance educational outcomes. However, identifying and analyzing the complex relationships between factors that influence students' learning preferences remains a challenge. This study applies Interpretive Structural Modeling (ISM) and Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) analysis to identify and evaluate the key factors that shape students' learning styles. There are five factors identified which are cognitive abilities, motivation, learning environments, teaching methods, and personal interests. Using ISM, a structural model is developed to represent the interrelationships between different factors, while MICMAC analysis categorizes these factors based on their driving and dependence power. The findings show the final model of learning styles obtained from the ISM process. As a result of the MICMAC analysis, the cognitive abilities factor is classified in the independence variable. Meanwhile, the teaching method factor is classified as a dependent variable. Next, the factors of motivation and learning environments are classified in the linkage variable. Finally, the personal interest factor is classified as an autonomous variable. In conclusion, the results provide a detailed framework for understanding the dynamics of students' learning styles and offer practical insights for educators to tailor their teaching strategies.

Keywords **:** *Learning Styles; Teaching Strategies; Interpretive Structural Modeling; Cross-Impact Matrix Multiplication Applied to Classification; Decision Making*

I. INTRODUCTION

Students' learning styles refer to the preferences and tendencies in how they process and engage with information. The diversity of learning styles among students is influenced by a variety of factors, including cognitive abilities, motivational drivers, and environmental conditions [1]. These factors are often interdependent and must be examined holistically to gain a comprehensive understanding of students' learning behaviors.

While several models have been proposed to categorize learning styles such as Visual, Auditory, Reading/Writing, and Kinesthetic (VARK), recent advancements suggest that a more nuanced approach is necessary, considering the dynamic interplay between these factors [2]. ISM and MICMAC analysis are effective tools for addressing these complexities. ISM helps in developing a clear, hierarchical representation of how various factors influence each other, while MICMAC analysis categorizes these factors based on their driving and dependent power.

This study uses both methodologies (ISM and MICMAC) to develop a student learning style model at Muadzam Shah Polytechnic, Pahang. A total of 70 students representing 7 academic departments at Muadzam Shah Polytechnic were appointed as a participant in this study. All the factors that have been developed in the model during the ISM process are classified into four variables namely independence, dependence, linkage, and autonomous. This classification process is important to identify what measures can be used by lecturers to provide a more effective impact on learning styles.

II. LITERATURE REVIEW

A. Learning Styles and Their Impact

Learning styles have been an essential topic in educational research for decades. Scholars like Fleming and Silver have emphasized that understanding how students prefer to learn can significantly enhance educational practices and improve learning outcomes. The VARK model, which categorizes learners into visual, auditory,

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read/write, and kinesthetic preferences, remains a widely accepted framework. However, newer research challenges the simplicity of these models, highlighting the importance of incorporating emotional, cognitive, and environmental influences in understanding learning preferences [3].

In addition to cognitive abilities, factors such as motivation, emotional intelligence, and self-regulation are increasingly recognized as significant drivers of learning styles [4]. For example, motivated students are more likely to adapt their learning strategies to fit the demands of the environment, leading to changes in how they approach learning tasks [5]. Environmental factors, including classroom settings and technology integration, also play a pivotal role in determining students' engagement with learning [6].

B. Learning Style Factors

Cognitive abilities encompass the ways an individual perceives, learns, and processes information. This study examines cognitive abilities elements such as perception, attention, memory, language skills, problem-solving and reasoning, executive functions, processing speed, visual and spatial abilities, emotional intelligence, and metacognition [7].

Motivation is a crucial aspect of the learning process, as it determines an individual's engagement and commitment to acquiring new. Learners with high motivation are more likely to actively participate in challenging activities, persist in their efforts, and adopt effective learning strategies. This study examines motivation elements such as intrinsic and extrinsic motivation, needs, goals, drive, incentives, expectancy, arousal, self-determination, persistence, emotions, self-efficacy, social and cultural influences, and reinforcement [8].

Learning environments have a significant impact on student engagement and academic achievement. Research has shown that student learning is closely tied to the time and effort students devote to their studies. This study examines learning environmental elements such as physical environment, social environment, psychological environment, instructional environment, cultural environment, technological environment, organizational environment, learning resources and materials, student-centered environment, and support systems [9].

The relationship between teaching methods and learning styles has been a topic of significant interest in the field of education. Researchers have posited that individuals may utilize distinct "styles" or approaches to acquire knowledge and skills [10, 11]. This study examines teaching methods elements such as teaching content, teaching strategies, instructional resources and materials, teacher's role, student's role, communication and interaction, assessment and evaluation, and pacing and timing [12].

The pursuit of knowledge and the cultivation of personal interests are integral to the human condition, driving individuals to engage in a rich tapestry of learning experiences that shape their intellectual and emotional landscapes. While the significance of educational and occupational interests in predicting learning and work outcomes has been well-documented [13], the deeper complexities of individual interests and their multifaceted development within diverse historical, social, and cultural contexts remain an area ripe for further exploration. This study examines personal interests' elements in learning such as content-related interests, specific learning modalities (visual, auditory, reading/writing, kinesthetic), activity preferences, and goal orientation [14].

C. Interpretive Structural Modeling (ISM)

ISM is a method used to analyze complex systems by organizing and interpreting the relationships between various components. It has been successfully applied to educational contexts to model the influence of different factors on learning outcomes [15]. According to Gupta et al. [16], ISM helps to represent the interdependencies between factors systematically, enabling a clearer understanding of how they interact. In the context of learning styles, ISM allows educators and researchers to visualize how cognitive, motivational, and environmental factors influence students' learning preferences [17].

ISM involves creating a reachability matrix to assess the direct and indirect relationships between elements, followed by the development of a hierarchical model. This approach enables researchers to determine which factors are central in shaping learning outcomes and which ones are more dependent on others [18].

D. MICMAC Analysis

MICMAC analysis, developed by Civello et al. [19], is used to assess the relative importance of factors in a system by categorizing them based on their driving and dependence power. In educational settings, this tool has been used to analyze the influence of factors like teaching methods, motivation, and technology integration on student learning [6]. The MICMAC method divides factors into four categories:

i) Independent (high driving power, low dependence)
ii) Dependent (high dependence, low driving power)
iii) Linking (high driving power, high dependence)
iv) Autonomous (low driving power, low dependence)

These categorizations help in identifying which factors need to be prioritized in designing effective educational strategies. Factors with high driving power, for instance, should be leveraged to optimize learning experiences, while dependent factors may

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require external influences to maximize their impact [19, 20].

III. RESEARCH METHODOLOGY

A. Learning Style Factors & Elements

Learning style factors and elements were collected from a literature review. The main factors in this study consisted of cognitive abilities, motivation, learning environments, teaching methods, and personal interests. The investigation explored how these factors and elements influenced learner performance outcomes in various educational contexts. Table 1 shows the factors and elements involved in learning styles in this study.

Table 1

Factor	Element
Cognitive Abilities	Perception, Attention, Memory, Language Skills, Problem-Solving and Reasoning, Executive Functions, Processing Speed, Visual and Spatial Abilities, Emotional Intelligence, Metacognition
Motivation	Intrinsic and Extrinsic Motivation, Needs, Goals, Drive, Incentives, Expectancy, Arousal, Self-Determination, Persistence, Emotions, Self-Efficacy, Social and Cultural Influences, Reinforcement
Learning Environments	Physical Environment, Social Environment, Psychological Environment, Instructional Environment, Cultural Environment, Technological Environment, Organizational Environment, Learning Resources and Materials, Student-Centered Environment, Support Systems
Teaching Methods	Teaching Content (Subject Matter), Teaching Strategies, Instructional Resources and Materials, Teacher's Role, Student's Role, Communication and Interaction, Assessment and Evaluation, Pacing and Timing
Personal Interests	Content-Related Interests, Specific Learning Modalities (Visual, Auditory, Reading/Writing, Kinesthetic), Activity Preferences, Goal Orientation

B. ISM Approach

Learning style factors and elements were collected from a literature review. Interpretive Structural Modelling is a well-established methodology that has been widely utilized in the field of operations research and management science to analyse complex systems and identify the relationships between various components or elements within those systems. In this study, there are three main steps which are:

1. Step 1 - Identifying Learning Style Factors & Elements:
   Learning style factors and elements were collected from a literature review. The main factors in this study consisted of cognitive abilities, motivation, learning environments, teaching methods, and personal interests.
2. Step 2 - Constructing the Reachability Matrix: Pairwise comparisons were made to assess the relationships between factors. A binary reachability matrix was constructed to indicate whether one factor influenced another (1 for influence, 0 for no influence).
3. Step 3 - Hierarchical Structuring: The reachability matrix was processed to create an ISM model, depicting the factors in a hierarchical structure. This model helped identify the most influential and dependent factors in shaping learning styles.

C. MICMAC Analysis

After developing the ISM model, MICMAC analysis was used to categorize the factors based on their driving power and dependence. Factors were evaluated for their ability to influence other factors and their reliance on other elements in the system. This analysis provided a comprehensive view of the relative importance of each factor. The MICMAC method divides factors into four categories:

i) Independent (high driving power, low dependence)
ii) Dependent (high dependence, low driving power)
iii) Linking (high driving power, high dependence)
iv) Autonomous (low driving power, low dependence)

IV. RESULTS AND DISCUSSION

A. Identifying Learning Style Factors & Elements

Learning style factors and elements were collected from a literature review. The main factors in this study consisted of cognitive abilities, motivation, learning environments, teaching methods, and personal interests. Table 1 shows the factors and elements involved in learning styles in this study.

B. Constructing the Reachability Matrix

Pairwise comparisons were made to assess the relationships between factors. A binary reachability matrix was constructed to indicate whether one

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factor influenced another (1 for influence, 0 for no influence). Table 2 shows the reachability matrix.

Table 2

Learning Style Factor	Cognitive Abilities	Motivation	Learning Environments	Teaching Methods	Personal Interests	**Driving Power**
Cognitive Abilities	1	1	1	1	0	**4**
Motivation	0	1	0	0	0	**1**
Learning Environments	0	1	1	1	0	**3**
Teaching Methods	0	1	1	1	0	**3**
Personal Interests	0	0	0	0	1	**1**
Dependence Power	**1**	**4**	**3**	**3**	**1**	

C. Hierarchical Structuring

The reachability matrix was processed to create an ISM model, depicting the factors in a hierarchical structure. This model helped identify the most influential and dependent factors in shaping learning styles. Figure 1 shows the final model of learning style based on hierarchical structuring in ISM approach.

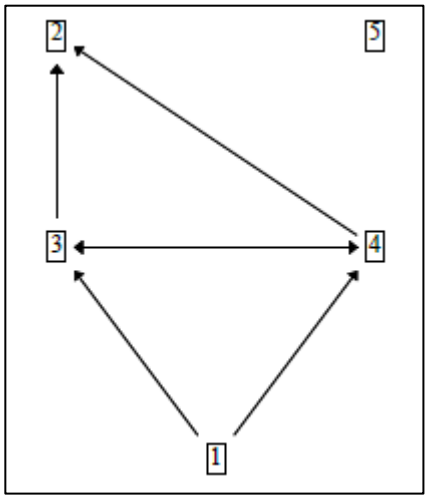

Figure 1

D. MICMAC Analysis of Learning Style Factor

MICMAC analysis divides factors into four categories which is Independent (high driving power, low dependence), Dependent (high dependence, low driving power), Linking (high driving power, high dependence), and Autonomous (low driving power, low dependence). Figure 2 shows the result in MICMAC analysis.

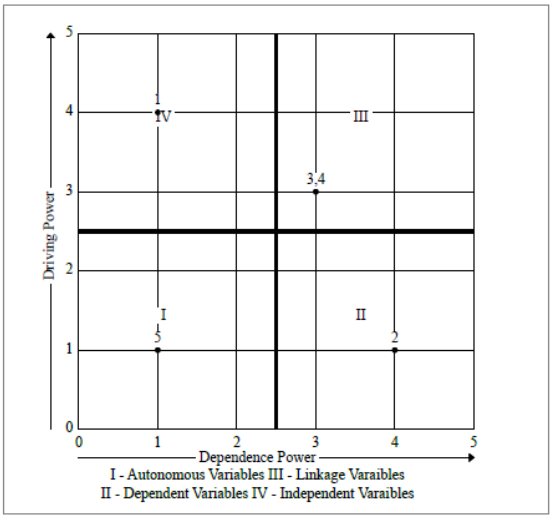

Figure 2

Based on the result in MICMAC analysis, cognitive abilities classified in the independence variable. Independent variable refers to a factor that has high influence on other variables in the system but exhibits low dependency on them. These variables act as drivers of the system, meaning they shape the behavior of other variables without being significantly affected by changes in the system themselves. They are the levers of change that can be strategically targeted to bring about desired outcomes in the system. Understanding and managing independent variables is essential for effective decision-making, as they set the stage for how other variables behave. Independent variables are a primary focus in strategic planning and systems analysis. By identifying and leveraging these variables, lectures and students can influence the system effectively and steer it in a desired direction.

The finding indicated, motivation classified in the dependence variable. Dependent variable refers to a factor or variable whose behavior is influenced by other factors in the system. It is characterized by a high level of dependency on other

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variables but has a low level of influence over them. Dependent variables typically represent outcomes or effects within the system under analysis. Understanding dependent variables helps students and lectures focus on the key drivers that need to be addressed to impact these outcomes.

Meanwhile, learning environments and teaching methods classified in the linkage variable. Linkage variable is a type of variable that exhibits both high influence and high dependency within the system being analyzed. These variables are dynamic and critical because they are both impacted by other variables and simultaneously have a strong impact on them. They represent the levers of change within a system, as they are both sensitive to external conditions and capable of altering the system's state. Understanding these variables helps in identifying critical points where interventions can have widespread effects but require careful monitoring to avoid unintended consequences. Linkage variables are often the focus of strategic interventions because their dual nature of influence and dependency means they are central to the system's dynamics. Mismanaging these variables can destabilize the system, but effectively leveraging them can drive significant progress.

The final MICMAC analysis found that personal interests classified in the autonomous variable. Autonomous variable refers to a type of variable that exhibits low influence and low dependency within the system being analyzed. These variables are relatively isolated, meaning they are neither significantly affected by other variables nor do they strongly influence the system as a whole. They are generally non-critical to the system's dynamics, as their interactions with other variables are minimal. Autonomous variables can be excluded from the central focus of analysis if resources and efforts need to be prioritized for more impactful variables. However, in some cases, they might evolve into more significant variables if the system's dynamics change over time. Autonomous variables are typically of low priority when formulating strategies because their interactions with the system are limited. However, they might still be worth monitoring, as their status could change if new dynamics emerge.

V. CONCLUSION

This study demonstrates the effectiveness of ISM and MICMAC analysis in identifying and analyzing the complex factors influencing students' learning styles. The hierarchical ISM model reveals the interdependencies between cognitive abilities, motivation, learning environments, teaching methods, and personal interests, while MICMAC analysis categorizes these factors based on their influence.

The findings suggest that cognitive abilities play pivotal roles in shaping students' learning styles. Educators can use these insights to prioritize strategies that enhance motivation, learning environments, and personal interests. In conclusion, the results provide a detailed framework for understanding the dynamics of students' learning styles and offer practical insights for educators to tailor their teaching strategies. Future research could explore the impact of cultural and technological factors on students' learning styles, particularly in the context of digital learning environments and diverse educational settings.

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REKABENTUK DAN PEMBANGUNAN MESIN MINI PENCELUR DAN PENCABUT BULU PUYUH UNTUK APLIKASI LATIHAN TVET

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Abstrak

Penternakan puyuh merupakan subsektor ternakan unggas yang semakin berkembang di Malaysia, namun aktiviti pemprosesan seperti penceluran dan pencabutan bulu masih banyak dilakukan secara manual yang menjejaskan kecekapan operasi. Kajian ini bertujuan mereka bentuk dan membangunkan mesin mini pencelur dan pencabut bulu puyuh untuk aplikasi penternakan skala kecil dan latihan TVET. Kajian menggunakan pendekatan *Design and Development Research* (DDR) yang melibatkan fasa analisis keperluan, reka bentuk, pembangunan prototaip dan ujian operasi. Mesin yang dibangunkan menggunakan konsep drum statik dengan tapak berputar serta dilengkapi dengan sistem penceluran yang mempunyai kawalan suhu menggunakan penderia dalam julat 55°C hingga 65°C. Hasil pemerhatian menunjukkan peningkatan kecekapan pemprosesan, pengurangan masa pencabutan bulu serta peningkatan konsistensi hasil berbanding kaedah manual. Secara keseluruhannya, mesin ini berpotensi meningkatkan produktiviti penternak kecil serta menyokong pembelajaran berasaskan amali dalam bidang TVET.

Kata kunci: mesin pencabut bulu; puyuh; penceluran unggas; inovasi pertanian; TVET

Abstract

Quail farming is an emerging poultry sector in Malaysia, However, processing activities such as scalding and defeathering are still largely performed manually, resulting in low efficiency. This study aims to design and develop a mini quail scalder and plucker for small-scale farming and TVET training applications. The study adopts a Design and Development Research (DDR) approach involving needs analysis, design, prototype development, and operational testing. The developed machine utilizes a static drum with a rotating base equipped with rubber plucker fingers and an integrated scalding system with temperature control maintained between 55°C and 65°C using a temperature sensor. Preliminary observations indicate improved processing efficiency, reduced defeathering time, and more consistent results compared to manual methods. Overall, the developed machine demonstrates potential to enhance small-scale quail processing productivity and support hands-on learning in TVET education.

Keywords: *defeathering machine, quail, poultry scalding, agriculture innovation, TVET*

I. PENGENALAN

Penternakan puyuh merupakan salah satu sektor penternakan unggas yang semakin mendapat perhatian kerana kadar pembiakannya yang tinggi serta tempoh pengeluaran yang singkat. Selain menghasilkan telur, puyuh juga menghasilkan daging yang mempunyai nilai pemakanan yang tinggi dan permintaan yang semakin meningkat di pasaran tempatan.

Walaubagaimanapun, aktiviti pemprosesan puyuh selepas penyembelihan masih menghadapi beberapa cabaran, khususnya dalam proses penceluran dan pencabutan bulu. Kaedah manual memerlukan masa yang lama serta tenaga kerja yang tinggi, terutamanya apabila melibatkan jumlah ternakan yang banyak. Selain itu, kaedah manual juga boleh menyebabkan ketidakseragaman dalam hasil pemprosesan.

Penggunaan mesin pencabut bulu unggas telah diperkenalkan bagi meningkatkan kecekapan pemprosesan dan mengurangkan kebergantungan kepada tenaga kerja manual. Walaubagaimanapun, kebanyakan mesin yang terdapat di pasaran direka untuk ayam bersaiz besar dan kurang sesuai digunakan untuk puyuh yang bersaiz kecil.

Dalam konteks Pendidikan dan Latihan Teknikal dan Vokasional (TVET), penggunaan mesin pemprosesan berskala kecil amat penting bagi memberikan pendedahan amali kepada pelajar mengenai teknologi pemprosesan hasil ternakan. Oleh itu, kajian ini dijalankan bagi merekabentuk dan membangunkan sebuah mesin mini pencelur dan pencabut bulu puyuh yang sesuai digunakan oleh penternak kecil serta institusi TVET.

II. KAIAN LITERATUR

A. *Mesin Pencabut Bulu Unggas*

Mesin pencabut bulu unggas telah dibangunkan bagi meningkatkan kecekapan pemprosesan selepas proses penyembelihan. Kajian oleh Adewumi et al. menunjukkan bahawa penggunaan mesin pencabut bulu dapat meningkatkan kadar pemprosesan serta mengurangkan kebergantungan kepada tenaga kerja manual [1]. Mesin ini biasanya menggunakan sistem drum berputar yang dilengkapi dengan getah pencabut bulu (*rubber fingers*) yang berfungsi menanggalkan bulu apabila unggas berputar di dalam drum.

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Akinoso dan Oladosu turut menjelaskan bahawa konfigurasi *rubber fingers* dan kelajuan putaran drum memainkan peranan penting dalam menentukan keberkesanan proses pencabutan bulu [2].

B. *Proses Penceluran dalam Pemprosesan Unggas*

Proses penceluran merupakan langkah penting sebelum proses pencabutan bulu dilakukan. Proses ini melibatkan perendaman unggas dalam air panas bagi melemahkan pegangan bulu pada folikel kulit. Menurut Barbut, suhu penceluran yang sesuai bagi kebanyakan unggas berada dalam julat 55°C hingga 65°C bagi memastikan bulu dapat ditanggalkan dengan mudah tanpa merosakkan kulit karkas [3].

Selain itu, kestabilan suhu dan tempoh penceluran turut mempengaruhi keberkesanan proses pencabutan bulu. Kawalan suhu yang baik dapat meningkatkan kualiti pemprosesan serta mengurangkan kerosakan pada kulit unggas.

C. *Mesin Pemprosesan Unggas Berskala Kecil*

Penternak kecil sering menghadapi kekangan dalam mendapatkan mesin pemprosesan berskala industri disebabkan kos yang tinggi. Menurut laporan FAO, pembangunan mesin pemprosesan unggas berskala kecil dapat membantu meningkatkan produktiviti penternak kecil serta mempercepatkan proses pemprosesan ternakan [4].

Walaupun kebanyakan mesin yang dibangunkan tertumpu kepada ayam, prinsip operasi mesin pencabut bulu juga boleh diaplikasikan kepada unggas lain seperti puyuh kerana struktur bulunya hampir sama.

Kajian terkini menunjukkan bahawa penggunaan mesin pemprosesan unggas berskala kecil terus berkembang bagi menyokong industri ternakan moden dan sistem latihan TVET [5].

III. METODOLOGI KAJIAN

Kajian ini menggunakan pendekatan Rekabentuk dan Pembangunan (*Design and Development Research*, DDR) yang menekankan proses pembangunan produk melalui beberapa fasa sistematik seperti analisis keperluan, reka bentuk, pembangunan prototaip serta penilaian prestasi. Pendekatan DDR sering digunakan dalam kajian yang melibatkan pembangunan produk atau inovasi dalam bidang pendidikan dan teknologi kerana ia membolehkan penyelidik menilai keberkesanan sesuatu reka bentuk melalui proses penambahbaikan secara berperingkat.

Dalam kajian ini, pembangunan mesin mini pencelur dan pencabut bulu puyuh dijalankan melalui tiga fasa utama iaitu analisis keperluan, reka bentuk dan pembangunan prototaip, serta ujian prestasi mesin.

A. *Fasa Analisis Keperluan*

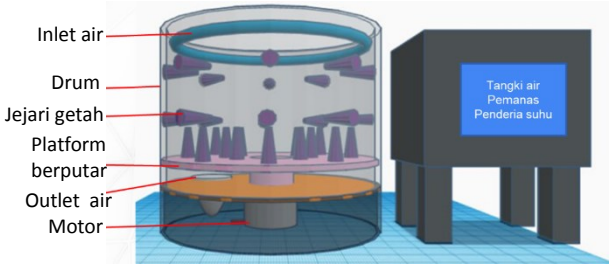
Fasa ini dijalankan bagi mengenal pasti masalah yang dihadapi dalam aktiviti pemprosesan puyuh selepas penyembelihan. Pemerhatian awal menunjukkan bahawa proses pencabutan bulu puyuh masih banyak dilakukan secara manual yang memerlukan masa yang lama serta tenaga kerja yang tinggi. Selain itu, institusi TVET juga menghadapi kekangan dari segi ketiadaan peralatan pemprosesan puyuh berskala kecil yang sesuai digunakan dalam aktiviti pembelajaran amali.

Berdasarkan analisis keperluan ini, pembangunan sebuah mesin mini pencelur dan pencabut bulu puyuh dilihat sebagai satu penyelesaian yang berpotensi untuk meningkatkan kecekapan pemprosesan serta menyediakan kemudahan latihan praktikal kepada pelajar.

B. *Fasa Rekabentuk dan Pembangunan Prototaip*

Pada fasa ini, mesin mini pencelur dan pencabut bulu puyuh direka dengan menggunakan konsep sistem pencabutan bulu berasaskan tapak berputar. Berbeza dengan kebanyakan mesin pencabut bulu unggas yang menggunakan drum berputar, rekabentuk mesin ini mengekalkan drum dalam keadaan statik, manakala bahagian tapak bawah yang dilengkapi dengan getah pencabut bulu (*rubber plucker fingers*) berputar untuk menanggalkan bulu puyuh.

Semasa operasi, puyuh yang telah melalui proses penceluran dimasukkan ke dalam drum mesin. Bahagian tapak berputar yang dipasang dengan *rubber plucker fingers* akan berputar menggunakan motor elektrik. Pergerakan putaran pada tapak ini menyebabkan bulu puyuh tertanggal apabila bersentuhan dengan getah pencabut bulu pada bahagian tapak dan dinding drum.



Rajah 1 – Reka bentuk mesin mini pencelur dan pencabut bulu puyuh

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Rekabentuk ini dipilih bagi memastikan proses pencabutan bulu dapat dilakukan dengan lebih stabil serta sesuai untuk unggas bersaiz kecil seperti puyuh. Selain itu, reka bentuk drum statik juga membantu meningkatkan kestabilan mesin serta memudahkan operasi dalam skala kecil terutamanya untuk tujuan latihan di institusi TVET.

Mesin yang dibangunkan terdiri daripada beberapa komponen utama iaitu:

• drum pencabut bulu (statik)
• tapak berputar yang dilengkapi *rubber plucker fingers*
• *rubber plucker fingers* pada dinding drum
• motor elektrik
• rangka mesin
• tangki penceluran
• sistem saliran air

Reka bentuk mesin ini mengambil kira faktor keselamatan pengguna, kemudahan operasi serta kesesuaian penggunaan dalam skala kecil terutamanya untuk tujuan latihan di institusi TVET.

Jadual 1. Spesifikasi teknikal mesin mini pencelur dan pencabut bulu puyuh (QSP)

Komponen / Parameter	Spesifikasi
Jenis mesin	Mesin mini pencelur dan pencabut bulu puyuh
Konsep operasi	Drum statik dengan tapak berputar
Sistem pencabutan bulu	Rubber plucker fingers
Kedudukan rubber plucker	Tapak berputar dan dinding drum
Sistem pemacu	Motor elektrik
Mekanisme putaran	Putaran pada bahagian tapak
Sistem penceluran	Tangki penceluran dengan pemanas
Kawalan suhu	Penderia suhu
Julat suhu penceluran	55°C – 65°C
Masa rendaman	± 30 saat
Kapasiti operasi	± 5 ekor puyuh setiap kitaran
Masa pencabutan bulu	± 20 saat setiap kitaran
Aplikasi mesin	Penternakan puyuh skala kecil dan latihan TVET

Spesifikasi ini menunjukkan bahawa mesin yang dibangunkan direka untuk operasi berskala kecil dengan penekanan kepada keselamatan, kemudahan penggunaan serta kesesuaian untuk aktiviti latihan amali di institusi TVET.

C. *Sistem Penceluran dan Kawalan Suhu*

Selain fungsi pencabutan bulu, mesin yang dibangunkan turut dilengkapi dengan sistem penceluran bagi memudahkan proses penanggalan bulu puyuh sebelum dimasukkan ke dalam mesin pencabut bulu. Proses penceluran dilakukan dengan merendam puyuh dalam air panas bagi melemahkan pegangan bulu pada folikel kulit.

Bagi memastikan suhu air berada dalam julat yang sesuai, sistem penceluran dilengkapi dengan penderia suhu (*temperature sensor*) yang berfungsi memantau suhu air secara berterusan. Penderia ini disambungkan kepada sistem kawalan yang membolehkan suhu air dikekalkan dalam julat yang ditetapkan.

Dalam kajian ini, suhu penceluran dikawal dalam julat 55°C hingga 65°C, iaitu julat suhu yang sesuai bagi memudahkan proses pencabutan bulu tanpa merosakkan kulit puyuh seperti yang disarankan dalam kajian pemprosesan unggas [3]. Sistem kawalan suhu ini membantu memastikan proses penceluran berlaku secara lebih konsisten berbanding kaedah pemanasan manual.

Penggunaan penderia suhu ini juga meningkatkan keselamatan operasi kerana ia dapat mengelakkan suhu air menjadi terlalu tinggi serta membantu pengguna memantau keadaan proses penceluran dengan lebih mudah.

Rajah 2 – Sistem penceluran dan sensor suhu

D. *Fasa Ujian Prestasi Mesin*

Ujian prestasi dijalankan bagi menilai keberkesanan mesin yang dibangunkan. Beberapa parameter telah diperhatikan semasa ujian dijalankan, antaranya:

• masa pemprosesan bagi seekor puyuh
• tahap keberkesanan pencabutan bulu
• kapasiti pemprosesan mesin bagi setiap kitaran operasi

Puyuh yang telah disembelih terlebih dahulu melalui proses penceluran dengan merendamnya dalam air panas sebelum dimasukkan ke dalam mesin

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pencabut bulu. Mesin kemudian dihidupkan bagi menanggalkan bulu puyuh melalui putaran platform yang dilengkapi dengan *rubber plucker fingers*.

Rajah 3 – Mesin semasa ujian operasi

Hasil ujian prestasi ini digunakan bagi menilai kecekapan mesin serta mengenalpasti potensi penambahbaikan pada reka bentuk mesin yang dibangunkan.

IV. KEPUTUSAN DAN PERBINCANGAN

Hasil ujian menunjukkan bahawa mesin pencabut bulu puyuh yang dibangunkan mampu meningkatkan kecekapan pemprosesan berbanding kaedah manual.

Beberapa dapatan utama kajian adalah:

- masa pencabutan bulu seekor puyuh dapat dikurangkan dengan ketara
- kebanyakan bulu berjaya ditanggalkan dengan baik
- mesin mampu memproses beberapa ekor puyuh dalam satu masa

Penggunaan mesin ini juga dapat mengurangkan keletihan pekerja serta meningkatkan produktiviti pemprosesan ternakan. Dapatan ini selari dengan kajian terdahulu yang menunjukkan bahawa penggunaan mesin pencabut bulu mampu meningkatkan kecekapan pemprosesan unggas dan mengurangkan masa kerja manual [1], [2].

Selain itu, sistem penceluran yang dilengkapi dengan penderia suhu turut membantu meningkatkan keberkesanan proses pencabutan bulu. Kawalan suhu dalam julat yang sesuai memastikan bulu puyuh dapat dilonggarkan dengan lebih baik sebelum proses pencabutan dilakukan. Hasil pemerhatian menunjukkan bahawa penggunaan sistem penceluran yang dikawal oleh penderia suhu ini membantu menghasilkan proses pencabutan bulu yang lebih bersih dan konsisten berbanding kaedah manual.

Penggunaan sistem kawalan suhu ini juga menjadikan mesin yang dibangunkan lebih sesuai digunakan dalam persekitaran latihan TVET kerana ia memberikan pendedahan kepada pelajar mengenai penggunaan teknologi kawalan suhu dalam proses pemprosesan hasil ternakan.

Bagi menilai keberkesanan pembangunan mesin yang dicadangkan, perbandingan pemerhatian telah dilakukan antara kaedah manual, prototaip pertama dan prototaip kedua yang dibangunkan. Perbandingan ini memberi gambaran terhadap penambahbaikan fungsi mesin dari segi kecekapan pemprosesan, kestabilan suhu penceluran serta keberkesanan pencabutan bulu.

Jadual 2 Perbandingan Pemerhatian Antara Kaedah Manual, Prototaip 1 dan Prototaip 2

Aspek Pemerhatian	Kaedah Manual	Prototaip 1	Prototaip 2
Kaedah pencabutan bulu	Dicabut secara manual menggunakan tangan	Mesin pencabut bulu dengan drum statik dan tapak berputar	Mesin pencabut bulu dengan sistem penceluran terkawal
Sistem penceluran	Rendaman air panas secara manual	Rendaman air panas tanpa kawalan suhu	Tangki penceluran dengan penderia suhu
Kawalan suhu	Tiada kawalan khusus	Suhu tidak konsisten	Suhu dikawal dalam julat 55°C – 65°C
Kecekapan pencabutan bulu	Bergantung kepada kemahiran pengendali	Pencabutan bulu lebih cepat tetapi kurang konsisten	Pencabutan bulu lebih bersih dan konsisten
Masa pemprosesan	Lebih lama	Lebih cepat berbanding manual	Lebih cepat dan lebih stabil
Keselamatan operasi	Risiko terkena air panas	Lebih selamat berbanding manual	Lebih selamat dengan sistem kawalan suhu
Kesesuaian untuk latihan TVET	Terhad	Sesuai untuk demonstrasi asas	Sangat sesuai untuk latihan amali TVET

Jadual 2 menunjukkan bahawa pembangunan mesin melalui beberapa fasa prototaip telah menghasilkan penambahbaikan dari segi kestabilan suhu penceluran, kecekapan pencabutan bulu serta keselamatan operasi. Penambahbaikan utama dalam prototaip kedua ialah integrasi sistem penceluran

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dengan kawalan suhu menggunakan penderia, yang membantu memastikan proses penceluran berlaku secara lebih konsisten sebelum proses pencabutan bulu dijalankan.

Pembangunan mesin pencabut bulu puyuh ini menunjukkan bahawa teknologi mekanisasi boleh membantu meningkatkan kecekapan pemprosesan ternakan berskala kecil. Mesin yang dibangunkan juga mempunyai potensi untuk digunakan oleh penternak kecil yang tidak mampu membeli mesin pemprosesan berskala industri.

Selain itu, mesin ini juga boleh digunakan sebagai bahan pembelajaran praktikal dalam kursus agroteknologi dan pemprosesan hasil ternakan di institusi TVET.

V. KESIMPULAN

Kajian ini berjaya merekabentuk dan membangunkan sebuah mesin mini pencelur dan pencabut bulu puyuh berskala kecil yang berpotensi meningkatkan kecekapan pemprosesan ternakan. Mesin yang dibangunkan mampu mengurangkan masa pemprosesan serta membantu meningkatkan produktiviti penternak puyuh berskala kecil.

Selain itu, pembangunan mesin ini turut menyokong pembelajaran berasaskan amali dalam bidang agroteknologi dengan memberi pendedahan kepada pelajar mengenai penggunaan teknologi dalam industri pertanian.

Kajian lanjut boleh dijalankan bagi menambahbaik rekabentuk mesin serta meningkatkan lagi kapasiti pemprosesan.

PENGHARGAAN

Penulis merakamkan penghargaan kepada Kolej Komuniti Rembau atas sokongan dan kemudahan yang diberikan sepanjang proses pembangunan dan pengujian mesin ini.

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PEMBANGUNAN PERANGKAP SERANGGA *GLOW-IN-THE-DARK* BERSEPADU DENGAN PEMBELAJARAN MESIN BAGI PENGESANAN DAN PENGIRAAN SERANGGA

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Abstrak

Serangga perosak merupakan ancaman utama terhadap produktiviti tanaman dan pemantauan secara manual sering memerlukan masa serta tenaga kerja yang tinggi. Kajian ini membangunkan perangkap serangga jenis *glow-in-the-dark* (GITD) yang diintegrasikan dengan pembelajaran mesin bagi tujuan pengesanan dan pengiraan serangga secara automatik. Dua prototaip telah dibangunkan, iaitu prototaip pertama menggunakan pita *glow-in-the-dark*, manakala prototaip kedua menggunakan serbuk strontium aluminate yang dicampurkan dengan gam pelekat serangga. Campuran sebanyak 20g serbuk strontium aluminate dengan 100ml gam pelekat disapu pada permukaan perangkap dan diuji menggunakan beberapa variasi warna. Keputusan menunjukkan rawatan kuning-hijau merekodkan tangkapan tertinggi iaitu purata 31 ekor serangga, berbanding 6 ekor bagi kawalan. Prototaip kedua turut meningkatkan tempoh nyalaan daripada 2–3 jam kepada 4–12 jam. Model pembelajaran mesin yang dibangunkan menggunakan *Google Teachable Machine* menunjukkan ketepatan purata 87.5% dalam pengelasan serangga. Dapatan kajian membuktikan bahawa integrasi bahan fotoluminesen dan pembelajaran mesin berpotensi meningkatkan kecekapan pemantauan serangga dalam sistem pertanian pintar dan menyokong SDG 2, SDG 12 dan SDG 13.

Kata kunci: *glow-in-the-dark*, perangkap serangga, pembelajaran mesin, pemantauan serangga, pertanian pintar

Abstract

Insect pests are a major threat to crop productivity, while manual monitoring requires considerable time and labour. This study developed a glow-in-the-dark (GITD) insect trap integrated with machine learning for automatic insect detection and counting. Two prototypes were developed, where the first prototype used glow-in-the-dark tape and the second prototype used strontium aluminate powder mixed with insect adhesive glue. A mixture of 20 g strontium aluminate and 100 ml adhesive glue was applied to the trap surface and tested with several colour variations. The results showed that the yellow-green treatment recorded the highest insect capture, with an average of 31 insects compared to only 6 insects for the control treatment. The second prototype also improved glow duration from 2–3 hours to 4–12 hours. The machine learning model developed using Google Teachable Machine achieved an average classification accuracy of 87.5%. The findings indicate that the integration of photoluminescent materials and machine learning has strong potential to improve insect monitoring efficiency in smart agriculture while supporting SDG 2, SDG 12 and SDG 13.

Keywords: *glow-in-the-dark, insect trap, machine learning, insect monitoring, smart farming*

I. PENGENALAN

Serangga perosak merupakan salah satu ancaman utama kepada pengeluaran tanaman pertanian. Serangan serangga boleh menyebabkan kerosakan pada daun, batang serta buah tanaman sehingga menjejaskan kualiti dan kuantiti hasil. Dalam usaha mengawal serangan ini, penggunaan racun kimia sering menjadi pilihan utama petani. Walaubagaimanapun, penggunaan racun kimia secara berterusan boleh memberi kesan negatif terhadap alam sekitar, kesihatan manusia serta meningkatkan kos pengeluaran pertanian.

Pendekatan Pengurusan Perosak Bersepadu (*Integrated Pest Management*, IPM) diperkenalkan sebagai strategi yang lebih lestari dengan menggabungkan pelbagai kaedah kawalan perosak termasuk kawalan fizikal, biologi dan mekanikal. Salah satu kaedah yang digunakan ialah perangkap serangga, yang berfungsi untuk menarik dan memerangkap serangga perosak bagi tujuan pemantauan populasi.

Perangkap serangga lazimnya menggunakan faktor tarikan seperti warna, cahaya atau bahan kimia tertentu. Kajian menunjukkan bahawa warna tertentu seperti kuning, biru dan hijau mampu menarik pelbagai jenis serangga perosak seperti whitefly, aphids dan thrips.

Seiring dengan perkembangan teknologi digital, penggunaan pembelajaran mesin (*machine learning,* ML) semakin meluas dalam sektor pertanian, khususnya dalam analisis imej bagi pengesanan objek. Teknologi ini berpotensi membantu proses pengesanan dan pengiraan serangga secara automatik tanpa memerlukan pemerhatian manual yang berterusan.

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Oleh itu, kajian ini bertujuan membangunkan perangkap serangga jenis *glow-in-the-dark* yang diintegrasikan dengan pembelajaran mesin bagi menyokong pemantauan populasi serangga secara lebih sistematik.

II. KAJIAN LITERATUR

A. *Perangkap berwarna dalam Pemantauan Serangga*

Perangkap berwarna telah digunakan secara meluas dalam pemantauan populasi serangga perosak. Kajian menunjukkan bahawa serangga seperti whitefly dan aphids sangat tertarik kepada warna kuning kerana sensitiviti visual mereka terhadap spektrum warna tersebut [2]. Selain itu, perangkap biru sering digunakan untuk menarik thrips dalam sistem tanaman rumah hijau.

Santer et al. [4] menyatakan bahawa keberkesanan perangkap serangga sangat bergantung kepada persepsi visual serangga terhadap warna tertentu. Oleh itu, pemilihan warna perangkap yang sesuai adalah penting bagi meningkatkan kecekapan perangkap dalam menarik serangga sasaran.

B. *Penggunaan Bahan Fotoluminesen*

Bahan fotoluminesen seperti strontium aluminate mempunyai keupayaan untuk menyerap tenaga cahaya pada waktu siang dan memancarkan cahaya dalam keadaan gelap. Sifat ini membolehkan bahan tersebut digunakan sebagai sumber cahaya pasif tanpa memerlukan tenaga elektrik. Dalam konteks perangkap serangga, penggunaan bahan fotoluminesen berpotensi meningkatkan keterlihatan perangkap pada waktu malam serta menarik serangga yang aktif dalam keadaan cahaya rendah. [5].

Kajian terkini menunjukkan bahawa bahan fotoluminesen berasaskan strontium aluminate mempunyai tempoh nyalaan yang lebih panjang dan lebih stabil berbanding bahan glow-in-the-dark konvensional [6].

C. *Pembelajaran Mesin dalam Pertanian Pintar*

Pembelajaran mesin (*machine learning* – ML) merupakan teknologi kecerdasan buatan yang membolehkan sistem komputer mengenal pasti corak dalam data dan membuat keputusan secara automatik. Dalam sektor pertanian, teknologi ini telah digunakan untuk mengesan penyakit tanaman, mengenal pasti serangga perosak serta menganalisis imej tanaman [3].

Model klasifikasi imej membolehkan sistem mengenal pasti objek dalam imej dan mengira bilangan objek secara automatik. Platform seperti *Google Teachable Machine* membolehkan pengguna membangunkan model pengecaman imej dengan mudah tanpa memerlukan kemahiran pengaturcaraan yang kompleks.

Selain itu, penggunaan teknik computer vision dan pembelajaran mesin dalam pengesanan serangga semakin meningkat kerana mampu meningkatkan ketepatan pemantauan dan mengurangkan kebergantungan kepada pemerhatian manual [7], [8].

III. METODOLOGI KAJIAN

Kajian ini menggunakan pendekatan Rekabentuk dan Pembangunan (*Design and Development Research*, DDR) yang menekankan proses pembangunan produk melalui beberapa fasa sistematik seperti analisis keperluan, reka bentuk, pembangunan prototaip serta penilaian prestasi. Pendekatan DDR sering digunakan dalam kajian yang melibatkan pembangunan produk atau inovasi dalam bidang pendidikan dan teknologi kerana ia membolehkan penyelidik menilai keberkesanan sesuatu reka bentuk melalui proses penambahbaikan secara berperingkat.

A. *Pembangunan Prototaip*

Kajian ini menggunakan pendekatan pembangunan prototaip yang melibatkan rekabentuk, pembangunan dan pengujian perangkap serangga. Dua prototaip perangkap telah dibangunkan seperti berikut:

Prototaip	Bahan	Tempoh pancaran
P1	Pita *glow-in-the-dark* (GITD) + gam pelekat serangga	2–3 jam
P2	Serbuk strontium aluminate + gam pelekat serangga	4–12 jam

Prototaip kedua dibangunkan bagi meningkatkan tempoh pancaran perangkap.

Rajah 1 - Prototaip 1 (kiri) dan Prototaip 2 (kanan)

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B. *Penyediaan Perangkap*

Sebanyak 20 g serbuk strontium aluminate dicampurkan dengan 100 ml gam pelekat serangga sehingga sebati. Campuran ini kemudian disapu pada permukaan plastik perangkap.

Lima rawatan telah dijalankan seperti berikut:

Rawatan	Campuran
C	Kawalan
T1	Gam + kuning
T2	Gam + hijau
T3	Gam + kuning-hijau
T4	Gam + biru

Perangkap digantung secara rawak di antara tanaman.

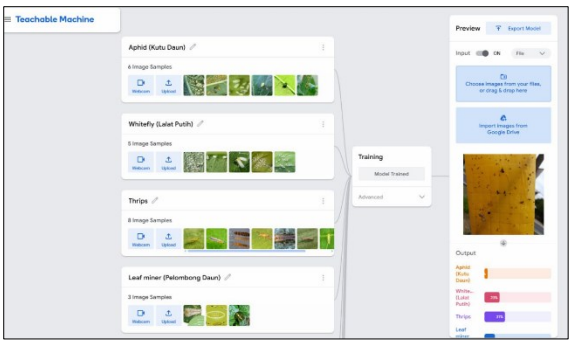
Rajah 2 – rawatan berbeza digantung secara rawak

C. *Integrasi Pembelajaran Mesin*

Model pembelajaran mesin (*machine learning*) dibangunkan menggunakan platform *Google Teachable Machine* bagi mengenalpasti spesies serangga yang terperangkap secara automatik.

Langkah pembangunan model:

1. Pengumpulan imej serangga daripada perangkap
2. Pelabelan imej mengikut kategori serangga
3. Latihan model klasifikasi
4. Pengujian model menggunakan kamera telefon pintar



Rajah 3 – *Google Teachable Machine* digunakan untuk mengenalpasti serangga dan pecahan peratus serangga pada perangkap

Model ini digunakan untuk mengenal pasti spesies serangga dan mengira jumlah tangkapan secara automatik.

Berikut adalah konsep Sistem GITD Sticky Trap Bersepadu dengan pembelajaran mesin (*Machine Learning*)

Perangkap GITD
↓
Serangga terperangkap
↓
Imej diambil menggunakan kamera
↓
Model Machine Learning
↓
Pengecaman spesies serangga
↓
Pengiraan automatik serangga

IV. KEPUTUSAN DAN PERBINCANGAN

Keputusan eksperimen menunjukkan bahawa rawatan T3 (kuning-hijau) berjaya memerangkap bilangan serangga tertinggi berbanding rawatan lain.

Rawatan	Keputusan
C	Rendah
T1	Sederhana
T2	Sederhana
T3	Tinggi
T4	Sederhana

Keputusan ini menunjukkan bahawa spektrum warna kuning-hijau mempunyai daya tarikan visual yang lebih tinggi terhadap serangga perosak.

Selain itu, penggunaan serbuk strontium aluminate dalam prototaip kedua berjaya meningkatkan tempoh nyalaan antara **4 hingga 12 jam**, berbanding prototaip pertama yang hanya mampu menyala selama **2 hingga 3 jam**.

Keputusan dari Model pembelajaran mesin menunjukkan prestasi yang memuaskan dengan ketepatan purata 87.5%.

Kategori Serangga	Accuracy (%)
Aphid	91.0
Whitefly	88.0
Thrips	86.0
Lain-lain	85.0
Purata	**87.5**

Kajian GITD Sticky Trap menyokong beberapa Matlamat Pembangunan Lestari (SDG), antaranya:

SDG 2 – Sifar Kelaparan

Menyokong pengeluaran makanan yang lebih mampan melalui kawalan serangga perosak secara

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fizikal tanpa penggunaan racun kimia yang berlebihan.

SDG 12 – Penggunaan dan Penghasilan yang Bertanggungjawab

Menggalakkan penggunaan kaedah kawalan perosak yang lebih mesra alam dan mengurangkan residu bahan kimia dalam sistem pertanian.

SDG 13 – Tindakan Iklim

Mengurangkan penggunaan racun kimia serta tenaga elektrik dalam sistem kawalan serangga, sekaligus menyokong amalan pertanian yang lebih lestari.

V. KESIMPULAN

Kajian ini membangunkan satu inovasi perangkap serangga *glow-in-the-dark* yang menggunakan bahan fotoluminesen strontium aluminate bagi meningkatkan keberkesanan perangkap pada waktu malam. Prototaip kedua menunjukkan prestasi yang lebih baik dari segi tempoh nyalaan dan keupayaan memerangkap serangga.

Selain itu, integrasi pembelajaran mesin membolehkan proses pengesanan dan pengiraan serangga dilakukan secara automatik melalui analisis imej. Inovasi ini berpotensi menyokong pembangunan pertanian pintar serta boleh digunakan sebagai alat bantu pembelajaran dalam bidang agroteknologi.

PENGHARGAAN

Penulis merakamkan penghargaan kepada Kolej Komuniti Rembau atas sokongan dan kemudahan yang diberikan sepanjang proses pembangunan dan pengujian mesin ini.

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Kajian Faktor Yang Mempengaruhi Pemilihan TVET Sebagai Laluan Kerjaya Dalam Kalangan Pelajar Kolej Komuniti Pasir Gudang

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Abstrak

Pendidikan dan Latihan Teknikal dan Vokasional (TVET) merupakan satu laluan pendidikan yang menekankan kemahiran praktikal dan berperanan penting dalam memenuhi keperluan tenaga kerja industri di Malaysia. Kajian ini bertujuan untuk mengenal pasti faktor-faktor yang mempengaruhi pemilihan TVET sebagai laluan kerjaya dalam kalangan pelajar Kolej Komuniti Pasir Gudang iaitu dengan memberi tumpuan kepada aspek minat pelajar, persepsi terhadap kebolehpasaran graduan, serta sokongan keluarga dan rakan sebaya. Kajian ini menggunakan reka bentuk kuantitatif berbentuk tinjauan deskriptif dengan penglibatan seramai 145 orang pelajar sebagai responden di mana data dikumpul melalui soal selidik berstruktur skala Likert dan dianalisis menggunakan perisian SPSS bagi mendapatkan nilai min dan peratusan. Dapatan kajian menunjukkan bahawa ketiga-tiga faktor yang dikaji berada pada tahap tinggi, iaitu minat pelajar (skor min = 3.68), persepsi terhadap kebolehpasaran graduan (skor min = 3.69) dan sokongan keluarga serta rakan sebaya (skor min = 3.67). Hasil analisis ini menunjukkan bahawa pelajar mempunyai kecenderungan positif terhadap TVET sebagai laluan pendidikan dan kerjaya. Secara keseluruhannya, kajian ini menunjukkan bahawa minat pelajar, persepsi terhadap kebolehpasaran graduan TVET, serta sokongan sosial mempengaruhi pemilihan TVET sebagai laluan kerjaya, di samping membuktikan bahawa TVET relevan dengan keperluan industri.

Kata kunci: TVET, pemilihan kerjaya, minat pelajar, kebolehpasaran graduan, sokongan sosial.

Abstract

Technical and Vocational Education and Training (TVET) is an educational pathway that emphasizes practical skills and plays an important role in meeting the needs of the industry workforce in Malaysia. This study aims to identify factors that influence the selection of TVET as a career path among students of Pasir Gudang Community College, namely by focusing on aspects of student interest, perceptions of graduate marketability, and family and peer support. This study uses a quantitative design in the form of a descriptive survey with the involvement of 145 students as respondents where data was collected through a structured Likert scale questionnaire and analyzed using SPSS software to obtain mean values and percentages. The findings of the study showed that all three factors studied were at a high level, namely student interest (mean score = 3.68), perception of graduate marketability (mean score = 3.69) and family and peer support (mean score = 3.67). The results of this analysis showed that students had a positive tendency towards TVET as an educational and career path. Overall, this study showed that student interest, perception of TVET graduate marketability, and social support influenced the selection of TVET as a career path, in addition to proving that TVET is relevant to industry needs.

Keywords: *TVET, career choice, student interest, graduate employability, social support.*

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I.0 PENGENALAN

Pendidikan Teknikal dan Latihan Vokasional (TVET) terus memainkan peranan penting dalam membangunkan modal insan dan memenuhi keperluan pekerja dalam sektor perindustrian Malaysia. Selain itu, TVET menawarkan peluang pendidikan alternatif kepada pelajar yang lebih cenderung kepada kemahiran teknikal.

Walaupun pelbagai usaha telah dijalankan oleh pihak kerajaan dan institusi pendidikan untuk menambah baik TVET, pilihan pelajar untuk mengikuti TVET dipengaruhi oleh beberapa faktor. Ini termasuk motivasi pembelajaran, persepsi tentang persekitaran kerja, dan kesan sosial terhadap ahli keluarga dan rakan sekerja. Pandangan negatif terhadap pendidikan TVET boleh mengurangkan minat dan motivasi pelajar untuk menyertai program ini, seterusnya menjejaskan kejayaan dan keberkesanan program TVET.Justeru, kajian ini bertujuan untuk mengenal pasti faktor-faktor yang mempengaruhi pemilihan TVET sebagai laluan kerjaya di kalangan pelajar Kolej Komuniti Pasir Gudang.

1.1 Latar Belakang Kajian

Kolej Komuniti Pasir Gudang merupakan salah satu institusi yang menawarkan program Pendidikan Teknikal dan Latihan Vokasional (TVET) kepada pelajar yang dapat memenuhi permintaan industri. Program TVET menawarkan pembelajaran secara praktikal serta pengetahuan teknikal yang boleh meningkatkan penguasaan kemahiran praktikal di tempat kerja.

Walau bagaimanapun, terdapat pelbagai faktor yang mempengaruhi pemilihan TVET sebagai laluan pendidikan dan pekerjaan. Ini termasuk faktor seperti kesan rakan sebaya, persepsi orang ramai terhadap TVET, dan sokongan daripada keluarga. Di samping itu, faktor seperti motivasi dan minat juga memainkan peranan penting dalam menentukan kemungkinan pelajar akan memilih bidang yang dinyatakan di atas. Sehubungan dengan itu, matlamat kajian ini adalah untuk mengenal pasti faktor-faktor yang mempengaruhi pemilihan TVET sebagai laluan kerjaya di Kolej Komuniti Pasir Gudang.

1.2 Penyataan Masalah

Walaupun program TVET menawarkan pengalaman praktikal dan persediaan kerjaya jangka panjang, terdapat beberapa peluang pembelajaran yang masih belum mencapai tahap standard yang ditetapkan.Beberapa faktor, seperti persepsi negatif terhadap program TVET, maklumat kekurangan peluang pekerjaan, dan kesan keluarga serta rakan sebaya, boleh mempengaruhi keputusan pelajar untuk meneruskan bidang pengajian di dalam TVET. Terdapat banyak kajian telah dijalankan di Kolej Komuniti Pasir Gudang untuk mengenal pasti faktor-faktor yang mempengaruhi hasil pembelajaran. Walau bagaimanapun, adalah penting untuk memahami faktor utama yang mempengaruhi pilihan pelajar terhadap TVET, jadi intervensi boleh digunakan untuk meningkatkan penglibatan pelajar.

1.3 Objektif Kajian

Kajian ini bertujuan untuk:

- Mengenal pasti **tahap minat pelajar** terhadap pemilihan TVET sebagai laluan kerjaya.
- Menilai **persepsi pelajar terhadap kebolehpasaran graduan TVET** dalam menentukan pilihan kerjaya.
- Menentukan **pengaruh sokongan keluarga dan rakan sebaya** terhadap pemilihan TVET sebagai laluan kerjaya.

1.4 Persoalan Kajian

Kajian ini bertujuan untuk menjawab persoalan berikut:

- Apakah **tahap minat pelajar** terhadap pemilihan TVET sebagai laluan kerjaya di Kolej Komuniti Pasir Gudang?
- Bagaimanakah **persepsi terhadap kebolehpasaran graduan TVET** mempengaruhi pemilihan kerjaya pelajar?
- Sejauh manakah **sokongan keluarga dan rakan sebaya** mempengaruhi pemilihan TVET sebagai laluan kerjaya?

1.5 Kepentingan Kajian

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Kajian ini diharapkan dapat memberikan manfaat kepada:

- **Pelajar** dapat meningkatkan kesedaran dan kefahaman mereka tentang peluang kerjaya yang disediakan oleh program TVET, serta membantu mereka merumuskan pendapat yang lebih tepat tentang pendidikan dan laluan kerjaya.

- **Pihak pengurusan Kolej Komuniti Pasir Gudang**, sebagai rujukan untuk menambahbaik program TVET dan strategi promosi.

- **Penggubal kurikulum** dapat membangunkan kurikulum yang menyokong pembangunan dan pelaksanaan TVET di Malaysia secara menyeluruh.

- **Pengkaji akademik**, sebagai sumber maklumat dan data untuk kajian ini, menyediakan data dan analisis yang berguna sebagai asas untuk menganalisis tahun-tahun lepas dalam industri TVET, khususnya dalam memahami faktor yang mempengaruhi pemilihan bidang pendidikan dan pekerjaan.

1.6 Skop Kajian

- Kajian ini tertumpu kepada pelajar Kolej Komuniti Pasir Gudang yang mengikuti program TVET. Skop kajian meliputi tiga faktor utama iaitu minat pelajar, persepsi terhadap kebolehpasaran graduan, dan sokongan keluarga/rakan sebaya dalam mempengaruhi pemilihan TVET sebagai laluan kerjaya.

2.0 SOROTAN KAJIAN

Menurut Syed Lamsah Syed Chear (2025), projek Pendidikan Teknikal dan Latihan Vokasional (TVET) Institut Pengajian Tinggi (IPT) Malaysia kini sedang dijalankan. Kajian ini menunjukkan bahawa TVET mempunyai peranan penting dalam mencegah kekurangan buruh yang menjejaskan permintaan industri dan menghalang pembangunan ekonomi negara. Pelaksanaan kurikulum berfokuskan industri dan latihan praktikal membantu meningkatkan tahap kelulusan TVET di alam pekerjaan.

Selain itu, kajian ini mendapati permintaan terhadap pekerja dalam sektor teknikal dan vokasional semakin meningkat khususnya dalam bidang pembuatan, teknologi dan pembuatan. Ini menunjukkan TVET mempunyai prospek kerja yang baik dan boleh memberi peluang kerja yang stabil kepada graduan. Secara ringkasnya, kajian ini menunjukkan bahawa TVET di IPT Malaysia selaras dengan keperluan tenaga kerja,permintaan industri dan sokongan kerajaan.

Mohamad Zhurad Haron (2024) dalam kajian yang bertajuk Halatuju Pelajar TVET: Kesan Minat Terhadap Niat Kerjaya Pelajar Teknologi Automotif Di Kolej Vokasional menyatakan minat yang tinggi dalam bidang yang dipelajari membantu pelajar membuat pilihan kerjaya lebih tepat, sejajar dengan Teori Holland yang menekankan kepentingan keserasian antara minat dan pilihan kerjaya untuk kejayaan masa depan. Faktor lain seperti media, jantina, sokongan keluarga, dan pengaruh sosial turut mempengaruhi minat dan niat kerjaya.

Kajian oleh Mohd Zulfakar Mohd Nawi dan Mohd Huzaifah Mohd Anuar (2023) bertajuk Pengaruh Peranan Ibu Bapa Terhadap Kemasukan Pelajar ke Institusi Teknikal dan Vokasional: Satu Kajian Tinjauan Sistematik dan mengkaji kesan ibu bapa terhadap keperluan pendidikan institusi TVET. Dapatan kajian menunjukkan bahawa sokongan ibu bapa memainkan peranan penting dalam mempengaruhi kemasukan pelajar ke institusi TVET. Sokongan ini merangkumi penglibatan ibu bapa, galakan terhadap minat pelajar serta persepsi positif terhadap pendidikan vokasional. Secara keseluruhannya, kajian ini menegaskan bahawa pengaruh ibu bapa merupakan faktor penting dalam membantu pelajar membuat keputusan memilih TVET sebagai laluan pendidikan dan kerjaya.

Farrah Syamimi Che Ros et al (2023) bertajuk Kebolehpasaran Graduan Wanita TVET ILJTM Zon Sabah dalam Pemilihan Kerjaya. Kajian ini mengkaji keberkesanan graduan TVET dalam menyiapkan tugasan berkaitan kerja. Kajian ini menawarkan pandangan tentang faktor-faktor yang mempengaruhi pemilihan pekerjaan dan tabiat kerja pelajar di institusi TVET yang terletak di bawah ILJTM Zon Sabah. Dapatan kajian menunjukkan bahawa kemahiran teknikal, pengetahuan praktikal, dan motivasi diri adalah faktor penting dalam meningkatkan kebolehpasaran graduan wanita. Kajian ini bertujuan untuk menunjukkan bahawa pendidikan TVET boleh mewujudkan peluang kerja yang lebih menguntungkan dan meningkatkan kadar pengijazahan di tempat kerja.

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Kajian yang dijalankan oleh Azri bin Said (2022) bertajuk Kualiti dan Kebolehpasaran Graduan Kolej Vokasional, yang mengkaji kualiti graduan serta kebolehpasaran mereka di tempat kerja. Kajian ini menyumbang kepada usaha institusi pendidikan vokasional dalam melahirkan graduan yang mempunyai kemahiran teknikal, intelek, dan profesional yang diperlukan oleh industri. Dapatan kajian menunjukkan bahawa latihan kemahiran, pengalaman praktikal, dan penguasaan kemahiran insaniah merupakan faktor penting yang meningkatkan kebolehpasaran graduan kolej vokasional. Kajian ini mencadangkan program pendidikan vokasional dapat melahirkan pekerja mahir yang memenuhi permintaan industri dan menambah bilangan pekerja di sekolah siswazah.

3.0 METODOLOGI KAJIAN

3.1 Responden

Populasi dalam kajian ini ialah pelajar Kolej Komuniti Pasir Gudang bagi sesi II 2025/2026. Sampel terdiri daripada 145 pelajar dari semester satu hingga semester tiga.

Saiz sampel (S) yang dicadangkan ialah seramai 103 orang daripada jumlah populasi (N) sebanyak 145 orang berdasarkan jadual penentuan sampel oleh Krejcie dan Morgan (1970).Oleh itu, pemilihan 145 orang pelajar di Kolej Komuniti Pasir Gudang adalah mencukupi untuk mewakili populasi kajian.

Pelajar Sijil Kolej Komuniti Pasir Gudang dipilih sebagai responden kerana mereka mewakili populasi pelajar di Kolej Komuniti Pasir Gudang Selain itu, hasil kajian ini juga boleh dijadikan rujukan oleh pengkaji lain pada masa akan datang.

3.2 Instrumen Kajian

Kajian ini menggunakan tinjauan deskriptif sebagai reka bentuk kajian kuantitatif. Melalui edaran soal selidik, reka bentuk ini digunakan untuk menentukan tahap minat pelajar, persepsi pelajar mengenai kebolehpasaran graduan TVET dan kesan sokongan rakan sebaya dan keluarga. Soal selidik adalah alat yang digunakan dalam kajian ini untuk mengumpul data. Soal selidik ini dibahagikan kepada dua bahagian khususnya iaitu:

Bahagian A : Demografi

Bahagian B : Faktor yang mempengaruhi pemilihan TVET sebagai laluan kerjaya iaitu mengenal pasti **tahap minat pelajar**,**persepsi pelajar terhadap kebolehpasaran graduan TVET** dan **pengaruh sokongan keluarga dan rakan sebaya**.Bahagian ini mengandungi 15 soalan kesemuanya

Bahagian A soal selidik ini adalah latar belakang responden, yang mempunyai kaitan dengan umur, jantina, program, dan semester akademik. Bahagian B soal selidik ini merangkumi soalan tertutup dengan skala Likert.

Satu set soalan khusus dengan kemungkinan respons berasaskan skala *Likert* membentuk soal selidik tertutup atau berstruktur. Sangat Tidak Setuju (1), Tidak Setuju (2), Setuju (3), dan Sangat Setuju (4) membentuk format skala Likert.

3.3 Kaedah Penganalisaan Data

Perisian Statistical Package For Social Sciences (SPSS) For Windows Version 23.0 telah digunakan pada komputer untuk menilai data yang dikumpul. Nilai min dan peratusan ditentukan sebagai sebahagian daripada proses analisis data.

3.3.1 Min

Nilai min digunakan untuk mengkaji faktor yang mempengaruhi pemilihan TVET sebagai laluan kerjaya dalam kalangan pelajar Kolej Komuniti Pasir Gudang

3.3.2 Peratusan

Selain itu, peratus digunakan untuk menilai kurikulum, umur, jantina, dan semester pengajian sampel yang dipilih.

3.4 Kesahan dan Kebolehpercayaan Instrumen

Untuk menjamin kesahan (validity) kandungan, soal selidik akan melalui semakan oleh dua orang pakar dalam bidang pendidikan. Manakala untuk kebolehpercayaan (reliability), ujian *Alpha Cronbach* akan dilaksanakan ke atas data awal untuk memastikan setiap item mempunyai nilai kebolehpercayaan melebihi 0.70.

3.5 Etika Kajian

Kajian ini akan dijalankan dengan mematuhi garis panduan etika penyelidikan. Responden akan dimaklumkan tentang tujuan kajian dan penglibatan mereka adalah secara sukarela. Segala maklumat responden akan dirahsiakan dan digunakan hanya untuk tujuan akademik sahaja. Selain itu, identiti responden tidak akan didedahkan kepada mana-mana pihak dan semua data yang diperoleh akan digunakan semata-mata bagi tujuan analisis kajian.

4.0 ANALISIS DAN DAPATAN KAJIAN

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Dapatan analisis data daripada soal selidik yang diberikan kepada peserta kajian ini. Tujuan analisis ini adalah untuk mengenal pasti faktor yang mempengaruhi pemilihan responden terhadap Pendidikan dan Latihan Teknikal dan Vokasional (TVET). Teknik statistik deskriptif digunakan untuk menganalisis data bagi menentukan peratusan dan kekerapan bagi setiap item yang dikaji.

15 item soal selidik dalam kajian ini telah dipecahkan kepada tiga konstruk utama iaitu minat dalam bidang TVET, kesan potensi kerjaya TVET, dan sokongan rakan sebaya dan keluarga untuk pilihan bidang TVET. Lima item dimasukkan dalam setiap konstruk untuk mengukur tahap persetujuan responden menggunakan pernyataan yang berkaitan dengan faktor tersebut.

Bagi memudahkan pemahaman ke atas taburan jawapan responden, hasil kajian dipaparkan dalam bentuk jadual. Penemuan analisis kemudiannya digunakan untuk menilai kecenderungan responden untuk bidang TVET dan menentukan pembolehubah utama yang mempengaruhi pemilihan mereka.

Jadual 1: Latar Belakang Responden

Item	Bilangan	Peratus
Jantina		
Lelaki	44	30.3
Perempuan	101	69.7
Umur		
18 -20 tahun	132	91
21 – 30 tahun	13	9
Program		
Sijil Fesyen dan Pakaian	16	11
Sijil Dandanan Rambut	27	18.6
Sijil Pengoperasian Perniagaan	25	17.2
Sijil Teknologi Maklumat	45	31
Sijil Terapi dan Kecantikan	32	22.1
Semester		
Semester 1	18	12.4
Semester 2	103	71
Semester 2	24	16.6

Seramai 145 pelajar telah mengambil bahagian dalam kajian ini berdasarkan analisis demografi responden. Dari segi jantina, 44 responden (30.3%) adalah lelaki dan 101 responden (69.7%) adalah wanita. Keputusan ini menunjukkan bahawa majoriti peserta kajian adalah pelajar perempuan. Hanya 13 responden (9%) berumur antara 21 hingga 30 tahun. Majoriti responden iaitu 132 (91%) berumur antara 18 hingga 20 tahun. Ini menunjukkan majoriti responden adalah golongan dewasa muda yang sering menghadiri kolej TVET untuk mendapatkan pendidikan peringkat sijil.

Mengikut program pengajian, Sijil Teknologi Maklumat mempunyai bilangan responden yang paling ramai (45 individu, atau 31%), diikuti oleh Sijil Terapi dan Kecantikan (32 individu, atau 22.1%), Sijil Dandanan Rambut (27 individu, atau 18.6%), Sijil Operasi Perniagaan (25 individu, atau 17.2%), dan Sijil Fesyen dan Pakaian (16%). Pengagihan ini menunjukkan bahawa pelajar dari pelbagai program akademik di KKPG telah mengambil bahagian dalam kajian ini.

Pelajar Semester 2 membentuk sebahagian besar responden (103, atau 71%), diikuti oleh pelajar Semester 3 (24, atau 16.6%), dan pelajar Semester 1 (18, atau 12.4%). Menurut data ini, majoriti responden berada pada pertengahan pengajian di Kolej Komuniti Pasir Gudang.

Jadual 2: Minat Pelajar Kolej Komuniti Pasir Gudang Terhadap TVET

ITEM	MIN	TAHAP
1.Saya berminat untuk membina kerjaya dalam bidang TVET.	3.68	TINGGI
2. Program TVET yang saya ikuti selaras dengan minat saya.	3.64	TINGGI
3.Saya lebih gemar pembelajaran berbentuk amali berbanding teori.	3.66	TINGGI
4. Bidang TVET sesuai dengan cita-cita dan kerjaya saya pada masa akan datang.	3.70	TINGGI
5. Saya seronok mengikuti pembelajaran dalam program TVET.	3.74	TINGGI

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Lima faktor bagi mengukur minat pelajar Kolej Komuniti Pasir Gudang terhadap TVET telah dianalisis, dan keputusan menunjukkan bahawa nilai min setiap item jatuh antara 3.64 hingga 3.74 dan sisihan piawainya jatuh antara 0.53 hingga 0.61. Purata nilai min konstruk ialah 3.68 di mana ini menunjukkan bahawa pelajar sangat berminat dengan program TVET.

Majoriti pelajar bersetuju dan sangat bersetuju bahawa mereka mempunyai minat yang tinggi dalam bidang TVET. Ia selari dengan dapatan pada persoalan keinginan mereka untuk meneruskan kerjaya dalam bidang tersebut, kesesuaian program dengan minat mereka, kecenderungan mereka untuk pembelajaran praktikal, dan keseronokan mereka belajar dalam program TVET. Selain itu, pelajar percaya bahawa profesion TVET sejajar dengan matlamat dan kerjaya masa depan mereka.

Angka sisihan piawai yang rendah menunjukkan bahawa tiada perbezaan yang ketara dalam pendapat responden dan bahawa jawapan mereka adalah agak konsisten. Secara keseluruhan, keputusan ini menunjukkan bahawa pelajar mempunyai minat yang tinggi terhadap TVET, yang merupakan salah satu faktor utama yang mempengaruhi pemilihan TVET mereka sebagai bidang pengajian dan kerjaya.

Jadual 3: Persepsi Pelajar Kolej Komuniti Pasir Gudang Terhadap Kebolehpasaran Graduan TVET

ITEM	MIN	TAHAP
1.Graduan TVET mempunyai peluang pekerjaan yang tinggi	3.68	TINGGI
2. Kemahiran TVET sangat diperlukan oleh industri	3.67	TINGGI
3.TVET membantu mendapatkan pekerjaan dengan cepat.	3.70	TINGGI
4. Majikan menghargai graduan berkemahiran teknikal.	3.66	TINGGI
5. TVET menjamin masa depan kerjaya yang stabil	3.76	TINGGI

Nilai min bagi setiap lima soalan yang menilai pendapat pelajar Kolej Komuniti Pasir Gudang tentang kebolehpasaran graduan TVET jatuh antara 3.66 hingga 3.76, manakala sisihan piawai jatuh antara 0.48 hingga 0.59. Jumlah nilai min konstruk ialah 3.69, menunjukkan bahawa pelajar mempunyai pendapat yang tinggi tentang bagaimana graduan TVET boleh dipasarkan.

Menurut penyelidikan ini, kebanyakan pelajar bersetuju dan sangat percaya bahawa graduan TVET mempunyai kadar pekerjaan yang tinggi, industri sangat memerlukan kebolehan TVET, dan TVET membantu graduan mencari pekerjaan dengan lebih cepat. Selain itu, pelajar berpendapat bahawa TVET boleh memastikan masa depan pekerjaan yang lebih kukuh dan peluang pekerjaan yang lebih cerah menanti graduan yang mempunyai kemahiran teknikal.

Secara keseluruhan, keputusan ini menunjukkan bahawa pelajar mempunyai pendapat yang sangat positif tentang kebolehpasaran graduan TVET dan meningkatkan kepercayaan mereka terhadap TVET sebagai laluan kerjaya dan pendidikan yang berkaitan dengan tuntutan industri semasa.

Jadual 4: Sokongan Keluarga Dan Rakan Sebaya Terhadap TVET

ITEM	MIN	TAHAP
1. Keluarga saya menyokong pilihan saya dalam TVET	3.76	TINGGI
2. Galakan ibu bapa mempengaruhi pilihan kerjaya saya	3.65	TINGGI
3.Rakan sebaya memberi pengaruh positif terhadap pilihan TVET	3.63	TINGGI
4.Pandangan orang sekeliling meningkatkan keyakinan saya	3.66	TINGGI
5.Sokongan sosial mendorong saya memilih TVET	3.65	TINGGI

Lima soalan yang menilai sokongan keluarga dan rakan sebaya untuk TVET telah dianalisis dan keputusan menunjukkan bahawa nilai min setiap item memberi bacaan antara 3.63 hingga 3.76, dengan sisihan piawai antara 0.45 hingga 0.64. Nilai min keseluruhan konstruk ialah 3.67 di mana ini menunjukkan tahap sokongan sosial yang kukuh untuk memilih TVET.

Melalui penyelidikan ini, majoriti pelajar berada pada julat bersetuju dan sangat bersetuju bahawa mereka menerima sokongan daripada rakan sebaya, ibu bapa, keluarga dan orang lain di kawasan terdekat apabila mereka memutuskan untuk meneruskan TVET sebagai laluan kerjaya dan pendidikan. Pemerhatian menunjukkan bahawa

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sumber sokongan ini meningkatkan jati diri pelajar dan memberi inspirasi kepada mereka untuk melanjutkan pelajaran dalam sektor TVET.

Angka sisihan piawai yang rendah menunjukkan bahawa tiada perbezaan yang ketara dalam pendapat responden dan jawapan mereka adalah agak konsisten. Secara keseluruhannya, keputusan ini menunjukkan sokongan rakan sebaya dan keluarga merupakan faktor penting dalam keputusan pelajar Kolej Komuniti Pasir Gudang untuk meneruskan TVET sebagai laluan bidang kerjaya.

Ketiga-tiga pembolehubah yang telah dikaji iatu minat dalam sektor TVET, persepsi terhadap pilihan kerjaya TVET dan sokongan keluarga dan rakan sebaya; didapati sangat dipersetujui oleh majoriti responden berpandukan analisis data yang telah diperolehi. Keputusan ini menunjukkan bahawa pilihan bidang TVET dipengaruhi oleh kedua-dua pembolehubah luaran dan dalaman, termasuk sokongan sosial dan persepsi peluang pekerjaan.

Secara keseluruhannya, analisis data menunjukkan bahawa ketiga-tiga pembolehubah ini saling berkaitan dan memberi kesan ketara kepada kecenderungan responden untuk memilih medan TVET. Dalam Bab 5, yang mengandungi perbincangan tentang kajian, cadangan penambahbaikan, dan kesimpulan umum kajian, hasil penyiasatan ini akan dibincangkan dengan lebih terperinci.

5.0 PERBINCANGAN DAN CADANGAN

5.1 PERBINCANGAN

Pendidikan dan Latihan Teknikal dan Vokasional (TVET) merupakan faktor yang mempengaruhi pendidikan di Kolej Komuniti Pasir Gudang. Dapatan menunjukkan bahawa pelajar mempunyai minat yang tinggi di dalam TVET. Sokongan daripada keluarga dan rakan sebaya juga merupakan faktor penting yang menggalakkan pelajar mempunyai pandangan TVET yang positif.

5.1.1 Tahap minat pelajar Kolej Komuniti Pasir Gudang

Dapatan kajian menunjukkan bahawa tahap pendidikan di Kolej Komuniti Pasir Gudang berkenaan dengan TVET (Pendidikan dan Latihan Teknikal dan Vokasional) adalah tinggi. Majoriti pelajar menunjukkan sikap positif terhadap bidang ini dan berminat untuk meneruskan kerjaya dalam bidang teknikal dan kemahiran. Mereka juga percaya bahawa kemahiran yang dipelajari dapat membantu meningkatkan peluang pekerjaan pada masa hadapan. Selain itu, program TVET lebih menumpukan kepada pembelajaran secara praktikal berbanding teori. Pelajar juga menyatakan bahawa mereka berminat untuk mengikuti program TVET dan percaya bahawa program ini dapat membantu mereka mencapai matlamat kerjaya pada masa hadapan. Secara keseluruhannya, dapatan kajian menunjukkan minat yang tinggi terhadap TVET merupakan salah satu faktor utama yang menggalakkan pelajar memilih bidang ini sebagai laluan pengajian dan pekerjaan.

5.1.2 Persepsi Pelajar Kolej Komuniti Pasir Gudang Terhadap Kebolehpasaran Graduan TVET

Dapatan kajian menunjukkan persepsi pelajar Kolej Komuniti Pasir Gudang terhadap pelajar lulusan Latihan Teknikal dan Vokasional (TVET) adalah agak tinggi. Majoriti pelajar mempunyai persepsi positif bahawa graduan TVET mempunyai kemahiran kerja yang baik di tempat kerja. Di sinilah kemahiran teknikal dan praktikal yang diperolehi semasa program amat TVET diperlukan oleh pihak industri. Di samping itu, pelajar percaya bahawa graduan TVET mempunyai peluang yang baik untuk mendapatkan pekerjaan. Ia juga terbukti bahawa penguasaan kemahiran melalui program TVET dapat membantu graduan memperoleh pekerjaan yang lebih stabil dan mewujudkan lebih banyak peluang pekerjaan dalam banyak sektor. Secara umumnya, kenyataan ini menunjukkan fakta bahawa pelajar melihat TVET sebagai bidang pengajian dan pekerjaan yang selaras dengan keperluan industri semasa.

5.1.3 Sokongan Keluarga Dan Rakan Sebaya Terhadap TVET

Dapatan kajian menunjukkan faktor keluarga dan rakan sebaya memainkan peranan yang penting dalam pemilihan TVET di Kolej Komuniti Pasir Gudang. Matlamat utama pendidikan adalah agar pelajar mendapat bimbingan dan sokongan daripada ibu bapa, ahli keluarga, rakan sebaya, dan orang lain di sekitar mereka untuk meneruskan pendidikan di TVET. Sokongan sosial ini membantu meningkatkan keinginan seseorang untuk belajar dan memberikan motivasi untuk memilih peluang pendidikan dan profesional dalam sektor teknikal.Secara ringkasnya, kajian ini menunjukkan bahawa keluarga dan

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rakan sokongan merupakan faktor penting yang mempengaruhi hasil pembelajaran pelajar, baik dari segi motivasi mahupun persepsi positif terhadap pelajar lulusanTVET.

5.2 CADANGAN

Berdasarkan dapatan kajian, beberapa cadangan boleh digunakan untuk meningkatkan keberkesanan program TVET.Di antaranya ialah :

5.2.1 Merangka polisi yang menggalakkan pendidikan TVET dan menyokong institusi pendidikan.

Jabatan Pendidikan Politeknik dan Kolej Komuniti (JPPKK) mesti menyediakan dasar yang boleh menggalakkan pelajar memilih TVET sebagai laluan pendidikan. Contohnya, menyediakan pelajar TVET dengan bantuan kewangan, biasiswa atau elaun. Di samping itu, institusi pendidikan mesti menyediakan sumber seperti bengkel dan peralatan latihan yang memudahkan proses pembelajaran.

5.2.2 Menyediakan strategi untuk membangunkan kemahiran berdasarkan keperluan industri supaya program TVET kekal relevan dilaksanakan.

Program TVET perlu selaras dengan keperluan industri supaya pelajar dapat mempelajari kemahiran yang sesuai dengan alam pekerjaan. Oleh itu, kerjasama antara institusi pendidikan dan industri merupakan elemen penting bagi memastikan kurikulum dan Latihan Kemahiran yang disampaikan selaras dengan keperluan semasa industri. Melalui kerjasama ini, pelajar dapat mempelajari kemahiran yang diperlukan di tempat kerja dan seterusnya meningkatkan peluang mereka untuk mendapat pekerjaan selepas tamat pengajian.

5.3.3 Bagi memberikan hasil yang positif kepada industri dan graduan, pemantauan secara berterusan perlu dilaksanakan dan diperkukuhkan.Jabatan Pendidikan Politeknik dan Kolej Komuniti (JPPKK) hendaklah menyokong perlaksanaan program TVET secara berterusan bagi memastikan program tersebut dijalankan dengan berkesan dan mencapai tahap yang dikehendaki. Pemantauan ini adalah penting untuk menentukan sejauh mana keberkesanan program dalam meningkatkan kadar lulusan graduan TVET dan memastikan hasil pembelajaran pelajar memenuhi permintaan industri. Sebarang kelemahan atau kekurangan dalam pelaksanaan program dapat dikenal pasti dengan lebih mudah dan penambahbaikan boleh ditambahbaik secara berterusan bagi memastikan program TVET adalah relevan dan berkualiti tinggi.

6.0 KESIMPULAN

Secara kesimpulannya, kajian ini bertujuan untuk mengenal pasti faktor-faktor yang mempengaruhi pemilihan Pendidikan dan Latihan Teknikal dan Vokasional (TVET) sebagai laluan kerjaya di kalangan pelajar Kolej Komuniti Pasir Gudang. Berdasarkan dapatan kajian, dapat disimpulkan bahawa pendidikan TVET mempunyai impak yang besar kepada industri melalui pengajaran yang lebih praktikal dan peluang pembelajaran yang berkait dengan keperluan industri. Selain itu, pelajar mempunyai persepsi positif terhadap keupayaan pelajar lepasan TVET untuk membantu mereka mendapatkan pekerjaan dengan lebih mudah. Sokongan daripada keluarga dan rakan sebaya turut mengekalkan faktor penting dalam mempengaruhi pelajar untuk memilih TVET dalam alam pekerjaan. Secara umumnya, faktor seperti minat, persepsi tentang aktiviti berkaitan kerja, dan sokongan sosial merupakan faktor penting yang mendorong pelajar memilih program TVET sebagai laluan kerjaya. Bagi memastikan program TVET sentiasa relevan, berkualiti tinggi, dan mampu melahirkan graduan yang mampu memenuhi permintaan tenaga kerja dalam industri, kerjasama antara institusi pendidikan dan pihak industri perlu diperkukuh dan dipertingkatkan.

7.0 PENGHARGAAN

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Keberkesanan Pengurusan Aset Dalam Kalangan Warga Kolej Komuniti Pasir Gudang

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Abstrak

Pengurusan aset alih kerajaan merupakan aspek penting dalam memastikan tadbir urus organisasi dilaksanakan secara cekap dan berkesan. Kolej Komuniti Pasir Gudang (KKPG) melaksanakan pengurusan aset selaras dengan pekeliling yang ditetapkan, namun masih berdepan isu kekangan sumber manusia khususnya ketiadaan juruteknik serta pelupusan aset yang tertangguh apabila aset usang disimpan melebihi tempoh sewajarnya akibat kelewatan penyelenggaraan dan penilaian. Sehubungan itu, kajian ini dijalankan bagi menilai tahap keberkesanan pengurusan aset dalam kalangan warga KKPG berdasarkan lima faktor utama iaitu pengetahuan dan kepatuhan staf, keberkesanan sistem dan maklumat aset, pelaksanaan pengurusan dan pemantauan aset, sokongan pengurusan serta kepuasan staf. Kajian ini melibatkan 41 orang responden yang dipilih secara rawak mudah, dengan data dikumpulkan melalui soal selidik Skala Likert lima mata dan dianalisis menggunakan SPSS versi 26.0 secara deskriptif. Dapatan kajian menunjukkan bahawa pengurusan aset di KKPG berada pada tahap memuaskan dan dilaksanakan secara sistematik, dengan pengetahuan dan kepatuhan staf serta sokongan pengurusan dikenal pasti sebagai faktor utama yang menyumbang kepada keberkesanan tersebut walaupun berhadapan dengan isu-isu yang lain. Secara keseluruhannya, pengurusan aset di KKPG berada pada tahap baik dan berpotensi untuk terus diperkukuhkan melalui penambahbaikan berterusan, khususnya dalam aspek sumber manusia dan kecekapan pelupusan aset.

Kata Kunci : *Pengurusan Aset, Keberkesanan Pengurusan Aset, Kolej Komuniti*

Abstract

The management of government movable assets is a crucial component in ensuring that organizational governance is implemented efficiently and effectively. Kolej Komuniti Pasir Gudang manages its assets in accordance with the prescribed government circulars; however, several challenges remain, particularly in terms of human resource constraints, such as the absence of technical personnel, as well as delays in asset disposal where obsolete assets are retained beyond the appropriate period due to delayed maintenance and evaluation processes. Therefore, this study was conducted to assess the effectiveness of asset management among the staff of Kolej Komuniti Pasir Gudang based on five key factors, namely staff knowledge and compliance, the effectiveness of asset systems and information, the implementation of asset management and monitoring, management support, and staff satisfaction. This study involved 41 respondents selected through simple random sampling. Data were collected using a five-point Likert scale questionnaire and analyzed descriptively using SPSS version 26.0. The findings reveal that asset management practices at Kolej Komuniti Pasir Gudang are at a satisfactory level and are implemented systematically. Staff knowledge and compliance, together with management support, were identified as the primary factors contributing to the effectiveness of asset management despite the existence of several related challenges. In conclusion, asset management at Kolej Komuniti Pasir Gudang is at a good level and demonstrates strong potential for further enhancement through continuous improvement efforts, particularly in the areas of human resource capacity and the efficiency of asset disposal processes.

Keywords : Asset Management, Effectiveness of Asset Management, Community College

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I. PENGENALAN

Pengurusan aset yang bersistematik dan berkesan dianggap penting dalam memberi manfaat optimum kepada sesebuah organisasi bagi memastikan kelancaran operasi di semua jabatan dan institusi pendidikan. Dalam sektor awam, aset merangkumi pelbagai komponen seperti bangunan, kemudahan infrastruktur, peralatan dan teknologi yang digunakan bagi menyokong sepenuhnya sistem penyampaian perkhidmatan kepada masyarakat. Oleh yang demikian, bagi memastikan aset kerajaan dapat diurus, dipantau dan diselenggara dengan baik sepanjang kitaran hayatnya, pengurusan aset yang cekap dan berkesan amat penting dilaksanakan di semua institusi/ jabatan kerajaan. Menurut kajian oleh Azri et al.[1], pengurusan aset dalam agensi kerajaan perlu dilaksanakan secara sistematik. Ia mestilah melalui proses perancangan, pemantauan dan penyelenggaraan bagi memastikan penggunaan aset yang optimum serta meningkatkan keberkesanan operasi sesebuah organisasi.

Di Malaysia, pengurusan aset sektor awam turut diperkukuhkan melalui pelaksanaan dasar dan garis panduan seperti Manual Pengurusan Aset Menyeluruh Kerajaan (MPAM) yang menekankan pengurusan aset secara bersepadu merangkumi aspek perolehan, penggunaan, penyelenggaraan dan pelupusan aset. Manual ini diperkenalkan bagi memastikan aset kerajaan diurus secara telus, sistematik dan mematuhi piawaian pengurusan kewangan sektor awam. Walau bagaimanapun, beberapa laporan berkaitan tadbir urus sektor awam sebagai contoh Laporan Ketua Audit negara menunjukkan masih terdapat kelemahan dalam pengurusan aset seperti kawalan dalaman yang tidak mencukupi, ketidakpatuhan terhadap prosedur, penguatkuasaan yang lemah serta pengurusan inventori yang kurang teratur. Sekiranya tidak ditangani dengan baik, keadaan ini boleh menjejaskan keberkesanan pengurusan aset serta kecekapan operasi organisasi. Dalam konteks institusi pendidikan, pengurusan aset memainkan peranan penting kerana aset seperti peralatan makmal, kemudahan pembelajaran dan peralatan ICT merupakan sumber utama yang menyokong proses pengajaran dan pembelajaran. Kajian pengurusan aset di sektor awam menunjukkan bahawa keberkesanan pengurusan aset dipengaruhi oleh beberapa faktor seperti pemantauan aset, kualiti maklumat aset serta kompetensi sumber manusia dalam mengurus aset organisasi.
Sehubungan itu, bagi memastikan pengurusan aset di Kolej Komuniti Pasir Gudang (KKPG) dilaksanakan dengan berkesan, penilaian terhadap tahap pelaksanaannya perlu dilakukan secara menyeluruh dengan mengambil kira pelbagai faktor yang mempengaruhi keberkesanan pengurusan aset di institusi tersebut. Selain itu, tahap kepuasan staf terhadap pengurusan aset juga perlu diberi perhatian kerana staf merupakan pengguna utama aset dalam melaksanakan tugasan harian mereka.

Oleh itu, kajian ini dijalankan bagi menilai keberkesanan pengurusan aset terhadap warga Kolej Komuniti Pasir Gudang dari perspektif staf. Dapatan kajian ini diharapkan dapat membantu pihak pengurusan mengenal pasti tahap keberkesanan pengurusan aset serta tahap kepuasan staf terhadap pengurusan aset yang dilaksanakan, seterusnya mencadangkan langkah penambahbaikan yang bersesuaian bagi meningkatkan kecekapan pengurusan aset di institusi tersebut.

Pernyataan Masalah

Pelaporan analisis data daripada Kajian Semula Pengurusan 2025 mendapati kelemahan isu penyelenggaraan dan pelupusan disebabkan ketiadaan juruteknik diketengahkan oleh Unit Pengurusan Aset dan Fasiliti (UPAF), Kolej Komuniti Pasir Gudang. Kelewatan penyelenggaraan bagi satu-satu aset menyebabkan aset usang disimpan melebihi tempoh sewajarnya sekaligus berhadapan dengan pelupusan aset yang tertangguh. Keberkesanan pengurusan aset bagi jabatan atau institusi perlu dinilai melalui kepuasan warga dalam memastikan peluang penambahbaikan dilaksanakan.

Kajian terdahulu [2] menunjukkan bahawa kekangan sumber manusia dan peruntukan kewangan merupakan antara faktor utama yang menjejaskan keberkesanan pengurusan aset dalam organisasi awam. Kekurangan tenaga teknikal seperti juruteknik menyebabkan pemantauan dan penyelenggaraan aset tidak dapat dilaksanakan secara optimum, sekali gus membawa kepada kelewatan dalam proses pelupusan aset disamping kekangan sumber yang menyumbang kepada penggunaan aset yang tidak efisien serta kelemahan dalam sistem pengurusan aset sedia ada. Sementara itu, hasil dapatan melalui kajian oleh Liu et al.[3] mendapati isu seperti keupayaan pasukan pengurusan aset iaitu sumber manusia tidak mencukupi merupakan salah satu cabaran yang dihadapi dalam menguruskan aset di institusi.
Beberapa kajian lepas menggariskan isu dalam menghalang keberkesanan pengurusan aset yang cekap dan sistematik, namun terdapat kajian oleh Tajudin et al.[4] yang memfokuskan kepada faktor yang mempengaruhi prestasi pengurusan aset di agensi kerajaan. Hasil kajian mengetengahkan amalan penyelenggaraan yang tidak berkesan membawa kepada isu pengurusan aset dalam sektor awam.

Oleh yang demikian, isu ini perlu diberi perhatian sewajarnya dengan keperluan kajian yang lebih terperinci untuk menilai secara keseluruhan melalui perspektif kepuasan warga terhadap pelaksanaan pengurusan aset di Kolej Komuniti Pasir Gudang

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Objektif Kajian

Kajian ini dilaksanakan bertujuan menilai keberkesanan pengurusan aset terhadap warga Kolej Komuniti Pasir Gudang. Secara khususnya, objektif kajian adalah seperti berikut :-

1)Mengenal pasti tahap pengetahuan dan kepatuhan staf terhadap pengurusan aset.

2)Menilai keberkesanan sistem dan maklumat pengurusan aset yang digunakan di institusi.

3)Menilai pelaksanaan pengurusan dan pemantauan aset di Kolej Komuniti Pasir Gudang.

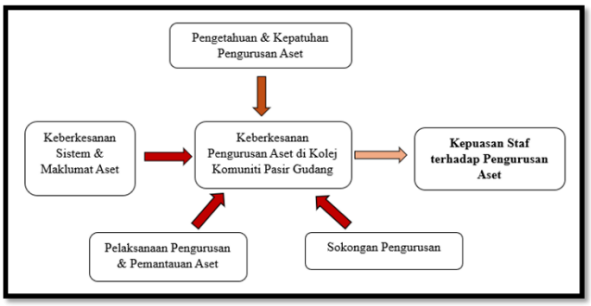
4)Mengenal pasti tahap sokongan pengurusan terhadap pengurusan aset.

5)Mengukur tahap kepuasan staf terhadap pengurusan aset di Kolej Komuniti Pasir Gudang.

Kerangka Konsep Kajian

Kerangka konsep kajian yang dibangunkan adalah seperti dibawah :

Rajah 1 : Kerangka Konsep



Kerangka konsep kajian ini dibangunkan bagi menilai keberkesanan pengurusan aset di Kolej Komuniti Pasir Gudang melalui faktor-faktor yang telah dikenalpasti. Kajian ini memberi tumpuan kepada empat faktor utama iaitu pengetahuan dan kepatuhan staf terhadap pengurusan aset, keberkesanan sistem dan maklumat aset, pelaksanaan pengurusan serta pemantauan aset, dan sokongan pengurusan.

Kesemua faktor ini dijangka mempengaruhi tahap kepuasan staf terhadap pengurusan aset di institusi. Sekiranya pengurusan aset dilaksanakan secara sistematik, telus dan efisien, maka tahap kepuasan staf terhadap pengurusan aset dijangka meningkat

II. KAJIAN LITERATUR

1) Pengurusan Aset

Pengurusan aset merupakan satu proses sistematik yang melibatkan perancangan, perolehan, penggunaan, penyelenggaraan serta pelupusan aset organisasi secara efektif dan efisien. Pengurusan aset yang berkesan mampu meningkatkan kecekapan sesebuah organisasi yang menguruskannya serta dapat memastikan sumber digunakan secara optimum [5]. Ia juga memberi kesan positif kepada organisasi dan penggunaan sumber yang lebih efektif.

Dalam memastikan aset kerajaan digunakan secara telus dan memberikan manfaat kepada organisasi, pengurusan aset memainkan peranan penting terutamanya dalam sektor awam.

Kajian oleh Ahmad [6], mendapati bahawa sistem pengurusan aset yang teratur dapat meningkatkan keberkesanan pengurusan sumber serta mengurangkan risiko kehilangan atau kerosakan aset yang berlaku di organisasi.

2) Pengurusan Aset Dalam Sektor Pendidikan

Dalam sektor pendidikan, kolej komuniti dan politeknik antara institusi pendidikan yang mempunyai pelbagai jenis aset alih yang merangkumi kemudahan pembelajaran seperti peralatan makmal dan juga peralatan ICT. Oleh yang demikian, pengurusan aset yang berkesan dan sistematik amat penting dan diperlukan bagi memastikan aset tersebut dapat menyokong proses pengajaran dan pembelajaran berjalan lancar dan teratur.

Tahap keberkesanan pengurusan aset yang dikaji melalui kepuasan warga kolej terhadap pengurusan aset di institusi pendidikan dipengaruhi oleh beberapa faktor utama seperti kecekapan dalam penyelenggaraan, pemantauan serta rekod aset [7].

3) Sistem Pengurusan Aset

Peredaran masa yang semakin laju, mengembangkan lagi keupayaan dalam perkembangan teknologi. Penggunaan sistem digital telah dinormalisasikan terhadap apa juga aspek bagi memudahkan semua perkara. Perkembangan teknologi maklumat juga telah membawa kepada penggunaan sistem digital yang lebih mudah dan tersusun dalam pengurusan aset dalam organisasi. Sistem yang digunakan dalam pengurusan aset samada alih atau tak alih seperti Sistem Pemantauan Pengurusan Aset (SPPA) dan MySPATA telah diperkenalkan bagi membantu organisasi dalam merekod dan memantau aset secara lebih sistematik dan berkesan

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Ini dapat dijelaskan juga di dalam kajian Nasir et al.[8], dimana penggunaan sistem pengurusan aset iaitu Sistem Pemantauan Pengurusan Aset (SPPA) yang berasaskan teknologi dapat meningkatkan kecekapan pengurusan aset sekaligus dapat memudahkan proses pemantauan dan pelaporan aset dalam satu sistem berpusat.

Kajian oleh Yusdira [9], turut bersetuju dengan pandangan ini, dimana kajian berkaitan pengurusan aset dalam sektor awam turut menunjukkan bahawa penggunaan sistem pengurusan aset dapat meningkatkan pemantauan aset serta membantu organisasi mengurus sumber dengan lebih berkesan

4) Faktor Yang Mempengaruhi Keberkesanan Aset

Kajian terdahulu turut menunjukkan bahawa beberapa faktor mempengaruhi keberkesanan pengurusan aset dalam organisasi. Faktor- faktor penemuan diantaranya adalah pengetahuan staf terhadap pengurusan aset, kepatuhan terhadap prosedur aset semasa, keberkesanan penggunaan sistem maklumat aset serta sokongan pengurusan secara berterusan.

Kajian oleh Rahman [10], menunjukkan bahawa faktor penting dalam memastikan pengurusan aset dilaksanakan dengan berkesan adalah merujuk kepada tahap pengetahuan staf itu sendiri berkaitan pengurusan aset di organisasi. Selain daripada itu, sokongan pihak pengurusan yang berterusan juga merupakan faktor penting yang telah ditekankan dalam kajiannya dalam memastikan pelaksanaan pengurusan aset berjalan dengan lancar.

III. KAEDAH PENYELIDIKAN

Penyelidikan ini menggunakan rekabentuk kuantitatif dan kajian berbentuk deskriptif menggunakan metodologi melalui kaedah tinjauan iaitu soal selidik. Pendekatan ini digunakan bagi menilai keberkesanan pengurusan aset dalam kalangan warga Kolej Komuniti Pasir Gudang. Kaedah ini dipilih disebabkan ia sesuai digunakan bagi mengukur tingkahlaku, sikap dan pandangan atau pendapat individu sebagaimana yang dinyatakan Fullan (1991).

Kajian deskriptif digunakan untuk mengenal pasti tahap keberkesanan pengurusan aset berdasarkan beberapa konstruk kajian seperti yang telah dinyatakan iaitu pengetahuan dan kepatuhan warga terhadap pengurusan aset, keberkesanan sistem yang digunakan dalam menguruskan aset, pelaksanaan pemantauan aset di KKPG serta sokongan pengurusan. Soal selidik telah diedarkan secara atas talian kepada warga iaitu pensyarah dan staf Kolej Komuniti Pasir Gudang yang bertanggungjawab secara langsung dalam pengurusan aset di institusi. Data kajian dikumpul melalui borang soal selidik menggunakan skala Likert lima mata dan dianalisis menggunakan perisian *Statistical Package for Social Sciences (SPSS) versi 26.*

Jadual 1 : Skala Likert 5 mata
(Maklumbalas Soal Selidik)

1	Sangat Tidak Setuju
2	Tidak Setuju
3	Tidak Pasti
4	Setuju
5	Sangat Setuju

Analisis bagi mendapatkan hasil dapatan kajian dilakukan menggunakan statistik deskriptif seperti min dan sisihan piawai seperti jadual di bawah :-

Jadual 2 : Interprestasi Skor Min

Skor Min	**Tahap Min**
1.00 hingga 2.33	Rendah
2.34 hingga 3.67	Sederhana
3.68 hingga 5.00	Tinggi

IV. KEPUTUSAN DAN PERBINCANGAN

Terdapat 2 bahagian utama maklumat yang perlu dianalisis berdasarkan soal selidik yang telah dibangunkan. Bahagian tersebut meliputi :-

Jadual 3 : Item Soalan Soal Selidik

Bahagian	**Item Soalan**
Bahagian A	Maklumat Demografi
Bahagian B	5 Konstruk/ Faktor Utama 1) Pengetahuan dan Kepatuhan Pengurusan Aset. 2) Keberkesanan Sistem dan Maklumat Aset 3) Pelaksanaan Pengurusan dan Pemantauan Aset 4) Sokongan Pengurusan 5) Kepuasan Staf terhadap Pengurusan Aset

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Bahagian A : Maklumat Demografi Responden

Jadual 4 : Maklumat Demografi Responden

Faktor Demografi	Item		Kekerapan (%)
Program/ Unit	Pentadbiran	13	31.7
	UPA	2	4.9
	STM	8	19.5
	SPP	4	9.8
	SFP	9	22.0
	STK	4	9.8
	SDR	1	2.4
Tempoh Berkhidmat	<1 tahun	5	12.2
	1-3 tahun	6	14.6
	4-6 tahun	2	4.9
	>6 tahun	28	68.3
Penglibatan secara langsung dalam Pengurusan Aset	Ya	34	82.9
	Tidak	7	17.1

Jadual 4 merujuk kepada dapatan maklumat demografi responden yang telah menjawab soal selidik. Dapatan kajian menunjukkan Unit Pentadbiran merupakan responden yang paling ramai terlibat secara langsung dalam pengurusan aset di KKPG dengan kekerapan 31.7% berbanding Program SDR (Sijil Dandanan Rambut) yang menunjukkan hanya 2.4% sahaja yang terlibat secara langsung dalam pengurusan aset.

Seramai 28 orang responden telah berkhidmat melebihi 6 tahun perkhidmatan manakala seramai 34 orang responden yang mewakili 82.9% telah melibatkan diri secara langsung dalam pengurusan aset di Kolej Komuniti Pasir Gudang.

Bahagian B :

Analisis Dapatan Objektif Kajian 1

Tahap Pengetahuan Dan Kepatuhan Staf Terhadap Pengurusan Aset.

Jadual 5 : Taburan Responden Berdasarkan Tahap Pengetahuan Dan Kepatuhan Staf Terhadap Pengurusan Aset

ITEM	M	SP
Saya faham tanggungjawab saya terhadap aset yang berada di bawah jagaan saya	4.48	0.59
Saya mengetahui tatacara pengurusan aset alih kerajaan yang berkuatkuasa.	4.21	0.68
Saya memahami keperluan merekodkan pergerakan aset.	4.36	0.62
Saya sedar kepentingan melaporkan kerosakan aset menggunakan sistem i-selenggara.	4.46	0.59
Saya mematuhi prosedur pengurusan aset yang ditetapkan.	4.39	0.66
Semua aset di bawah jagaan saya direkodkan dalam KEWPA 7.	4.46	0.67
Saya mengikuti prosedur pelupusan aset di KKPG.	4.29	.0.71
Panduan prosedur pengurusan aset adalah jelas dan mudah difahami.	4.34	0.61
Nilai Min Keseluruhan	**4.37**	**0.52**

Jadual 5 menunjukkan Taburan Responden Berdasarkan Tahap Pengetahuan Dan Kepatuhan Staf Terhadap Pengurusan Aset di KKPG.

Analisis menunjukkan bahawa tahap pengetahuan dan kepatuhan staf terhadap pengurusan aset di KKPG berada pada tahap yang tinggi dengan skor min keseluruhan diperolehi sebanyak 4.37 dengan sisihan piawai 0.52. Dapatan ini menunjukkan bahawa majoriti staf yang terlibat secara langsung dan tidak langsung dalam menguruskan aset di KKPG memahami sepenuhnya tanggungjawab mereka terhadap aset di bawah jagaan masing-masing serta mematuhi prosedur pengurusan aset yang ditetapkan.

Analisis Dapatan Objektif Kajian 2

Keberkesanan Sistem Dan Maklumat Pengurusan Aset.

Jadual 6 : Taburan Responden Berdasarkan Keberkesanan Sistem Dan Maklumat Pengurusan Aset.

ITEM	M	SP
Sistem SPPA mudah digunakan.	3.97	0.61
Rekod aset dalam sistem adalah tepat dan terkini.	4.04	0.70
Sistem membantu memudahkan tugas saya sebagai PIC lokasi.	4.24	0.62
Penyimpanan rekod dalam SPPA mengurangkan risiko kehilangan data	4.17	0.66
Saya mengetahui laman web	4.24	0.66

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Unit Aset digunakan di KKPG untuk urusan pengurusan aset.		
Laman web mudah diakses dan digunakan.	4.14	0.57
Rekod dan maklumat di laman web membantu saya melaksanakan tugas sebagai PIC lokasi.	4.24	0.58
Laman web sentiasa dikemaskini untuk rujukan warga KKPG.	4.17	0.58
Nilai Min Keseluruhan	**4.15**	**0.49**

Jadual 6 menunjukkan Taburan Responden Berdasarkan Keberkesanan Sistem Dan Maklumat Pengurusan Aset di KKPG.

Analisis mendapati skor min keseluruhan bagi keberkesanan sistem dan maklumat aset berada pada tahap tinggi iaitu nilai min 4.15 dengan sisihan piawai 0.49.

Ini menunjukkan bahawa sistem yang digunakan di KKPG iaitu Sistem Pemantauan Pengurusan Aset (SPPA) dan laman web Unit Pengurusan Aset dan Fasiliti KKPG membantu staf sepenuhnya dalam melaksanakan tugas berkaitan pengurusan aset.

Analisis dapatan Objektif Kajian 3

Pelaksanaan Pengurusan Dan Pemantauan Aset

Jadual 7 : Taburan Responden Berdasarkan Pelaksanaan Pengurusan dan Pemantauan Aset di Kolej Komuniti Pasir Gudang.

ITEM	M	SP
Pemeriksaan aset berkala dilaksanakan mengikut jadual.	4.34	0.57
Pemeriksaan dijalankan dengan teliti dan telus.	4.26	0.70
Hasil laporan pemeriksaan aset dibentangkan kepada warga KKPG.	4.41	0.59
Saya memahami kategori aset yang layak dilupuskan.	4.17	0.66
Prosedur pelupusan mudah diikuti.	4.17	0.62
Dokumentasi pelupusan adalah teratur dan mudah disediakan.	4.26	0.63
Proses melaporkan kerosakan mudah melalui i-Selenggara.	4.36	0.66
Kerosakan aset ditangani dalam tempoh munasabah.	4.14	0.76
Penyelenggaraan pencegahan dijalankan mengikut jadual.	4.19	0.67
Nilai Min Keseluruhan	**4.26**	**0.56**

Jadual 7 menunjukkan Taburan Responden Berdasarkan Pelaksanaan Pengurusan dan Pemantauan Aset di KKPG.

Dapatan kajian menunjukkan bahawa pelaksanaan pengurusan dan pemantauan aset berada pada tahap tinggi dengan skor min keseluruhan sebanyak 4.26 dan sisihan piawai 0.56.

Ini menunjukkan bahawa pemeriksaan aset berkala, proses pelupusan aset serta penyelenggaraan aset dilaksanakan secara sistematik di Kolej Komuniti Pasir Gudang.

Analisis Dapatan Objektif Kajian 4

Sokongan Pengurusan

Jadual 8 : Taburan Responden Berdasarkan Sokongan Pengurusan.

ITEM	M	SP
Pengurusan sentiasa memantau dan mengambil berat isu aset.	4.39	0.58
Pengurusan memberi sokongan apabila isu aset berlaku.	4.39	0.62
Komunikasi antara pegawai aset dan staf adalah jelas.	4.34	0.61
Taklimat dan makluman berkaitan pengurusan aset mencukupi.	4.26	0.67
Nilai Min Keseluruhan	**4.34**	**0.56**

Jadual 8 menunjukkan Taburan Responden Berdasarkan Sokongan Pengurusan dalam melaksanakan Pengurusan Aset di KKPG.

Analisis kajian mendapati bahawa sokongan pengurusan terhadap pengurusan aset berada pada tahap yang tinggi dengan skor min sebanyak 4.34 dan sisihan piawai 0.56.

Ini menunjukkan bahawa pihak pengurusan memberi perhatian terhadap isu pengurusan aset dan menyediakan komunikasi serta maklumat yang mencukupi kepada warga staf di KKPG.

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Analisis Dapatan Objektif Kajian 5

Tahap Kepuasan Staf Terhadap Pengurusan Aset

Jadual 9 : Taburan Responden Berdasarkan Tahap Kepuasan Staf Terhadap Pengurusan Aset.

ITEM	M	SP
Saya berpuashati dengan pengurusan aset secara keseluruhan di KKPG.	4.34	0.57
Proses pendaftaran aset alih baharu berjalan lancar.	4.29	0.55
Pelupusan aset dilaksanakan secara teratur dan telus.	4.31	0.60
Pengurusan aset yang sistematik memudahkan tugasan harian saya.	4.26	0.63
Nilai Min Keseluruhan	**4.30**	**0.55**

Jadual 9 menunjukkan Taburan Responden Berdasarkan Tahap Kepuasan Staf Terhadap Pengurusan Aset.

Hasil analisis secara keseluruhan mendapati kesemua 4 item soal selidik di bawah tahap kepuasan staf terhadap pengurusan aset di KKPG berada pada tahap tinggi iaitu diantara 4.34 hingga 4.26 dengan skor min keseluruhan sebanyak 4.30.

Keputusan positif ini memperlihatkan pengurusan aset yang sistematik di Kolej Komuniti Pasir Gudang telah membantu memudahkan tugas staf serta meningkatkan kecekapan pengurusan aset di institusi.

V. KESIMPULAN

Secara keseluruhannya, hasil dapatan kajian menunjukkan bahawa pengurusan aset di Kolej Komuniti Pasir Gudang berada pada tahap yang baik dan memuaskan. Faktor seperti pengetahuan dan kepatuhan staf yang memperolehi min yang tertinggi diikuti 4 faktor lain iaitu sokongan pengurusan, kepuasan staf terhadap pengurusan aset, pelaksanaan pengurusan dan pemantauan aset dan keberkesanan sistem dan maklumat aset memainkan peranan yang sangat penting dalam memastikan pengurusan aset dilaksanakan dengan berkesan dan sistematik.

PENGAKUAN

Penghargaan dan ucapan jutaan terima kasih ini ditujukan kepada semua pihak yang telah memberikan kerjasama serta dorongan dalam meluangkan masa memberi apa sahaja bantuan secara langsung ataupun tidak langsung.

Penghargaan juga turut ditujukan kepada pihak pengurusan serta warga staf Kolej Komuniti Pasir Gudang dalam memberikan kerjasama yang sangat baik untuk menjawab soal selidik yang telah diedarkan serta membantu dalam penyediaan maklumat dan data yang diperlukan sepanjang kajian dilaksanakan.

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Persepsi Pelajar Terhadap Pembelajaran Teknologi Percetakan Digital bagi Program Diploma Teknologi Media Cetak di Politeknik Muadzam Shah, Pahang.

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Abstrak

Perkembangan teknologi percetakan daripada percetakan konvensional kepada percetakan digital telah membawa perubahan ketara dalam bidang dunia percetakan yang telah mempengaruhi kaedah pengajaran dan pembelajaran teknologi percetakan. Percetakan digital atau lebih dikenali sebagai *Digital Printing* merupakan kaedah percetakan yang mencetak terus daripada imej berasaskan digital kepada pelbagai jenis media atau bahan cetakan. Ia merupakan satu teknologi moden yang telah merevolusikan industri percetakan tradisional iaitu *offset printing* kepada *digital printing*. Percetakan digital merupakan salah satu kursus yang terdapat dalam Program Diploma Teknologi Media Cetak di Jabatan Rekabentuk & Komunikasi Visual, Politeknik Muadzam Shah, Pahang yang merupakan satu-satunya politeknik di Malaysia yang mempunyai kursus ini. Oleh hal yang demikian, kajian ini dijalankan bagi mengenal pasti persepsi pelajar terhadap pembelajaran percetakan digital dalam kalangan pelajar bagi Program Diploma Teknologi Media Cetak. Kajian ini melibatkan 90 responden yang terdiri daripada pelajar semester 2 hingga 6 Program Diploma Teknologi Media Cetak di Politeknik Muadzam Shah. Kaedah pengumpulan data dikumpul dengan menggunakan kaedah kuantitatif iaitu melalui pengedaran borang soal selidik kepada semua responden. Instrumen kajian menggunakan skala Likert lima mata bagi mengukur tahap persepsi pelajar terhadap pembelajaran teknologi percetakan digital, kefahaman pelajar terhadap pembelajaran teknologi percetakan digital, kemahiran dan penguasaan pelajar terhadap pembelajaran teknologi percetakan digital, kaedah pengajaran pensyarah di dalam kelas dan cabaran yang dihadapi oleh pelajar dalam proses pembelajaran teknologi percetakan digital. Dapatan kajian menunjukkan bahawa majoriti pelajar Program Diploma Teknologi Media Cetak mempunyai persepsi yang positif terhadap pembelajaran percetakan digital walaupun terdapat beberapa cabaran dan kekangan dalam menguasai perisian teknologi digital seperti cabaran dalam menggunakan perisian percetakan digital, masalah teknikal dan kesukaran mengendalikan mesin digital kerana ketiadaan mesin di jabatan dan masa amali yang terhad. Oleh hal yang demikian diharapkan kajian ini dapat membantu pensyarah dan politeknik dalam menambah baik strategi PdP serta kemudahan peralatan agar memenuhi keperluan kursus semasa.

Kata kunci : *persepsi, pembelajaran, percetakan digital, Teknologi Media Cetak*

Abstract

The development of printing technology from conventional printing to digital printing has brought significant changes to the printing industry, influencing teaching and learning methods in printing technology. Digital printing is a modern printing method that prints from digital images directly onto various media or materials. Modern technology has revolutionized the traditional printing industry. Digital printing is one of the courses available in the Diploma Print Media Technology Program at the Department of Design & Visual Communication, Polytechnic Muadzam Shah, Pahang, which is the only polytechnic in Malaysia to offer this course. This study was conducted to identify students' perceptions of learning in digital printing within the Diploma Print Media Technology Program. This study involved 90 respondents, comprising students in semesters 2 to 6 of the Diploma Print Media Technology Program at Polytechnic Muadzam Shah. The data collection method used was quantitative, with questionnaires distributed to all respondents. The study instrument used a Likert scale to measure students' perceptions, understanding, and skills learning digital printing technology, lecturers' teaching methods in the classroom, and the challenges students faced in the process of learning digital printing technology.

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The findings of the study show that the majority of students in the Diploma Print Media Technology Program have a positive perception of learning digital printing despite several challenges and constraints in mastering digital technology software, such as challenges in using digital printing software, technical problems, and difficulty operating digital machines due to the absence of machines in the department and limited practical time. In conclusion, hopefully this study can assist lecturers and polytechnics in improving teaching and learning strategies and equipment facilities to meet current course requirements.

Keywords **:** *perception, learning, digital printing, Print Media Technology*

I. PENGENALAN

Teknologi percetakan digital di Malaysia semakin berkembang pesat dan memberi impak yang besar dalam industri percetakan. Perkembangan teknologi ini telah membawa perubahan besar dalam bidang percetakan, termasuk dalam institusi Pendidikan dan Latihan Teknikal dan Vokasional (TVET). Percetakan digital merupakan proses percetakan secara langsung daripada fail digital ke pelbagai jenis media seperti kertas, kain, plastik atau bahan bercetak tanpa menggunakan plat cetakan seperti percetakan konvensional *(offset)*. Percetakan digital juga dikenali sebagai teknik percetakan menggunakan fail digital seperti PDF, JPEG, TIFF dan sebagainya yang dihantar terus ke pencetak digital berteknologi tinggi untuk menghasilkan cetakan. Percetakan digital pada masa kini amat mudah dan sesuai digunakan kerana lebih bercirikan cetakan terus dari komputer, percetakan yang lebih pantas, kos efektif untuk cetakan yang rendah, berkualiti tinggi, mudah untuk proses reka bentuk dan ubah suai fail serta keupayaan pengeluaran item dalam kuantiti yang kecil mengikut permintaan pelanggan berbanding percetakan konvensional.

Perubahan teknologi percetakan digital ini bukan sahaja melibatkan penggunaan mesin dan perisian teknologi terkini, tetapi ia juga mempengaruhi penyediaan fail digital, penyelenggaraan peralatan dan kawalan kualiti produk akhir serta pengurusan warna yang baik dan berkualiti. Oleh itu, institusi TVET seperti Politeknik Muadzam Shah, Pahang harus memastikan kurikulum yang ditawarkan selaras dengan keperluan teknologi terkini dan semasa bagi Program Teknologi Media Cetak. Kursus Percetakan Digital *(Digital Printing)* merupakan salah satu kursus yang wajib pelajari oleh dalam program ini. Justeru itu, bagi melengkapkan pembelajaran program diploma ini, pelajar perlu dilengkapkan dengan pengetahuan teori, amali dan kemahiran praktikal yang relevan dan selari dengan kehendak industri.

Sehubungan dengan itu, kajian ini dijalankan bagi mengenal pasti persepsi pelajar terhadap pembelajaran teknologi percetakan digital bagi Program Diploma Teknologi Media Cetak di Politeknik Muadzam Shah, Pahang. Kajian dijalankan terhadap pelajar yang telah mempelajari kursus Digital Printing semasa di semester 3 bagi mod konvensional dan semester 2 bagi mod *Work Based Learning* (WBL) Program Diploma Teknologi Media Cetak di Politeknik Muadzam Shah. Selari dengan Revolusi Perindustrian 4.0, industri percetakan harus menggunakan perisian reka bentuk dan mesin cetak yang lebih mudah serta berpotensi mengubah keseluruhan dunia perindustrian. Perubahan teknologi daripada percetakan konvensional kepada percetakan digital telah memberikan sumbangan dan impak yang besar dalam dunia percetakan. Oleh itu, pelajar di institusi diwajibkan untuk mempelajari perubahan teknologi ini agar pembelajaran dan ilmu yang diperolehi seiring dengan kehendak industri semasa.

Pernyataan Masalah

Percetakan digital adalah salah satu kursus dalam Program Diploma Teknologi Media Cetak di Politeknik Muadzam Shah, Pahang yang merupakan satu-satunya politeknik yang mempunyai program tersebut. Program ini telah melibatkan dua mod pembelajaran iaitu mod konvensional dan mod terkini *Work-Based Learning* (WBL). Bagi mod konvensional, pelajar telah mempelajari kursus ini pada semester 3, manakala mod WBL pada semester 2 pengajian. Namun, timbul persoalan mengenai persepsi pelajar terhadap keberkesanan kursus ini dalam memenuhi keperluan Program Diploma Teknologi Media Cetak. Pertama, persepsi pelajar terhadap minat, kesungguhan, pandangan serta kefahaman mereka terhadap kursus ini. Persepsi pelajar ini membantu untuk meningkatkan pencapaian pelajar serta menambahbaik kaedah pengajaran dan pembelajaran (PdP). Selain itu, elemen yang perlu dikaji ialah kemahiran dan penguasaan pelajar terhadap pembelajaran teknologi percetakan digital. Kemahiran yang mereka perolehi memainkan peranan yang amat penting dalam menentukan sejauh mana mereka bersedia untuk bekerja dalam industri percetakan. Kemahiran ini juga dapat menyumbang kepada penambahbaikan

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kurikulum program. Seterusnya, cabaran yang dihadapi oleh pelajar dalam mempelajari kursus ini termasuklah kekurangan alatan dan mesin terkini merupakan salah satu cabaran yang dihadapi oleh pelajar di Politeknik Muadzam Shah yang boleh menyebabkan pelajar tidak dapat menguasai ilmu dengan baik. Oleh itu, adalah penting untuk mengetahui dan mengenal pasti keperluan latihan serta kemudahan pembelajaran yang diperlukan oleh pelajar.

Objektif Kajian

1. Mengenal pasti tahap persepsi pelajar terhadap pembelajaran teknologi percetakan digital dalam aspek kefahaman, minat dan keberkesanan PdP.
2. Menilai tahap kemahiran dan penguasaan pelajar terhadap pembelajaran teknologi percetakan digital.
3. Mengenal pasti cabaran yang dihadapi oleh pelajar semasa mempelajari kursus teknologi percetakan digital.

Persoalan Kajian

1. Apakah persepsi pelajar terhadap pembelajaran teknologi percetakan digital?
2. Bagaimanakah tahap kemahiran dan penguasaan pelajar terhadap pembelajaran teknologi percetakan digital?
3. Apakah cabaran yang dihadapi oleh pelajar semasa mempelajari kursus teknologi percetakan digital?

Kepentingan Kajian

1. Menambah baik kaedah pengajaran dan pembelajaran (PdP) dalam bidang percetakan digital.

Hasil kajian ini dapat membantu pensyarah dalam menilai sejauh mana pendekatan pengajaran sedia ada berkesan serta menambah baik kaedah PdP terutama dalam penyampaian topik percetakan digital. Maklum balas dan persepsi pemahaman pelajar membantu pensyarah dalam menyesuaikan strategi PdP agar lebih interaktif, berfokus dan mesra pelajar.

2. Mengenal pasti keperluan latihan dan kemudahan pembelajaran yang diperlukan oleh pelajar Politeknik Muadzam Shah.

Kajian ini membantu pihak jabatan menilai sama ada kemudahan sedia ada yang terdapat di Jabatan Rekabentuk & Komunikasi Visual, Politeknik Muadzam Shah seperti perisian digital, mesin cetak digital, masa amali dan praktikal mencukupi atau perlu ditambah baik. Maklum balas ini penting untuk memastikan pelajar mendapat latihan yang relevan dan menyeluruh dalam bidang pengajian mereka.

3. Meningkatkan pencapaian akademik dan kesediaan pelajar ke arah industri

Kajian ini dapat membantu pelajar dalam meningkatkan pencapaian akademik. Pihak institusi Politeknik Muadzam Shah juga dapat merancang pendekatan yang lebih efektif untuk para pelajar menjalani latihan industri nanti. Pihak institusi juga perlu menyediakan alatan serta kemudahan mesin percetakan digital sebagai persediaan para pelajar ke latihan industri

4. Menyumbang kepada penambaikan kurikulum (CQI) program

Hasil kajian ini boleh dijadikan rujukan untuk menyemak dan menambah baik kandungan kursus *Digital Printing Technology* dan Program Diploma Teknologi Media Cetak serta struktur latihan praktikal supaya lebih sejajar dengan keperluan semasa industri percetakan.

5. Sebagai rujukan kajian pada masa hadapan

Sebagai salah satu kursus yang baharu dilaksanakan, kajian ini menjadi asas kepada penyelidik lain terutama dalam bidang yang sama yang ingin mengkaji aspek pembelajaran percetakan teknologi digital terutama dari sudut keberkesanan pengajaran, tahap kemahiran pelajar atau integrasi teknologi baharu.

II. KAJIAN LITERATUR

Perkataan persepsi pelajar atau lebih mudah dikatakan sebagai tanggapan, pandangan atau pemahaman pelajar terhadap sesuatu perkara yang mereka alami, lihat atau pelajari. Persepsi juga ialah suatu proses yang kompleks di mana seseorang pelajar atau individu memilih, mengatur serta mentafsir rangsangan yang diterima daripada deria mereka untuk membentuk gambaran yang bermakna tentang dunia sekelilingnya (Mohd Najib Ghafar, 1999) [1]. Nor Hasmaliza dan Zamri (2016) [2] menyatakan persepsi positif terhadap kemahiran-kemahiran yang pelajar perolehi berpotensi mewujudkan peluang dan memberi inspirasi kepada pelajar untuk meningkatkan keupayaan dan kemahiran mereka dalam persekitaran profesional. Menurut kajian Padmanaban, Ruhizan dan Mohd Isa

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(2021) [3] pula menegaskan bahawa persepsi positif terhadap pengetahuan berpotensi memotivasikan pelajar untuk mengekalkan semangat dan ketekunan dalam proses pembelajaran mereka. Seterusnya, menurut Sabarini (2021) [4], persepsi adalah kesan, gambaran atau tanggapan yang dimiliki oleh seseorang individu setelah orang tersebut menyerap untuk mengetahui beberapa hal (objek) melalui panca indra. Persepsi juga dapat didefinisikan sebagai proses menerima, menyeleksi, mengorganisasikan, mengartikan, menguji dan memberikan reaksi kepada rangsangan panca indra atau sesuatu data (Warurah, 2022) [5]. Dalam kajian Tari (2023) [6] pula, berpendapat persepsi memberi makna pada rangsangan sensorik yang tidak hanya mencakupi emosi, tetapi juga harapan dan motivasi. Selain itu, kajian oleh Hamid et al. (2024) [7] menilai persepsi terhadap pelajar program diploma di Politeknik Sultan Azlan Shah berhubung dengan penguasaan pengetahuan dan kemahiran praktikal yang diperlukan.

Pembelajaran adalah proses interaksi antara guru dengan sumber belajar dalam suatu lingkungan belajar. Kata pembelajaran berarti proses, cara, dan perbuatan yang menjadikan orang atau makhluk hidup belajar. Secara terminologi, pembelajaran merupakan proses yang melibatkan individu dalam upaya memperoleh pengetahuan, keterampilan dan nilai-nilai positif dengan memanfaatkan berbagai sumber belajar. Mohd Daud (2012) [8] berpendapat pembelajaran adalah satu proses untuk membina pengetahuan dan mengembangkan potensi diri melalui interaksi, pemikiran kritis dan pengalaman hidup. Dalam kajian Jihad dan Haris (2013) [9] menyatakan bahawa pembelajaran adalah proses yang terdiri daripada kombinasi dua aspek belajar dan mengajar, belajar berfokus kepada aktiviti peserta didik dan mengajar berorintasikan pada peranan guru sebagai pemberi pelajaran. Seterusnya, Khairani (2017) [10] memaklumkan bahawa pembelajaran adalah proses membantu peserta didik (pelajar) agar dapat belajar dengan baik. Pembelajaran merupakan kombinasi terstruktur yang mencakupi unsur-unsur manusiawi, iaitu pelajar atau guru, material atau bahan seperti buku, papan tulis, kapur dan alat belajar, kemudahan fasiliti seperti ruang kelas, audiovisual serta prosedur yang saling mempengaruhi dalam rangka mencapai tujuan pembelajaran (Fakhrurrazi, 2018) [11]. Manakala menurut Michael Nagel dan Laura Scholes (2016) [12], pembelajaran adalah proses di mana individu berkesempatan untuk mengembangkan pemahaman dan keterampilan melalui pengalaman, interaksi sosial dan refleksi melalui proses pembelajaran. Seterusnya, pembelajaran digital bukan bererti masa depan pendidikan, ia adalah realiti masa kini (Sal Khan, 2025) [13].

Menurut Helmut Kipphan (2001) [14] percetakan digital ialah proses pemindahan imej digital secara terus ke permukaan cetakan tanpa penggunaan plat percetakan konvensional yang mana lebih fleksibel dan sesuai untuk cetakan jangka pendek, data berubah-ubah *(variable data printing)* serta proses pengeluaran pantas tanpa langkah pra-tekan *(prepress)* yang rumit dan membebankan. Seterusnya Frank J. Romano (2004) [15] menyatakan bahawa percetakan digital ialah teknologi cetakan berdasarkan fail elektronik, yang membolehkan cetakan dilakukan mengikut kepada permintaan dengan kandungan yang berubah-ubah. Selain itu, kata-kata juga disokong daripada Yagoub, Y. (2017) [16] bahawa percetakan digital merupakan satu pendekatan baharu dalam pengeluaran media cetak yang lebih fleksibel, kos efektif dan responsif terhadap kehendak pasaran semasa. Percetakan digital di Malaysia dilihat sebagai satu evolusi penting dalam industri media cetak yang menawarkan kebolehsuaian tinggi dan kecekapan masa pengeluaran (Mohd Fauzi Ahmad, 2012) [17]. Seterusnya, Kamaludin dan Zainal (2021) [18] pula menegaskan percetakan digital menjadi teknologi utama dalam industri cetakan masa kini kerana keupayaan mencetak secara terus dari fail digital dan menyesuaikan hasil cetakan dengan permintaan pelanggan. Ismail dan Rahman (2021) [19] menyatakan dalam kajian mereka berkenaan percetakan digital menawarkan solusi efektif untuk percetakan bahan promosi dengan kos yang rendah dan tempoh masa yang singkat, sesuai dengan kehendak pelanggan dan industri semasa.

Teknologi Media Cetak merangkumi keseluruhan proses peralatan yang digunakan dalam penghasilan bahan bercetak, dari reka bentuk hingga penghasilan produk akhir (Helmut Kipphan, 2001) [20]. Dalam kajian Bhatia dan Suri (2018) [21] teknologi media cetak kini menggabungkan proses digital dan automasi bagi meningkatkan fleksibiliti, kualiti dan kecekapan pengeluaran hasil cetakan. Selain itu, Salleh dan Rosli (2019) [22] berpendapat bahawa teknologi media cetak di Malaysia semakin berkembang dengan integrasi teknologi digital terutama penggunaan mesin yang merangkumi kepada peningkatan kecekapan dan kualiti produk cetakan. Percetakan digital juga merupakan satu teknologi moden yang membolehkan penghasilan cetakan secara terus dari fail digital ke permukaan bahan, tanpa memerlukan plat seperti percetakan tradisional (Mohd Zin, 2021) [23]. Dalam kajian,

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Hamzah (2023) [24] menyatakan bahawa dalam era Revolusi Industri 4.0, percetakan digital memainkan peranan penting dalam pengeluaran yang bersifat automatik, pintar, dan tersuai mengikut permintaan pengguna.

III. KAJIAN METODOLOGI

Rekabentuk Kajian

Rekabentuk kajian ialah satu rangka kerja yang merangkumi kaedah pengumpulan dan menganalisis data yang sesuai dengan jenis penyelidikan yang dijalankan. Ianya digunakan untuk menentukan kaedah pengumpulan data, pemilihan sampel, instrumen kajian, prosedur pelaksanaan dan teknik menganalisis data untuk memastikan hasil dapatan kajian yang diperolehi adalah sah dan boleh dipercayai. Kaedah kajian yang digunakan dalam penyelidikan ini adalah kaedah tinjauan sebelum memulakan edaran soalan selidik kepada responden. Merujuk kajian John W. Creswell (2014) [25] menyatakan rekabentuk kajian kuantitif digunakan untuk mengukur pemboleh ubah secara numerik dan menganalisis data menggunakan statistik kajian tinjauan dan eksperimen. Kajian dijalankan secara kuantitatif dengan menggunakan borang soal selidik sebagai instrumen kajian

Populasi Kajian

Populasi kajian ialah merujuk kepada keseluruhan kumpulan individu, objek atau sesuatu yang mempunyai ciri-ciri tertentu serta menjadi fokus utama dalam sesuatu kajian atau penyelidikan yang dijalankan. Populasi juga merujuk kepada dari masa sumber data itu diambil. Populasi merupakan jumlah semua penduduk atau kumpulan yang besar dan banyak yang mendiami sesuatu tempat, daerah, negeri atau negara. Kumpulan ini menjadi fokus utama dalam penyelidikan (Ahmad Munawar & Mohd Nor Shahizan, 2014) [26]. Populasi kajian dalam kajian ini adalah pelajar semester 2 hingga 6 yang telah mempelajari kursus DVP30253 Digital Printing dan DVP20263 Digital Printing (WBL) bagi Program Diploma Teknologi Media Cetak di Politeknik Muadzam Shah, Pahang iaitu seramai 90 orang pelajar.

Instrumen Kajian

Dalam kajian ini instrumen kajian yang digunakan ialah dengan mengedar borang soal selidik secara dalam talian menggunakan platform *google form* kepada pelajar Program Diploma Teknologi Media Cetak yang telah mempelajari kursus *Digital Printing.* Borang terbahagi kepada 6 bahagian iaitu bahagian A, B, C, D, E dan F. Dalam bahagian A adalah berkaitan dengan maklumat demografi latar belakang pelajar reponden. Di bahagian B pula melibatkan soalan persepsi pelajar terhadap pembelajaran teknologi percetakan digital. Manakala di bahagian C soalan berkenaan kefahaman pelajar terhadap pembelajaran teknologi digital. Soalan berkaitan kemahiran dan penguasaan pelajar terhadap pembelajaran teknologi percetakan digital disediakan di bahagian D. Seterusnya, di bahagian E soalan berkenaan kaedah pengajaran pensyarah di dalam kelas. Soalan terakhir di bahagian F disediakan berkenaan cabaran yang dihadapi oleh pelajar dalam pembelajaran teknologi percetakan digital. Format maklum balas yang digunakan pada bahagian B hingga E iaitu lima mata skala likert dengan mewakili 5 skala iaitu skala 1 = sangat tidak setuju, skala 2 = tidak setuju, skala 3 = tidak pasti, skala 4 = setuju, skala 5 = sangat setuju.

Kaedah Pengukuran Kajian

Kaedah pengukuran dalam kajian ini merupakan nilai skor min yang akan digunakan untuk mengukur tahap penilaian responden terhadap soalan-soalan yang diberikan. Proses pengiraan akan dilakukan bagi menghasilkan nilai min setiap aspek yang dikaji. Hasil dapatan dikira untuk mendapatkan nilai purata min bagi setiap kumpulan skor min. Jadual di bawah menunjukkan bahawa interpretasi skor min berada di antara 1.01 hingga 2.33 dianggap pengukuran rendah. Bagi nilai min 2.34 hingga 3.66 dianggap sederhana. Seterusnya, nilai min bagi 3.67 hingga 5.00 dianggap sebagai pengukuran yang tinggi. Dapatan interpretasi skor min bagi kajian menggunakan skala pengukuran yang dicadangkan oleh N. Ashikin A. J dan M. Syawal. A (2023) [27] seperti yang dinyatakan dalam jadual 1.

Jadual 1: Interpretasi Skor Min

Skor Min	Interpretasi Skor Min
1.00 hingga 2.33	Rendah
2.34 hingga 3.66	Sederhana
3.67 hingga 5.00	Tinggi

Sumber : N. Ashikin A. J dan M. Syawal. A (2023)

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IV. KEPUTUSAN DAN PERBINCANGAN

A. Data Demografik Responden

i. Jantina (Lelaki dan Perempuan)

Jadual 4.1 : Maklumat Jantina Responden

Jantina	Kekerapan	Peratusan
Lelaki	51	56.7
Perempuan	39	43.3
Jumlah	**90**	**100**

Kajian ini melibatkan 90 responden pelajar yang terdiri daripada 51 responden atau 56.7% adalah responden lelaki manakala 39 atau 43.3% merupakan responden perempuan. Taburan pelajar lelaki dan perempuan responden kajian dijelaskan dalam jadual 4.1.

ii. Semester Pengajian Responden

Jadual 4.2 : Semester Pengajian Responden

Semester	Kekerapan	Peratusan
Semester 2	18	20.0
Semester 3	20	22.2
Semester 4	14	15.6
Semester 5	19	21.1
Semester 6	19	21.1
Jumlah	**90**	**100**

Dari segi aspek semester pengajian, responden bermula dari semester 2 hingga semester 6 bagi Program Diploma Teknologi Media Cetak di Jabatan Rekabentuk & Komunikasi Visual, Politeknik Muadzam Shah, Pahang. Dapatan mendapati 18 orang responden, bersamaan 20% daripada pelajar adalah daripada semester 2 dan 20 orang responden atau 22.2% adalah pelajar daripada semester 3. Responden dari semester 4 pula, dengan jumlah 14 orang responden bersamaan 15.6% pelajar. Seterusnya, kajian mendapati hasil dapatan yang sama iaitu 19 orang responden bersamaan 21.1% daripada pelajar semester 5 dan semester 6.

Data Analisis Deskriptif

B. Persepsi Pelajar Terhadap Pembelajaran Teknologi Percetakan Digital

Jadual 4.3 : Persepsi Pelajar Terhadap Pembelajaran Teknologi Percetakan Digital

Item	Soalan	Min	SP	Tahap
B1	Saya berminat untuk mempelajari topik teknologi percetakan digital.	4.45	0.75	Tinggi
B2	Saya lebih suka topik percetakan digital berbanding percetakan tradisional.	4.36	0.81	Tinggi
B3	Saya sanggup meluangkan masa tambahan untuk memahami teknologi percetakan digital.	4.32	0.86	Tinggi
B4	Saya melihat pembelajaran teknologi percetakan digital sebagai satu pengalaman yang menyeronokkan.	4.50	0.82	Tinggi
B5	Pembelajaran teknologi percetakan digital membuatkan saya lebih teruja untuk hadir ke kelas.	4.46	0.76	Tinggi
Jumlah		**4.41**	**0.80**	**Tinggi**

Berdasarkan Jadual 4.3, hasil kajian responden terhadap persepsi pelajar terhadap pembelajaran teknologi percetakan digital bagi kursus digital printing di Politeknik Muadzam Shah. Bagi pernyataan item B1, analisis soalan pelajar berminat untuk mempelajari topik teknologi percetakan digital menunjukkan skor min pada tahap tinggi dengan nilai 4.45 dan sisihan piawai 0.75. Bagi item B2 pula, pelajar lebih suka topik percetakan digital berbanding percetakan tradisional, menunjukkan skor min 4.36 dengan nilai sisihan piawai 0.81. Seterusnya, bagi item B3, pelajar yang sanggup meluangkan masa tambahan untuk memahami teknologi percetakan digital menunjukkan tahap min pada skor tinggi dengan nilai min 4.32 serta nilai sisihan piawai 0.86. Dengan nilai min 4.50 dan sisihan piawai 0.82 pada tahap tinggi merupakan soalan pelajar melihat pembelajaran teknologi percetakan digital sebagai satu pengalaman yang menyeronokkan bagi analisis pernyataan item B4. Manakala, bagi item B5 dengan soalan analisis pembelajaran teknologi percetakan digital membuatkan saya lebih teruja untuk hadir ke kelas, menunjukkan nilai skor min 4.46 dan sisihan piawai 0.76 berada pada tahap tinggi.

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Dapatan kajian bagi persepsi pelajar terhadap pembelajaran teknologi percetakan digital dalam jadual di 4.3 menunjukkan skor min paling rendah ialah 4.32 dengan sisihan piawai 0.86 manakala skor min paling tinggi ialah 4.50 dengan sisihan piawai 0.82. Hasil ini dapat dikatakan bahawa persepsi pelajar terhadap pembelajaran teknologi percetakan digital berada di tahap tinggi dengan nilai skor min 4.41 dan sisihan piawai 0.80 dapat dilihat dari segi minat, keterujaan dan kesanggupan pelajar untuk mempelajari kursus ini.

C. Tahap Kefahaman Pelajar Terhadap Pembelajaran Teknologi Percetakan Digital

Jadual 4.4 : Tahap Kefahaman Pelajar Terhadap Pembelajaran Teknologi Percetakan Digital

Item	Soalan	Min	SP	Tahap
C1	Saya memahami konsep asas teknologi percetakan digital seperti percetakan inkjet (inkjet printing) dan percetakan laser (laser printing).	4.43	0.60	Tinggi
C2	Saya tahu membezakan antara proses percetakan digital dan proses percetakan tradisional.	4.53	0.57	Tinggi
C3	Saya boleh menjelaskan semula proses asas percetakan digital selepas sesi pembelajaran berlansung.	4.38	0.69	Tinggi
C4	Saya mudah memahami pengajaran berkaitan perisian teknologi percetakan digital.	4.42	0.58	Tinggi
C5	Pembelajaran teknologi percetakan digital meningkatkan kemahiran teknikal saya.	4.44	0.54	Tinggi
Jumlah		**4.44**	**0.59**	**Tinggi**

Dapatan kajian menunjukkan analisis data tahap kefahaman pelajar terhadap pembelajaran teknologi percetakan digital. Pernyataan bagi item C1 dengan soalan pelajar memahami konsep asas teknologi percetakan digital seperti percetakan inkjet dan percetakan laser menunjukkan nilai skor min 4.43 dengan sisihan piawai 0.60 pada tahap tinggi. Dengan jumlah skor min 4.53 dan sisihan piawai 0.57, pelajar tahu membezakan antara proses percetakan digital dan proses percetakan tradisional bagi item C2, menunjukkan tahap min berada di tahap tinggi. Seterusnya, item bagi C3 dengan soalan analisis pelajar boleh menjelaskan semula proses asas percetakan digital selepas sesi pembelajaran berlangsung menunjukkan nilai skor min 4.38 dan sisihan piawai 0.69 pada tahap tinggi. Manakala nilai skor min 4.42 dan sisihan piawai 0.58 pada tahap tinggi menunjukkan soalan bagi item C4 iaitu pelajar mudah memahami pengajaran berkaitan perisian teknologi percetakan digital. Akhir sekali, bagi item C5 dengan soalan pembelajaran bahawa teknologi percetakan digital meningkatkan kemahiran teknikal pelajar menunjukkan skor min 4.44 dengan sisihan piawai 0.54 pada tahap tinggi.

Dapatan kajian bagi item C kefahaman pelajar terhadap pembelajaran teknologi percetakan digital seperti dalam jadual 4.4 menunjukkan skor min paling rendah ialah 4.38 denagan sisihan piawai 0.69 manakala skor min paling tinggi 4.53 sisihan piawai 0.57. Secara kesimpulannya dapat disimpulkan bahawa pembelajaran teknologi percetakan digital dapat dan membantu meningkatkan kefahaman pelajar dalam kursus ini. Dapatan ini dapat dilihat dengan jelas apabila jumlah keseluruhan skor min 4.44 dengan sisihan piawai 0.59 pada tahap tinggi.

D. Kemahiran dan Penguasaan Pelajar Terhadap Pembelajaran Teknologi Percetakan Digital

Jadual 4.5 : Kemahiran dan Penguasaan Pelajar Terhadap Pembelajaran Teknologi Percetakan Digital

Item	Soalan	Min	SP	Tahap
D1	Saya boleh menguasai ilmu percetakan digital dengan baik.	4.42	0.65	Tinggi
D2	Saya mampu menyiapkan tugasan berkaitan percetakan digital tanpa bantuan pensyarah.	4.13	0.94	Tinggi

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D3	Saya lebih yakin menghasilkan bahan cetakan selepas mengikuti kursus ini.	4.40	0.63	Tinggi
D4	Pembelajaran teknologi percetakan digital membantu saya untuk bersedia menghadapi latihan industri nanti.	4.38	0.69	Tinggi
D5	Penggunaan teknologi percetakan digital membantu meningkatkan pencapaian akademik saya.	4.46	0.62	Tinggi
Jumlah		**4.35**	**0.70**	**Tinggi**

Berdasarkan jadual di atas, hasil kajian responden menunjukkan kemahiran dan penguasaan pelajar terhadap pembelajaran teknologi percetakan digital. Hal ini dapat dilihat berdasarkan dapatan hasil kajian apabila nilai skor min ialah 4.42 dengan sisihan piawai 0.65, iaitu tahap tinggi terhadap pernyataan soalan item D1 pembelajaran teknologi percetakan digital meningkatkan kemahiran teknikal pelajar. Bagi item D2, analisis soalan pelajar yang mampu menyiapkan tuasan berkaitan percetakan digital tanpa bantuan pensyarah menunjukkan jumlah skor min 4.13 dengan sisihan piawai 0.94 pada tahap tinggi. Selain itu, pelajar yang lebih yakin menghasilkan bahan cetakan selepas mempelajari kursus ini berada pada soalan item D3 dengan nilai skor min 4.40 dengan sisihan piawai 0.63 pada tahap tinggi. Seterusnya, item D4 pembelajaran teknologi percetakan digital membantu pelajar bersedia menghadapi latihan industri nanti, menunjukkan skor 4.38 dan sisihan piawai 0.69 dengan tahap min tinggi. Bagi item terakhir D5, penggunaan teknologi percetakan digital membantu meningkatkan pencapaian akademik pelajar dengan nilai min 4.46 dan sisihan piawai 0.62 berada pada tahap pencapaian min tinggi.

Hasil dapatan mendapati skor min terendah iaitu 4.13 dengan sisihan piawai 0.94 manakala skor min tertinggi 4.46, sisihan piawai 0.62. Jumlah keseluruhannya bagi pernyataan kemahiran dan penguasaan pelajar terhadap pembelajaran teknologi percetakan digital menunjukkan tahap tinggi dengan nilai skor min 4.35 dan sisihan piawai 0.70. Oleh hal yang demikian, dapat disimpulkan bahawa pelajar memberikan persepsi yang baik terhadap kemahiran dan penguasaan mereka terhadap pembelajaran teknologi percetakan digital bagi Program Diploma Teknologi Media Cetak di Politeknik Muadzam Shah, Pahang.

E. Kaedah Pengajaran Pensyarah di Dalam Kelas

Jadual 4.5 : Kaedah Pengajaran Pensyarah di Dalam Kelas

Item	Soalan	Min	SP	Tahap
E1	Pensyarah menggunakan kaedah pengajaran yang mudah difahami.	4.55	0.54	Tinggi
E2	Pensyarah memberikan penerangan topik pembelajaran dengan jelas semasa kelas percetakan digital dilaksanakan.	4.54	0.57	Tinggi
E3	Pensyarah menggunakan bahan bantu mengajar tambahan seperti tayangan video berkaitan proses percetakan digital.	4.51	0.54	Tinggi
E4	Pensyarah menggalakkan pelajar bertanya dan berbincang semasa sesi PdP berlangsung.	4.56	0.50	Tinggi
E5	Kaedah pengajaran pensyarah membantu saya lebih yakin dengan kursus percetakan digital.	4.50	0.57	Tinggi
Jumlah		**4.53**	**0.54**	**Tinggi**

Dapatan kajian menunjukkan kaedah pengajaran pensyarah di dalam kelas bagi kursus percetakan digital Program Diploma Teknologi Media Cetak. Bagi pernyataan E1, pensyarah menggunakan kaedah pengajaran yang mudah difahami

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menunjukkan jumlah skor min 4.55 dengan sisihan piawai 0.54 pada tahap tinggi. Hasil dapatan bagi item E2 pula, dengan pernyataan soalan bahawa pensyarah memberikan penerangan topik pembelajaran dengan jelas semasa kelas percetakan digital dilaksanakan, menunjukkan skor min 4.54 dengan sisihan piawai 0.57, iaitu pada tahap tinggi. Kajian juga mendapati skor min 4.51 dan sisihan piawai 0.54 berdasarkan pensyarah yang menggunakan bahan bantu mengajar tambahan seperti tayangan video berkaitan proses percetakan digital dengan tahap tinggi dinyatakan pada item E3. Seterusnya, dengan jumlah skor min 4.56 dan sisihan piawai 0.50 pada tahap tinggi, pernyataan soalan pensyarah yang menggalakkan pelajar bertanya dan berbincang semasa sesi PdP berlangsung dinyatakan pada item E4. Manakala bagi item E5 pula, kaedah pengajaran pensyarah membantu saya lebih yakin dengan kursus percetakan digital, menunjukkan nilai skor min 4.50 dengan sisihan piawai 0.57 berada pada tahap tinggi.

Hasil dapatan mendapati kaedah pengajaran pensyarah di dalam kelas bagi kursus percetakan digital ini amat berkesan. Keberkesanan dapatan ini jelas dinyatakan di dalam jadual yang menunjukkan skor min yang paling rendah 4.50 dengan sisihan piawai 0.57 manakala skor min paling tinggi ialah 4.56 dan sisihan piawai 0.50. Secara keseluruhannya, dapatan berada pada tahap tinggi dengan nilai skor min 4.53 dan sisihan piawai 0.54.

F. Cabaran Yang Dihadapi Oleh Pelajar Dalam Pembelajaran Teknologi Percetakan Digital

Jadual 4.7 : Cabaran Yang Dihadapi Oleh Pelajar Dalam Pembelajaran Teknologi Percetakan Digital

Item	Soalan	Min	SP	Tahap
F1	Saya menghadapi kesukaran dalam menggunakan perisian teknologi percetakan digital.	3.60	1.09	Sederhana
F2	Saya menghadapi masalah teknikal yang mengganggu proses pembelajaran.	3.72	1.17	Tinggi
F3	Saya menghadapi masalah kesukaran untuk mengendalikan mesin percetakan digital kerana ketiadaan mesin di jabatan.	3.63	1.15	Sederhana
F4	Saya memerlukan latihan tambahan berkaitan teknologi percetakan digital.	3.93	0.99	Tinggi
F5	Saya memerlukan masa yang lebih banyak lagi dalam pembelajaran amali teknologi percetakan digital.	3.92	0.93	Tinggi
Jumlah		**3.76**	**1.06**	**Tinggi**

Dapatan kajian juga mendapati terdapat beberapa cabaran yang dihadapi oleh pelajar semasa mempelajari pembelajaran teknologi percetakan digital daripada tajuk kajian ini yang dapat dilihat pada jadual 4.7. Bagi item F1, pelajar menghadapi kesukaran untuk menggunakan perisian teknologi percetakan digital, yang menunjukkan skor min 3.60 dan sisihan piawai 1.09 berada di tahap sederhana. Kajian juga mendapati nilai skor min 3.72 dengan sisihan piawai 1.17, iaitu pada tahap tinggi berdasarkan pernyataan bahaw pelajar menghadapi masalah teknikal yang mengganggu proses pembelajaran pada item F2. Seterusnya, dengan jumlah skor min 3.63 dan sisihan piawai 1.15, tahap sederhana dengan pernyataan pelajar memerlukan latihan tambahan berkaitan teknologi percetakan digital dinyatakan pada item F3. Manakala bagi item F4 pula, latihan tambahan berkaitan teknologi percetakan digital menunjukkan nilai skor min 3.93 dengan sisihan piawai 0.99 pada tahap tinggi. Pelajar memerlukan masa yang lebih banyak lagi dalam pembelajaran amali teknologi percetakan digital, menunjukkan cabaran yang dihadapi oleh pelajar dalam pembelajaran teknologi percetakan digital dengan skor min 4.5 dan sisihan piawai 0.93, tahap tinggi didapati daripada hasil kajian F5.

Hasil dapatan bagi pernyataan dalam jadual di atas mendapati skor min terendah 3.60 dengan sisihan piawai 1.09 manakala skor tertinggi 3.93 dan sisihan piawai 0.99. Jumlah keseluruhan cabaran yang dihadapi oleh pelajar dalam pembelajaran teknologi percetakan digital menunjukkan pada tahap tinggi dengan skor min keseluruhan 3.76 serta

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sisihan piawai 1.06. Ini jelas menggambarkan bahawa pelajar Program Diploma Teknologi Media Cetak sangat menghadapi cabaran ketika mempelajari kursus percetakan digital.

V. KESIMPULAN

Kesimpulannya, hasil dapatan keseluruhan bagi kajian menunjukkan responden bersetuju dan memberikan maklum balas persepsi yang positif terhadap pembelajaran teknologi percetakan digital bagi Program Diploma Teknologi Media Cetak di Politeknik Muadzam Shah, Pahang. Kajian mengenai persepsi pelajar terhadap pembelajaran teknologi percetakan digital ini wajar dijalankan bagi menilai dan mengenal pasti minat, kefahaman, kemahiran dan penguasaan pelajar terhadap pembelajaran teknologi percetakan digital, kaedah pengajaran pensyarah di dalam kelas dan cabaran yang dihadapi oleh pelajar semasa mempelajari kursus ini. Hasil kajian ini amat penting bagi menentukan dan menilai tahap minat, kefahaman, penglibatan pelajar dalam kursus tersebut. Ia juga memberikan gambaran sama ada kandungan silibus kursus, kaedah pengajaran pensyarah, kemudahan peralatan dan mesin serta pembelajaran teori dan amali yang digunakan selari dengan keperluan industri semasa. Secara keseluruhannya menunjukkan bahawa pelajar mempunyai minat terhadap pembelajaran teknologi percetakan digital dan faham mengenai topik tersebut. Walaupun maklum balas yang diberikan oleh semua pelajar adalah positif, terdapat beberapa cabaran yang dihadapi oleh pelajar dalam mempelajari kursus ini. Cabaran ini timbul disebabkan oleh kekangan mesin cetak digital terkini yang diperuntukkan untuk program ini. Oleh itu, para pelajar tidak dapat menguasai latihan dan praktikal penggunaan mesin dengan baik ketika mempelajari kursus ini di politeknik dan hanya akan mempelajari mesin cetak digital ketika menjalani latihan industri nanti.

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A Study on Personality Traits and Academic Performance among Students at Politeknik Mersing Johor

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Abstract

This study examines the relationship between personality traits and academic performance among students at Politeknik Mersing Johor, recognising that personality plays a crucial role in shaping students' attitudes, behaviours, and learning approaches. Grounded in the Big Five Personality Traits Model, which consists of openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism. The research adopts a quantitative design using a structured questionnaire adapted from the Big Five Personality Inventory, alongside students' Grade Point Average (GPA) as a measure of academic performance. Data were collected from a sample of 119 students across various academic programmes, and analysed using descriptive statistics and mean analysis. The findings indicate that certain personality traits, particularly openness to experience, are likely to have a significant positive relationship with academic performance, while personality traits such as conscientiousness may exhibit a negative relationship due to increased stress and emotional instability. Overall, this study provides valuable insights for educators, academic advisors, and students in understanding the influence of personality on academic success and highlights the importance of developing targeted strategies to enhance learning outcomes in higher education institutions.

Keywords **:** *Personality Traits, Academic Performance, Big Five Personality Model, Higher Education.*

I. INTRODUCTION

Personality determines a set of important characteristics and that is how people interact with others. (Ghazi et al, 2013) [1]. Human personality is the combination of a number of traits. A trait really makes it easier to describe people and even compare them to others. So, traits are basically the building blocks of personality. When we talk about personality traits, we're looking at those unique characteristics that shape who someone is. Personality itself is this unique mix of thoughts, feelings, and behaviours that define a person. But then, traits are those specific characteristics that come together to form that bigger picture. It's like, if you think about it, traits are what you can point to when describing someone. For instance, if you say someone is outgoing and friendly, those traits—extraversion and agreeableness—play a big role in shaping their personality overall. Personality also refers to the relatively stable patterns of thoughts, emotions, and behaviours that characterize individuals. In educational psychology, personality traits are often examined using the Big Five Personality Model, which includes five major dimensions such as openness, conscientiousness, extraversion, agreeableness, and neuroticism. These traits influence how students interact with their learning environment and manage academic responsibilities. These properties affect how people think, feel and behave in a variety of situations. Intellectual curiosity, positive imagination, emotional openness, and mentality are all indicators of openness. The tendency to be well organized, motivated and responsibly targeted is known as conscience. The tendency to hostile emotions such as shame, anger, fear, disgust, sadness, and shame is associated with neurosis. The tendency for great crowds to be talkative, powerful, energetic and passionate, and like people like people is known as the extra version. Supportive, noble and reliable ability is known as compatibility (Wagerman & Funder, 2007) [2].

Apart from personality traits, academic performance is a term used to describe performance outcomes, indicating how well a person is doing in achieving a particular goal. This focuses on the educational environment, particularly on the focus of activities at universities. Academic achievement can be assessed on many criteria, including more educational aspects such as grades and test results, cumulative metrics and very broad indicators such

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as formal school acquired procedural and declarative knowledge.

Lecturers use a variety of evaluation methods to track student progress and understanding throughout semesters. Formative assessments, such as quizzes and assignments, help identify areas of struggle and provide extra help, while summative assessments, like midterms and finals, gauge what students have learned by the end of a course or semester. In universities, academic performance is measured through grades, test scores, and other evaluative metrics (Hanson, 2000) [3]. Factors affecting academic performance include personal traits like motivation, study habits, and prior knowledge, as well as external influences like the quality of education, curriculum design, and socioeconomic status. Effective academic performance involves a solid understanding of subjects, critical thinking skills, and practical application of knowledge.

Therefore, it is important to understand how personality traits influence academic performance among students at Politeknik Mersing Johor. Identifying these relationships may help educators design more effective academic support systems and counselling programs. Several studies have demonstrated that personality traits significantly influence academic success. For example, research involving thousands of university students found that conscientiousness is the most consistent predictor of academic achievement. Students with high conscientiousness tend to be more organized, disciplined, and responsible, which helps them complete assignments, prepare for examinations, and maintain consistent study habits.

In Malaysia, polytechnic institutions such as Politeknik Mersing Johor aim to produce skilled graduates who are not only academically competent but also possess strong personal characteristics. Therefore, the following research objective are established:

a) To study seeks to examine how personality traits influence the academic performance of students at Politeknik Mersing Johor.

b) To identify the dominant personality traits among students at Politeknik Mersing Johor.

c) To determine which personality traits significantly influence students' academic performance.

II. LITERATURE REVIEW

Personality traits refer to relatively stable patterns of thinking, feeling, and behaving that characterize individuals. These traits influence how individuals perceive situations and respond to various life experiences, including academic tasks and learning environments. Personality traits are considered relatively stable over time and can influence individuals' behaviors across different contexts. The **Big Five Personality Model**, also known as the Five-Factor Model, is widely used in psychological and educational research (Mamadov S, 2022) [4]. This model categorizes personality into five broad traits: openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism. These traits provide a comprehensive framework for understanding human personality and its impact on behavior.

Research has shown that these five traits are reliable predictors of various life outcomes, including academic achievement, job performance, and interpersonal relationships. In educational settings, personality traits influence students' study habits, motivation levels, and academic engagement. For example, students who are highly organized and disciplined may be more likely to complete assignments on time and maintain consistent study routines. Therefore, the following research objectives are established examining personality traits can help researchers better understand the factors contributing to students' academic performance.

A. Big Five Personality Model

Openness to experience refers to an individual's curiosity, creativity, and willingness to explore new ideas and experiences. Students who score high in openness tend to enjoy learning new concepts, engaging in intellectual discussions, and exploring different perspectives. These students often demonstrate strong critical thinking skills and creativity in problem-solving.

Studies have suggested that openness to experience is positively associated with intellectual curiosity and learning engagement. Although its direct relationship with academic performance is generally weaker than that of conscientiousness, openness may still contribute to academic success by encouraging deeper learning and greater intellectual exploration.

Conscientiousness is widely regarded as the most important personality trait associated with academic performance. This trait reflects qualities such as discipline, organization, responsibility,

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persistence, and goal-oriented behaviour. Students who score high in conscientiousness tend to be hardworking, reliable, and capable of managing their time effectively. Numerous studies have demonstrated that conscientiousness is strongly correlated with academic achievement. Students with high levels of conscientiousness are more likely to develop effective study habits, complete assignments on time and maintain consistent effort in their academic work. A meta-analysis examining multiple studies found that conscientiousness is a robust predictor of students' academic performance and GPA across different educational levels. Furthermore, research involving thousands of students across multiple countries confirmed that conscientiousness consistently shows the strongest positive relationship with academic achievement compared to other personality traits.

Extraversion is characterized by sociability, confidence, passion, and energy. Students with high levels of extraversion tend to enjoy interacting with others and participating in group activities. In educational environments, extraverted students may benefit from collaborative learning, group discussions, and classroom participation. However, research findings on the relationship between extraversion and academic performance are mixed. Some studies suggest that extraversion may positively influence academic performance through active participation and communication skills. On the other hand, other studies indicate that extreme social engagement may distract students from academic tasks. Overall, extraversion tends to have a weaker relationship with academic performance compared to conscientiousness.

Agreeableness refers to traits such as kindness, cooperation, empathy, and trust. Students who score high in agreeableness are generally cooperative and sustain good relationships with lecturers and friends. These students often work well in group environments and demonstrate supportive attitudes toward others. Although agreeableness may contribute to positive social interactions and collaborative learning environments, its direct impact on academic performance is generally moderate. Some studies suggest that agreeableness may indirectly support academic success by promoting teamwork, effective communication, and supportive peer relationships in educational environments

Neuroticism refers to emotional instability, anxiety, moodiness, and vulnerability to stress. Students with high levels of neuroticism may experience difficulties managing stress, anxiety, and negative emotions, which can affect their ability to concentrate and perform academically.

Research has shown that neuroticism is generally associated with lower academic performance due to increased stress and emotional difficulties. Students who experience high levels of anxiety may struggle with examinations, deadlines, and academic pressure. However, some studies suggest that moderate levels of anxiety may motivate students to work harder and prepare more thoroughly for academic tasks.

B. Academic Performance

Academic performance is widely recognized as an important indicator of students' success in educational institutions. It reflects the extent to which students have achieved their educational goals and mastered the knowledge and skills taught during their academic programs. Academic performance is commonly measured through indicators such as Grade Point Average (GPA), examination results, coursework assessments, and overall academic achievements. According to Philip G. Altbach and Jamil Salmi [5], academic performance plays a significant role in determining students' educational outcomes and future career opportunities in higher education institutions.

Researchers have emphasized that academic performance is influenced by a variety of factors, including cognitive abilities, motivation, study habits, learning strategies, personality traits, and environmental influences. These factors interact with each other and contribute to students' ability to succeed academically. Studies have shown that students who demonstrate effective time management, strong motivation, and consistent study habits tend to achieve higher academic performance (Richardson, Abraham, & Bond,2012) [6].

In higher education, academic performance is often used as a benchmark to evaluate students' progress and institutional effectiveness. Educational institutions rely on academic performance indicators to assess whether students are meeting learning outcomes and academic standards. According to Alexander W. Astin [7], students' academic performance is closely related to their level of involvement in educational activities, including classroom participation, interaction with educators, and engagement in learning tasks.

Academic performance is influenced by a wide range of factors, which can generally be categorized into internal and external factors. Internal factors

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refer to characteristics within the student, such as intelligence, motivation, personality traits, learning styles, and study habits. External factors, on the other hand, include family background, teaching quality, learning environment, peer influence, and institutional support. Research has shown that psychological factors such as motivation, self-discipline, and self-efficacy play significant roles in determining students' academic performance (Richardson, Abraham, & Bond, 2012) [8]. Students who hold strong essential motivation and effective learning strategies tend to perform better academically because they are more committed to their learning goals.

Furthermore, personality traits have been recognized as a vital psychological factor influencing academic performance. Studies based on the Five-Factor Model of personality indicate that certain personality traits, particularly conscientiousness, are strongly associated with academic success. Students who demonstrate high levels of conscientiousness tend to be systematic, responsible, and persistent in completing academic tasks. These characteristics enable them to manage their time effectively, complete assignments on schedule, and maintain consistent study routines (McAbee & Oswald, 2014) [9]. As a result, conscientious students often achieve higher academic performance compared to their peers.

Another important factor influencing academic performance is the learning environment provided by educational institutions. A supportive learning environment that includes effective teaching methods, accessible learning resources, and positive student–teacher relationships can significantly enhance students' academic outcomes. According to York, Gibson, and Rankin (2015) [10], academic success is not only determined by students' intellectual abilities but also by institutional factors such as teaching quality, academic support services, and learning amenities. Institutions that provide supportive academic environments can encourage students to engage more actively in their studies and achieve better academic results.

In addition, students' study habits and time management skills play an essential role in determining their academic performance. Effective study strategies, such as regular revision, goal setting, and proper time management, allow students to organize their academic assignments more efficiently. Students who develop strong study habits are better able to cope with academic challenges and maintain consistent academic performance throughout their studies.

Overall, previous studies specify that academic performance is influenced by multiple factors that interact with each other, including psychological characteristics, environmental conditions, and learning behaviours. Understanding these factors is important for educators, researchers, and educational institutions in developing strategies to improve students' academic outcomes. By identifying the key factors that contribute to academic success, institutions can design effective academic support programs that help students achieve their full potential.

III. RESEARCH METHODOLOGY

a) Sampling

This study adopted a quantitative case study design to explore on how personality traits of students affect their academic performance. Data were collected from questionnaire responses collected from 119 students enrolled in different academic programs. These responses provided evidence that reflected students' personality traits satisfied their academic performance. The findings may also provide insights for higher education institutions to examine how personality traits influence the academic performance of students.

b) Data Sources

The questionnaire instrument was divided into four sections: Section A, which encompasses respondent's demographics including gender, department, current semester and current GPA. Section B contains questions related to big five personality trait. Section C consist of student's academic performance and last section which is Section D is feedback or suggestions from respondents. A structured questionnaire was administered to students to obtain direct feedback on student's personality traits with their academic performance. The instrument comprised quantitative items measured on a Likert scale to capture students' levels of satisfaction on academic performance and a personality trait. The responses were analysed using descriptive statistics to summarize the quantitative data. This approach provided a more comprehensive understanding to support student's personality traits with academic performance.

c) Data Analysis

The interpretation of mean scores was based on the five-point Likert scale interval classification suggested by Miller and Salkind (2002) [11], where the range of each category was calculated using the formula (highest score – lowest score) divided by the

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number of categories. The interpretation of mean scores on the 5-point Likert scale is as in Table 3.1

Table 3.1 Interpretation Mean Score (Miller & Salkind, 2002)

Mean Scores	Interpretation
1.00-1.80	Very low/Negative
1.81-2.60	Low/Negative
2.61-3.40	Moderate
3.41-4.20	High/Positive
4.21-5.00	Very High/Very Positive

IV. RESULT AND DISCUSSION

A) Demographic of Respondents

The demographic profile of the respondents focuses on gender, department, the respondents' semester of study and cumulative grade point average (CGPA).

Table 4.1 Gender's Respondents

Gender	Frequency	Percentage (%)
Male	39	32.8
Female	80	67.2
	119	100

Table 4.1 shows that a total of 119 respondents participated in providing feedback for the study. The number of female respondents is higher than that of male respondents. A total of 67.2% of the respondents were female, while only 32.8% were male.

Table 4.2 Department's Respondents

Department	Frequency	Percentage (%)
JP	77	64.7
JKE	13	10.9
JTMK	29	24.4

Table 4.2 shows the respondents of the study who come from three main departments at Politeknik Mersing Johor. Respondents from the Department of Commerce which is 64.7%, Department of Electrical Engineering represent 10.9%. Meanwhile, respondents from the Department of Information and Communication Technology represent 24.4%.

Table 4.3 Semester's Respondents

Semester	Frequency	Percentage (%)
Sem 1	28	23.5
Sem 2	41	34.5
Sem 3	7	5.9
Sem 4	38	31.9
Sem 5	3	2.5
Sem 6	2	1.7

Table 4.3 shows the distribution of respondents across six semesters of study. Respondents from Semester 2 recorded the highest number of responses at 34.5% followed by Semester 4 with 31.9%. Semester 1 accounted for 23.5%, Semester 3 for 5.9% and Semester 5 for 2.5%. Meanwhile, respondents for semester 6 recorded the lowest percentage of responses at only 1.7%.

Table 4.4 CGPA's Respondents

Semester	Frequency	Percentage (%)
1.00-1.99	9	7.6
2.00-2.49	2	1.7
2.50-2.99	15	12.6
3.00-3.49	39	32.8
3.50-4.00	54	45.4

Table 4.4 shows the distribution of respondent's CGPA. The highest number of CGPA is 3.50-4.00 at 45.4% followed by 3.00-3.49 with 32.8%. CGPA 2.50-2.99 for 12.6%, 1.00-1.99 for 7.6% and the lowest percentage of CGPA 2.00-2.49 at only 1.7%.

B) PERSONALITY TRAITS

Table 4.5 Openness to Experience

Bil	Items	Mean	Score Level
B1.	I enjoy learning new things	4.49	Very positive
B2.	I like to explore new ideas and concepts	4.41	Very positive
B3.	I enjoy trying different learning methods/	4.10	Positive
B4.	I am curious about many different things	4.44	Very positive
B5.	I enjoy thinking creatively to solve problems	4.21	Very positive

Based on the table 4.5, it shows that all items recorded high mean scores, ranging from 4.10 to 4.49, indicating a positive to very positive level of agreement among respondents. Most items, including items B1 enjoying learning new things, (B2) exploring new ideas, (B4) being curious, and (B5) thinking creatively, were interpreted as very positive. Overall, the results suggest that the respondents demonstrate strong positive attitudes toward learning and creativity.

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Table 4.6 Conscientiousness

Bil	Items	Mean	Score Level
B6.	I plan my study schedule carefully.	3.79	Positive
B7.	I complete my assignments before the deadline.	4.31	Very positive
B8.	I pay attention during lectures.	4.11	Positive
B9.	I work hard to achieve good academic results.	4.43	Very positive
B10.	I manage my study time effectively.	4.05	Positive

The table shows that all items recorded **positive to very positive mean scores**, ranging from **3.79 to 4.43**. Items B7 and B9 were interpreted as **very positive**, indicating that respondents' complete assignments on time and work hard to achieve good academic results. The remaining items (B6, B8, and B10) were interpreted as **positive**, showing that respondents generally plan their study schedule, pay attention during lectures, and manage their study time effectively. Overall, the results indicate good study habits among the respondents.

Table 4.7 Extraversion

Bil	Items	Mean	Score Level
B11.	I enjoy interacting with my classmates.	4.31	Very positive
B12.	I actively participate in class discussions.	4.13	Positive
B13.	I feel confident expressing my ideas in class.	3.84	Positive
B14.	I enjoy working in group assignments.	4.03	Positive
B15.	I find it easy to make friends at college.	4.04	Positive

The table shows that all items recorded **positive to very positive mean scores**, ranging from **3.84 to 4.31**. Item B11 was interpreted as **very positive**, indicating that respondents enjoy interacting with their classmates. The remaining items (B12, B13, B14, and B15) were interpreted as **positive**, showing that respondents actively participate in class, feel confident expressing their ideas, enjoy group work, and find it easy to make friends at college. Overall, the results indicate good social interaction among the respondents.

Table 4.8 Agreeableness

Bil	Items	Mean	Score Level
B16.	I cooperate well with my classmates.	4.33	Very positive
B17.	I respect the opinions of others.	4.46	Very positive
B18.	I like helping friends who have difficulty in their studies.	4.26	Very positive
B19.	I try to maintain good relationships with my classmates.	4.41	Very positive
B20.	I am considerate of other people's feelings.	4.31	Very positive

The table shows that all items recorded **very positive mean scores**, ranging from **4.26 to 4.46**. This indicates that respondents demonstrate strong levels of cooperation, respect, helpfulness, good relationships, and consideration toward others. Overall, the results show a high level of agreeableness and positive interpersonal behavior among the respondents.

Table 4.9 Neuroticism

Bil	Items	Mean	Score Level
B21.	I feel stressed when I have many academic tasks.	3.84	Positive
B22.	I worry about my examination results.	4.36	Very positive
B23.	I feel nervous before examinations.	4.05	Positive
B24.	I feel upset when I get low grades.	4.23	Very positive
B25.	I feel anxious about my academic performance.	4.08	Positive

The table shows that the mean scores range from **3.84 to 4.36**, indicating **positive to very positive** responses. Items B22 and B24 were interpreted as **very positive**, showing that many respondents worry about examination results and feel upset when receiving low grades. The remaining items (B21, B23, and B25) were interpreted as **positive**, indicating that respondents experience stress, nervousness, and anxiety related to academic tasks

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and performance. Overall, the results suggest a moderate to high level of academic stress among the respondents.

C) ACADEMIC PERFORMANCE

Table 4.10 Academic Performance

Bil	Items	Mean	Score Level
C1.	I am satisfied with my academic performance.	3.92	Positive
C2.	I study regularly to improve my results.	4.15	Positive
C3.	I try my best to achieve good grades.	4.43	Very positive
C4.	I review my lessons after class.	3.76	Positive
C5.	I believe that my effort helps improve my academic performance.	4.50	Very positive

The table shows that the mean scores range from **3.76 to 4.50**, indicating **positive to very positive** responses. Items C3 and C5 were interpreted as **very positive**, showing that respondents try their best to achieve good grades and believe that their effort improves their academic performance. The remaining items (C1, C2, and C4) were interpreted as **positive**, indicating that respondents are generally satisfied with their performance, study regularly, and review their lessons after class. Overall, the results show a strong level of academic effort and positive attitude toward learning.

V. CONCLUSION

Based on the findings and discussion of this study, personality traits play an important role in influencing students' academic performance. The results indicate that respondents generally demonstrate high levels of positive personality characteristics, particularly in areas related to **openness, conscientiousness, agreeableness, and extraversion**, while also showing moderate levels of academic-related stress associated with **neuroticism**. Among the Big Five personality traits, **agreeableness** appears to be the most influential factor, as students reported strong agreement in statements effort toward achieving good academic results.

The findings also suggest that students who are organized, hardworking, cooperative, and motivated tend to achieve better academic outcomes. Positive attitudes toward learning, social interaction, and effort-based achievement further contribute to academic success. These results are consistent with meta-analytic studies showing that personality traits significantly predict academic performance, even when controlling for other variables (Richardson, Abraham, & Bond, 2012) [12]. Overall, this study concludes that personality traits are important psychological factors that influence students' academic performance. Understanding these traits can help educators, academic advisors, and institutions develop appropriate strategies to support students' learning development. By recognizing individual personality differences, higher education institutions can enhance teaching approaches, student engagement, and academic support programs to improve overall academic success.

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Kajian Keberkesanan Arena Usahawan JKE sebagai Medium Pembelajaran Keusahawanan Berasaskan Amali

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Abstrak

Kajian ini bertujuan menilai keberkesanan Arena Usahawan JKE sebagai medium pembelajaran keusahawanan berasaskan amali dalam kalangan pelajar. Platform ini memberi peluang kepada pelajar untuk menjalankan aktiviti perniagaan secara langsung serta mengaplikasikan pengetahuan keusahawanan yang dipelajari secara teori. Kajian ini menggunakan pendekatan kuantitatif melalui kaedah tinjauan dengan borang soal selidik sebagai instrumen kajian. Instrumen kajian merangkumi beberapa konstruk utama iaitu keberkesanan Arena Usahawan JKE sebagai medium pembelajaran, penglibatan pelajar dalam aktiviti perniagaan, pembangunan kemahiran keusahawanan, pembelajaran berasaskan amali, faktor pelaksanaan dan sokongan serta tahap kepuasan pelajar. Data dianalisis menggunakan statistik deskriptif iaitu min dan sisihan piawai. Dapatan kajian menunjukkan bahawa Arena Usahawan JKE berada pada tahap keberkesanan yang tinggi sebagai medium pembelajaran berasaskan amali. Pelajar menunjukkan penglibatan yang aktif dalam aktiviti perniagaan serta memperoleh pengalaman pembelajaran secara langsung yang membantu meningkatkan kemahiran keusahawanan seperti komunikasi, pengurusan kewangan, kreativiti dan keyakinan diri. Selain itu, tahap kepuasan pelajar terhadap pelaksanaan Arena Usahawan JKE juga didapati tinggi. Secara keseluruhannya, Arena Usahawan JKE berpotensi menjadi platform pembelajaran berasaskan pengalaman yang berkesan dalam menyokong pembangunan kompetensi keusahawanan pelajar.

Kata Kunci *: keusahawanan, pembelajaran berasaskan amali, experiential learning, penglibatan pelajar, Arena Usahawan JKE.*

This study aims to evaluate the effectiveness of the Arena Usahawan JKE as a medium of practical-based entrepreneurship learning among students. This platform provides students with the opportunity to carry out business activities directly and apply the entrepreneurial knowledge learned theoretically. This study uses a quantitative approach through a survey method with a questionnaire as the research instrument. The research instrument includes several main constructs, namely the effectiveness of the Arena Usahawan JKE as a learning medium, student involvement in business activities, entrepreneurial skill development, practical-based learning, implementation and support factors, and student satisfaction levels. The data is analyzed using descriptive statistics, namely the mean and standard deviation. The study findings show that the Arena Usahawan JKE is at a high level of effectiveness as a practical-based learning medium. Students show active involvement in business activities and gain direct learning experiences that help improve entrepreneurial skills such as communication, financial management, creativity, and self-confidence. In addition, the level of student satisfaction with the implementation of the Arena Usahawan JKE was also found to be high. Overall, the Arena Usahawan JKE has the potential to be an effective experiential learning platform in supporting the development of students' entrepreneurial competencies.

Keywords: *entrepreneurship, practice-based learning, experiential learning, student engagement, JKE Entrepreneur Arena*

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I. PENGENALAN

Keusahawanan semakin diiktiraf sebagai elemen penting dalam pembangunan modal insan dan peningkatan kebolehpasaran graduan di institusi pendidikan tinggi. Dalam persekitaran ekonomi yang semakin kompetitif, graduan bukan sahaja perlu menguasai pengetahuan teori, malah perlu memiliki kemahiran insaniah seperti komunikasi, kepimpinan, pemikiran kritikal dan keupayaan menyelesaikan masalah [1]. Pendidikan keusahawanan berperanan dalam membangunkan kemahiran tersebut serta meningkatkan kecenderungan pelajar untuk terlibat dalam aktiviti perniagaan.

Seiring dengan keperluan pembelajaran abad ke-21, pendekatan pembelajaran berasaskan pengalaman (*experiential learning*) semakin diberi penekanan kerana ia membolehkan pelajar menghubungkan pengetahuan teori dengan amalan melalui penglibatan aktif dalam situasi sebenar [2]. Pendekatan ini juga didapati mampu meningkatkan pemahaman serta keberkesanan pembelajaran dalam bidang keusahawanan [3]. Selain itu, faktor efikasi kendiri (*self-efficacy*) memainkan peranan penting dalam membentuk keyakinan dan kecenderungan pelajar untuk terlibat dalam aktiviti keusahawanan [4].

Bagi menyokong pendekatan tersebut, Arena Usahawan JKE diwujudkan sebagai platform pembelajaran autentik yang memberi peluang kepada pelajar menjalankan aktiviti perniagaan sebenar seperti pengurusan produk, pemasaran, kewangan dan perkhidmatan pelanggan. Pendekatan pembelajaran melalui pengalaman sebenar ini selari dengan konsep pembelajaran berasaskan kerja yang dapat membantu meningkatkan kemahiran praktikal serta kebolehpasaran graduan [5]. Walau bagaimanapun, kajian yang menilai secara empirikal keberkesanan platform ini sebagai medium pembelajaran keusahawanan berasaskan amali masih terhad. Oleh itu, kajian ini dijalankan bagi menilai keberkesanan Arena Usahawan JKE dalam meningkatkan penglibatan, pembangunan kemahiran serta kepuasan pelajar.

Kajian ini dijalankan untuk mencapai objektif-objektif berikut:

1. Menilai tahap keberkesanan Arena Usahawan JKE sebagai medium pembelajaran keusahawanan berasaskan amali.
2. Mengkaji penglibatan dan pembangunan kemahiran keusahawanan pelajar melalui Arena Usahawan JKE.
3. Menilai kepuasan pelajar dan mengenal pasti cadangan penambahbaikan Arena Usahawan JKE.

II. TINJAUAN LITERATUR

Tinjauan literatur ini membincangkan pendidikan keusahawanan, pembelajaran berasaskan amali, teori pembelajaran pengalaman, *self-efficacy* dan model kebolehpasaran graduan. Analisis kajian terdahulu membolehkan penyelidik memahami konsep, teori dan dapatan yang berkaitan dengan penglibatan pelajar dalam aktiviti keusahawanan serta pembangunan kemahiran yang menyokong kebolehpasaran graduan.

A) Pendidikan Keusahawanan Dalam Pendidikan Tinggi

Pendidikan keusahawanan merupakan satu pendekatan pembelajaran yang bertujuan membangunkan pengetahuan, kemahiran dan sikap yang diperlukan untuk mengenal pasti peluang perniagaan serta mengurus perniagaan secara berkesan. Dalam konteks pendidikan tinggi, pendidikan keusahawanan bukan sahaja menekankan aspek teori, tetapi juga memberi pendedahan kepada pengalaman praktikal yang membolehkan pelajar memahami realiti dunia perniagaan. Menurut kajian oleh Alain Fayolle dan Benoit Gailly, pendidikan keusahawanan mempunyai pengaruh yang signifikan terhadap pembentukan sikap dan niat keusahawanan dalam kalangan pelajar [6].

Selain itu, kajian juga menunjukkan bahawa pendekatan pembelajaran yang melibatkan pengalaman sebenar seperti projek perniagaan, simulasi perniagaan dan program inkubator pelajar dapat meningkatkan kefahaman pelajar terhadap konsep keusahawanan dengan lebih berkesan berbanding pembelajaran berasaskan kuliah semata-mata [7]. Oleh itu, pelaksanaan platform seperti Arena Usahawan JKE dilihat sebagai satu pendekatan yang relevan dalam menyokong pembangunan kemahiran keusahawanan pelajar di institusi pendidikan teknikal.

B) Teori Pembelajaran Pengalaman (Experiential Learning Theory – Kolb)

Teori Pembelajaran Pengalaman yang diperkenalkan oleh David A. Kolb menekankan bahawa proses pembelajaran berlaku melalui pengalaman secara langsung. Menurut Kolb, pembelajaran merupakan satu proses di mana pengetahuan terbentuk melalui transformasi

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pengalaman yang dilalui oleh individu [2]. Model pembelajaran pengalaman Kolb terdiri daripada empat peringkat utama iaitu pengalaman konkrit (*concrete experience*), pemerhatian reflektif (*reflective observation*),konseptualisasi abstrak (*abstract conceptualization*), dan eksperimen aktif (*active experimentation*).

Melalui pengalaman konkrit, individu terlibat secara langsung dalam sesuatu aktiviti atau situasi sebenar. Seterusnya, individu akan membuat pemerhatian dan refleksi terhadap pengalaman tersebut sebelum membentuk pemahaman konsep yang lebih mendalam. Akhir sekali, individu akan mengaplikasikan pengetahuan yang diperoleh melalui eksperimen aktif dalam situasi baharu. Pendekatan ini membolehkan pelajar belajar secara lebih bermakna kerana mereka terlibat secara aktif dalam proses pembelajaran. Dalam konteks Arena Usahawan, JKE pelajar berpeluang menjalankan aktiviti perniagaan sebenar yang membolehkan mereka memperoleh pengalaman praktikal serta mengaplikasikan pengetahuan yang dipelajari dalam situasi sebenar [8].

C) Teori Efikasi Kendiri (Self-Efficacy)

Konsep *self-efficacy* diperkenalkan oleh Albert Bandura melalui Teori Kognitif Sosial. *Self-efficacy* merujuk kepada kepercayaan individu terhadap keupayaan diri untuk melaksanakan sesuatu tugas atau mencapai sesuatu matlamat. Individu yang mempunyai tahap *self-efficacy* yang tinggi biasanya lebih yakin dalam menghadapi cabaran serta lebih cenderung untuk mencuba sesuatu yang baharu [9]. Dalam bidang keusahawanan, *self-efficacy* memainkan peranan penting dalam mempengaruhi kecenderungan individu untuk memulakan perniagaan. Kajian oleh Hui Zhao, Scott E. Seibert dan Gerald E. Hills mendapati bahawa *self-efficacy* bertindak sebagai faktor perantara yang mempengaruhi pembangunan niat keusahawanan dalam kalangan individu [4]. Oleh itu, pengalaman praktikal yang diperoleh melalui aktiviti perniagaan sebenar dapat membantu meningkatkan keyakinan pelajar terhadap keupayaan mereka untuk mengurus dan menjalankan perniagaan,

D) Model Kebolehpasaran (Employability Model)

Kebolehpasaran graduan merujuk kepada keupayaan seseorang graduan untuk memperoleh pekerjaan serta menyesuaikan diri dengan keperluan dunia pekerjaan. Model kebolehpasaran graduan yang dicadangkan oleh Lorraine Dacre Pool dan Peter Sewell menekankan bahawa kebolehpasaran dipengaruhi oleh komponen seperti pengetahuan, kemahiran generik, pengalaman praktikal, efikasi kendiri dan kemampuan refleksi terhadap pengalaman pembelajaran [10]. Pengalaman pembelajaran yang melibatkan situasi sebenar dapat meningkatkan kemahiran insaniah pelajar, termasuk komunikasi, kepimpinan, kerja berpasukan dan penyelesaian masalah. Oleh itu, pelaksanaan aktiviti keusahawanan seperti Arena Usahawan JKE memberi peluang kepada pelajar membangunkan kemahiran tersebut, sekaligus meningkatkan tahap kebolehpasaran mereka selepas tamat pengajian.

III. METODOLOGI KAJIAN

A) Reka Bentuk Kajian

Kajian ini menggunakan pendekatan kuantitatif dengan reka bentuk kajian tinjauan (*survey*). Pendekatan ini dipilih kerana ia sesuai untuk mengumpul maklumat berkaitan persepsi pelajar terhadap keberkesanan pelaksanaan Arena Usahawan JKE secara sistematik dan teratur. Data dikumpulkan melalui soal selidik yang diedarkan melalai platform '*Google Form'* yang diberikan kepada responden bagi mendapatkan maklum balas berkaitan pengalaman pembelajaran berasaskan amali, penglibatan dalam aktiviti perniagaan, pembangunan kemahiran keusahawanan serta faktor pelaksanaan program. Soal selidik ini membolehkan penyelidik mengumpul data yang standard dan seragam. Menurut R. Kothari (2004), setiap responden menjawab soalan yang sama, membolehkan penyelidik membandingkan jawapan dengan lebih mudah dan melakukan analisis data statistik yang lebih tepat [11].

B) Populasi Dan Sampel

Populasi kajian terdiri daripada pelajar semester 4 di Jabatan Kejuruteraan Elektrik, Politeknik Ungku Omar yang terlibat secara langsung dalam aktiviti Arena Usahawan JKE. Pelajar tersebut terdiri daripada tiga program pengajian iaitu Diploma Kejuruteraan Elektrik dan Elektronik (DEE), Diploma Kejuruteraan Elektronik (Komunikasi) (DEP) dan Diploma Kejuruteraan Elektronik (Komputer) (DTK). Jumlah keseluruhan populasi kajian adalah seramai 120 orang pelajar. Oleh kerana jumlah populasi yang terlibat adalah kecil dan mudah diakses, kajian ini menggunakan kaedah pensampelan menyeluruh (*census sampling*) di mana semua pelajar yang terlibat dijadikan responden kajian. Kaedah ini sesuai digunakan apabila jumlah populasi adalah terhad dan penyelidik berupaya mendapatkan data daripada keseluruhan populasi bagi meningkatkan ketepatan dapatan kajian [12].

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C) Instrumen Kajian

Instrumen kajian yang digunakan ialah borang soal selidik yang dibangunkan berdasarkan objektif kajian serta sorotan literatur berkaitan pendidikan keusahawanan dan pembelajaran berasaskan amali Soal selidik ini dibahagikan kepada beberapa bahagian iaitu *Bahagian A* yang memfokuskan maklumat demografi responden, *Bahagian B* mengenai keberkesanan Arena Usahawan sebagai medium pembelajaran, *Bahagian C* berkaitan penglibatan pelajar dalam aktiviti perniagaan, *Bahagian D* menilai pembangunan kemahiran keusahawanan, *Bahagian E* membincangkan pembelajaran berasaskan amali (*Experiential Learning*), *Bahagian F* menilai faktor pelaksanaan dan sokongan, manakala *Bahagian G* merangkumi kepuasan dan cadangan Setiap item dalam bahagian B hingga E menggunakan skala Likert lima mata seperti Jadual 1 Skala Likert merupakan kaedah yang lazim digunakan dalam penyelidikan sosial untuk mengukur sikap dan pendapat secara kuantitatif [13].

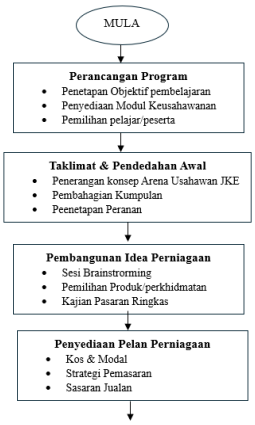
Jadual 1 menunjukkan skala Likert 5 mata yang biasa digunakan dalam kajian kuantitatif untuk mengukur sikap, pendapat, dan persepsi responden terhadap sesuatu pernyataan.

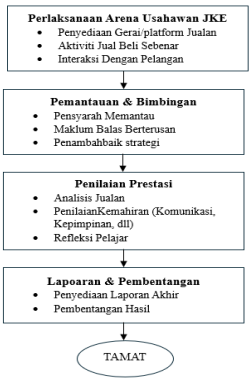
Jadual 1: Skala Likert

Skala	Nilai	Makna
1	Sangat Tidak Setuju	Responden sangat tidak bersetuju dengan pernyataan
2	Tidak Setuju	Responden tidak bersetuju dengan pernyataan
3	Neutral/Sederhana	Responden bersikap neutral atau tidak pasti
4	Setuju	Responden bersetuju dengan pernyataan
5	Sangat Setuju	Responden sangat bersetuju dengan pernyataan

D) Prosedur Pelaksanaan Arena Usahawan JKE

Rajah 1 menunjukkan carta alir pelaksanaan Arena Usahawan JKE yang digunakan dalam kajian ini.





Rajah 1 : Carta Alir Pelaksanaan Arena Usahawan JKE

Pelaksanaan Arena Usahawan JKE dijalankan secara sistematik melalui beberapa fasa utama, seperti ditunjukkan dalam **Rajah 1**. Program bermula dengan perancangan, termasuk penetapan objektif pembelajaran, penyediaan modul keusahawanan dan pemilihan peserta. Seterusnya, sesi taklimat dan pendedahan awal dijalankan bagi memperkenalkan konsep Arena Usahawan JKE serta pembahagian kumpulan. Pelajar kemudian membangunkan idea perniagaan, menyediakan pelan perniagaan, dan melaksanakan aktiviti jual beli sebenar melalui gerai atau platform jualan. Pemantauan dan bimbingan diberikan oleh pensyarah sepanjang program, diikuti dengan penilaian prestasi berdasarkan jualan dan kemahiran insaniah. Akhir sekali, pelajar menyediakan laporan dan pembentangan sebagai refleksi pengalaman pembelajaran mereka.

E) Kaedah Analisis Data

Data yang diperoleh daripada soal selidik dianalisis menggunakan kaedah statistik deskriptif termasuk pengiraan kekerapan, peratusan, min dan sisihan piawai bagi setiap item kajian. Dapatan data yang dikumpulkan melalui platform *Google Forms*, dieksport ke format Excel (.xlsx) dan dimuat naik ke perisian Jamovi untuk dianalisis.

Analisis ini bertujuan untuk menilai tahap persepsi pelajar terhadap keberkesanan Arena Usahawan JKE sebagai medium pembelajaran keusahawanan berasaskan amali.

F) Kesahan dan Kebolehpercayaan Instrume

Bagi memastikan instrumen kajian sesuai dan boleh dipercayai, proses kesahan dan kebolehpercayaan dijalankan sebelum pengumpulan data sebenar Kesahan instrumen merujuk kepada sejauh mana item soal selidik dapat mengukur perkara yang

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dikaji, dan dalam kajian ini, kesahan kandungan disemak oleh beberapa pensyarah pakar dalam bidang keusahawanan dan penyelidikan untuk memastikan setiap item jelas, relevan dan menepati objektif kajian Kebolehpercayaan instrumen pula diuji bagi memastikan konsistensi item, yang biasanya diukur menggunakan nilai Cronbach's Alpha, di mana nilai melebihi 0.70 menunjukkan tahap kebolehpercayaan yang baik Ujian kebolehpercayaan dijalankan untuk memastikan item dalam soal selidik konsisten dan sesuai digunakan bagi mengukur persepsi pelajar terhadap keberkesanan pelaksanaan Arena Usahawan JKE, dengan analisis Cronbach's Alpha dijalankan bagi setiap bahagian **Jadual 2** di bawah menunjukkan nilai Cronbach's Alpha (α) bagi setiap bahagian instrumen soal selidik yang digunakan dalam kajian ini.

Jadual 2 : Ujian Kebolehpercayaan Instrumen (Cronbach's Alpha)

Bahagian	Tajuk Bahagian	Bilangan Item	Cronbach's Alpha (α)	Tahap Kebolehpercayaan
B	Keberkesanan Arena Usahawan sebagai Medium Pembelajaran	5	0.982	Sangat Tinggi
C	Penglibatan Pelajar dalam Aktiviti Perniagaan	5	0.734	Memuaskan
D	Pembangunan Kemahiran Keusahawanan	5	0.948	Sangat Tinggi
E	Pembelajaran Berasaskan Amali (Experiental Learning)	5	0.959	Sangat Tinggi
F	Faktor Pelaksanaan dan Sokongan	5	0.874	Tinggi
G	Kepuasan dan Cadangan	3	0.947	Sangat Tinggi
Keseluruhan	**Semua Tajuk**	**28**	**0.932**	**Sangat Tinggi**

Berdasarkan **Jadual 2**, Ujian kebolehpercayaan instrumen menunjukkan nilai Cronbach's Alpha bagi setiap bahagian antara 0.734 hingga 0.982 dengan tahap kebolehpercayaan memuaskan hingga sangat tinggi Secara keseluruhan, instrumen 28 item mencatat nilai α = 0.932, menandakan tahap kebolehpercayaan yang sangat tinggi dan sesuai digunakan untuk mengukur persepsi pelajar terhadap keberkesanan Arena Usahawan JKE.

G) Operasional Pemboleh Ubah Kajian

Dalam kajian ini, beberapa pemboleh ubah dikenal pasti untuk menilai keberkesanan Arena Usahawan JKE sebagai medium pembelajaran keusahawanan berasaskan amali, termasuk keberkesanan medium pembelajaran, tahap penglibatan pelajar dalam aktiviti perniagaan, pembangunan kemahiran keusahawanan, pembelajaran berasaskan amali serta faktor pelaksanaan dan sokongan Setiap pemboleh ubah ditakrifkan mengikut konteks kajian dan diukur melalui item soal selidik yang dibangunkan berdasarkan objektif kajian dan tinjauan literatur, bagi menilai persepsi pelajar terhadap pengalaman dan manfaat penglibatan dalam aktiviti Arena Usahawan JKE Maklumat daripada item-item ini membolehkan penyelidik menilai tahap keberkesanan pelaksanaan Arena Usahawan JKE, dan **Jadual 3** menunjukkan ringkasan operasional pemboleh ubah kajian.

Jadual 3: Operasional Pemboleh Ubah Kajian

Bahagian Soal Selidik	Pemboleh Ubah	Definisi Operasional	Kod Item
Bahagian B	Keberkesanan Arena Usahawan sebagai Medium Pembelajaran	Persepsi pelajar terhadap keberkesanan Arena Usahawan JKE sebagai platform pembelajaran yang membantu mereka memahami konsep keusahawanan serta menghubungkan teori dengan amalan sebenar.	B1 – B5
Bahagian C	Penglibatan Pelajar dalam Aktiviti Perniagaan	Tahap penyertaan dan penglibatan aktif pelajar dalam pelbagai aktiviti perniagaan seperti perancangan, operasi jualan, pemasaran dan membuat keputusan berkaitan perniagaan.	C6 – C10
Bahagian D	Pembangunan Kemahiran Keusahawanan	Tahap peningkatan kemahiran yang diperoleh pelajar melalui penglibatan dalam Arena Usahawan JKE seperti kemahiran komunikasi, pengurusan kewangan, penyelesaian masalah, keyakinan diri dan sikap berdikari.	D11 – D15
Bahagian E	Pembelajaran Berasaskan Amali (Experiential Learning)	Tahap pengalaman pembelajaran pelajar melalui aktiviti amali dan pengalaman sebenar yang membantu mereka memahami situasi dunia perniagaan secara lebih mendalam.	E16 – E20
Bahagian F	Faktor Pelaksanaan dan Sokongan	Persepsi pelajar terhadap kemudahan, sokongan pensyarah, pengurusan serta garis panduan yang mempengaruhi kelancaran pelaksanaan Arena Usahawan JKE.	F21 – F25
Bahagian G	Kepuasan dan Cadangan	Tahap kepuasan keseluruhan pelajar terhadap pelaksanaan Arena Usahawan serta minat mereka untuk terus terlibat dalam aktiviti keusahawanan pada masa hadapan.	G26 – G27

H) Interprestasi Skor Min

Interpretasi skor min digunakan untuk menilai tahap persepsi responden terhadap setiap pemboleh ubah kajian. Skor min membolehkan pengkategorian persepsi kepada tahap rendah, sederhana, dan tinggi serta memberikan konteks yang jelas terhadap keputusan analisis statistik deskriptif [16]. Dengan interpretasi skor min, penyelidik dapat menilai keseluruhan persepsi atau kepuasan terhadap sesuatu program atau intervensi, contohnya keberkesanan Arena Usahawan JKE [17]. Julat interpretasi skor min untuk kajian ini ditunjukkan dalam **Jadual 4.**

Jadual 4: Interpretasi Skor Min

Julat Min	Tahap
1.00 – 2.33	Rendah
2.34 – 3.66	Sederhana
3.67 – 5.00	Tinggi

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IV. DAPATAN KAJIAN DAN KEPUTUSAN

Bab ini membincangkan dapatan yang diperoleh daripada kajian yang dijalankan. Sebanyak 120 set soal selidik dianalisis menggunakan perisian Jamovi bagi setiap item soal selidik. Penggunaan kaedah statistik seperti peratusan, kekerapan, min, sisihan piawai, atau ujian signifikan dapat menyokong dapatan dengan hujah yang lebih kuat serta mengurangkan elemen bias [14].

A) Analisa Demografi Responden

Berdasrkan **Jadual 5**, analisis taburan responden menunjukkan bahawa majoriti peserta adalah lelaki iaitu seramai 85 orang (70.8%) berbanding 35 orang perempuan (29.2%) dari keseluruhan 120 responden. Dari segi umur, kebanyakan responden berada dalam lingkungan 20–21 tahun (88.3%), manakala 6.7% berumur 18–19 tahun, 4.2% berumur 22–23 tahun dan hanya 0.8% berumur 24 tahun ke atas.

Bagi aspek bangsa, majoriti responden terdiri daripada Melayu (75%), diikuti India (15.8%), Cina (5%), Bumiputera Sabah/Sarawak (1.7%) dan lain-lain (2.5%). Ini menunjukkan komposisi responden yang pelbagai tetapi didominasi oleh kaum Melayu.

Dari segi program pengajian, sebahagian besar pelajar mengikuti Diploma Kejuruteraan Elektrik dan Elektronik (DEE) iaitu 68 orang (56.7%), diikuti Diploma Kejuruteraan Elektronik (Komunikasi) (DEP) dengan 34 orang (28.3%) dan Diploma Kejuruteraan Elektronik (Komputer) (DTK) seramai 18 orang (15%). Taburan ini memberi gambaran bahawa data diperoleh daripada kumpulan pelajar yang mewakili ketiga-tiga program utama di Jabatan Kejuruteraan Elektrik, Politeknik Ungku Omar.

Jadual 5: Taburan Responden Mengikut Jantina, Umur, Bangsa dan Program Pengajian

Kategori	Kumpulan	Bilangan (n)	Peratus (%)
Jantina	Lelaki	85	70.8
	Perempuan	35	29.2
Umur	18 – 19 tahun	8	6.7
	20 – 21 tahun	106	88.3
	22 – 23 tahun	5	4.2
	24 tahun ke atas	1	0.8
Bangsa	Melayu	90	75
	Cina	6	5
	India	19	15.8
	Bumiputera Sabah/Sarawak	2	1.7
	Lain-lain	3	2.5
Program Pengajian	Diploma Kejuruteraan Elektrik dan Elektronik (DEE)	68	56.7
	Diploma Kejuruteraan Elektronik (Komunikasi) (DEP)	34	28.3
	Diploma Kejuruteraan Elektronik (Komputer) (DTK)	18	15

B) Analisa Bahagia A- KeberkesananArena Usahawan sebagai Medium Pembelajaran

Hasil analisis data daripada **Jadual 6** menunjukkan bahawa Arena Usahawan JKE berkesan sebagai medium pembelajaran keusahawanan berasaskan amali. Semua item mencatatkan tahap tinggi dengan nilai min antara 4.29 hingga 4.38 dan sisihan piawai rendah (0.594–0.614), menandakan persepsi pelajar yang positif dan konsisten.

Item tertinggi ialah "Pembelajaran melalui Arena Usahawan JKE lebih berkesan berbanding teori" (min = 4.38), menunjukkan pendekatan pembelajaran amali memberi impak lebih baik berbanding teori semata-mata. Pelajar juga bersetuju bahawa aktiviti yang dijalankan selari dengan objektif pembelajaran, menyediakan pengalaman bermakna, dan membantu mengaitkan teori dengan amalan sebenar.

Secara keseluruhan, dapatan ini menegaskan bahawa Arena Usahawan JKE berfungsi sebagai platform pembelajaran pengalaman (*experiential learning*) yang efektif dalam meningkatkan pemahaman konsep keusahawanan serta memberi pendedahan kepada situasi perniagaan sebenar.

Jadual 6: Nilai Min dan Sisihan Piawai bagi Keberkesanan Arena Usahawan sebagai Medium Pembelajaran

Item	Min	Sisihan Piawai	Tahap
1. Arena Usahawan JKE membantu memahami konsep keusahawanan	4.29	0.614	Tinggi
2. Pembelajaran melalui Arena Usahawan JKE lebih berkesan berbanding teori	4.38	0.609	Tinggi
3. Aktiviti selari dengan objektif pembelajaran	4.33	0.599	Tinggi
4. Arena Usahawan JKE menyediakan pengalaman bermakna	4.35	0.603	Tinggi
5. Mengaitkan teori dengan amalan sebenar	4.32	0.594	Tinggi
Min Keseluruhan	**4.33**		

C) Analisa Bahagia B- Penglibatan Pelajar Dalam Aktiviti Perniagaan

Berdasarkan **Jadual 7**, semua item berada pada tahap tinggi (min 4.24–4.42) dengan min keseluruhan 4.33, menunjukkan bahawa pelajar memberi maklum balas positif terhadap penglibatan mereka dalam Arena Usahawan JKE. Dapatan ini menunjukkan bahawa penglibatan pelajar secara aktif dalam perancangan, operasi, kerja berpasukan, dan membuat keputusan perniagaan menyokong

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pembangunan kemahiran, minat, dan keyakinan dalam keusahawanan secara holistik.

Pendekatan keusahawanan secara holistik merujuk kepada integrasi aspek perniagaan dengan pembangunan kompetensi, pemikiran, nilai, dan sikap pelajar secara menyeluruh dalam konteks pembelajaran keusahawanan [18]. Kajian terdahulu menekankan bahawa pendidikan keusahawanan perlu dirangka secara holistik untuk menggabungkan aspek praktikal, kognitif, dan sosial, sekaligus membentuk kemahiran yang lebih relevan bagi pelajar dalam menghadapi cabaran dunia perniagaan sebenar [19].

Jadual 7: Nilai Min dan Sisihan Piawai bagi Penglibatan Pelajar dalam Aktiviti Perniagaan

Item	Min	Sisihan Piawai	Tahap
6. Terlibat secara aktif dalam perancangan aktiviti perniagaan	4.34	0.667	Tinggi
7. Terlibat secara lansung dalam operasi perniagaan (jualan, pemasaran, perkhidmatan pelanggan)	4.30	0.643	Tinggi
8. Arena Usahawan JKE menggalakkan kerja berpasukan di kalangan pelajar	4.42	0.575	Tinggi
9. Peluang membuat keputusan berkaitan perniagaan	4.33	0.555	Tinggi
10. Penglibatan dalam Arena Usahawan JKE meningkatkan minat terhadap keusahawanan	4.24	0.648	Tinggi
Min Keseluruhan	**4.33**		

D) Analisa Bahagia C- Pembangunan Kemahiran Keusahawanan

Berdasarkan **Jadual 8**, semua item berada pada tahap tinggi dengan nilai min antara 4.23 hingga 4.35 dan min keseluruhan adalah 4.31, menunjukkan bahawa pelajar memberikan maklum balas yang sangat positif terhadap sumbangan Arena Usahawan JKE. Dapatan ini menunjukkan bahawa semua aktiviti yang dijalankan di Arena Usahawan JKE bukan sahaja membantu meningkatkan kemahiran komunikasi, pengurusan kewangan, dan penyelesaian masalah, tetapi juga menyokong pembentukan keyakinan diri, sikap berdikari, tanggungjawab, dan pemikiran kritis di kalangan pelajar. Kesemua elemen ini secara kolektif menyokong pembangunan kemahiran keusahawanan secara menyeluruh dan holistik, sekaligus menyediakan pelajar dengan pengalaman pembelajaran yang praktikal dan relevan untuk menghadapi cabaran dunia perniagaan sebenar.

Selain itu, penglibatan aktif pelajar dalam setiap aktiviti membolehkan mereka mengaplikasikan pengetahuan teori ke dalam amalan sebenar, seterusnya meningkatkan kefahaman konsep keusahawanan secara lebih mendalam. Pendekatan ini juga membantu membentuk nilai profesionalisme, etika kerja, dan daya saing yang penting untuk menghadapi persekitaran perniagaan yang kompetitif.

Jadual 8: Nilai Min dan Sisihan Piawai bagi Pembangunan Kemahiran Keusahawanan

Item	Min	Sisihan Piawai	Tahap
11. Arena Usahawan JKE membantu meningkatkan kemahiran komunikasi	4.33	0.653	Tinggi
12. Arena Usahawan JKE dapat meningkatkan kemahiran pengurusan kewangan melalui aktiviti perniagaan	4.33	0.596	Tinggi
13. Kemahiran penyelesaian masalah bertambah baik melalui pengalaman sebenar	4.33	0.613	Tinggi
14. Meningkatkan keyakinan menjalankan aktiviti perniagaan sendiri	4.23	0.683	Tinggi
15. Arena Usahawan JKE membantu membentuk sikap berdikari dan bertanggungjawab	4.35	0.617	Tinggi
Min Keseluruhan	**4.31**		

E) Analisa Bahagia D- Pembelajaran Berasaskan Amali

Analisis ini bertujuan untuk menilai pengalaman pembelajaran melalui aktiviti sebenar dan impaknya terhadap pemikiran kritikal, daya ingatan, serta aplikasi pengetahuan pelajar [2]. Aktiviti pembelajaran berasaskan pengalaman (experiential learning) membolehkan pelajar mengaplikasikan teori dalam konteks praktikal, meningkatkan kefahaman konsep, serta memperkukuh kemahiran membuat keputusan dan penyelesaian masalah [19]. Kajian terdahulu menunjukkan bahawa pengalaman pembelajaran amali dapat meningkatkan keyakinan diri, kreativiti, dan penguasaan kemahiran keusahawanan secara holistik, sejajar dengan prinsip experiential learning yang menekankan pembelajaran melalui pengalaman langsung [20].

Jadual 9 menunjukkan nilai min dan sisihan piawai bagi setiap item yang dikaji, memberikan gambaran jelas mengenai persepsi pelajar terhadap keberkesanan Arena Usahawan JKE sebagai platform pembelajaran amali yang menyeluruh dan praktikal.

Berdasarkan **Jadual, 9** semua item menunjukkan tahap tinggi dengan nilai min antara 4.34 hingga 4.42 dan min keseluruhan 4.38, menunjukkan bahawa pelajar memberikan maklum balas yang positif terhadap Arena Usahawan JKE. Aktiviti yang dijalankan membolehkan pelajar belajar secara lebih berkesan melalui pengalaman sebenar, memahami cabaran sebenar dalam dunia perniagaan, serta meningkatkan kemahiran pemikiran kritikal. Selain

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itu, penglibatan dalam aktiviti ini membantu pelajar mengingati dan memahami pembelajaran dengan lebih baik, sekaligus membolehkan mereka mengaplikasikan teori ke dalam situasi praktikal. Dapatan ini menunjukkan bahawa Arena Usahawan JKE bukan sahaja meningkatkan pengalaman pembelajaran, tetapi juga berperanan sebagai platform pembelajaran berasaskan amali yang efektif, yang menyokong pembangunan kemahiran keusahawanan, keyakinan, kreativiti, dan kebolehan pelajar untuk menghadapi cabaran dunia perniagaan secara holistik.

Jadual 9: Nilai Min dan Sisihan Piawai bagi Pembelajaran Berasaskan Amali

Item	Min	Sisihan Piawai	Tahap
16. Belajar dengan jlebih berkesan melalui pengalaman sebenar	4.34	0.542	Tinggi
17. Aktiviti amali membantu memahami cabaran dunia perniagaan	4.42	0.559	Tinggi
18. Pembelajaran melalui Arena UsahawaN JKE meningkatkan pemikiran kritikal	4.34	0.615	Tinggi
19. Pengalaman amali membantu mengingati dan memahami pembelajaran dengan lebih baik	4.38	0.522	Tinggi
20. Arena Usahawan JKE sesuai dijadikan sebagai platform pembelajaran berasaskan amali	4.42	0.544	Tinggi
Min Keseluruhan	**4.38**		

F) Analisa Bahagian E – Faktor Pelaksanaan dan Sokongan

Berdasarkan **Jadual 10**, semua item berkaitan faktor pelaksanaan dan sokongan berada pada tahap tinggi dengan nilai min antara 4.27 hingga 4.39 dan min keseluruhan 4.34, menunjukkan bahawa pelajar menilai aspek sokongan dan pelaksanaan Arena Usahawan JKE secara positif. Item sokongan pihak jabatan membantu kelancaran Arena Usahawan JKE mencatatkan min tertinggi 4.39 (SP = 0.539), manakala item kemudahan yang disediakan mencukupi mencatatkan min terendah 4.27 (SP = 0.592).

Dapatan ini menunjukkan bahawa pelajar berpuas hati dengan kemudahan, jadual aktiviti, bimbingan dan pemantauan oleh pensyarah, serta peraturan dan garis panduan yang jelas. Kesemua faktor ini memainkan peranan penting dalam memastikan Arena Usahawan JKE dijalankan dengan lancar dan berkesan. Secara keseluruhan, faktor pelaksanaan dan sokongan yang baik menyokong keberkesanan program sebagai platform pembelajaran keusahawanan berasaskan amali, membolehkan pelajar menumpukan perhatian pada penglibatan aktif, pembangunan kemahiran, dan pengalaman praktikal dalam perniagaan.

Jadual 10 : Nilai Min dan Sisihan Piawai bagi Faktor Pelaksanaan dan Sokongan

Item	Min	Sisihan Piawai	Tahap
21. Kemudahan yang disediakan di Arena Usahawan JKE adalah mencukupi	4.27	0.592	Tinggi
22. Jadual pelaksanaan aktiviti adalah sesuai dan teratur	4.29	0.614	Tinggi
23. Bimbingan dan pemantauan daripada penyarah adalah mencukupi	4.37	0.533	Tinggi
24. Sokongan pihak jabatan membantu kelancaran Arena Usahawan JKE	4.39	0.539	Tinggi
25. Peraturan dan garis panduan pelaksanaan adalah jelas dan mudah difahami	4.36	0.547	Tinggi
Min Keseluruhan	**4.34**		

G) Analisa Bahagian F- Kepuasan dan Cadangan

Analisa ini dijalankan untuk mengkaji kepuasan pelajar terhadap perlakasaan Arena Usahawan JKE. Kajian terdahulu menekankan bahawa kepuasan pelajar berkait rapat dengan penglibatan aktif, pengalaman praktikal, dan pembangunan kemahiran keusahawanan, yang seterusnya meningkatkan minat dan keyakinan pelajar dalam menghadapi cabaran dunia perniagaan sebenar [21]. **Jadual 11** menunjukkan nilai min dan sisihan piawai bagi setiap item yang dikaji.

Jadual 11: Nilai Min dan Sisihan Piawai bagi Kepuasan dan Cadangan

Item	Min	Sisihan Piawai	Tahap
26. Berpuasa hati dengan perlaksanaan Arena Usahawan JKE	4.33	0.585	Tinggi
27. Berminat terlibat dalam keusahawanan pada masa hadapan	4.27	0.645	Tinggi
28. Arena Usahawan JKE perlu diteruskan dan ditambah baik pada masa akan datang	4.43	0.530	Tinggi
Min Keseluruhan	**4.34**		

Berdasarkan **Jadual 11**, semua item berkaitan kepuasan pelajar berada pada tahap tinggi dengan nilai min antara 4.27 hingga 4.43 dan min keseluruhan 4.34, menunjukkan bahawa pelajar memberikan maklum balas yang positif terhadap Arena Usahawan JKE. Item berminat terlibat dalam keusahawanan pada masa hadapan mencatatkan min tertinggi 4.43 (SP = 0.645), manakala item Arena Usahawan JKE perlu diteruskan dan ditambah baik pada masa akan datang mencatatkan min terendah 4.27 (SP = 0.530).

Dapatan ini menunjukkan bahawa pelajar berpuas hati dengan pelaksanaan program, memberi minat untuk terlibat dalam aktiviti keusahawanan pada masa hadapan, dan menyokong agar Arena

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Usahawan JKE diteruskan serta diperbaiki pada masa akan datang. Secara keseluruhannya, tahap kepuasan yang tinggi ini menegaskan bahawa Arena Usahawan JKE berjaya menjadi platform pembelajaran keusahawanan berasaskan amali yang berkesan, yang bukan sahaja memberi pengalaman praktikal tetapi juga meningkatkan minat dan motivasi pelajar dalam bidang keusahawanan.

I) Kesimpulan Dapatan Kajian

Bagi melihat gambaran keseluruhan dapatan kajian, perbandingan nilai min bagi setiap bahagian kajian telah dipersembahkan dalam bentuk carta radar seperti yang ditunjukkan dalam **Rajah 2**.

Rajah 2: Perbandingan Nilai Min bagi Setiap Bahagian Kajian Arena Usahawan JKE

Berdasarkan carta radar min bagi setiap bahagian kajian, dapat dirumuskan bahawa semua konstruk yang dikaji berada pada tahap tinggi, dengan nilai min sekitar 4.29 hingga 4.37. Ini menunjukkan bahawa pelaksanaan Arena Usahawan JKE secara keseluruhannya diterima dengan sangat positif oleh pelajar sebagai medium pembelajaran keusahawanan.

Secara khusus, ***Bahagian E***: *Pembelajaran Berasaskan Amali* (*Experiential Learning*) mencatatkan nilai min tertinggi, menunjukkan bahawa pendekatan pembelajaran secara praktikal melalui Arena Usahawan JKE sangat membantu pelajar memahami konsep keusahawanan secara lebih mendalam. Dapatan ini menggambarkan bahawa pengalaman sebenar menjalankan aktiviti perniagaan mampu meningkatkan kefahaman, keyakinan dan pengalaman pembelajaran pelajar.

Seterusnya, ***Bahagian B*** *(Keberkesanan Arena Usahawan sebagai Medium Pembelajaran*) dan ***Bahagian G*** *(Kepuasan dan Cadangan*) juga mencatatkan min yang tinggi. Ini menunjukkan bahawa pelajar bukan sahaja menganggap program ini berkesan, malah mereka juga berpuas hati serta menyokong agar program tersebut diteruskan dan dipertingkatkan pada masa hadapan.

Bagi ***Bahagian C*** (*Penglibatan Pelajar dalam Aktiviti Perniagaan*) dan ***Bahagian F*** (*Faktor Pelaksanaan dan Sokongan*), nilai min yang tinggi menunjukkan bahawa pelajar aktif terlibat dalam aktiviti yang dijalankan serta mendapat sokongan yang baik daripada pihak jabatan dan pensyarah dalam menjayakan program ini.

Walaupun ***Bahagian D*** (*Pembangunan Kemahiran Keusahawanan*) mencatatkan min yang sedikit lebih rendah berbanding bahagian lain, nilainya masih berada pada tahap tinggi, menunjukkan bahawa program ini tetap memberi sumbangan yang signifikan dalam membangunkan kemahiran keusahawanan pelajar.

Kesimpulannya, carta radar ini menunjukkan bahawa Arena Usahawan JKE berjaya berfungsi sebagai platform pembelajaran berasaskan amali yang berkesan, meningkatkan penglibatan pelajar, membangunkan kemahiran keusahawanan serta memberikan tahap kepuasan yang tinggi dalam kalangan pelajar. Oleh itu, program ini wajar diteruskan dan diperkukuhkan sebagai salah satu medium pembelajaran keusahawanan di jabatan.

V. PERBINCANGAN, RUMUSAN DAN CADANGAN

A) Perbincangan

Dapatan kajian menunjukkan bahawa Arena Usahawan JKE berkesan sebagai medium pembelajaran keusahawanan berasaskan amali. Pelajar memberikan maklum balas positif dan konsisten terhadap keberkesanan program, penglibatan, kemahiran yang diperoleh, faktor pelaksanaan, serta tahap kepuasan.

- Keberkesanan dan Penglibatan Pelajar

Pelajar menilai aktiviti ini sangat berkesan dalam memahami konsep keusahawanan, mengaitkan teori dengan amalan sebenar, serta memberi pengalaman pembelajaran yang bermakna. Penglibatan aktif pelajar dalam perancangan, operasi, kerja berpasukan, dan membuat keputusan perniagaan membolehkan mereka meningkatkan kemahiran komunikasi, pengurusan kewangan, penyelesaian masalah, keyakinan diri, serta sikap berdikari dan bertanggungjawab.

- Pembelajaran Berasaskan Amali:

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Aktiviti di Arena Usahawan JKE menyediakan pengalaman praktikal yang relevan, yang meningkatkan pemikiran kritikal, pemahaman, dan pengingatan pelajar. Hal ini menegaskan bahawa pendekatan berasaskan pengalaman (*experiential learning*) mampu menghubungkan teori dengan situasi sebenar dan mempersiapkan pelajar menghadapi cabaran dunia perniagaan.

- Faktor Pelaksanaan dan Sokongan:

Kemudahan, jadual aktiviti, bimbingan pensyarah, sokongan jabatan, serta garis panduan yang jelas memainkan peranan penting dalam memastikan program berjalan lancar dan berkesan. Faktor-faktor ini meningkatkan kepuasan pelajar dan memudahkan mereka memberi tumpuan kepada penglibatan aktif dalam aktiviti perniagaan.

- Kepuasan Pelajar:

Tahap kepuasan pelajar adalah tinggi. Pelajar berpuas hati dengan pelaksanaan program, berminat untuk terlibat dalam keusahawanan pada masa hadapan, dan bersetuju bahawa Arena Usahawan JKE perlu diteruskan dan diperbaiki pada masa akan datang.

B) Rumusan

Secara keseluruhannya, Arena Usahawan JKE didapati berkesan sebagai platform pembelajaran keusahawanan berasaskan amali. Program ini berjaya meningkatkan pengetahuan, kemahiran dan sikap keusahawanan pelajar melalui pengalaman praktikal yang membolehkan mereka mengaplikasikan teori dalam situasi sebenar. Pelaksanaan program yang terancang serta sokongan yang baik turut menyumbang kepada penglibatan pelajar yang lebih aktif dan bermakna. Selain itu, maklum balas positif dan tahap kepuasan yang tinggi dalam kalangan pelajar menunjukkan bahawa program ini berkesan dalam membina minat dan keyakinan pelajar terhadap bidang keusahawanan.

C) Cadangan

Berdasarkan dapatan kajian, beberapa cadangan untuk meningkatkan keberkesanan Arena Usahawan JKE adalah:

- Penambahbaikan Kemudahan dan Infrastruktur:

Memastikan kemudahan fizikal dan peralatan mencukupi bagi menyokong pelaksanaan aktiviti yang lebih kompleks.

- Pengembangan Aktiviti Berasaskan Amali:

Menambah variasi aktiviti yang lebih praktikal dan interaktif untuk mengukuhkan pengalaman pembelajaran sebenar.

- Bimbingan dan Pemantauan Lanjutan:

Menyediakan lebih banyak sesi bimbingan individu atau kumpulan bagi meningkatkan pemahaman, kemahiran pengurusan, dan keyakinan pelajar.

- Penglibatan Industri dan Komuniti:

Menggalakkan kerjasama dengan usahawan sebenar atau komuniti perniagaan untuk memberi pendedahan langsung kepada cabaran dunia perniagaan.

- Penilaian dan Penambahbaikan Berterusan:

Menjalankan tinjauan berkala untuk mendapatkan maklum balas pelajar dan memperbaiki aspek jadual, garis panduan, dan sokongan bagi memastikan program sentiasa relevan dan efektif.

VI. KESIMPULAN

Hasil kajian menunjukkan bahawa Arena Usahawan JKE berkesan sebagai platform pembelajaran keusahawanan berasaskan pengalaman (*experiential learning*). Dapatan kajian menunjukkan pelajar mempunyai tahap penglibatan, kemahiran, kepuasan dan persepsi yang tinggi dengan nilai min keseluruhan antara 4.31 hingga 4.38. Melalui pelaksanaan aktiviti program, pelajar berpeluang memperoleh pengalaman sebenar yang membantu meningkatkan kemahiran komunikasi, pengurusan kewangan, penyelesaian masalah, keyakinan diri serta sikap berdikari. Selain itu, pelajar juga dapat mengaplikasikan teori yang dipelajari ke dalam situasi praktikal. Faktor sokongan dan pelaksanaan program seperti kemudahan yang disediakan, jadual aktiviti, bimbingan pensyarah, sokongan jabatan serta garis panduan yang jelas turut menyumbang kepada kelancaran program. Secara keseluruhannya, Arena Usahawan JKE menyediakan pengalaman pembelajaran yang menyeluruh serta berkesan dalam membangunkan minat, keyakinan dan kemahiran

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Bridging The Water Literacy Gap: A Digital Approach To Promoting Sustainable Water Behaviour Among Malaysian Secondary Students

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Abstract

Water literacy is widely recognised as a multidimensional construct comprising knowledge, attitudes, and behaviour. However, behavioural change remains the most difficult dimension to develop, particularly in school-based environmental education. This study examined whether a digital learning approach could strengthen sustainable water-related behaviour among Malaysian secondary school students. A quantitative quasi-experimental design with a non-equivalent pretest-posttest control group was employed. The study involved 63 Form One students from two secondary schools in Miri, Sarawak, comprising 31 students in the digital learning group and 32 students in the conventional group. The intervention group used the interactive digital module through Minecraft Education Edition, while the control group received conventional teacher-centred instruction. Water-related behaviour was measured using a 15-item questionnaire, and the data were analysed using descriptive statistics, independent-samples t-tests, and Cohen's *d*. The findings showed no significant difference between the groups at pre-test, but the digital group achieved a significantly higher post-test mean score than the conventional group, $t(61) = 4.596$, $p < .001$, with a large effect size ($d = 1.158$). These findings indicate that digitally mediated, action-oriented learning can more effectively promote sustainable water-related behaviour and help bridge the behavioural gap in water literacy among Malaysian secondary school students.

Keywords: *Digital Learning; Environmental Education; Sustainable Water Behaviour; Water Literacy*

I. INTRODUCTION

Water literacy is increasingly recognised as a critical concern in environmental education because sustainable water management depends not only on what learners know about water, but also on how they value it and how they act in relation to its use. Recent scholarship conceptualises water literacy as a multidimensional construct encompassing water-related knowledge, attitudes, and behaviours, all of which are essential for promoting sustainable water management and social equity [1]–[4]. From this perspective, water literacy extends beyond factual understanding and positions learners as informed and responsible actors in responding to contemporary water challenges.

Within this framework, the behavioural dimension is particularly important because it reflects the extent to which environmental learning is translated into everyday water-use practices. However, previous studies indicate that although environmental education programmes often improve students' knowledge and attitudes towards water-related issues, behavioural change tends to be weaker, less consistent, and more difficult to sustain over time [5]–[7]. This suggests that the relationship between knowledge, attitudes, and behaviour is not automatic, as learners may demonstrate awareness and positive perceptions without consistently adopting sustainable water-use practices. Such a pattern points to a persistent behavioural gap in water literacy.

In Malaysia, environmental education has expanded in policy attention and curricular scope, yet a gap remains between students' environmental knowledge and their everyday practices, particularly in water use. Although the revised secondary school curriculum is broader, its implementation is still

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strongly shaped by exam-oriented teaching, limited student-centred pedagogy, and insufficient emphasis on environmental action in classroom practice [8]–[11]. Similar constraints are reported in other school contexts, where teacher-centred instruction, rigid curricula, and limited pedagogical training restrict the use of participatory and action-oriented approaches in environmental and sustainability education [12]–[15]. As a result, environmental education in Malaysia tends to be more effective in transmitting knowledge than in fostering sustained environmental practices and meaningful behavioural change among students [9], [16], [10], [17].

In response to this concern, digital technologies are increasingly regarded as promising tools for enhancing environmental education's interactivity, participation, and engagement. While recent studies suggest that digital approaches may support environmental learning, evidence remains limited regarding their effectiveness in strengthening the behavioural dimension of water literacy among Malaysian secondary school students [18]–[21]. This gap warrants further investigation, particularly whether digital approaches can move beyond raising awareness to foster more consistent and meaningful water-conservation practices in everyday life. Accordingly, this study examines whether a digital approach can help address the persistent behavioural gap in water literacy among Malaysian secondary school students. More specifically, it investigates the extent to which digital learning can contribute to stronger, sustainable water-related behaviour, alongside knowledge and attitudes, within the context of environmental education in Malaysia.

II. LITERATURE REVIEW

A. Conceptual Foundations of Water Literacy

Water literacy has been increasingly framed as a multidimensional educational construct that extends beyond the acquisition of factual knowledge about water systems. Water literacy is commonly defined as the culmination of water-related knowledge, attitudes, and behaviours, highlighting that being water literate requires not only understanding key concepts but also applying this understanding in everyday decisions about water use and management [1], [22]. Rather than focusing solely on scientific understanding, recent scholarship positions water literacy as the capacity to understand water-related issues, evaluate their implications, and respond through informed and responsible action, similar to how river and ocean literacy frameworks emphasise informed decision making and active stewardship of aquatic environments [1], [23]–[25]. In this sense, water literacy integrates cognitive, affective, and behavioural dimensions, commonly represented through knowledge, attitudes, and behaviours related to water resources, conservation, and sustainability, and is increasingly discussed within broader environmental and sustainability literacy agendas in both global and Southeast Asian contexts [1], [22], [26].

This conceptualisation is important because water-related challenges are not purely technical or hydrological in nature, but are embedded in socio-hydrological systems shaped by human values, social practices, and patterns of resource use [27]–[29], [2]. Accordingly, being water literate involves not only understanding how water systems function, but also recognising the social and environmental consequences of water misuse and being willing to adopt more sustainable practices [1], [27], [30], [28], [3], [22], [2]. Water literacy, therefore, aligns closely with the broader aims of environmental and sustainability education, which seek to cultivate environmentally responsible citizens rather than merely informed learners.

Recent literature further suggests that water literacy should be understood as a practical and action-oriented form of literacy that links understanding with behaviour and decision-making in socio-hydrological issues [1], [27], [30], [28], [3], [22], [29], [2]. In formal and non-formal educational settings, water education is increasingly expected to support not only awareness but also decision-making, problem-solving, and everyday water stewardship [26], [31], [29], [32]. From this perspective, the educational significance of water literacy lies in its potential to connect understanding with action, making the behavioural dimension especially important as an indicator of whether educational experiences translate into sustainable real-life practice.

B. The Knowledge–Attitude–Behaviour Gap in Water Literacy

Although water literacy is widely framed as knowledge, attitudes, and behaviour, many studies show these dimensions often develop unevenly, with stronger cognitive gains than behavioural change. Several interventions find that students hold accurate water knowledge and pro-conservation attitudes, yet daily practices remain inconsistent or unsustainable [33], [5], [1], [7], [6], [30]. For example, Moroccan and Spanish primary students report positive attitudes but show weak or unstable water saving habits and low responsibility for water issues [33], [5], [30]. Similarly, Romanian pupils express concern about water but need more support to translate this into concrete conservation actions

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[6]. Meta-analyses and broader environmental literacy work also report that knowledge is only weakly or inconsistently correlated with behaviour, and that behaviour change effects are smaller and more variable than knowledge gains [34]–[36].

Behavioural outcomes are described as more context dependent and fragile over time, influenced by motivation, habit, convenience, social norms, infrastructure, and school/family culture rather than information alone [5], [37], [35], [38], [2], [30]. Structural equation and systems models in water literacy and environmental education often find that knowledge improves attitudes, and attitudes relate to behaviour, but direct paths from knowledge to behaviour are weak or non-significant [22], [2], [36].

This persistent awareness-action gap has led authors to argue that water education must go beyond conceptual teaching to engage the practical, social, and habitual dimensions of water use, using contextual, participatory experiences that directly target everyday practice and structural barriers [1], [37], [6], [38], [2], [30]. Within this view, the behavioural dimension becomes a central indicator of whether water literacy is meaningfully realised in sustainable action, not a secondary add-on [1], [34], [2], [30].

C. Water Literacy in Malaysian Environmental Education

In Malaysia, environmental education has been incorporated into school curricula for many years, particularly through subjects such as Geography, Science, and other cross-curricular initiatives. Nevertheless, recent literature suggests that the implementation of environmental and climate-related education continues to face several pedagogical constraints. Although policy attention has increased, classroom practice is still often influenced by examination-oriented priorities, teacher-centred approaches, and limited emphasis on action-based learning [8], [39], [40]. Similar patterns are evident internationally, where climate and environmental topics are frequently treated as content to be covered rather than as a basis for cultivating action competence [12], [41].

These constraints are significant because environmental education is expected not only to transmit environmental knowledge but also to cultivate responsible values and everyday sustainable practices. However, when teaching is dominated by content delivery and assessment requirements, opportunities for participatory, reflective, and action-oriented learning may be reduced [8], [12], [39]. Other recent work has likewise pointed to limited pedagogical creativity and insufficient teacher preparation as challenges in promoting more engaging forms of environmental and sustainability learning, including in Malaysian preschool and religious education contexts [42]–[44]. At a broader level, global reviews of environmental education teaching practices highlight that teacher-centred instruction and textbook dependence remain widespread, even as policies call for more participatory and experiential approaches [45], [12]. Such conditions may partly explain why environmental learning outcomes in Malaysia and elsewhere are often stronger at the cognitive level than at the behavioural level [8], [43], [40].

This pattern is also reflected in local and regional studies related to water conservation and environmental practice. Hashim *et al.* found that although students demonstrated high levels of knowledge and positive attitudes towards water saving, their actual water-saving practices were only moderate [46]. A similar imbalance has been reported among Malaysian university students, who show high awareness of water conservation but relatively low engagement in conservation practices [47]. International research on water literacy likewise indicates that awareness and positive attitudes do not automatically translate into consistent pro-environmental behaviour [3], [2], [48]. These findings are important because they suggest that the main weakness in local water literacy is not necessarily a lack of awareness, but the limited translation of that awareness into consistent action.

Taken together, the Malaysian and international literature point to a recurring pattern in which students generally know the importance of environmental protection and may even express supportive attitudes, yet their actual practices do not fully reflect these orientations [8], [47], [40]. In the context of water literacy, this suggests that the behavioural dimension remains underdeveloped. Therefore, there is a need to explore pedagogical approaches that are more capable of influencing practice and not merely understanding, including contextual, participatory, and experience-based models of environmental learning [42], [45], [8], [48].

D. Digital Approaches in Environmental Education

Digital approaches have gained increasing attention in environmental education as tools for creating more interactive, participatory, and learner-centred learning experiences. These approaches include digital games, simulations, multimedia learning, mobile applications, virtual environments,

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augmented reality, and other technology-enhanced instructional strategies. Recent studies and reviews indicate that such tools are now widely used in environmental and sustainability education to move learning beyond passive reception of information and toward active engagement with environmental problems, decision-making, and real-world applications [18], [20], [49]–[52].

Recent evidence further suggests that digital technologies can support sustainability learning by improving learner engagement, environmental awareness, and participation. A systematic review covering studies published between 2013 and 2023 found that virtual reality and climate-change-focused digital tools were especially prominent and generally showed positive effects on students' sustainability concern and awareness [18]. Similar patterns have also been reported in studies on e-learning and multimedia platforms that combine videos, simulations, quizzes, and other interactive elements to make environmental content more engaging and accessible [51]. These findings suggest that digital tools can enrich environmental learning by providing immediate feedback, immersive visualisation, and repeated practice in context-rich settings.

Among the most frequently discussed approaches are gamified and game-based learning strategies, including serious games, Web 2.0-based digital games, mobile augmented reality, and simulation-based gamification. These approaches are often associated with higher levels of student engagement, active participation, problem-solving, and learn-by-doing experiences in relation to environmental issues [20], [53], [52], [54], [49], [55]. In environmental education, such features are particularly valuable because they enable learners to connect abstract environmental concepts with realistic situations, consequences, and choices.

However, although digital approaches consistently show positive effects on knowledge gain and attitudinal development, their influence on behaviour is less straightforward. A growing body of evidence indicates that digital games, immersive tools, and multimedia interventions can strengthen pro-environmental attitudes, behavioural intentions, and, in some cases, concrete environmental habits such as recycling, energy conservation, and water saving [21], [20], [53], [52], [54], [49], [55]. Nevertheless, these behavioural effects are often mixed, indirect, gradual, and highly dependent on contextual factors such as pedagogical design, scaffolding, learner motivation, and implementation setting. Reviews, therefore, emphasise that digital technology should not be assumed to produce behavioural change automatically; rather, its effectiveness depends on whether it is embedded within meaningful, participatory, and action-oriented pedagogy [18], [51], [56].

This issue is especially relevant to water literacy. Although most recent studies focus on environmental literacy and sustainability education more broadly, some evidence suggests that digital and gamified interventions can encourage ecological habits, including water- and energy-saving practices, particularly among school-aged learners [55]. However, direct evidence on digital interventions specifically targeting water-related behaviour remains limited, especially in the Malaysian secondary school context. Existing Malaysian research more often addresses digital literacy, student engagement, or general behaviour-related outcomes rather than water-specific environmental practices [57], [58]. This gap highlights the need for further empirical research on whether digital approaches can meaningfully strengthen the behavioural dimension of water literacy among Malaysian secondary school students.

III. RESEARCH METHODOLOGY

This study employed a quantitative quasi-experimental design using a non-equivalent pretest-posttest control group design. The design was selected because the intervention was implemented in intact classroom settings where random assignment was not feasible. Two groups of Form One students participated: one group (Treatment) received a digital learning intervention using the interactive module *Water Warriors: Save the World* through Minecraft Education Edition, while the comparison group (Control) received conventional teacher-centred instruction based on the same curriculum content.

The study was conducted in two secondary schools in Miri, Sarawak, Malaysia. The schools were selected purposively based on the availability of computer facilities, stable internet access, and students' prior exposure to water-related topics. One intact class from each school was involved, resulting in a total of 63 students, comprising 31 students in the digital group and 32 students in the conventional group.

Although the broader study examined water literacy across knowledge, attitudes, and behaviour, this article focuses only on the behavioural dimension. Water-related behaviour was measured using a 15-item questionnaire adapted from previous studies [59], [60]. The items assessed students' self-reported water-saving and conservation practices in daily life. Responses were recorded on a five-point Likert

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scale ranging from 1 (strongly disagree) to 5 (strongly agree). The instrument demonstrated acceptable content validity, with I-CVI values ranging from 0.83 to 1.00, and high scale-level validity indices (S-CVI/Ave = 0.955; S-CVI/UA = 1.000). A pilot study involving 31 students yielded a Cronbach's alpha of 0.702, indicating satisfactory internal consistency.

The intervention was conducted over eight weeks, with one session per week lasting approximately 90 minutes. Before the intervention, both groups completed a pre-test to determine baseline water-related behaviour. The digital group then followed the *Water Warriors: Save the World* module, whereas the control group continued with conventional instruction. At the end of the intervention, both groups completed a post-test using the same behavioural instrument.

Descriptive statistics, including mean and standard deviation, were used to summarise students' behavioural scores. Inferential analysis involved paired-samples *t*-tests to examine pre-post changes within each group and independent-samples *t*-tests to compare post-test differences between groups. The significance level was set at $p < 0.05$. In addition, Cohen's *d* was calculated to determine the magnitude of the intervention effect.

IV. RESULT AND DISCUSSION

A. Differences in Water-Related Behaviour between the Digital and Conventional Groups

An independent-samples *t*-test was conducted to compare water-related behaviour between the digital learning group and the conventional group at the pre-test and post-test stages. Table 1 shows that at pre-test, the digital group (M = 75.1, SD = 4.22) and the conventional group (M = 75.9, SD = 4.04) did not differ significantly, $t(61) = -0.788$, $p = .434$. This indicates that both groups were comparable in terms of water-related behaviour before the intervention.

At post-test, the digital group recorded a higher mean score (M = 85.8, SD = 3.50) than the conventional group (M = 80.5, SD = 5.43). The difference was statistically significant, $t(61) = 4.596$, $p < .001$, indicating that the digital learning approach was more effective than the conventional approach in improving students' water-related behaviour

Table 1

Group	Test	M	SD	df	p
Treatment	Pre	75.1	4.2	61	.434
Control	Pre	75.9	4.0	61	.434
Treatment	Post	85.8	3.5	61	< .001
Control	Post	80.5	5.4	61	< .001

The magnitude of the difference was further assessed using Cohen's *d*, as presented in Table 2. At pre-test, the effect size was very small ($d = -0.199$, 95% CI [-0.693, 0.297]), confirming baseline equivalence between the two groups. At post-test, the effect size was large ($d = 1.158$, 95% CI [0.619, 1.689]), indicating a strong practical effect of the digital intervention on students' water-related behaviour. Overall, the findings show that the digital learning approach produced a significantly greater improvement in water-related behaviour than the conventional instructional approach.

Table 2

Test	Cohen's d	95% CI	Interpretation
Pre	-0.199	[-0.693, 0.297]	Very small effect
Post	1.158	[0.619, 1.689]	Large effect

This finding is important because it speaks directly to a recurring issue in the water literacy literature: behaviour is often the weakest dimension compared with knowledge and attitudes. Previous studies have consistently shown that students may understand water-related issues and express positive views about conservation, yet fail to translate these into everyday practice [33], [5], [6], [30]. In the Malaysian context, similar patterns have been reported, with students demonstrating relatively encouraging knowledge and attitudes while actual water-saving practices remain only moderate [46], [61]. Against this background, the present study provides empirical support for the argument that the behavioural dimension of water literacy can be strengthened when pedagogy moves beyond information delivery and offers students more active and engaging learning experiences.

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A key contribution of this study, therefore, lies in showing that the behavioural gap is not fixed or inevitable. Rather, it may reflect the limitations of how environmental education is commonly delivered. As argued earlier, conventional environmental teaching in Malaysia is still often shaped by examination-oriented priorities, teacher-centred pedagogy, and insufficient emphasis on action-based learning [8], [62], [63], [43]. Under such conditions, students may be exposed to environmental content without sufficient opportunities to practise decision-making, experience consequences, or internalise habits linked to sustainable action. The stronger behavioural outcomes observed in the digital group suggest that the issue may not simply be students' lack of awareness, but the inadequacy of instructional approaches that remain too abstract, transmissive, and detached from lived practice.

This interpretation is consistent with broader research on digital environmental education. Recent reviews and empirical studies show that digital tools, particularly game-based and interactive approaches, can increase engagement, participation, and contextual understanding [18], [20], [51], [52]. However, the literature also cautions that digital approaches do not automatically produce behavioural change; their impact depends on pedagogical design, scaffolding, and the extent to which they support meaningful action-oriented learning [18], [56], [21]. The present findings align with that position. The positive behavioural effect observed here should not be interpreted as evidence that technology alone changes behaviour. Rather, it suggests that when digital tools are embedded in an interactive and structured learning environment, they can help create conditions more conducive to behavioural development than conventional instruction.

This point is theoretically significant. The findings reinforce the view that the relationship between knowledge, attitudes, and behaviour is neither direct nor automatic. As prior studies suggest, behaviour is shaped by a combination of habit, context, motivation, convenience, and social practice, not information alone [2], [38], [30]. In this sense, the stronger behavioural outcomes in the digital group may be interpreted as evidence that the intervention helped bridge, at least partially, the knowledge-attitude-behaviour gap by making learning more experiential, applied, and behaviourally relevant. The digital module likely supported this process not simply by presenting water issues, but by engaging students in forms of participation that made sustainable water use more concrete, imaginable, and actionable.

The study also carries important implications for environmental education in Malaysia. First, it suggests that strengthening water literacy requires greater attention to pedagogy, not merely content coverage. If behaviour is the weakest dimension, then educational responses should be designed to influence practice rather than simply expand awareness. Second, the findings support the inclusion of digitally mediated, participatory, and action-oriented learning approaches within environmental and geography education, especially where the goal is to foster sustainable habits and not just conceptual understanding. Third, the study contributes to local water literacy research by providing evidence from Malaysian secondary schools, a context in which behaviour-specific digital interventions remain underexamined.

Overall, this study supports the argument that bridging the water literacy gap requires more than teaching students about water. It requires learning environments that connect understanding with action in ways that are meaningful, engaging, and contextually grounded. The stronger behavioural outcomes observed in the digital group indicate that digital learning, when pedagogically structured and behaviourally targeted, can serve as a promising approach for promoting sustainable water-related behaviour among Malaysian secondary school students. In this sense, the study contributes not only to the literature on digital environmental education but also to the broader effort to reposition water literacy as an action-oriented educational goal rather than a primarily cognitive one.

V. CONCLUSION

This study examined whether a digital learning approach could help address the behavioural gap in water literacy among Malaysian secondary school students. The findings showed that, although both groups were comparable at baseline, students who participated in the digital intervention achieved significantly higher post-test scores in water-related behaviour than those who received conventional instruction. The large effect size further indicates that the intervention had substantial practical value, not merely statistical significance.

These findings suggest that the behavioural dimension of water literacy can be strengthened when environmental education is designed in a more interactive, participatory, and action-oriented

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manner. In contrast to conventional approaches that often prioritise content delivery, the digital module appears to have provided a more effective learning environment for translating environmental understanding into reported sustainable practice. This is especially important in the Malaysian context, where previous research has frequently shown that knowledge and attitudes towards water conservation are relatively encouraging, yet actual behaviour remains less convincing.

The study contributes to the literature in two main ways. First, it provides empirical evidence that the water literacy gap, particularly at the behavioural level, is pedagogically responsive rather than fixed. Second, it extends current research on digital environmental education by showing that digitally mediated learning can support not only engagement and awareness, but also more meaningful behaviour-related outcomes in the area of water conservation.

Nevertheless, the study has several limitations. The sample was limited to two schools in Miri, and the behavioural measure relied on students' self-reported responses. In addition, the study assessed short-term post-intervention outcomes and did not examine whether the reported behavioural improvements were sustained over time. Future research could therefore include larger and more diverse samples, observational or mixed-method measures of behaviour, and longitudinal designs to examine the durability of behavioural change.

Overall, the study suggests that bridging the water literacy gap requires more than improving what students know about water. It requires pedagogical approaches that help students practise, internalise, and sustain responsible water-related behaviour. In this respect, digital learning offers a promising direction for strengthening action-oriented environmental education in Malaysian schools.

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Kajian Keberkesanan Campuran Bitumen-Getah terhadap Ketahanan dan Rintangan Kegelinciran Turapan Jalan Raya

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Abstrak

Kajian ini dijalankan untuk menilai keberkesanan campuran bitumen-getah terhadap ketahanan dan rintangan kegelinciran turapan jalan raya. Objektif utama ialah menentukan kadar ketahanan turapan apabila dicampurkan dengan 3% tayar getah terpakai, serta menilai tahap rintangan kegelinciran. Sebanyak tiga sampel berbentuk silinder dihasilkan mengikut piawaian JKR/SPJ/2008-S4 dan diuji menggunakan dua kaedah makmal iaitu Ujian Marshall dan Ujian Rintangan Kegelinciran. Keputusan Ujian Marshall menunjukkan purata kestabilan 10,964 N dengan sisihan piawai 1,150 N (~10%) dan purata kekuatan 3,655 N/mm dengan sisihan piawai 87 N/mm (~2.4%). Kedua-dua nilai ini melepasi piawaian JKR (>8,000 N dan >2,000 N/mm). Sementara itu, Ujian Rintangan Kegelinciran mencatatkan purata 45 dengan sisihan piawai 3.0 (~6.6%), yang menepati kategori C dan sesuai digunakan pada semua jenis jalan. Nilai sisihan piawai yang rendah membuktikan bahawa data adalah konsisten dan boleh dipercayai. Dapatan ini menunjukkan bahawa campuran bitumen-getah bukan sahaja meningkatkan ketahanan turapan dan keselamatan jalan raya, malah berpotensi mengurangkan kos penyelenggaraan jangka panjang. Kajian ini menyokong penggunaan *Cup Lump Modified Asphalt* (CMA) sebagai alternatif turapan yang lebih tahan lama, selamat, dan mesra alam.

Keywords **:** *Turapan Jalan Raya, Kestabilan dan Kekutan, Rintangan Kegelinciran, Bitumen.*

Abstract

This study was conducted to evaluate the effectiveness of rubberized bitumen mixtures in improving pavement durability and skid resistance. The main objective was to determine the durability of asphalt when mixed with 3% waste tire rubber and to assess its skid resistance. Three cylindrical samples were prepared according to JKR/SPJ/2008-S4 standards and tested using two laboratory methods: the Marshall Test and the Skid Resistance Test. The Marshall Test results recorded an average stability of 10,964 N with a standard deviation of 1,150 N (~10%) and an average strength of 3,655 N/mm with a standard deviation of 87 N/mm (~2.4%). Both values exceeded JKR requirements (>8,000 N and >2,000 N/mm). Meanwhile, the Skid Resistance Test recorded an average value of 45 with a standard deviation of 3.0 (~6.6%), which meets Category C and is suitable for all road types. The relatively low standard deviation values confirm that the data are consistent and reliable. These findings demonstrate that rubberized bitumen mixtures not only enhance pavement durability and road safety but also have the potential to reduce long-term maintenance costs. This study supports the use of Cup Lump Modified Asphalt (CMA) as a more durable, safer, and environmentally sustainable alternative for road construction.

Keywords **:** *Road Pavement, Stability and Strength, Skid Resistance, Bitumen.*

I. PENGENALAN

Turapan jalan raya merupakan elemen asas dalam sistem pengangkutan sesebuah negara kerana ia menyumbang kepada kelancaran pergerakan. Turapan jalan raya di Malaysia kebanyakannya menggunakan bitumen kerana kosnya lebih rendah dan mudah diperoleh.

Namun, turapan jenis ini mempunyai kelemahan yang ketara dari segi ketahanan dan keselamatan. Jalan raya sering mengalami kerosakan seperti retakan, lubang, dan permukaan tidak rata dalam tempoh singkat, khususnya di kawasan trafik berat. Keadaan ini bukan sahaja meningkatkan kos penyelenggaraan, malah menjejaskan keselesaan pemanduan dan boleh meningkatkan risiko kemalangan akibat kehilangan kawalan kenderaan.

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Seiring dengan perkembangan teknologi bahan binaan, penggunaan bahan tambah dalam bitumen telah menjadi alternatif untuk meningkatkan prestasi turapan. Salah satu bahan yang berpotensi ialah getah tayar terpakai, yang bukan sahaja mudah diperoleh tetapi juga menyumbang kepada usaha kitar semula dan kelestarian alam sekitar.

II. KAJIAN LITERATUR

Turapan konvensional yang menggunakan bitumen biasa sering mengalami kerosakan dalam tempoh singkat akibat beban trafik berat dan keadaan iklim tropika. Rahmat et al. [1] menegaskan bahawa turapan konvensional hanya mampu bertahan sekitar enam bulan sebelum memerlukan penyelenggaraan semula, sekali gus meningkatkan kos dan menjejaskan keselamatan pengguna.

Penggunaan getah sebagai bahan tambah dalam bitumen telah lama dikaji oleh penyelidik tempatan dan antarabangsa. Al-Sabaeei et al. [2] melaporkan bahawa penambahan getah asli dalam bitumen meningkatkan kestabilan termal, ketahanan terhadap penuaan, serta fleksibiliti turapan. Kajian ini menekankan bahawa sifat kalis air dan tahan haba pada getah menjadikannya sesuai untuk iklim di Malaysia.

Penggunaan polimer termoplastik seperti *Styrene-Butadiene-Styrene* (SBS) telah terbukti meningkatkan keanjalan dan ketahanan turapan terhadap suhu tinggi. Airey [3] melaporkan bahawa polimer SBS memberikan kestabilan yang lebih baik dan mengurangkan retakan pada turapan, menjadikannya sesuai untuk kawasan beriklim panas. Di samping itu, penggunaan *fly ash* sebagai bahan tambah turut dikaji kerana ia mampu meningkatkan sifat mekanikal turapan serta menyokong agenda kelestarian melalui kitar semula sisa industri [4].

Terdapat juga kajian yang menilai penggunaan *nano-silica* sebagai bahan tambah dalam bitumen. Menurut Yusoff et al. [5], penambahan *nano-silica* meningkatkan rintangan terhadap kehausan dan mengurangkan kadar penuaan bitumen, sekali gus memanjangkan jangka hayat turapan. Sementara itu, penggunaan plastik kitar semula sebagai bahan tambah turut mendapat perhatian. Kajian oleh Hossain et al. [6] menunjukkan bahawa bitumen yang dicampur dengan plastik kitar semula meningkatkan ketahanan terhadap suhu tinggi dan mengurangkan masalah *rutting*, selain menyokong usaha mengurangkan pencemaran plastik.

Selain itu, Jaharudin et al. [7] meneliti keberkesanan *Crumb Rubber Modified Asphalt* (CRMA) di kawasan jalan yang terdedah kepada banjir. Hasil kajian menunjukkan bahawa CRMA lebih tahan terhadap takungan air berbanding turapan biasa, sekali gus meningkatkan jangka hayat jalan raya di kawasan berisiko banjir. Che Lat et al. [8] pula menekankan aspek kelestarian dalam penggunaan asfalt, dengan menyatakan bahawa penambahan bahan seperti getah bukan sahaja meningkatkan prestasi turapan, tetapi juga menyokong agenda kitar semula tayar terpakai.

Kajian terkini dalam bidang pembinaan jalan raya di Malaysia menunjukkan peralihan ke arah penggunaan bahan semula jadi bagi menghasilkan turapan yang lebih berkualiti dan lestari. Ghafar et al. [10] melaporkan bahawa penggunaan getah sekerap (*cup lump rubber*) sebagai bahan tambah mampu meningkatkan kekuatan permukaan jalan serta mengurangkan risiko kerosakan awal. Dari sudut saintifik, getah ini mengubah sifat *reologi* bitumen, iaitu cara bahan mengalir dan berubah bentuk, dengan bertindak sebagai pengikat yang menjadikan turapan lebih kenyal dan tahan tekanan. Selanjutnya, Abdulrahman et al. [11] mendapati bahawa campuran bitumen-getah menjadi lebih stabil apabila ditambah dengan bahan tambahan khas seperti *Evotherm*, sekali gus mengurangkan risiko turapan menjadi lembut atau berlekuk walaupun terdedah kepada suhu tinggi dan beban trafik berat.

Selain penggunaan getah, teknologi nano turut diperkenalkan untuk meningkatkan ketahanan turapan. Vigneswaran et al. [12] membuktikan bahawa penambahan debu halus *nanokomposit clay* ke dalam campuran bitumen-getah dapat mengukuhkan struktur turapan secara signifikan. Dari perspektif praktikal, inovasi ini membantu jalan raya mengekalkan keseimbangan antara kepekatan (supaya tidak cair ketika panas) dan kekenyalan (supaya tidak retak di bawah beban berulang).

Keseluruhannya, gabungan bahan tradisional seperti getah dengan teknologi moden seperti nanokomposit membuktikan potensi menghasilkan turapan yang lebih selamat, tahan lama, dan memerlukan penyelenggaraan minimum.

III. METODOLOGI KAJIAN

Kajian ini berbentuk ujian makmal yang bertujuan menilai keberkesanan campuran bitumen-getah terhadap ketahanan dan rintangan kegelinciran turapan jalan raya. Proses kajian melibatkan beberapa peringkat utama iaitu penyediaan sampel,

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pelaksanaan ujian makmal dan analisis data. Dua ujian utama digunakan iaitu Ujian *Marshall* untuk menilai ketahanan turapan dan Ujian *Skid Resistance* untuk menilai rintangan kegelinciran. Ujian yang dipilih merupakan kaedah standard yang digunakan oleh Jabatan Kerja Raya (JKR) dalam menilai kualiti turapan jalan.

Proses kajian dimulakan dengan penyediaan bahan utama iaitu bitumen gred penusukan (*Penetration Grade*) 60/70 yang dicampurkan dengan 3% getah tayar terpakai daripada jumlah berat bitumen. Penggunaan getah tayar ini berfungsi sebagai bahan tambah untuk meningkatkan kualiti campuran asfalt mengikut piawaian [9]. Bagi memastikan hasil kajian yang tepat, proses pencampuran dilakukan di bawah kawalan suhu dan masa yang sangat konsisten. Rajah 1 menunjukkan proses penyediaan sampel campuran bitumen-getah yang dijalankan di makmal. Langkah ini penting bagi menghasilkan campuran bitumen-getah yang *homogen* dan sebati sepenuhnya sebelum ia dibentuk menjadi sampel ujian.

Proses bermula dengan pemanasan bitumen sehingga mencapai suhu 140°C bagi memastikan ia berada dalam keadaan cair dan mudah dicampurkan. Getah tayar terpakai yang telah diproses dicampurkan ke dalam bitumen cair dan digaul sehingga seragam sepenuhnya. Campuran tersebut kemudian dimasukkan ke dalam acuan silinder khas dan dipadatkan menggunakan pemadat automatik *Marshall* dengan 75 hentakan pada setiap sisi. Setelah proses pemadatan selesai, sampel dikeluarkan daripada acuan, dilabel, dan diukur diameter serta ketebalannya untuk memastikan keseragaman sebelum ujian dijalankan.

Ujian *Marshall* dijalankan untuk menilai dua parameter utama iaitu kestabilan (N) dan kekuatan (N/mm). Sampel yang telah dihasilkan akan direndam dalam *water bath* bersuhu 60°C selama 20 minit bagi mewakili keadaan turapan ketika berada di bawah suhu operasi sebenar. Selepas itu, sampel diuji menggunakan mesin *Marshall* untuk mendapatkan bacaan kestabilan (N) dan kekuatan (N/mm). Kaedah ujian *Marshall* dapat dilihat dalam Rajah 2. Setiap sampel diuji sebanyak tiga kali, dan nilai purata serta standard deviation (SD) dikira. SD digunakan untuk menunjukkan tahap variasi antara sampel, manakala graf keputusan dilengkapkan dengan error bars ±SD bagi menggambarkan julat variasi data. Bacaan purata daripada ketiga-tiga sampel dibandingkan dengan piawaian JKR, iaitu kestabilan melebihi 8,000 N dan kekutan melebihi 2,000 N/mm [9].

Ujian *Skid Resistance*, yang dijalankan untuk menilai tahap keselamatan turapan dari segi rintangan kegelinciran. Ujian ini menggunakan alat *Skid Resistance*, di mana permukaan sampel dibasahkan dengan air bagi menggambarkan keadaan jalan raya ketika hujan. Bacaan diambil sebanyak lima kali bagi setiap sampel, dan purata dikira untuk menentukan nilai rintangan kegelinciran. Nilai tersebut kemudian dibandingkan dengan kategori keselamatan JKR, di mana bacaan purata 45 menepati kategori C, sesuai digunakan pada semua jenis jalan termasuk kawasan trafik berat dan selekoh [9].

Data daripada kedua-dua ujian dianalisis untuk mendapatkan purata nilai kestabilan, kekuatan dan rintangan kegelinciran. Hasil analisis ini kemudiannya dibandingkan dengan piawaian JKR [9] bagi menentukan keberkesanan campuran bitumen-getah.

Secara ringkas, metodologi kajian ini melibatkan penyediaan sampel bitumen-getah dengan ukuran piawai, pelaksanaan Ujian *Marshall* dan Ujian *Skid Resistance* serta analisis data untuk menilai sama ada campuran tersebut mampu meningkatkan prestasi turapan jalan raya dari segi ketahanan dan keselamatan.

Rajah 1 Proses Penyediaan Sampel Campuran Bitumen-Getah

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Rajah 2 Peralatan Ujian *Marshall*

Rajah 3 Peralatan Ujian Rintangan Kegelinciran

IV. KEPUTUSAN DAN PERBINCANGAN

Hasil kajian ini diperoleh melalui dua ujian makmal iaitu Ujian *Marshall* dan Ujian *Skid Resistance*. Kedua-dua ujian ini dijalankan bagi menilai keberkesanan campuran bitumen-getah terhadap ketahanan turapan jalan raya serta rintangan kegelinciran permukaan.

Bagi Ujian *Marshal,* sebanyak tiga sampel telah diuji dengan campuran bitumen-getah sebanyak 3% daripada berat bitumen. Keputusan menunjukkan purata kestabilan yang dicapai ialah 10,964 N, manakala purata kekuatan ialah 3,655 N/mm. Kedua-dua nilai ini melepasi piawaian yang ditetapkan oleh Jabatan Kerja Raya Malaysia iaitu kestabilan melebihi 8,000 N dan kekuatan melebihi 2,000 N/mm [9]. Keputusan Ujian *Marshall* ditunjukkan dalam Rajah 4 (Kestabilan) dan Rajah 5 (Kekuatan)

Dapatan ini selaras dengan kajian Al-Sabaeei et al. [2] yang melaporkan bahawa penambahan getah dalam bitumen meningkatkan kestabilan termal dan kekuatan turapan. Selain itu, Lat et al. [8] turut menegaskan bahawa penggunaan bahan tambah dalam asfalt mampu meningkatkan prestasi turapan serta mengurangkan kos penyelenggaraan jangka panjang.

Sementara itu, keputusan Ujian *Skid Resistance* menunjukkan purata bacaan rintangan kegelinciran sebanyak 45. Rajah 5 menunjukkan keputusan Ujian *Skid Resistance.* Nilai ini menepati kategori C dalam piawaian JKR, yang bermaksud turapan tersebut sesuai digunakan pada semua jenis jalan termasuk kawasan trafik berat, selekoh, dan laluan bandar [9].

Keputusan ini seiring dengan kajian Jaharudin et al. [7] yang menekankan keberkesanan *Crumb Rubber Modified Asphalt* (CRMA) dalam meningkatkan rintangan kegelinciran, khususnya di kawasan jalan yang terdedah kepada genangan air. Tambahan pula, Amaran et al. [4] menegaskan bahawa penggunaan bahan tambah lain seperti f*ly ash* juga mampu meningkatkan sifat mekanikal turapan.

Analisis statistik menunjukkan bahawa nilai sisihan piawai (SD) memainkan peranan penting dalam menilai kebolehulangan data kajian. SD yang rendah menandakan bahawa data adalah konsisten dan keputusan ujian boleh dipercayai.

Sebagai contoh, purata nilai kestabilan yang diperoleh ialah 10,964N dengan sisihan piawai sebanyak 1,150N, iaitu variasi sekitar 10%. Walaupun terdapat sedikit perbezaan antara sampel, nilai ini masih dianggap baik kerana semua sampel melepasi piawaian JKR yang menetapkan nilai minimum 8,000 N.

Dalam kajian makmal turapan, julat sisihan piawai yang diterima biasanya kurang daripada 15% daripada purata bagi ujian *Marshall* (kestabilan dan kekuatan), manakala bagi ujian *Skid Resistance*, sisihan piawai kurang daripada 10% dianggap baik kerana ia berkait rapat dengan aspek keselamatan jalan raya.

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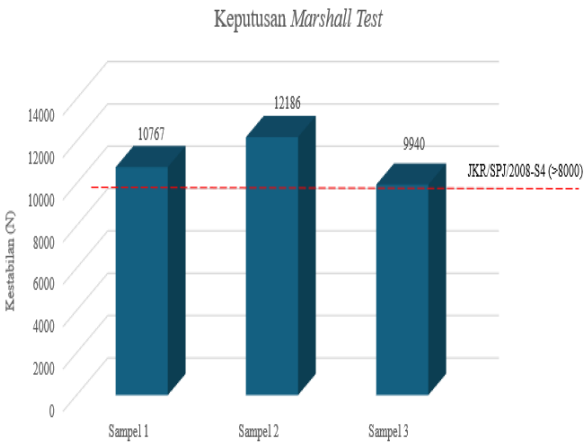
Keputusan kajian ini menunjukkan bahawa nilai sisihan piawai bagi semua ujian berada dalam julat yang boleh diterima. Bagi ujian kestabilan, purata 10,964 N dengan sisihan piawai sekitar 1,150 N (~10%) adalah memuaskan. Bagi ujian kekuatan, purata 3,652 N/mm dengan sisihan piawai 87 N/mm (~2.4%) menunjukkan tahap konsistensi yang sangat baik. Sementara itu, bagi ujian rintangan kegelinciran, purata 45.1 dengan sisihan piawai 3.0 (~6.6%) juga berada dalam julat yang diterima.

Dapatan ini membuktikan bahawa campuran bitumen-getah dengan kadar 3% bahan tambah tayar terpakai menghasilkan prestasi yang konsisten dan boleh dipercayai. Nilai sisihan piawai yang rendah menguatkan keyakinan bahawa campuran ini bukan sahaja memenuhi piawaian JKR/SPJ/2008-S4, tetapi juga berpotensi digunakan secara meluas dalam pembinaan jalan raya kerana sifatnya yang stabil, selamat, dan mesra alam.

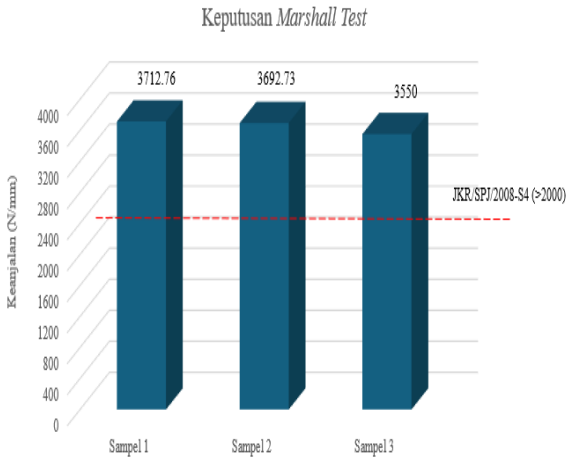
Secara keseluruhannya, dapatan kajian ini menunjukkan bahawa penggunaan bitumen-getah memberikan prestasi yang lebih baik berbanding turapan konvensional. Campuran ini bukan sahaja melepasi piawaian JKR dari segi ketahanan dan rintangan kegelinciran, malah berpotensi mengurangkan kos penyelenggaraan jangka panjang kerana turapan lebih tahan lama. Perbincangan ini mengesahkan bahawa CMA boleh dijadikan alternatif yang lebih selamat, berdaya tahan, dan sesuai untuk diaplikasikan secara meluas dalam sistem jalan raya di Malaysia.

Jadual 1 Keputusan Ujian *Marshall*

Sampel	Kestabilan (N)	Kekuatan (N/mm)
Sampel 1	10767	3712.76
Sampel 2	12186	3692.73
Sampel 3	9940	3550.00
Purata	**10964**	**3651.84**
Sisihan Piawai	**1,150**	**87**
Standard JKR/SPJ/2008 -S4	**>8000**	**>2000**



Rajah 4 Keputusan Ujian *Marshall* (Kestabilan)



Rajah 5 *Keputusan Ujian Marshall* (Kekuatan)

Jadual 2 Keputusan *Ujian Skid Resistance*

Sampel	Rintangan Kegelinciran
Sampel 1	43.4
Sampel 2	48.6
Sampel 3	43.2
Purata	**45.1**
Sisihan Piawai	**3.0**
Standard JKR/SPJ/2008 -S4	**40 - 50**

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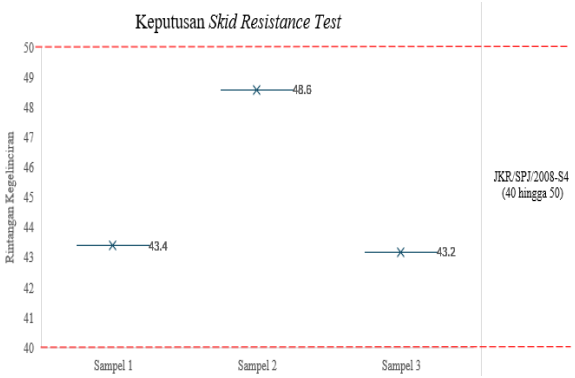

Rajah 6 Keputusan Ujian *Skid Resistance*

V. KESIMPULAN

Kajian ini telah menilai keberkesanan campuran bitumen-getah terhadap ketahanan dan rintangan kegelinciran turapan jalan raya melalui ujian makmal. Hasil Ujian *Marshall* menunjukkan purata kestabilan sebanyak 10,964N dan purata kekuatan sebanyak 3,655N/mm, kedua-duanya melepasi piawaian JKR/SPJ/2008-S4 yang menetapkan nilai minimum 8,000 N bagi kestabilan dan 2,000 N/mm bagi kekuatan [9]. Sementara itu, keputusan Ujian *Skid Resistance* mencatatkan purata bacaan 45, yang berada dalam julat 40–55 dan menepati kategori C dalam piawaian JKR. Hal ini membuktikan bahawa turapan bitumen-getah sesuai digunakan pada semua jenis jalan termasuk kawasan trafik berat, selekoh, dan laluan bandar [9]. Jadual 1 dan 2 menunjukkan keputusan ujian *Marshall* dan Ujian *Skid Resistance*.

Analisis sisihan piawai turut mengesahkan bahawa data yang diperoleh adalah konsisten dan boleh dipercayai, dengan semua nilai berada dalam julat yang diterima bagi kajian makmal turapan.

Secara keseluruhannya, dapatan kajian ini mengesahkan bahawa penggunaan bitumen-getah sebagai bahan tambah dalam turapan jalan raya bukan sahaja meningkatkan prestasi dari segi kekuatan dan keselamatan, tetapi juga berpotensi mengurangkan kos penyelenggaraan jangka panjang. Selain itu, penggunaan getah tayar terpakai dalam campuran bitumen turut menyokong agenda kelestarian alam sekitar melalui kitar semula bahan buangan, selaras dengan cadangan Lat et al. [8] yang menekankan aspek kelestarian dalam pembangunan infrastruktur.

Berdasarkan dapatan ini, beberapa cadangan boleh dikemukakan. Pertama, pihak berkuasa seperti JKR boleh mempertimbangkan penggunaan *Cup Lump Modified Asphalt* (CMA) secara lebih meluas dalam projek pembinaan jalan raya, khususnya di kawasan trafik berat dan berisiko tinggi. Kedua, kajian lanjutan perlu dijalankan dengan menambah bilangan sampel serta variasi peratusan getah bagi menentukan kadar optimum yang memberikan prestasi terbaik, seperti yang dicadangkan oleh Al-Sabaeei et al. [2]. Ketiga, kajian lapangan di jalan raya sebenar perlu dilakukan untuk menilai keberkesanan campuran ini dalam keadaan trafik dan iklim tropika Malaysia, seiring dengan saranan Jaharudin et al. [7] yang menekankan keperluan ujian lapangan bagi turapan CRMA di kawasan banjir.

Dengan langkah ini, penggunaan bitumen-getah dapat diperkukuh sebagai satu inovasi yang bukan sahaja meningkatkan prestasi turapan, tetapi juga menyumbang kepada keselamatan dan kelestarian infrastruktur jalan raya negara.

Berdasarkan dapatan kajian ini, terdapat beberapa ruang untuk kajian lanjutan yang boleh dijalankan bagi memperkukuh pemahaman tentang penggunaan getah tayar terpakai dalam campuran bitumen. Pertama, kajian boleh diperluaskan dengan menilai kesan penambahan getah tayar pada kadar yang berbeza, contohnya 5% atau 7%, bagi menentukan kadar optimum yang memberikan prestasi terbaik dari segi kestabilan, kekuatan, dan rintangan kegelinciran. Kedua, kajian jangka panjang terhadap ketahanan turapan di lapangan perlu dilakukan untuk menilai prestasi sebenar campuran bitumen-getah di bawah beban trafik berulang dan pelbagai keadaan cuaca. Kajian lapangan ini akan memberikan gambaran lebih realistik berbanding ujian makmal semata-mata.

Selain itu, kajian lanjutan juga boleh meneliti aspek ekonomi dan kelestarian dengan membandingkan kos penghasilan campuran bitumen-getah berbanding bitumen konvensional, serta menilai impak penggunaan sisa tayar terhadap pengurangan pencemaran alam sekitar. Kajian terhadap sifat fizikal dan kimia campuran, seperti keupayaan menahan suhu tinggi atau rintangan terhadap retakan, juga boleh dijalankan untuk memperluaskan skop penilaian. Dengan menjalankan kajian lanjutan ini, penggunaan getah tayar terpakai dalam campuran bitumen bukan sahaja dapat diperkukuh dari sudut teknikal, tetapi juga dari perspektif ekonomi dan kelestarian, sekali gus menyokong usaha pembangunan jalan raya yang lebih mampan di Malaysia.

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Kajian Keberkesanan *Urea Formaldehyde* dalam Meningkatkan Ketahanan Siling Kapur

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Abstrak

Kajian ini dijalankan untuk menilai keberkesanan penggunaan Urea Formaldehyde (UF) sebagai bahan tambah dalam penghasilan siling kapur kalis air. Objektif utama adalah membandingkan kandungan lembapan dan kekuatan antara siling kapur asal dengan siling kapur campuran UF, serta menentukan peratus optimum UF yang memberikan prestasi terbaik. Tiga peratus campuran UF telah diuji iaitu 10%, 30%, dan 50%. Kaedah kajian melibatkan penghasilan sampel mengikut spesifikasi JKR, diikuti ujian kandungan lembapan melalui rendaman selama 24 jam dan ujian kekuatan menggunakan mesin pemampatan hidraulik. Hasil kajian menunjukkan bahawa penambahan UF berjaya mengurangkan kadar penyerapan air daripada 37.36% kepada 21.21%, serta meningkatkan kekuatan daripada 2.88 bar kepada 3.07 bar, melepasi piawaian minimum MS EN 1296:2010. Campuran UF sebanyak 50% didapati paling optimum kerana memberikan kandungan lembapan paling rendah dan kekuatan tertinggi. Walaupun UF terbukti berkesan, isu pelepasan formaldehid perlu diberi perhatian kerana had pelepasan yang dibenarkan oleh WHO dan OSHA adalah sekitar 0.1 ppm bagi ruang dalaman. Oleh itu, kajian lanjutan wajar menilai tahap pelepasan UF serta meneroka bahan alternatif bio-berasaskan yang lebih mesra alam untuk memastikan keberkesanan dan kelestarian jangka panjang.

Keywords **:** *Urea Formaldehyde, Siling Kapur, Kalis Kelembapan, Kekuatan Struktur*

Abstract

This study was conducted to evaluate the effectiveness of Urea Formaldehyde (UF) as an additive in producing water-resistant gypsum ceiling boards. The main objective was to compare moisture content and strength between conventional gypsum ceilings and UF-modified samples, and to determine the optimum UF percentage for best performance. Three UF mixtures were tested: 10%, 30%, and 50%. The methodology involved sample preparation according to JKR specifications, followed by moisture absorption tests through 24-hour immersion and strength tests using a hydraulic compression machine. Results indicated that UF addition significantly reduced water absorption from 37.36% to 21.21%, while increasing strength from 2.88 bar to 3.07 bar, exceeding the minimum requirement of MS EN 1296:2010. The 50% UF mixture was found to be the most effective, providing the lowest moisture content and highest strength. Although UF proved effective, concerns regarding formaldehyde emissions must be addressed, as WHO and OSHA set the permissible indoor exposure limit at approximately 0.1 ppm. Therefore, future studies should quantify UF emissions and explore bio-based alternatives to ensure long-term effectiveness and sustainability.

Keywords **:** *Urea Formaldehyde, Gypsum Ceiling, Moisture Resistance, Structural Strength*

I. PENGENALAN

Malaysia merupakan sebuah negara yang mempunyai pelbagai jenis bangunan, termasuk bangunan komersial, kediaman, dan infrastruktur awam. Seiring dengan pertumbuhan ekonomi dan pembangunan yang pesat, terdapat peningkatan dalam pembinaan bangunan-bangunan tinggi dan kompleks. Walau bagaimanapun, pembinaan bangunan yang pesat ini juga melibatkan cabaran dalam pemeliharaan dan keselamatan bangunan.

Kerosakan dan kecacatan pada binaan bangunan boleh menimbulkan pelbagai implikasi dan kesan negatif kepada semua pihak sama ada secara langsung mahupun tidak langsung. Salah satu masalah yang kerap dihadapi oleh pemilik bangunan di Malaysia adalah masalah kebocoran siling. Kebocoran siling boleh menyebabkan kerosakan kepada bangunan, termasuk kerosakan struktur,

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kehilangan harta benda, dan gangguan kepada penghuni, malah akan memburukkan pandangan dan nilai estetika sesebuah bangunan.

II. KAJIAN LITERATUR

Masalah kebocoran siling dan bumbung telah lama menjadi isu utama dalam sektor pembinaan di Malaysia dan negara tropika lain. Abdullah et al. [1] menekankan bahawa kebocoran bumbung memberi kesan langsung terhadap struktur bangunan dan keselesaan penghuni, manakala Fadzil dan Rahman [2] pula mendapati kelembapan berlebihan menjadi punca utama kerosakan siling serta menjejaskan nilai estetika bangunan. Kajian oleh Ismail dan Yusof [3] menunjukkan bahawa kelembapan yang tinggi boleh menggalakkan pertumbuhan kulat dan kulapuk, sekali gus menjejaskan kualiti udara dalaman.

Dalam konteks iklim tropika, Kamarudin dan Yahya [4] menegaskan bahawa penyelesaian inovatif diperlukan untuk mengatasi masalah kebocoran yang berulang akibat hujan lebat dan kelembapan berterusan. Kajian di Singapura oleh Lee dan Tan [5] serta Quek dan Lim [6] turut menyokong dapatan ini, dengan menekankan bahawa bangunan bertingkat tinggi lebih terdedah kepada masalah kebocoran kerana reka bentuk kompleks dan pendedahan berterusan kepada hujan.

Selain itu, Ng dan Wong [7] serta Wong dan Lim [8] di Hong Kong mendapati bahawa kelemahan bahan binaan tradisional menjadi faktor utama kebocoran, dan mereka mencadangkan penggunaan bahan tambahan atau teknologi baharu untuk meningkatkan ketahanan terhadap air. Kajian tempatan oleh Poh dan Ng [9] serta Zainal dan Abdullah [10] pula menekankan bahawa kelembapan yang tinggi dalam iklim tropika memerlukan bahan binaan yang lebih tahan lasak dan kalis air.

Secara keseluruhannya, literatur terdahulu menunjukkan bahawa kelembapan dan kebocoran merupakan masalah berulang dalam bangunan tropika. Oleh itu, penggunaan bahan tambahan seperti *Urea Formaldehyde* dalam siling kapur adalah satu pendekatan yang relevan untuk meningkatkan sifat kalis air dan kekuatan struktur, selari dengan keperluan semasa industri pembinaan [11]–[13].

Penyelidikan kontemporari dalam industri bahan binaan kini menunjukkan anjakan ketara ke arah integrasi bahan tambah mesra alam, khususnya bagi meningkatkan prestasi sistem gipsum dan papan siling. Balti et al. [14] mendapati bahawa sisa biologi (*biowaste*) daripada kayu dan kertas mampu mengoptimumkan prestasi biokomposit gipsum berprestasi higroskopik secara berkesan. Selari dengan itu, penggunaan gentian semula jadi turut mendapat perhatian meluas. Obidiegwu et al. [16] pula melaporkan kejayaan penggunaan serat pisang dan tempurung kelapa dalam memperkukuh struktur mekanikal papan siling plaster. Selain aspek kekuatan, Madarasinghe et al. [15] pula menekankan kepentingan gentian sabut kelapa dalam meningkatkan kapasiti penebat dan keselesaan terma bagi papan siling di kawasan beriklim tropika. Kepelbagaian sumber bio-berasaskan ini mencerminkan usaha global untuk mengurangkan kebergantungan kepada bahan sintetik dalam aplikasi siling kapur.

Walaupun bahan-bahan semula jadi ini menunjukkan potensi besar, penggunaan *Urea Formaldehyde* dalam kajian ini tetap relevan kerana ia terbukti mampu mengurangkan kadar penyerapan air dan meningkatkan kekuatan siling kapur dengan ketara. Oleh itu, kajian ini bukan sahaja menilai keberkesanan UF sebagai bahan tambah, tetapi juga membuka ruang untuk perbandingan dengan alternatif *bio-based* yang sedang dibangunkan dalam penyelidikan global.

III. METODOLOGI KAJIAN

Kajian ini melibatkan beberapa peringkat utama iaitu penyediaan sampel, ujian kandungan lembapan, ujian kekuatan, serta analisis data.

Langkah pertama adalah penyediaan sampel siling kapur dengan campuran UF pada tiga peratusan berbeza iaitu 10%, 30%, dan 50%. Nisbah bancuhan ditentukan mengikut spesifikasi yang telah ditetapkan, manakala ukuran sampel pula mengikuti Piawaian JKR [11] iaitu 9mm tebal, 300mm lebar, dan 400mm panjang. Bancuhan UF dimasukkan ke dalam acuan dan dibiarkan mengeras sebelum dikeringkan pada suhu terkawal. Setiap kumpulan sampel dihasilkan sebanyak lima ulangan (n=5) bagi memastikan kebolehpercayaan data. Proses penghasilan sampel siling kapur dengan campuran UF ditunjukkan dalam Rajah 1.

Ujian kandungan lembapan dijalankan dengan merendam sampel selama 24 jam di dalam bekas berisi air. Berat sampel direkodkan sebelum dan selepas proses pengeringan, dan peratusan kadar serapan air dikira menggunakan formula yang ditetapkan. Proses pengeringan dilakukan pada suhu

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terkawal bagi memastikan konsistensi keputusan. Kaedah ujian kandungan lembapan dapat dilihat dalam Rajah 2.

Ujian kekuatan pula dijalankan menggunakan mesin pemampatan hidraulik dengan kelajuan pemampatan 5 mm/min. Sampel diletakkan pada kedudukan yang betul sebelum ujian pemampatan dan ujian patah dijalankan. Prosedur ini dirujuk secara khusus kepada piawaian MS EN 1296:2010 bagi memastikan keputusan yang diperoleh sah dan boleh dibandingkan dengan standard antarabangsa. Rajah 3 menunjukkan prosedur ujian kekuatan menggunakan mesin pemampatan hidraulik.

Data yang diperoleh daripada kedua-dua ujian direkodkan dan dianalisis untuk menentukan keberkesanan campuran UF berbanding siling asal. Analisis dilakukan dengan membandingkan purata kandungan lembapan dan kekuatan antara kumpulan sampel, serta menilai peratus optimum UF yang memberikan prestasi terbaik.

Metodologi ini bukan sahaja memastikan kajian dijalankan secara sistematik dan berlandaskan piawaian yang sah, tetapi juga memberikan asas yang kukuh untuk menilai keberkesanan penggunaan UF dalam meningkatkan sifat kalis air dan kekuatan siling kapur.

Rajah 1 Proses Penghasilan Sampel Siling Kapur dengan Campuran *Urea Formaldehyde* (Uf).

Rajah 2 Ujian Kandungan Lembapan Melalui Rendaman Selama 24 jam

Rajah 3 Ujian Kekuatan Menggunakan Mesin Pemampatan Hidraulik.

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IV. KEPUTUSAN DAN PERBINCANGAN

Hasil ujian menunjukkan bahawa penggunaan *Urea Formaldehyde* (UF) sebagai bahan tambah dalam siling kapur memberikan kesan positif terhadap sifat kalis air dan kekuatan struktur.

Ujian kandungan lembapan mendapati bahawa siling asal tanpa campuran UF mencatatkan kadar serapan air sebanyak 37.36%. Sebaliknya, siling kapur dengan campuran UF menunjukkan penurunan yang ketara, iaitu 34.34% bagi campuran 10%, 28.28% bagi campuran 30%, dan serendah 21.21% bagi campuran 50%. Keputusan ujian kandungan lembapan ditunjukkan dalam Rajah 4. Keputusan ini jelas membuktikan bahawa semakin tinggi peratus UF yang digunakan, semakin rendah kadar penyerapan air, sekali gus meningkatkan sifat kalis air siling kapur. Kesemua nilai ini berada di bawah had piawaian 60% yang ditetapkan oleh BS EN 14246:2006 [12], menandakan bahawa siling kapur campuran UF memenuhi standard antarabangsa.

Dari segi kekuatan, siling asal hanya mencapai nilai 2.88 bar, iaitu di bawah piawaian minimum 3.0 bar yang ditetapkan oleh MS EN 1296:2010 [13]. Namun, siling kapur dengan campuran UF menunjukkan peningkatan yang konsisten, dengan nilai 3.01 bar bagi campuran 10%, 3.03 bar bagi campuran 30%, dan 3.07 bar bagi campuran 50%. Rajah 5 memperlihatkan perbandingan keputusan ujian kekuatan antara siling asal dan campuran UF. Keputusan ini membuktikan bahawa penambahan UF bukan sahaja meningkatkan sifat kalis air, tetapi juga memperkukuhkan daya tahan siling terhadap tekanan dan beban.

Campuran 50% didapati paling optimum kerana ia memberikan kandungan lembapan paling rendah dan kekuatan tertinggi, menjadikannya pilihan terbaik untuk aplikasi pembinaan. Purata kandungan lembapan dan kekuatan bagi setiap sampel siling ditunjukkan dalam Jadual 1.

Perbincangan ini selari dengan kajian terdahulu yang menekankan bahawa kelembapan berlebihan merupakan punca utama kebocoran siling dan kerosakan struktur bangunan di Malaysia [1], [2]. Kajian oleh Ismail dan Yusof [3] menunjukkan bahawa kelembapan yang tinggi boleh menjejaskan integriti bangunan serta kualiti udara dalaman akibat pertumbuhan kulat. Dapatan kajian ini juga menyokong pandangan Kamarudin dan Yahya [4] yang menekankan keperluan inovasi bahan binaan untuk mengatasi masalah kebocoran dalam iklim tropika. Kajian di Singapura oleh Lee dan Tan [5] serta Quek dan Lim [6] turut mendapati bahawa bangunan bertingkat tinggi lebih terdedah kepada masalah kebocoran kerana reka bentuk kompleks dan pendedahan berterusan kepada hujan. Selain itu, Ng dan Wong [7] serta Wong dan Lim [8] di Hong Kong menegaskan bahawa kelemahan bahan binaan tradisional menjadi faktor utama kebocoran, dan mencadangkan penggunaan bahan tambahan atau teknologi baharu untuk meningkatkan ketahanan terhadap air. Kajian tempatan oleh Poh dan Ng [9] serta Zainal dan Abdullah [10] pula menekankan bahawa kelembapan yang tinggi dalam iklim tropika memerlukan bahan binaan yang lebih tahan lasak dan kalis air.

Walaupun keberkesanan UF terbukti dalam meningkatkan sifat kalis air dan kekuatan siling kapur, isu keselamatan dan kesan alam sekitar akibat pelepasan *formaldehid* perlu diberi perhatian serius. Pelepasan gas ini berpotensi menjejaskan kualiti udara dalaman serta kesihatan penghuni bangunan. Kajian oleh Calvez et al. [17] menekankan keperluan penggunaan pelekat bio-berasaskan yang bebas *formaldehid* dalam panel kayu sebagai langkah untuk mengurangkan risiko pencemaran udara dalaman. Selari dengan itu, Yang et al. [18] menunjukkan bahawa resin berasaskan *lignin* mampu menjadi alternatif yang lebih lestari kepada resin UF, dengan prestasi mekanikal yang kompetitif serta impak alam sekitar yang lebih rendah.

Oleh itu, dapatan kajian ini bukan sahaja menegaskan keberkesanan UF sebagai bahan tambah dalam meningkatkan prestasi siling kapur, tetapi juga membuka ruang perbandingan dengan bahan bio-berasaskan yang sedang pesat dibangunkan dalam penyelidikan global. Pendekatan ini penting bagi memastikan keseimbangan antara prestasi teknikal, keselamatan penghuni, dan kelestarian alam sekitar dalam aplikasi siling kapur pada masa hadapan. Sehubungan itu, kajian lanjutan yang menilai impak kesihatan akibat pelepasan *formaldehid* serta penerokaan bahan alternatif mesra alam adalah amat diperlukan untuk menjamin keberkesanan dan kelestarian jangka panjang.

Selain itu, isu pelepasan *formaldehid* daripada penggunaan UF perlu diberi perhatian khusus dalam konteks keselamatan kediaman. Pelepasan gas *formaldehid* yang berlebihan boleh menjejaskan kualiti udara dalaman dan kesihatan penghuni. Menurut piawaian antarabangsa, had pelepasan *formaldehid* yang dibenarkan oleh Pertubuhan Kesihatan Sedunia (WHO) dan Pentadbiran Keselamatan dan Kesihatan Pekerjaan (OSHA) adalah sekitar 0.1 ppm bagi ruang dalaman. Oleh itu,

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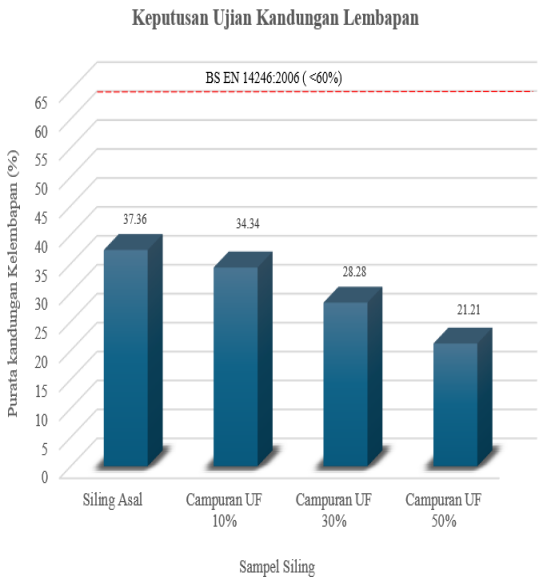
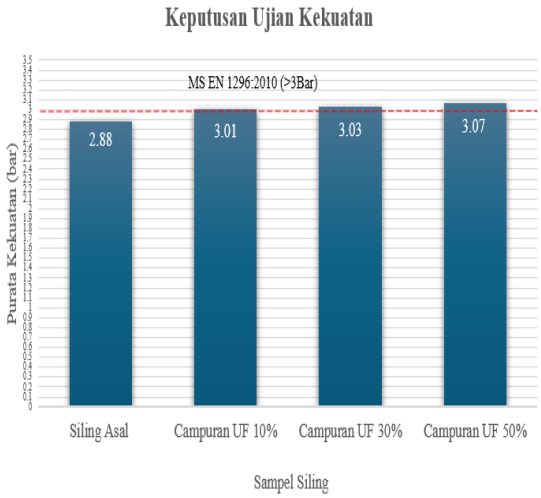
kajian masa depan wajar menilai tahap pelepasan *formaldehid* daripada siling kapur campuran UF untuk memastikan ia berada di bawah paras selamat yang ditetapkan. Pendekatan ini bukan sahaja mengukuhkan aspek etika dan praktikaliti kajian, tetapi juga menyokong usaha global ke arah penggunaan bahan binaan yang lebih selamat dan mesra alam.

Jadual 1 Purata Kandungan Lembapan dan Kekuatan Siling Kapur Asal Berbanding Campuran *Urea Formaldehyde* (UF)

Sampel Siling	Purata Kandungan Lembapan (%)	Purata Kekuatan (bar)
Siling Asal (tanpa UF)	37.36	2.88
Campuran UF 10%	34.34	3.01
Campuran UF 30%	28.28	3.03
Campuran UF 50%	21.21	3.07



Rajah 4 Keputusan Ujian Kandungan Lembapan Bagi Siling Asal dan Campuran UF.



Rajah 5 Keputusan Ujian Kekuatan Bagi Siling Asal dan Campuran UF.

V. KESIMPULAN

Secara keseluruhannya, kajian ini membuktikan bahawa penggunaan UF sebagai bahan tambah adalah berkesan dalam meningkatkan ketahanan siling kapur terhadap kebocoran dan tekanan. Penemuan ini bukan sahaja menyumbang kepada penyelesaian masalah kebocoran siling dalam iklim tropika Malaysia, tetapi juga membuka ruang kepada inovasi bahan binaan yang lebih tahan lama.

Selain itu, kajian lanjutan perlu memberi tumpuan kepada ketahanan jangka panjang. Siling kapur yang dihasilkan dengan campuran UF wajar diuji dalam keadaan simulasi sebenar seperti pendedahan kepada cahaya UV, kitaran basah-kering, serta suhu tinggi. Ujian sebegini dapat memberikan gambaran lebih jelas tentang prestasi siling dalam tempoh penggunaan yang panjang, termasuk daya tahan terhadap kulat, kulapuk, dan perubahan warna.

Di samping itu, aspek keselamatan dan alam sekitar tidak boleh diketepikan. Pelepasan formaldehid daripada UF perlu dinilai secara kuantitatif kerana ia boleh menjejaskan kualiti udara dalaman dan kesihatan penghuni. Menurut piawaian antarabangsa seperti WHO dan OSHA, had pelepasan formaldehid yang dibenarkan bagi ruang dalaman adalah sekitar 0.1 ppm. Oleh itu, kajian masa depan wajar mengukur tahap pelepasan UF dalam aplikasi siling kapur bagi memastikan ia berada di bawah paras selamat yang ditetapkan. Pendekatan ini penting untuk mengukuhkan aspek etika dan praktikaliti kajian.

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Akhir sekali, kajian masa depan boleh meneroka penggunaan bahan alternatif yang lebih mesra alam seperti sabut kelapa atau gentian semula jadi lain. Bahan ini bukan sahaja berpotensi meningkatkan kelestarian, malah dapat mengurangkan pergantungan kepada bahan kimia sintetik. Kajian kos-manfaat juga wajar dijalankan bagi menilai sama ada penggunaan UF memberikan nilai ekonomi yang lebih baik berbanding siling konvensional.

PENGHARGAAN

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Digital Learning Tools and Student Engagement In TVET Education: An Empirical Study at A Community College

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Abstract

Digital technologies have transformed teaching and learning practices in higher education, particularly in Technical and Vocational Education and Training (TVET), by enabling more flexible and engaging learning environments. However, the extent to which these digital learning tools enhance student engagement remains a critical question. This study aims to examine the effectiveness of digital learning tools in improving student engagement at Pasir Gudang Community College. A quantitative research approach was employed, involving 30 students from the Certificate in Information Technology programme who responded to a structured questionnaire. The study focused on three main digital tools: CIDOS Learning Management System (LMS), instructional videos, and digital eBooks. Data were analysed using descriptive statistics through mean score calculation, while reliability analysis using Cronbach's Alpha yielded a value of 0.89, indicating high internal consistency. The findings revealed a high level of student engagement, with an overall mean score of 4.37 (agree) on a five-point Likert scale. The results indicate that digital learning tools improve access to learning materials, enhance students' understanding of course content, and increase motivation to participate in learning activities. These findings highlight the importance of integrating digital learning strategies in TVET education to create more effective and engaging learning experiences.

Keywords: *Digital learning; Educational technology; Learning management system; Student engagement; TVET education*

I. INTRODUCTION

The evolution of technology has impacted teaching and learning in many ways as we know in higher education. Digital technologies allow educators to bring content through flexible and interactive learning contexts. Numerous educational institutions are adopting digital learning platforms to make teaching more effective and improve the overall learning experience of students [1],[4].

Digital learning tools are vital in TVET as technical subjects can be best demonstrated and understood through concepts. Lecturers can make use of digital learning platforms to upload multimedia learning resources like instructional videos, and online notes with reading materials that help students better understand complicated technical mechanisms [3],[5].

With digital learning environments, students can also access their learnings outside of classroom classes. Students can go back to lectures, review explanations and learn resources at their own pace. This flexibility encourages independent learning and allows students to take more ownership of their learning [2],[6].

Despite the prevalence of digital learning adoption by higher education institutions, limited evidence exists for the effectiveness of such learning in promoting student engagement within TVET Community college context [1],[7].

Thus, this study seeks to investigate the impact of digital learning tools on student engagement among students at Pasir Gudang Community College.

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II. LITERATURE REVIEW

Digital learning is any type of learning that uses digital technologies to support teaching and learning activities. Advances in educational technologies have allowed institutions to design more digitally supportive learning environments, thus providing easier access to resources needed for study [1],[2].

Prior research has shown that students can access and work with learning materials at their convenience [10],[11], enabling them to may revisit their own learning objects as many times as needed over time. Various multimedia learning resources like instructional videos, digital modules and visual demonstrations increase students' understanding of complex theories [3],[5].

Student engagement is recognized as a key component of successful learning. Engagement is the degree to which students are participating in, motivated and involved with learning activities. The development of digital learning platforms enhances engagement, as the students can engage with their content and actively participate in the ongoing activities [1],[4].

Recent studies emphasize that LMS have a great impact in helping higher education institutions ensure digital learning. LMS platforms enable lecturers to organize course materials, deliver instructional content and promote communication between lecturers and students. LMS platforms can make learning more interactive through forums for discussion, online quizzes, and multimedia resources. They also create online spaces that keep students linked to course content and encourage ongoing involvement in the learning experience [4],[8].

Digital learning technologies are becoming increasingly important for the digital transformation of Technical and Vocational Education and Training (TVET) because such platforms support teaching technical and practical subjects. TVET education is characterized by complex processes, technical demonstrations and practical competence. Digital tools, including instructional videos, interactive modules and digital simulations, help students better visualize technical processes while still allowing them to review demonstrations as often as needed. Such learning flexibility facilitates students to deepen their understanding of technical concepts and supports more engagement in learning activities [7],[9].

III. RESEARCH METHODOLOGY

A. Research Design

This study used quantitative research methods to explore students' experience on digital learning tools used in enhancing their learning process. Quantitative research is often applied in the field of education to gather structured data on participant perceptions and attitudes. This especially allows researchers to gather quantifiable data, which may be statistically analyzed for patterns and trends regarding whether digital learning tools are effective in increasing engagement with students.

A total of 30 students from the Information Technology Certificate program (STM) in Pasir Gudang Community College served as respondents. Since the students actively participated in courses that employed digital learning tools during teaching and learning processes, a convenience sampling method was adopted to target the respondents. All students came from the same major and have been exposed to online learning environments designed by the lecturers; hence they were suitable subjects for this research.

In this study, students were introduced to a variety of digital learning tools embedded in their courses. The tools included:

• CIDOS Learning Management System (LMS)

• Instructional Videos

• Digital eBooks

CIDOS LMS (Learning Management System) was the main digital learning platform that was used by the institution. Lecturers used the platform to share lecture notes, course materials, assignments and further reading. It provided students with anytime and anywhere method of accessing course materials which translated into flexible learning.

Technical concepts were illustrated using video instruction, providing a visual and step-by-step demonstration of processes. The students can go through these videos once again to repeat the content of the study, which enables them to better understand complex topics. On the other

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hand, digital eBooks were given as tools for supplemental learning to contain structured explanations, diagrams and supporting materials crucial to enhance students' understanding of course topics.

These digital tools were applied for a complete academic semester prior to data collection. Throughout this time, students engaged frequently with the digital platforms and resources as part of their learning activities, accessing lecture materials, instructional videos and consulting ebooks in digital form. This provided students with an opportunity to get adequate exposure to digital learning tools before they could share their experiences through a questionnaire.

This study utilized a structured questionnaire to capture students' perceptions on using digital learning tools. The questionnaire included several statements, accessibility of learning materials, knowledge and understanding on course topics and students' participation in learning activities. Respondents were requested to report their level of agreement on a five-point Likert scale, from 1 (Strongly Disagree) to 5 (Strongly Agree).

Reliability analysis (using Cronbach's Alpha) was performed to assess the reliability of the instrument. This analysis was conducted to assess the internal reliability of the questionnaire items utilized in this study. In social science research, Cronbach's Alpha value above 0.70 is widely accepted as an indication that the instrument can be trusted in measuring the study constructs.

The data collected was analysed using correlations of descriptive statistical method, especially through mean scores calculation. A mean score analysis was conducted to assess the students' general level of agreement with each statement regarding digital learning tools and student engagement. Findings were subsequently explained in exploring how effective digital tools for learning aid students to enhance their engagement with the process of learning.

B. Research Instrument

The research instrument used in the study was a structured questionnaire that aimed to measure students' perceptions on the effectiveness of digital learning tools in supporting their learning engagement. Participants were asked qualitative questions regarding the questionnaire designed based on concepts of digital learning, and student engagement, specifically in several fields discussed from previous educational technology studies.

The survey questionnaire comprised of two salient parts. Section A gathered demographic information about respondents, including their program of study and academic background. Section B had statements about students' use of digital learning tools in their courses. The statements primarily pertained to the accessibility of learning materials, understanding of course content, and students' participation in learning activities.

All items in Section B were assessed on a five-point Likert scale, phrased as follows:

1 = Strongly Disagree

2 = Disagree

3 = Neutral

4 = Agree

5 = Strongly Agree

The level of students' agreement towards each statement concerning the potential abilities that the digital learning tools can have in promoting engagement in learning is further captured using this measurement scale.

C. Reliability Analysis

This Cronbach's Alpha reliability analysis was also conducted to ensure the consistency and reliability of the questionnaire instrument. Reliability refers to the internal consistency of measurement items related to construction based on common method in quantitative research.

In this study, the instrument had good reliability as its Cronbach's Alpha value was 0.89. A Cronbach's Alpha at or above 0.70 meets the threshold for acceptable reliability, and an alpha value of greater than 0.80 indicates good internal consistency according to widely accepted standards in research. Thus, results

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confirmed that the questionnaire items used in this study were reliable for measuring students' perceptions of digital learning tools and their engagements.

D. Data Analysis Method

The data obtained from the questionnaire were analysed with descriptive statistical analysis. The results of descriptive statistics were reported to summarize and interpret students' responses towards the use of digital learning tools.

The analysis was centred on the computation of mean scores for all items on each questionnaire. The total score of mean analysis shows the level of agreement among the respondents on the items related to digital learning tools and enhancing students' engagement.

The mean scores were interpreted according to the scale commonly used in educational research:

Table 1. Scale commonly used in educational research

Mean Score Range	Interpretation
1.00 – 2.00	Low Level
2.01 – 3.00	Moderate Level
3.01 – 4.00	High Level
4.01 – 5.00	Very High Level

Thus, based on the findings gathered from the data analysis, it could establish whether the use of digital learning tools in our courses helped improve students' engagement and learning experience.

IV. RESULT AND DISCUSSION

A.Mean Score Analysis

The results indicate that the overall mean score for this study was 4.37, showing a high level of consensus among students on the effectiveness of digital learning tools. This indicates that the students view digital learning technologies as supportive of their experience.

Table 2 Students' Perception towards Digital Learning

Item	Mean
Access to learning materials	4.42
Understanding course topics	4.35
Learning motivation	4.38
Communication with lecturers	4.33
Learning flexibility	4.40
Active participation	4.31
Independent learning	4.36
Engaging learning environment	4.39

Overall Mean = 4.37

The highest mean score of 4.42 was recorded for access to learning materials among the items measured, implying that students strongly agree with digital learning tools help in easy access to course material. Students can access all lecture notes, videos and learning resources anytime using digital platforms which foster flexibility within the learning process.

In addition, learning flexibility scored the second-highest mean value at 4.40 as students prefer to study their learning materials outside of the class environment. One additional con of digital learning is the flexibility presented by some of the major digital learning tools; students can review explanations, rewatch instructional videos and refer to a variety of digital resources all in accordance with their individual comprehension and pace.

The engaging learning environment measured obtained 4.39, implying that the use of digital learning tools enhances to some extent and makes learning process appear more attractive and interesting for learners. Multimedia learning materials like instructional videos and digital eBooks are integrated to encourage a more dynamic learning environment compared to traditional lecture-based education.

positive impact on the motivation of students for learning and independent, autonomous studying. The mean score for learning motivation is 4.38, and independent learning has a mean score of 4.36. The results indicate that digital learning environments promote the autonomy and responsibility of students with respect to their own learning since students can access learning materials independently.

In addition, the average score for communicating with lecturers is 4.33, stating that students can also interact with their lecturer through Digital Learning Platform. Students interact with lecturers through such platforms as the CIDOS Learning Management System (LMS), from which they can also extract

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learning materials and feedback on their assignments.

B. Discussion

This study found that digital learning tools have a significant influence on students to improve the process of learning in TVET education. The findings indicate that most students are optimistic about the use of digital learning technologies in their classes.

The implementation of the CIDOS Learning Management System (LMS) assists lectures to arrange orderly learning materials and make it easier for students to access course resources. Lecture notes, learning materials and assignments can be provided by the platform, allowing students to refer to them even after their class sessions.

Instructional videos also help support students' learning of technical concepts. Technical subjects in TVET education frequently require complex procedures and practical demonstrations. Instruction videos are visual explanations of processes where students can see the movement in a stepwise manner; an explanation helps them better understand what they learn.

Digital eBooks, on the other hand, act as structured learning resources that include further explanations and references for subjects covered in class. This resource allows the students to reinforce their knowledge of theory and challenges them for independent learning.

In general, the role of digital learning tools helps to make a more flexible, interactive and engaged classroom for students. The results indicate that digital technologies could affect students' participation, motivation and understanding of course topics, which are critical components of the academic engagement process.

V. LIMITATIONS

Though several important conclusions can be drawn from this study, there are several limitations that need to be addressed. First, the number of respondents was limited to 30, and this small sample size reduces the generalizability of the results. The respondents are a sample of 110 students enrolled in the Information Technology Certificate program at Pasir Gudang Community College. Consequently, the results are likely to represent perceptions of students at a particular academic level and may not capture completely the narratives of students from other programs or institutions.

As such studies would cover sample sizes across various TVET institutions, it might offer universal insights into the effectiveness of digital learning tools. Moreover, future studies can be done on other digital educational technologies and their effect on various facets of learning such as student performance, collaborative skill or problem-solving.

VI. CONTRIBUTION TO KNOWLEDGE

The findings of this study contribute to the current body of knowledge by providing empirical evidence on how effective digital learning tools can be in facilitating student engagement within students at TVET community colleges. Extensive literature has discussed the role of digital learning technologies in higher education, but comparatively limited studies have directly addressed the delivery of digital learning tools within the TVET context.

These findings underscore the need for using digital learning technologies including Learning Management System, instructional videos and digital learning resources to facilitate teaching and learning in technical and vocational education. These technologies offer flexible access to learning material and allow students to revisit learning content outside of class sessions.

Additionally, this study may offer practical knowledge for the development of more effective digital learning environments in line with the needs of educators and institutions. The results indicate that the utilized digital learning strategies implemented in TVET can enhance educational experiences for students and promote more engaging teaching approaches.

It adds to the discourse on digital transformation in TVET education with a specific focus towards community colleges that offer skill-based, industry-aligned knowledge for students.

VII. CONCLUSION

The effects of digital learning tools on student engagement among students in the Information Technology Certificate program at Pasir Gudang Community College. This study was aimed at investigating the impact of three digital learning tools, namely the CIDOS Learning Management System (LMS), instructional videos and digital eBooks utilized in teaching and learning for one academic semester.

The study's results also show that students have favorable attitudes about using digital learning tools in their courses. The findings show that digital learning technologies increase the accessibility of

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students to learning materials, provide greater understanding of courses topics and promote more active participation in learning activities. Students agree with the statement providing an overall mean score in study.

The results also show that digital learning tools enable flexible learning environments by allowing students to access course materials at any time and review learning resources in their own time. This is especially vital in an area of study such as TVET education, where students are typically required to grasp abstract technical theories and physical processes.

Besides, the use of media learning resources including explanatory videos and digital eBooks provides students with a more interactive and engaging learning experience. These digital tools allow students to visualize technical processes, review explanations and enhance their understanding of course material.

It is thus imperative that future Teaching and Learning practices in TVET institutions continue to leverage on the need for innovative digital learning strategies that support increased student engagement, enable improved learning outcomes and prepare students with essential skills needed in a digital era.

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Kajian Pembangunan Sistem Amaran Halangan Berasaskan Sensor Ultrasonik bagi menyokong Mobiliti Individu OKU Penglihatan

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Abstrak

Kajian ini bertujuan membangunkan sistem amaran halangan berasaskan sensor ultrasonik bagi meningkatkan keselamatan dan mobiliti individu kurang upaya (OKU) penglihatan yang menghadapi kesukaran mengesan halangan menggunakan tongkat konvensional yang terhad kepada sentuhan fizikal dan jarak dekat. Walaupun pelbagai sistem pengesanan halangan telah dibangunkan, kebanyakannya masih terhad dari segi kos, kebolehgunaan dan keupayaan maklum balas masa nyata yang intuitif kepada pengguna. Oleh itu, sistem yang dicadangkan menggunakan mikropengawal ESP32 sebagai unit pemproses utama yang diintegrasikan dengan sensor ultrasonik untuk mengesan objek pada jarak tertentu, serta motor getaran dan buzzer sebagai mekanisme maklum balas. Metodologi kajian merangkumi reka bentuk sistem, integrasi perkakasan serta pembangunan perisian menggunakan Arduino IDE. Pengujian sistem dijalankan bagi menilai keupayaan pengesanan halangan serta keberkesanan maklum balas berdasarkan variasi jarak objek. Hasil kajian menunjukkan bahawa sistem mampu mengesan halangan secara masa nyata dan memberikan maklum balas yang berbeza mengikut tahap kedekatan objek. Secara keseluruhannya, sistem ini menyumbang kepada pembangunan peranti bantuan kos rendah yang praktikal dan mesra pengguna.

Kata Kunci: Sensor Ultrasonik; Sistem Amaran Halangan; OKU Penglihatan; Mikropengawal ESP32; Maklum Balas Masa Nyata; Peranti Bantuan Mobiliti.

Abstract

This study aims to develop an ultrasonic sensor-based obstacle warning system to enhance the safety and mobility of visually impaired individuals, who often face difficulties in detecting obstacles using conventional canes. The proposed system utilizes an ESP32 microcontroller integrated with an ultrasonic sensor, vibration motor, and buzzer to provide real-time feedback. The methodology includes system design, hardware integration, and software development using Arduino IDE, followed by system testing to evaluate detection performance and feedback effectiveness. The results indicate that the system is capable of detecting obstacles and providing differentiated feedback based on distance. This study contributes to the development of a low-cost, practical, and user-friendly assistive mobility device.

Keywords: *Ultrasonic Sensor; Obstacle Detection System; Visually Impaired Individuals; ESP32 Microcontroller; Real-Time Feedback; Assistive Mobility Device.*

I. PENGENALAN

Teknologi bantuan (assistive technology) memainkan peranan penting dalam meningkatkan kualiti hidup individu kurang upaya, khususnya bagi golongan OKU penglihatan. Individu dengan masalah penglihatan sering menghadapi kesukaran dalam mengesan halangan semasa bergerak, yang boleh meningkatkan risiko kemalangan dalam persekitaran harian [2]. Kebanyakan pengguna masih bergantung kepada tongkat konvensional yang hanya mampu mengesan objek melalui sentuhan fizikal dalam jarak yang terhad [1].

Seiring dengan perkembangan teknologi, pelbagai sistem pengesanan halangan telah dibangunkan menggunakan sensor ultrasonik dan mikropengawal bagi meningkatkan keupayaan navigasi pengguna [3], [11]. Kajian terkini juga menunjukkan bahawa penggunaan pelbagai sensor dan sistem pintar mampu meningkatkan ketepatan pengesanan halangan serta keselamatan pengguna [11], [14].

Walau bagaimanapun, kebanyakan sistem sedia ada masih mempunyai kekangan seperti kos yang tinggi, reka bentuk yang kompleks serta kurang penekanan terhadap maklum balas yang intuitif kepada pengguna [14], [15]. Oleh itu, terdapat

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keperluan untuk membangunkan sistem yang lebih ringkas, kos rendah serta mudah digunakan dalam situasi sebenar.

Berbanding dengan sistem sedia ada, kajian ini menekankan penggunaan mikropengawal kos rendah iaitu ESP32 yang diintegrasikan dengan kombinasi maklum balas getaran dan bunyi bagi memberikan amaran yang lebih intuitif kepada pengguna. Pendekatan ini bukan sahaja meningkatkan kebolehgunaan sistem, malah memastikan peranti yang dibangunkan lebih praktikal dan mampu milik untuk aplikasi sebenar.

Kajian ini dijangka dapat meningkatkan keselamatan, kebolehgerakan dan kualiti hidup individu OKU penglihatan melalui penggunaan peranti bantuan yang kos efektif, praktikal dan mudah digunakan dalam situasi sebenar.

Oleh itu, kajian ini mencadangkan pembangunan sistem pengesanan halangan yang kos rendah dan praktikal menggunakan mikropengawal ESP32 dengan mekanisme maklum balas yang intuitif.

Sehubungan itu, objektif kajian ini adalah:

i. Mereka bentuk sistem amaran halangan berasaskan sensor ultrasonik menggunakan mikropengawal ESP32.
ii. Membangunkan prototaip sistem yang mampu mengesan halangan pada jarak tertentu.
iii. Menguji keberkesanan sistem dalam memberikan maklum balas getaran dan bunyi secara masa nyata.

II. PERNYATAAN MASALAH

Individu kurang upaya penglihatan sering menghadapi kesukaran untuk mengesan halangan ketika bergerak di persekitaran harian. Kebanyakan pengguna masih bergantung kepada tongkat konvensional yang hanya mampu mengesan objek melalui sentuhan fizikal serta dalam jarak yang terhad. Keadaan ini menyebabkan pengguna sukar mengenal pasti halangan lebih awal dan boleh meningkatkan risiko kemalangan. Oleh itu, pembangunan sistem amaran halangan berasaskan sensor ultrasonik dan mikropengawal ESP32 diperlukan bagi membantu individu OKU penglihatan mengesan halangan dengan lebih awal melalui maklum balas getaran secara masa nyata.

III. KAJIAN LITERATUR

Kajian oleh Dakopoulos dan Bourbakis menunjukkan bahawa penggunaan sensor elektronik seperti ultrasonik dan inframerah mampu meningkatkan keupayaan pengesanan halangan tanpa memerlukan sentuhan fizikal [1]. Selain itu, Bhowmick dan Hazarika turut menekankan kepentingan teknologi bantuan dalam meningkatkan mobiliti dan kebebasan individu OKU penglihatan [2].

Kajian terkini menunjukkan bahawa penggunaan sistem pintar yang menggabungkan sensor ultrasonik dengan teknik pemprosesan moden mampu meningkatkan prestasi pengesanan halangan secara signifikan [11]. Tambahan pula, kajian oleh Patel et al. menyatakan bahawa penggunaan pelbagai jenis sensor dapat meningkatkan ketepatan sistem, namun meningkatkan kerumitan dan kos pembangunan [14].

Walau bagaimanapun, kajian oleh Arguello Prada dan Santacruz Forero mendapati bahawa kebanyakan sistem sedia ada masih belum memenuhi keperluan pengguna sebenar dari segi kebolehgunaan dan maklum balas yang intuitif [15]. Oleh itu, pembangunan sistem yang lebih praktikal dan kos efektif masih diperlukan.

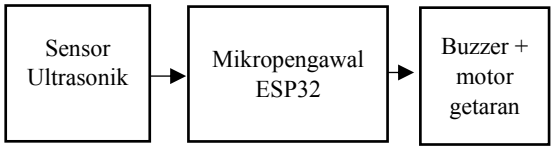
IV. METODOLOGI

Kajian ini melibatkan beberapa peringkat pembangunan sistem iaitu reka bentuk sistem, integrasi perkakasan dan pembangunan perisian. Pada peringkat pertama, reka bentuk sistem dibangunkan bagi menentukan susunan komponen utama seperti sensor ultrasonik, mikropengawal ESP32 dan motor getaran. Sensor ultrasonik digunakan untuk mengesan jarak antara pengguna dengan objek di hadapan.

Pada peringkat kedua, semua komponen perkakasan disambungkan kepada papan mikropengawal ESP32. Sensor ultrasonik berfungsi dengan menghantar dan menerima gelombang ultrasonik bagi mengukur jarak objek.

Seterusnya, perisian sistem dibangunkan menggunakan perisian Arduino IDE. Kod atur cara ditulis bagi memproses data jarak daripada sensor dan mengaktifkan motor getaran apabila objek dikesan dalam julat jarak yang telah ditetapkan.

Reka bentuk sistem ini menekankan integrasi kos rendah dengan kecekapan pemprosesan data secara masa nyata bagi memastikan sistem yang dibangunkan adalah praktikal untuk aplikasi sebenar.



Rajah 1: Rajah blok sistem

Seperti yang ditunjukkan dalam Rajah 1, sistem terdiri daripada sensor ultrasonik, mikropengawal ESP32 serta aktuator iaitu buzzer dan motor getaran sebagai mekanisme maklum

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balas.

V. KEPUTUSAN DAN PERBINCANGAN

Pengujian sistem dijalankan bagi menilai keberkesanan pengesanan halangan menggunakan sensor ultrasonik yang dikawal oleh mikropengawal ESP32. Hasil ujian menunjukkan bahawa sistem mampu mengesan objek pada jarak tertentu dan memberikan tindak balas yang berbeza melalui buzzer dan motor getaran berdasarkan jarak objek yang dikesan.

Apabila objek berada dalam julat kurang daripada 50 cm, sistem akan mula memberikan amaran kepada pengguna. Semakin dekat objek dengan pengguna, intensiti getaran dan kekerapan bunyi buzzer akan meningkat bagi memberi maklum balas yang lebih jelas mengenai tahap bahaya.

Jadual 1: Pengujian sistem

Bil	Jarak Objek dari sensor (cm)	Status Buzzer	Status Motor Getaran
1	> 50 cm	Tidak berbunyi	Tidak bergetar
2	50 cm	Bunyi perlahan	Getaran lemah
3	30 - 40 cm	Bunyi sederhana	Getaran sederhana
4	< 20 cm	Bunyi lebih kerap	Getaran kuat
5	Tiada objek	Tidak berbunyi	Tidak bergetar

Keputusan menunjukkan bahawa sistem memberikan tindak balas yang konsisten terhadap perubahan jarak objek. Semakin dekat objek, semakin tinggi intensiti getaran dan kekerapan bunyi yang dihasilkan. Corak ini membuktikan bahawa sistem mampu menyampaikan maklumat jarak secara intuitif kepada pengguna. Sistem mampu mengesan halangan sehingga jarak maksimum 50 cm dengan tindak balas masa nyata yang stabil.

Selain itu, sistem ini lebih ringkas dan kos efektif berbanding sistem berasaskan pemprosesan imej. Walau bagaimanapun, kekangan seperti penggunaan satu jenis sensor sahaja boleh mempengaruhi ketepatan dalam keadaan tertentu.

Sistem ini menunjukkan prestasi masa nyata yang stabil dalam keadaan pengujian terkawal, sekali gus membuktikan kesesuaiannya untuk aplikasi bantuan mobiliti sebenar.

Secara keseluruhan, keputusan menunjukkan bahawa sistem berfungsi dengan baik dan mampu memberikan maklum balas yang konsisten berdasarkan jarak objek. Sistem ini berpotensi untuk diaplikasikan dalam persekitaran sebenar seperti laluan pejalan kaki dan kawasan awam.

VI. KESIMPULAN

Kajian ini berjaya membangunkan sistem amaran halangan berasaskan sensor ultrasonik menggunakan mikropengawal ESP32 bagi meningkatkan keselamatan dan mobiliti individu OKU penglihatan. Sistem yang dibangunkan mampu mengesan halangan dan memberikan maklum balas secara masa nyata. Sumbangan utama kajian ini adalah pembangunan peranti bantuan kos rendah yang praktikal dan mudah digunakan.

Keunikan sistem ini terletak pada gabungan maklum balas getaran dan buzzer yang diselaraskan dengan jarak pengesanan, membolehkan pengguna memahami tahap bahaya secara lebih intuitif. Selain itu, penggunaan mikropengawal ESP32 sebagai platform utama menjadikan sistem ini lebih kos efektif berbanding pendekatan berasaskan pemprosesan imej yang lebih kompleks.

Penambahbaikan pada masa hadapan boleh melibatkan integrasi pelbagai sensor bagi meningkatkan ketepatan dan kebolehpercayaan sistem dalam pelbagai keadaan persekitaran.

Kesimpulannya, sistem yang dibangunkan menunjukkan potensi sebagai peranti bantuan kos rendah yang berkesan untuk individu OKU penglihatan. Integrasi sensor ultrasonik dengan maklum balas getaran dan bunyi membolehkan pengguna memperoleh maklumat persekitaran secara intuitif, seterusnya meningkatkan keselamatan dan mobiliti pengguna. Sistem ini juga berkesan sebagi alat bantuan mobiliti yang praktikal.

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Selain itu, penghargaan turut diberikan kepada pelajar yang terlibat dalam pembangunan projek ini atas komitmen dan usaha mereka dalam menyiapkan sistem yang dibangunkan. Tidak dilupakan juga kepada rakan-rakan pensyarah yang telah memberikan pandangan dan cadangan yang membina sepanjang proses penyelidikan ini dijalankan.

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Deep Learning-Based Structural Monitoring of Oil Palm Inflorescences for Early-Stage Pollination Assessment Using UAV Imagery

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Abstrak

Kajian ini dijalankan untuk suatu sistem pemantauan awal pendebungaan kelapa sawit berasaskan dron tanpa pemandu (UAV) dan deep learning bagi memantau keseimbangan bunga jantan dan bunga betina dalam kawasan mikro-plot terkawal berkeluasan 10 × 10 pokok. Sistem yang dicadangkan diintegrasikan dengan pengesanan imej bunga menggunakan model YOLO, pengiraan Pollination Ratio Index (PRI), dan beberapa analisis statistik bagi menilai perkembangan pendebungaan. Data dikumpulkan dari November 2025 hingga Januari 2026 dengan mengambil kira faktor altitud, halangan kanopi, dan keadaan angin. Keputusan menunjukkan bahawa variasi struktur bunga memberi kesan signifikan terhadap nilai PRI dan keseimbangan pengesanan, dengan perbezaan statistik yang signifikan diperoleh melalui analisis ANOVA ($p < 0.05$). Kajian ini membuktikan bahawa pemantauan struktur bunga menggunakan UAV berpotensi menjadi mekanisme sokongan keputusan yang lebih awal dan lebih sistematik berbanding kaedah pemerhatian manual yang konvensional.

Abstract

This study was conducted to develop an early-stage oil palm pollination monitoring system based on Unmanned Aerial Vehicle (UAV) technology and deep learning to monitor the balance between male and female flowers within a controlled 10 × 10 tree micro-plot area. The proposed system integrates floral image detection using a YOLO model, Pollination Ratio Index (PRI) computation, and several statistical analyses to evaluate pollination development. Data were collected from November 2025 to January 2026, taking into account altitude, canopy occlusion, and wind-condition factors. The findings indicate that variations in floral structure significantly affect PRI values and detection balance, with statistically significant differences identified through ANOVA analysis ($p < 0.05$). This study demonstrates that UAV-based floral structure monitoring has strong potential to serve as an earlier and more systematic decision-support mechanism compared to conventional manual observation methods.

Keywords **:** *Oil palm inflorescence, Deep learning, Object detection, Pollination monitoring, Precision agriculture, Elaeidobius kamerunicus, UAV-based imaging*

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I. INTRODUCTION

Oil palm cultivation forms a critical component of agricultural production systems across Southeast Asia, particularly in Malaysia, Indonesia, and Thailand, where humid tropical climatic conditions support large-scale plantation development. The region contributes a substantial proportion of the global palm oil supply, making yield stability and sustainability central to both economic and ecological considerations. Effective pollination in oil palm is strongly influenced by the balance between male and female inflorescences and the activity of the primary pollinator species, Elaeidobius kamerunicus. Variability in this floral gender distribution influences pollination success, fruit set stability, and ultimate yield outcomes. However, systematic monitoring of floral ratios at fine spatial scales is rarely implemented operationally, as conventional assessments rely on manual field observations that are labor-intensive, spatially limited, and difficult to standardize.

Recent advances in Unmanned Aerial Vehicle (UAV) deployment have enabled high-resolution aerial imaging in plantation environments. Existing UAV-based systems primarily focus on post-flowering indicators, such as fruit ripeness detection, canopy health, and vegetation stress analysis. This leaves a significant gap in ecological monitoring approaches that directly assess early reproductive-stage floral balance.

This study addresses this gap by proposing a UAV-based ecological monitoring system designed to evaluate pollination risk within a controlled experimental zone in Kemahang, Kelantan. The framework integrates structured image-based floral gender detection with a Pollination Ratio Index (PRI) and an indirect estimation model of pollinator capacity associated with E. kamerunicus. By operating within a 10 × 10 micro-plot from November 2025 to January 2026, the study evaluates modeling feasibility across varying environmental conditions, contributing toward advancing data-driven pollination management strategies.

II. LITERATURE REVIEW

A. Deep Learning in Oil Palm Detection Convolutional neural networks (CNN) and object detection architectures like YOLO have been widely applied in precision agriculture for fresh fruit bunch (FFB) detection, ripeness grading, and yield estimation. These models perform well in complex plantation environments with uneven lighting and canopy occlusion. However, AI applications have primarily concentrated on post-pollination harvest optimization instead of early-stage reproductive monitoring.

B. Pollination Ecology and E. kamerunicus Oil palm pollination heavily depends on the weevil Elaeidobius kamerunicus, which was introduced into Southeast Asia in the 1980s to improve pollination efficiency. Traditional research relies on field-based insect trapPRIng, floral bagging, and manual inflorescence counting. Digital approaches to quantify male and female inflorescence distribution as early ecological indicators remain underexplored.

C. UAV-Based Monitoring in Precision Agriculture UAVs have become vital for crop monitoring, spatial mapping, and automated detection tasks. While UAV imagery is utilized for canopy analysis and tree counting in oil palm systems, reproductive-stage floral structures have received limited attention. Bridging deep learning detection frameworks with ecological pollination assessment via UAV presents an untapped opportunity.

III. RESEARCH METHODOLOGY

The research methodology for the proposed study is structured around a four-layer system architecture: Image Acquisition, Deep Learning Detection, Spatial Aggregation, and Pollination Decision-Support. Here is the abstracted methodology detailing how the research is designed and executed:

1. Dataset Preparation and Preprocessing

Dataset Restructuring: A public oil palm floral dataset from Roboflow Universe (originally containing five classes) was restructured into a binary classification problem: Male_Inflorescence and Female_Inflorescence. All female developmental stages (pre-receptive, receptive, post-receptive) were merged into a single class, and fruit clusters were excluded to focus strictly on early reproductive stages.

Preprocessing: Images were resized to 640 × 640 pixels to meet YOLO input requirements. Default YOLO augmentations, including mosaic augmentation, scaling, and horizontal flipping, were retained to improve the model's generalisation across different lighting and occlusion conditions.

2. Deep Learning Model Configuration

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Architecture: A YOLO-based object detection model was selected for its real-time inference capabilities and suitability for UAV deployment.

Training Parameters: The model was configured for 100 epochs using a Stochastic Gradient Descent (SGD) optimizer and a composite detection loss function (covering classification, bounding box regression, and objectness).

3. Experimental Design and UAV Deployment

Test Site Configuration: The field deployment utilized a controlled 10 × 10 oil palm tree grid (100 trees total), divided into 20 independent micro-plots consisting of 5 adjacent trees each.

Data Collection: UAVs captured overlapping RGB images across varying plantation elevations between November 2025 and January 2026. Altitude was treated as a flexible contextual parameter based on terrain, while wind conditions during flights were manually categorized into three levels: Low, Moderate, and High.

4. Spatial Aggregation and Index Computation

Confidence Weighting: To mitigate the impact of low-confidence detections caused by canopy occlusion or wind blur, inflorescence counts (Mp and Fp) were calculated using a probabilistic, confidence-weighted formulation.

Pollination Ratio Index (PRI): A normalized mathematical proxy was introduced to estimate female floral availability within each micro-plot. It is calculated as PRIp = Fp / (Mp + Fp), where Mp denoted as Male Inflorescence Count and Fp as Female Inflorescence Count which is the values closer to 1 indicate a female-dominant distribution and values closer to 0 indicate a male-dominant distribution.

5. Statistical Validation

Model Evaluation: The YOLO model's performance was evaluated using standard object detection metrics: Mean Average Precision (mAP@50), Precision, Recall, F1-score, and a Confusion Matrix.

Environmental Impact Analysis: A One-Way Analysis of Variance (ANOVA) paired with Tukey's Honestly Significant Difference (HSD) post-hoc test was utilized to determine if wind categories significantly affected the Pollination Index. Linear and variance regression models were applied to quantify the directional influence and magnitude of wind-induced spatial instability.

Figure 1 Prototype 1

Figure 2 Prototype 2

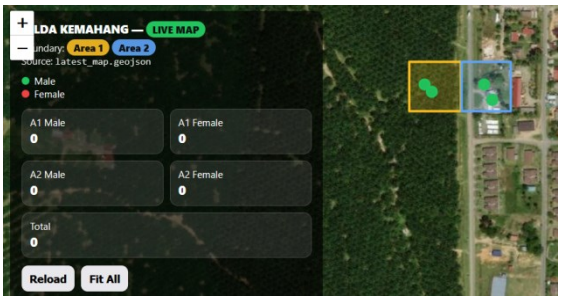

Figure 3 Output Example

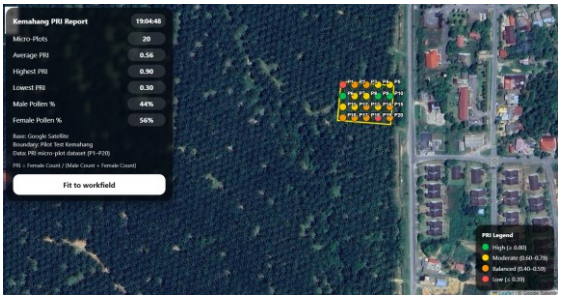

Figure 4 Detail Output Example

IV. CONCLUSION AND DISCUSSION

This study presents a structured deep learning–based framework for early-stage monitoring of oil palm inflorescences using UAV-acquired imagery. By restructuring a multi-class dataset into a binary detection model, the proposed approach demonstrates that male and female inflorescences

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can be reliably identified under realistic environmental conditions.

The introduction of a spatial aggregation mechanism and a Pollination Index enables structured interpretation of floral distribution prior to fruit formation. While the framework does not directly measure pollinator activity, it establishes a scalable and modular foundation for ecological monitoring within precision oil palm management.

Statistical validation incorporating ANOVA, regression modelling, and robustness testing strengthens the analytical credibility of the proposed system. The inclusion of environmental sensitivity assessment further reflects practical deployment considerations beyond laboratory-controlled scenarios.

Importantly, this work positions structural floral detection as a precursor layer within a broader pollination intelligence ecosystem. The modular architecture allows seamless integration with future ground-based pollinator density sensing systems, enabling the transition from structural observation to biological validation.

Such integration represents the next logical step toward a multi-layered AI-driven pollination monitoring framework. By bridging aerial floral detection with ground-level ecological sensing, the system has the potential to evolve into a comprehensive pollination decision-support platform.

Future research will focus on empirical coupling between floral distribution patterns and pollinator density estimation, paving the way for biologically informed precision agriculture strategies in oil palm plantations.

Detection Feasibility and Practical Implication

The results demonstrate that binary deep learning–based detection of oil palm inflorescences is technically feasible under realistic field conditions. The model successfully distinguished male and female inflorescences across varying wind categories and terrain contexts.

The restructuring of the dataset into a binary classification framework contributed to improved detection stability and reduced inter-class ambiguity. This supports the practicality of simplifying floral-stage modelling when the objective is early-stage pollination monitoring rather than detailed phenological classification.

Environmental Sensitivity and Operational Robustness

Wind condition emerged as an operational factor influencing detection stability. While wind does not directly represent pollination dynamics, its statistical association with Pollination Index variability highlights the importance of environmental context during UAV deployment.

The inclusion of environmental categorisation strengthens the robustness of the framework and reflects real plantation conditions rather than laboratory-controlled imaging scenarios.

Structural Floral Monitoring as an Ecological Proxy

This study positions structural floral detection as a digital proxy for early pollination-stage monitoring. Unlike conventional approaches that directly measure insect activity, the present framework focuses on the availability and distribution of male and female inflorescences.

Such a structural approach does not substitute biological pollinator assessment. However, it offers a scalable and spatially structured monitoring layer that may complement traditional ecological sampling.

By quantifying floral distribution patterns, plantation managers may identify spatial heterogeneity that could influence pollination outcomes before fruit development becomes observable.

Economic Implication (Cautious Perspective)

Although yield data were not incorporated in this prototype phase, early-stage detection of floral imbalance may offer long-term management benefits.

Potential implications include:

i.Early identification of uneven reproductive-stage distribution

ii.Improved planning for pollination monitoring efforts

iii, Reduced dependency on reactive yield-based assessment.

It is important to note that no direct economic valuation was conducted in this study. Any productivity implication remains conceptual and requires longitudinal validation linking floral structure, pollinator density, and fruit set outcomes.

Contribution to Precision Agriculture

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This study contributes to precision agriculture by shifting the focus from fruit-stage detection toward pre-fruit reproductive-stage monitoring. Most AI-based oil palm research concentrates on yield estimation; in contrast, this framework introduces a structured floral detection layer that precedes fruit formation.

The modular architecture enables future integration with pollinator density sensing systems and spatial ecological modelling, thereby supporting a multi-layered plantation intelligence framework.

Chart 1 Micro-Plot Pollination Ratio Index (PRI)

Plot	Male Count	Female Count	PRI
P1	12	8	0.40
P2	9	11	0.55
P3	15	5	0.25
P4	7	13	0.65
P5	10	10	0.50

Figure 2 Flower Distribution

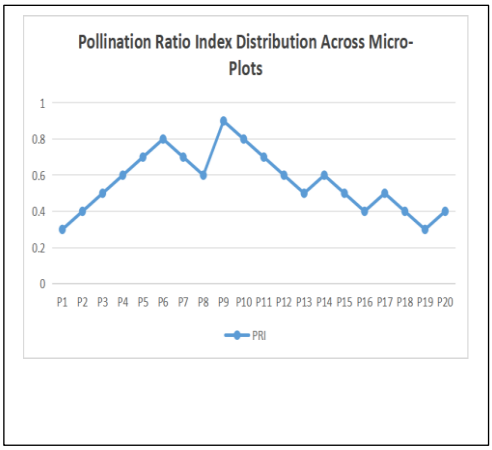

Figure 3 Wind Effect (ANOVA Concept)

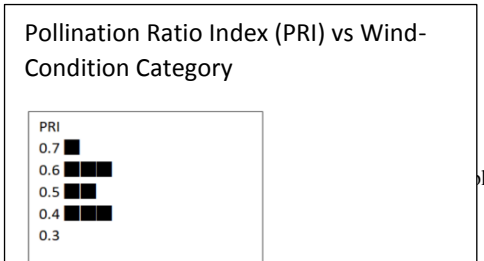

Figure 3 Wind Effect (ANOVA Concept)

This study at FGV Kemahang demonstrates that deep learning-based aerial monitoring provides a viable proxy for early-stage pollination assessment. By identifying spatial heterogeneity in floral distribution, plantation managers can preemptively address pollination deficits before they manifest as poor fruit sets.

V. CONCLUSION

This study presents a structured deep learning–based framework for early-stage monitoring of oil palm inflorescences using UAV-acquired imagery. By transforming a multi-class dataset into a binary detection model, the system demonstrates that male and female inflorescences can be reliably identified under realistic plantation conditions. This establishes the technical feasibility of applying AI-driven object detection to reproductive-stage monitoring, which has traditionally been overlooked in oil palm research.

The introduction of the Pollination Ratio Index (PRI) provides a simple yet interpretable metric for assessing floral distribution at the micro-plot level. By quantifying the proportion of female inflorescences relative to total floral presence, the PRI serves as a structured proxy for evaluating pollination receptivity. Although it does not directly measure pollinator activity, it offers a consistent and scalable indicator for early-stage ecological assessment.

Spatial aggregation across the 10 × 10 plantation grid further enables the analysis of micro-level variability in floral distribution. The observed variation in PRI values highlights the presence of spatial heterogeneity, which may influence pollination balance across the plantation. Such

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insights are not easily obtainable through conventional manual inspection methods and demonstrate the advantage of UAV-assisted monitoring systems.

Statistical modelling, including regression analysis and ANOVA, strengthens the analytical validity of the framework. The incorporation of environmental factors, particularly wind conditions, provides additional context for evaluating detection stability and operational robustness. While wind is treated primarily as a technical variable, its inclusion reflects realistic deployment conditions and enhances the reliability of the system.

Despite these contributions, the study remains limited by the absence of direct pollinator validation and the use of a generalized dataset. The Pollination Index should therefore be interpreted as a structural indicator rather than a biological measurement. Future work must incorporate ground-based sensing systems to establish a direct relationship between floral distribution and pollinator density.

In conclusion, this work establishes a scalable and modular foundation for AI-assisted pollination monitoring in oil palm plantations. Beyond its current scope, the framework opens a pathway toward a multi-layered ecological intelligence system that integrates aerial detection with ground-based biological sensing. The proposed Phase 2 rover integration is expected to enable direct pollinator density validation, bridging the gap between structural observation and biological reality. This progression positions the system as a potential cornerstone for next-generation precision agriculture, where real-time ecological insights can support adaptive plantation management and long-term yield sustainability.

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In addition, the authors would like to recognise the contributions of the project development team, including technical assistants and research collaborators involved in UAV integration, data acquisition, and system implementation. Their efforts were instrumental in translating the conceptual framework into a working prototype.

This work forms part of an ongoing research initiative toward the development of an integrated AI-based pollination monitoring system, with future expansion into aerial-ground system integration through autonomous rover platforms. The authors welcome collaboration with industry partners, particularly within the oil palm sector, to further validate and scale the system in real plantation environments.

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Tahap Pengetahuan Pelajar Jabatan Perdagangan Politeknik Kuching Sarawak Terhadap Penggunaan Kecerdasan Buatan (*Artificial Intelligence*) Dalam Membantu Proses Pembelajaran

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Abstrak

Kajian ini bertujuan mengenal pasti tahap pengetahuan pelajar Jabatan Perdagangan Politeknik Kuching Sarawak terhadap penggunaan kecerdasan buatan (AI) dalam pembelajaran, selaras dengan perkembangan teknologi yang semakin pesat dan berperanan meningkatkan kecekapan serta memperkaya pengalaman pendidikan yang lebih adaptif dan berpersonal. Walaupun AI tidak dapat menggantikan peranan guru, teknologi ini berpotensi menyokong pendidik dalam menyediakan bahan pengajaran yang lebih efisien serta membantu pelajar mengoptimumkan pembelajaran mengikut gaya dan tahap kefahaman masing-masing. Kajian ini menggunakan pendekatan kuantitatif melalui instrumen soal selidik yang diedarkan secara dalam talian kepada sampel pelajar diploma Jabatan Perdagangan menggunakan teknik pensampelan rawak. Data yang diperoleh dianalisis secara deskriptif bagi menilai tahap pengetahuan pelajar terhadap penggunaan AI. Dapatan kajian menunjukkan bahawa tahap pengetahuan pelajar berada pada tahap sederhana, menandakan mereka mempunyai pemahaman yang agak baik serta sikap yang positif terhadap teknologi ini, namun masih terdapat ruang untuk penambahbaikan. Kesimpulannya, kajian ini memberi implikasi penting dalam merangka kurikulum yang lebih komprehensif serta membantu pembuat dasar pendidikan dalam merancang inisiatif yang lebih efektif bagi mengintegrasikan AI dalam pengajaran dan pembelajaran.

Kata kunci: AI; kecerdasan buatan; pembelajaran; tahap pengetahuan

Abstract

This study aims to identify the level of knowledge among students of the Commerce Department at Politeknik Kuching Sarawak regarding the use of artificial intelligence (AI) in learning, in line with the rapid development of technology that enhances efficiency and enriches more adaptive and personalized educational experiences. Although AI cannot replace the role of teachers, it has the potential to support educators in delivering more efficient teaching materials and assist students in optimizing their learning according to their individual learning styles and levels of understanding. This study adopts a quantitative approach using a questionnaire instrument distributed online to a sample of diploma students from the Commerce Department through random sampling techniques. The data obtained were analysed descriptively to assess the students' level of knowledge regarding the use of AI. The findings indicate that the students' level of knowledge is at a moderate level, suggesting that they possess a good understanding and a positive attitude towards this technology, although there is still room for improvement. In conclusion, this study provides important implications for designing a more comprehensive curriculum and assists policymakers in planning more effective initiatives to integrate AI into teaching and learning.

Keywords: *AI; artificial intelligence; learning; level of knowledge*

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I. PENGENALAN

Dalam era pembangunan teknologi masa kini, proses pengajaran dan pembelajaran boleh dipertingkatkan dengan penggunaan kecerdasan buatan (AI). Dalam konteks pendidikan masa kini, AI menawarkan pelbagai kemudahan dalam analisis data, pengurusan kelas, serta sokongan pembelajaran yang dipersonalisasi. AI melibatkan penerapan algoritma dan pemprosesan data untuk menganalisis maklumat, memahami situasi dan bertindak berdasarkan data yang diperoleh (Srinivasi et al. 2022). Namun, tahap pengetahuan pelajar mengenai penggunaan AI dalam konteks pendidikan masih belum mendapat perhatian yang mencukupi. Kertas kerja ini bertujuan untuk mengkaji tahap pengetahuan pelajar terhadap penggunaan AI dalam pembelajaran serta mengenal pasti cabaran dan potensi yang ada dalam menerapkan teknologi ini dikalangan pelajar institusi pengajian tinggi terutamanya.

II. OBJEKTIF KAJIAN

Objektif kajian ini dijalankan adalah untuk

a) mengenal pasti platform Kecerdasan Buatan (AI) yang kerap anda gunakan oleh pelajar untuk proses pembelajaran
b) mengenal tahap pengetahuan pelajar tentang penggunaan Kecerdasan Buatan (AI) dalam membantu proses pembelajaran
c) mengenal pasti cabaran yang dihadapi oleh pelajar terhadap penggunaan Kecerdasan Buatan (AI) dalam pembelajaran

III. SOROTAN KAJIAN

Menurut Aina dan Salami (2020), tahap pengetahuan pelajar tentang AI masih pada tahap asas dan banyak yang tidak memahami sepenuhnya aplikasi dan potensi teknologi ini dalam pendidikan. Penerimaan pelajar terhadap penggunaan AI dalam pendidikan dipengaruhi oleh faktor-faktor seperti kesedaran teknologi, kebimbangan terhadap privasi, dan kepercayaan terhadap keberkesanan teknologi tersebut (Muniandy & Lee, 2021). Kesedaran pelajar tentang etika penggunaan AI adalah penting dalam memahami bagaimana AI boleh mempengaruhi proses pembelajaran dan kehidupan sosial pelajar. Ini kerana menurut Berryman et al. (2021) menyatakan bahawa pelajar yang terdedah kepada aplikasi AI dalam pembelajaran menunjukkan peningkatan dalam prestasi akademik dan penglibatan dalam kelas. Mereka juga lebih cenderung untuk menunjukkan minat terhadap penggunaan teknologi dalam pendidikan masa depan. Begitu juga kajian yang dijalankan oleh Alimisis (2016) yang menunjukkan bahawa AI dapat meningkatkan pembelajaran melalui interaksi yang lebih personal atau pembelajaran yang lebih peribadi dan sesuai dengan keperluan pelajar. Wang et al. (2020) menyatakan bahawa AI berpotensi untuk meningkatkan kecekapan pembelajaran melalui penggunaan platform e-pembelajaran yang didorong oleh AI. Kecerdasan buatan telah digunakan dalam banyak aplikasi pembelajaran seperti tutor maya, sistem pembelajaran adaptif, dan analisis data untuk memahami prestasi pelajar. Guru memainkan peranan yang besar dalam meningkatkan pengetahuan pelajar tentang AI, dan kajian menunjukkan bahawa program latihan untuk pendidik dapat membantu meningkatkan pemahaman pelajar mengenai teknologi ini (Mouza et al., 2020). Kajian juga menekankan pentingnya memasukkan pengajaran AI dalam kurikulum pendidikan di sekolah-sekolah dan institusi pengajian tinggi terutamanya untuk mempersiapkan pelajar menghadapi cabaran dan peluang yang dibawa oleh kemajuan teknologi ini (Khan et al., 2021).

IV. METODOLOGI

Kajian ini dijalankan menggunakan pendekatan kuantitatif. Instrumen kajian adalah soal selidik berstruktur digunakan untuk mengumpul. Item kajian dibina sendiri dan telah disemak oleh pakar penyelidikan yang terdiri daripada pensyarah PhD. Selain itu, ujian keboleh percayaan item (Cronbach Alpha) di mana nilai yang diperoleh bagi setiap pemboleh ubah ialah 0.940 (Pengetahuan) dan 0.929 (Cabaran). Sampel kajian dipilih secara rawak. Sampel kajian adalah pelajar diploma dari Politeknik Kuching Sarawak. Analisis yang digunakan dalam kajian ini adalah analisis deskriptif untuk mencari tahap berdasarkan nilai min. Penentuan tahap berdasarkan skor min adalah seperti yang ditunjukkan dalam Jadual 1 yang dipetik dalam kajian Ngadiman et al. (2019).

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Jadual 1: Tafsiran Skor Min

Skor min	Tafsiran
1.00– 1.99	Lemah
2.00– 2.99	Rendah
3.00– 3.99	Sederhana
4.00– 5.00	Tinggi

(Sumber: Nagadiman et al., 2019)

V. HASIL KAJIAN

Responden kajian ini adalah seramai 152 pelajar Jabatan Perdagangan Politeknik Kuching Sarawak. Latar belakang responden adalah seperti yang ditunjukkan dalam Jadual 2. Majoriti responden mencapai HPNM pada tahap sederhana (2.00 – 2.99) tidak mengambil kira pelajar semester 1 yang belum lagi mempunyai HPNM.

a) Latar Belakang Responden

Jadual 2: Latar Belakang Responden

Item		n	%
Semester	1	50	32.9
	2	18	11.8
	3	62	40.8
	4	2	1.3
	5	11	7.2
	6	9	5.9
HPNM	1.00 - 2.00	1	0.7
	2.00 - 2.99	40	26.3
	3.00 - 3.33	34	22.4
	3.43 - 3.67	17	11.2
	3.68 - 4.00	10	6.6
	Semester 1 (Tiada HPNM)	50	32.9
Min	1.00	4	2.6
	2.00	13	8.6
	3.00	69	45.4
	4.00	49	32.2
	5.00	17	11.2
Tempoh Penggunaan AI setiap kali anda membuka platform tersebut	1 hingga 2 jam	18	11.8
	30 minit hingga 1 jam	64	42.1
	Kurang dari 30 minit	59	38.8
	Lebih daripada 2 jam	11	7.2

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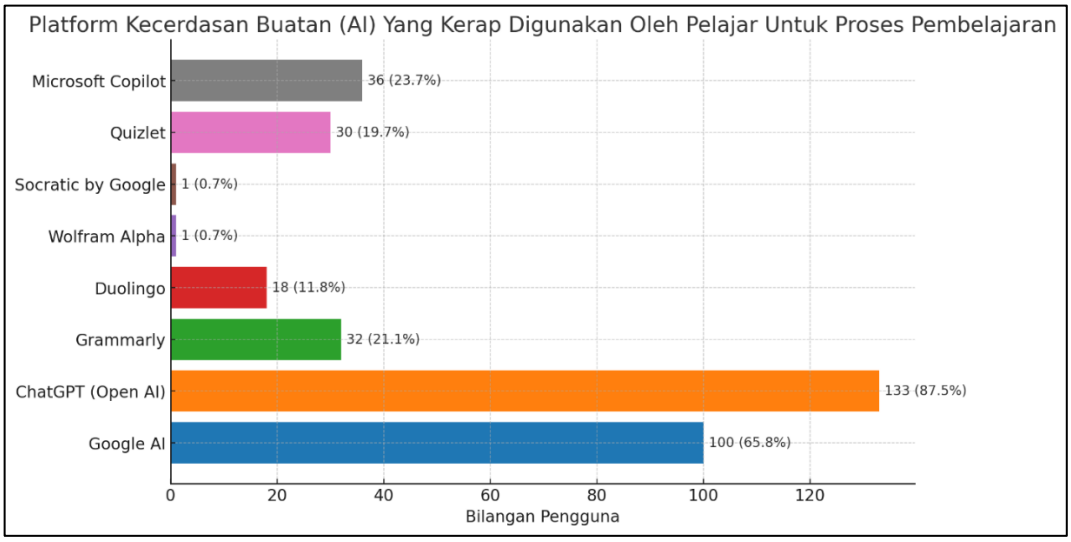
b) Platform Kecerdasan Buatan (AI) Yang Kerap Gunakan Oleh Pelajar Untuk Proses Pembelajaran



Rajah 1: Dapatan Analisis

Rajah 1 menunjukkan platform kecerdasan buatan (AI) yang kerap digunakan oleh pelajar dalam proses pembelajaran. Dapatan menunjukkan bahawa ChatGPT (OpenAI) mencatatkan penggunaan tertinggi dengan 133 orang pelajar (87.5%), diikuti oleh Google AI sebanyak 100 orang (65.8%). Selain itu, platform lain yang turut digunakan termasuk Microsoft Copilot (23.7%), Grammarly (21.1%), Quizlet (19.7%) dan Duolingo (11.8%). Sementara itu, penggunaan Wolfram Alpha dan Socratic by Google amat rendah, masing-masing hanya 0.7%. Dapatan ini membuktikan bahawa pelajar lebih cenderung menggunakan platform AI yang bersifat interaktif dan mesra pengguna seperti ChatGPT dan Google AI berbanding aplikasi khusus yang lebih niche. Penggunaan aplikasi Wolfram Alpha dan Socratic agak rendah kerana pendedahan yang kurang dikalangan pengguna di Malaysia. Socratic terhad kepada subjek sekolah dan ianya sangat popular di peringkat sekolah menengah di negara barat berbanding Malaysia. .

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c) Tahap Pengetahuan Pelajar Tentang Penggunaan Kecerdasan Buatan (AI) Dalam Membantu Proses Pembelajaran

Jadual 3: Dapatan Analisis

No	Item	Min	S.P	Tahap
P1	Saya mempunyai pengetahuan yang jelas mengenai apa itu kecerdasan buatan (AI).	3.520	0.869	Sederhana
P2	Saya tahu tentang penggunaan AI dalam pembelajaran akademik.	3.803[2]	0.854	Sederhana
P3	Saya sering mencari maklumat mengenai AI untuk memperkaya pengetahuan saya.	3.743[3]	0.931	Sederhana
P4	Saya pernah menggunakan alat berasaskan AI untuk membantu dalam pembelajaran.	3.711	0.904	Sederhana
P5	Saya percaya AI boleh membantu mempercepatkan proses pembelajaran saya.	3.717	0.931	Sederhana
P6	Penggunaan AI dalam pembelajaran membantu saya memahami konsep atau topik yang sukar dengan lebih baik.	3.816[1]	0.909	Sederhana
P7	Saya rasa penggunaan AI dalam pembelajaran sangat membantu dalam menyiapkan tugasan atau projek saya	3.671	0.919	Sederhana
P8	Saya merasa yakin untuk menggunakan AI dalam menyelesaikan masalah atau tugasan akademik.	3.401	0.998	Sederhana
P9	Saya menggunakan alat berasaskan AI untuk meningkatkan productiviti pembelajaran saya.	3.520	0.949	Sederhana
P10	Saya menggunakan alat berasaskan AI kerana memberi maklumat yang lebih tepat dan cepat.	3.388	0.942	Sederhana

Nota: [1,2,3] Min Tertinggi

Jadual 3 menunjukkan dapatan untuk menilai tahap pengetahuan pelajar tentang penggunaan AI dalam membantu proses pembelajaran. Secara keseluruhan, tahap pengetahuan adalah sederhana. Ini menunjukkan bahawa pelajar mempunyai pengetahuan yang agak baik dan kearah positif terhadap AI, namun begitu tahap pengetahuan mereka masih belum mencapai tahap yang tinggi dalam semua aspek. Item yang memperoleh min tertinggi ialah item P6 di mana penggunaan AI membantu pelajar memahami konsep atau topik yang sukar dengan lebih baik (min = 3.8161, S.P = 0.909), diikuti oleh P2 iaitu pelajar juga mempunyai kesedaran tentang penggunaan AI dalam pembelajaran akademik (min = 3.8032, S.P = 0.854) dan P3 menjelaskan bahawa terdapat pelajar yang kerap mencari maklumat tambahan mengenai AI untuk memperkayakan pengetahuan mereka (min = 3.7433, S.P = 0.931).

d) Cabaran Yang Dihadapi Oleh Pelajar Terhadap Penggunaan Kecerdasan Buatan (AI) Dalam Pembelajaran

Jadual 4: Dapatan Kajian

No	Item	Min	S.P	Tahap
C1	Saya menghadapi kesukaran untuk memahami cara menggunakan alat berasaskan AI untuk pembelajaran.	2.467	0.934	Rendah
C2	Ketiadaan kemahiran teknikal saya menjadi halangan untuk menggunakan AI dalam pembelajaran.	2.362	0.946	Rendah

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C3	Saya tidak mempunyai akses yang mencukupi kepada teknologi yang diperlukan untuk menggunakan AI, seperti internet atau peranti yang sesuai.	2.204	1.038	Rendah
C4	Saya merasa AI tidak selalu memberikan maklumat yang tepat atau relevan untuk keperluan pembelajaran saya.	2.809	1.072	Rendah
C5	Saya tidak tahu platform AI mana yang sesuai untuk membantu saya dalam pembelajaran.	2.678	1.160	Rendah
C6	Saya sering merasa kurang yakin dengan cadangan atau jawapan yang diberikan oleh alat AI.	2.855[3]	1.057	Rendah
C7	Terlalu banyak pilihan platform AI membuatkan saya bingung untuk memilih yang paling sesuai.	2.868[2]	1.102	Rendah
C8	Saya merasa AI tidak cukup menyokong gaya pembelajaran saya yang lebih berfokus kepada interaksi manusia (seperti dengan guru atau rakan pelajar).	2.921[1]	1.013	Rendah
C9	Saya menghadapi masalah dalam memahami arahan atau antaramuka pengguna (UI) dalam aplikasi berasaskan AI.	2.618	0.949	Rendah
C10	Saya merasakan penggunaan AI dalam pembelajaran memerlukan masa yang terlalu banyak untuk mempelajari dan menguasainya.	2.658	0.977	Rendah

Nota: [1,2,3] Min Tertinggi

Sementara itu Jadual 4 menjawab objektif ketiga iaitu untuk mengenal pasti cabaran yang dihadapi oleh pelajar terhadap penggunaan Kecerdasan Buatan (AI) dalam pembelajaran. Secara keseluruhannya, semua cabaran yang letakkan dalam soal selidik adalah berada pada tahap rendah. Ini menunjukkan mungkin pelajar sudah biasa menggunakan AI ini secara kerap sehingga mereka dapat mengatasi sebarang masalah yang timbul akibat penggunaannya. Walaupun begitu, dapatan ini menunjukkan cabaran utama pelajar adalah (C8) di mana pelajar merasa AI tidak cukup menyokong gaya pembelajaran saya yang lebih berfokus kepada interaksi manusia (min = 2.9211, S.P = 1.013). Ini menjelaskan bahawa sebahagian pelajar masih lebih selesa dengan kaedah pembelajaran berasaskan interaksi manusia. Selain itu, (C7) di mana pelajar juga berdepan kekeliruan kerana terlalu banyak pilihan platform AI (min = 2.8682, S.P = 1.102), dan diikuti oleh item C6, di mana pelajar rasa kurang yakin terhadap cadangan atau jawapan yang diberikan oleh AI (min = 2.8553, S.P = 1.057).

VI. KESIMPULAN

Penggunaan AI dalam pembelajaran memberikan banyak potensi untuk meningkatkan pengalaman pendidikan bagi pelajar institusi pengajian tinggi terutamanya. Penggunaannya semakin meluas, memberikan peluang untuk memperibadikan pembelajaran, meningkatkan kualiti pengajaran dan mempermudah proses penilaian. Tahap pengetahuan pelajar terhadap penggunaan AI dalam pembelajaran adalah penting untuk memastikan mereka dapat memanfaatkan potensi teknologi ini secara lebih efektif. Oleh itu, kajian ini penting untuk memberi gambaran mengenai bagaimana AI boleh dimanfaatkan untuk memperbaiki kualiti pembelajaran serta untuk menyediakan pelajar dengan pengetahuan dan kemahiran yang diperlukan untuk menghadapi dunia yang semakin bergantung kepada teknologi. Secara keseluruhan, tahap pengetahuan adalah sederhana. Ini menunjukkan bahawa pelajar mempunyai pengetahuan yang agak baik dan kearah positif terhadap penggunaan AI, namun begitu tahap pengetahuan mereka masih belum mencapai tahap yang tinggi dalam semua aspek. Semua cabaran yang letakkan dalam soal selidik adalah berada pada tahap rendah. Ini menunjukkan mungkin pelajar sudah biasa

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menggunakan AI ini secara kerap sehingga mereka dapat mengatasi sebarang masalah yang timbul akibat penggunaannya. Namun demikian, sebahagian pelajar masih lebih selesa dengan kaedah pembelajaran berasaskan interaksi manusia. Kajian ini boleh digunakan untuk merangka kurikulum yang lebih baik dalam mendidik pelajar mengenai penggunaan AI dalam pembelajaran. Disamping itu juga, secara tidak langsung dapat membantu dasar pendidikan dalam merancang inisiatif yang lebih baik untuk mengintegrasikan teknologi AI dalam pembelajaran.

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SOKONGAN SOSIAL SEBAGAI FAKTOR PELINDUNG KESIHATAN MENTAL PELAJAR TVET: ANALISIS TAHAP SOKONGAN DAN HUBUNGANNYA DENGAN KEMURUNGAN

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Abstrak

Kesihatan mental pelajar institusi Pendidikan dan Latihan Teknikal dan Vokasional (TVET) semakin mendapat perhatian berikutan peningkatan tekanan akademik, latihan kemahiran dan cabaran sosioekonomi yang dihadapi oleh pelajar. Sokongan sosial dikenal pasti sebagai faktor penting yang berpotensi mempengaruhi kesejahteraan psikologi pelajar, khususnya dalam mengurangkan risiko kemurungan. Sehubungan itu, kajian ini dijalankan untuk menentukan tahap sokongan sosial dan tahap kemurungan dalam kalangan pelajar kolej komuniti, menganalisis hubungan antara sokongan sosial dan kemurungan, serta mengenal pasti perbezaan tahap kemurungan berdasarkan jantina dan pendapatan keluarga.

Kajian ini menggunakan pendekatan kuantitatif berbentuk tinjauan dengan melibatkan seramai 120 orang pelajar kolej komuniti sebagai responden. Data dikumpulkan menggunakan soal selidik berstruktur berskala Likert tujuh mata dan dianalisis menggunakan statistik deskriptif serta inferensi melalui perisian Statistical Package for the Social Sciences (SPSS). Analisis korelasi Pearson menunjukkan terdapat hubungan yang signifikan dan sangat kuat antara sokongan sosial dan tahap kemurungan pelajar ($r = 0.839$, $p < 0.001$). Analisis perbezaan pula menunjukkan bahawa tiada perbezaan yang signifikan dalam tahap kemurungan berdasarkan faktor jantina dan pendapatan keluarga.

Secara keseluruhannya, dapatan kajian ini membuktikan bahawa sokongan sosial memainkan peranan yang sangat signifikan sebagai faktor pelindung kesejahteraan psikologi pelajar kolej komuniti. Kajian ini memberi implikasi penting kepada pihak institusi dalam merangka strategi sokongan pelajar yang lebih holistik, berasaskan bukti empirikal dan selari dengan keperluan pendidikan TVET.

Kata kunci: *sokongan sosial, kemurungan, kesejahteraan psikologi, pelajar kolej komuniti, pendidikan TVET*

Abstract

The mental health of students in Technical and Vocational Education and Training (TVET) institutions has received increasing attention due to the increasing academic pressure, skills training and socioeconomic challenges faced by students. Social support has been identified as an important factor that has the potential to influence students' psychological well-being, especially in reducing the risk of depression. Accordingly, this study was conducted to determine the level of social support and depression levels among community college students, analyze the relationship between social support and depression, and identify differences in depression levels based on gender and family income.

This study used a quantitative survey approach involving 120 community college students as respondents. Data were collected using a structured questionnaire with a seven-point Likert scale and analyzed using descriptive and inferential statistics using the Statistical Package for the Social Sciences (SPSS) software. Pearson correlation analysis showed that there was a significant and very strong relationship between social support and student depression levels ($r = 0.839$, $p < 0.001$). Analysis of variance showed that there was no significant difference in depression levels based on gender and family income.

Overall, the findings of this study demonstrate that social support plays a very significant role as a protective factor for the psychological well-being of community college students. This study has important implications for institutions in designing more holistic student support strategies, based on empirical evidence and in line with the needs of TVET education.

Keywords **:** *social support, depression, psychological well-being, community college students, TVET education*

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I. PENGENALAN

A. Latar Belakang Kajian

Kesihatan mental pelajar institusi pengajian tinggi merupakan komponen penting dalam pembangunan modal insan yang holistik dan mampan. Dalam konteks pendidikan Technical and Vocational Education and Training (TVET), pelajar bukan sahaja berhadapan dengan tuntutan akademik, malah turut menanggung tekanan berkaitan latihan kemahiran, keperluan praktikal, kekangan kewangan serta ketidaktentuan peluang kerjaya selepas tamat pengajian. Tekanan berterusan ini berpotensi menjejaskan kesejahteraan psikologi pelajar dan meningkatkan risiko masalah kesihatan mental seperti kemurungan.

Literatur terkini menunjukkan bahawa isu kesihatan mental dalam kalangan pelajar institusi pengajian tinggi semakin membimbangkan di peringkat global. Laporan World Health Organization (2023) menegaskan bahawa kemurungan merupakan antara gangguan mental yang paling kerap dialami oleh pelajar dan memberi kesan langsung terhadap fungsi kognitif, motivasi pembelajaran dan pencapaian akademik. Kajian pasca-pandemik turut menunjukkan peningkatan simptom kemurungan dan tekanan emosi dalam kalangan pelajar akibat ketidaktentuan ekonomi, perubahan persekitaran pembelajaran dan kebimbangan terhadap masa depan kerjaya (Auerbach et al., 2022; Liu et al., 2022).

Dalam konteks TVET, cabaran kesihatan mental pelajar menjadi lebih kompleks. Pelajar TVET perlu mengimbangi pembelajaran teori dengan latihan praktikal, penilaian berasaskan kompetensi serta jangkaan kebolehpasaran graduan oleh industri. OECD (2023) dan UNESCO (2024) melaporkan bahawa pelajar TVET berisiko mengalami tekanan psikologi sekiranya sokongan institusi dan persekitaran pembelajaran yang kondusif tidak disediakan secara menyeluruh. Keadaan ini menunjukkan bahawa kesejahteraan psikologi pelajar TVET merupakan isu yang signifikan dan wajar diberi perhatian serius.

Sokongan sosial telah dikenal pasti secara konsisten dalam kajian-kajian lepas sebagai faktor psikososial utama yang mempengaruhi kesejahteraan mental individu. Sokongan sosial merangkumi bantuan emosi, maklumat dan sokongan instrumental yang diterima daripada keluarga, rakan sebaya dan institusi. Kajian oleh Labrague (2023) serta Lee et al. (2023) mendapati bahawa sokongan sosial yang kukuh berupaya mengurangkan simptom kemurungan dan meningkatkan kesejahteraan emosi pelajar. Tambahan pula, kajian longitudinal oleh Santini et al. (2024) menegaskan bahawa sokongan sosial bertindak sebagai faktor pelindung yang menstabilkan kesan tekanan akademik terhadap kesihatan mental.

Walaupun kepentingan sokongan sosial terhadap kesejahteraan pelajar telah dibuktikan secara meluas, kebanyakan kajian terdahulu lebih tertumpu kepada pelajar universiti arus perdana dan institusi penyelidikan. Kajian empirikal yang memfokuskan pelajar kolej komuniti dan konteks TVET di Malaysia masih terhad. Jurang ini menunjukkan keperluan kepada kajian yang lebih kontekstual bagi memahami hubungan antara sokongan sosial dan kemurungan dalam kalangan pelajar kolej komuniti, selari dengan keperluan pembangunan pendidikan TVET yang berorientasikan kesejahteraan dan kelestarian pelajar.

B. Pernyataan Masalah

Pelajar kolej komuniti merupakan kumpulan yang berpotensi terdedah kepada tekanan psikologi disebabkan oleh gabungan tuntutan akademik, latihan kemahiran, kekangan kewangan serta tanggungjawab keluarga. Dalam konteks pendidikan Technical and Vocational Education and Training (TVET), cabaran ini menjadi lebih signifikan kerana pelajar perlu menyesuaikan diri dengan pembelajaran berasaskan kompetensi, latihan praktikal serta penilaian kemahiran yang intensif. Tekanan berterusan yang tidak ditangani secara sistematik berpotensi meningkatkan risiko masalah kesihatan mental, khususnya kemurungan.

Kajian terkini menunjukkan bahawa isu kesihatan mental dalam kalangan pelajar institusi pengajian tinggi semakin membimbangkan di peringkat global. Pertubuhan Kesihatan Sedunia melaporkan bahawa kemurungan merupakan antara penyumbang utama kepada penurunan fungsi akademik dan kesejahteraan psikologi pelajar (World Health Organization, 2023). Dalam konteks pendidikan pasca-pandemik, beberapa kajian mendapati bahawa pelajar TVET turut mengalami tekanan psikologi yang tinggi akibat perubahan mod pembelajaran, ketidaktentuan ekonomi dan kebimbangan terhadap kebolehpasaran graduan (OECD, 2023; UNESCO, 2024).

Sokongan sosial telah dikenal pasti secara meluas dalam literatur sebagai faktor pelindung utama yang berupaya mengurangkan kesan tekanan psikologi dan simptom kemurungan. Kajian oleh Labrague (2023) serta Lee et al. (2023) mendapati bahawa pelajar yang menerima sokongan sosial yang kukuh daripada keluarga, rakan sebaya dan institusi menunjukkan tahap kemurungan yang lebih rendah dan kesejahteraan emosi yang lebih baik. Selain itu, kajian longitudinal oleh Santini et al. (2024) turut menegaskan bahawa sokongan sosial berfungsi sebagai mekanisme penimbal yang mengurangkan kesan tekanan akademik terhadap kesihatan mental pelajar.

Walau bagaimanapun, kebanyakan kajian terdahulu lebih tertumpu kepada pelajar universiti

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arus perdana dan institusi penyelidikan, manakala kajian empirikal yang memfokuskan pelajar kolej komuniti dan institusi TVET di Malaysia masih terhad. Kekurangan kajian dalam konteks ini menyebabkan pemahaman terhadap corak sokongan sosial dan tahap kemurungan pelajar kolej komuniti masih belum menyeluruh.

Selain itu, faktor demografi seperti jantina dan pendapatan keluarga sering dikaitkan dengan perbezaan tahap kemurungan dalam kalangan pelajar. Namun, dapatan kajian terdahulu menunjukkan hasil yang tidak konsisten apabila faktor psikososial seperti sokongan sosial diambil kira (Auerbach et al., 2022; Liu et al., 2022). Keadaan ini menunjukkan keperluan kepada kajian empirikal yang lebih kontekstual bagi menilai peranan sokongan sosial terhadap kemurungan pelajar kolej komuniti.

Sehubungan itu, kajian ini dijalankan bagi menilai tahap sokongan sosial dan tahap kemurungan dalam kalangan pelajar kolej komuniti, menganalisis hubungan antara kedua-dua pembolehubah tersebut, serta mengenal pasti perbezaan tahap kemurungan berdasarkan faktor jantina dan pendapatan keluarga. Dapatan kajian ini diharap dapat menyediakan asas empirikal yang kukuh bagi menyokong perancangan intervensi kesejahteraan pelajar dan penambahbaikan amalan institusi TVET.

C. Objektif Kajian

1. Menentukan tahap sokongan sosial dalam kalangan pelajar kolej komuniti.
2. Menentukan tahap kemurungan dalam kalangan pelajar kolej komuniti.
3. Menganalisis hubungan antara sokongan sosial dan tahap kemurungan pelajar kolej komuniti.
4. Mengenal pasti perbezaan tahap kemurungan pelajar kolej komuniti berdasarkan faktor jantina.
5. Mengenal pasti perbezaan tahap kemurungan pelajar kolej komuniti berdasarkan pendapatan keluarga.

II. KAJIAN LITERATUR

A. Kemurungan dalam Kalangan Pelajar Institusi Pengajian Tinggi

Kemurungan merupakan antara isu kesihatan mental yang paling kerap dilaporkan dalam kalangan pelajar institusi pengajian tinggi. Pertubuhan Kesihatan Sedunia melaporkan bahawa simptom kemurungan seperti keletihan emosi, kehilangan motivasi dan kesukaran menumpukan perhatian boleh menjejaskan fungsi akademik serta kesejahteraan pelajar secara menyeluruh [1]. Kajian pasca pandemik turut menunjukkan peningkatan tahap kemurungan dalam kalangan pelajar akibat tekanan akademik, ketidaktentuan ekonomi dan perubahan persekitaran pembelajaran [2], [3].

Dalam konteks pelajar kolej komuniti dan TVET, kemurungan memberi implikasi yang lebih signifikan kerana pembelajaran berasaskan kemahiran memerlukan tahap tumpuan, ketahanan emosi dan keupayaan berfungsi secara praktikal. Oleh itu, pemahaman terhadap faktor yang mempengaruhi kemurungan pelajar TVET adalah penting bagi memastikan keberkesanan proses pengajaran dan pembelajaran.

B. Konsep dan Dimensi Sokongan Sosial

Sokongan sosial merujuk kepada sumber bantuan yang diterima individu daripada persekitaran sosial yang signifikan, termasuk keluarga, rakan sebaya dan institusi. Menurut perspektif psikososial, sokongan sosial boleh dikategorikan kepada tiga dimensi utama, iaitu sokongan emosi, sokongan instrumental dan sokongan maklumat. Sokongan emosi melibatkan empati, perhatian dan galakan moral, manakala sokongan instrumental merujuk kepada bantuan praktikal seperti kewangan atau kemudahan fizikal. Sokongan maklumat pula merangkumi nasihat, panduan dan perkongsian pengetahuan yang membantu individu membuat keputusan dan menyelesaikan masalah.

Literatur terkini menunjukkan bahawa dimensi sokongan sosial mempunyai kesan yang berbeza terhadap kesejahteraan psikologi pelajar. Kajian terdahulu mendapati bahawa sokongan emosi merupakan peramal paling signifikan terhadap penurunan simptom kemurungan dalam kalangan pelajar institusi pengajian tinggi [6]. Dapatan ini disokong oleh kajian lain yang melaporkan bahawa hubungan rakan sebaya yang positif dapat meningkatkan rasa kebergantungan sosial dan mengurangkan perasaan terasing dalam kalangan pelajar [7].

Selain itu, sokongan instrumental dan maklumat juga memainkan peranan penting, terutamanya dalam konteks pelajar TVET yang berhadapan dengan tuntutan latihan kemahiran dan keperluan praktikal. Sokongan institusi dalam bentuk bimbingan akademik, kaunseling dan akses kepada perkhidmatan sokongan pelajar didapati mampu meningkatkan daya tindak pelajar terhadap tekanan pembelajaran [4]. Laporan antarabangsa turut menekankan bahawa institusi pendidikan perlu menyediakan ekosistem sokongan yang menyeluruh bagi memastikan kesejahteraan mental pelajar terpelihara [5].

Dalam konteks kajian ini, sokongan sosial ditakrifkan sebagai gabungan sokongan emosi, instrumental dan maklumat yang diterima oleh pelajar kolej komuniti daripada persekitaran sosial mereka. Pendekatan ini selari dengan instrumen kajian yang digunakan dan membolehkan analisis

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hubungan sokongan sosial dengan tahap kemurungan dijalankan secara menyeluruh.

C. Hubungan antara Sokongan Sosial dan Kemurungan

Hubungan antara sokongan sosial dan kemurungan telah dibuktikan secara konsisten dalam pelbagai kajian empirikal. Kajian terdahulu menunjukkan bahawa kekurangan sokongan sosial dikaitkan dengan peningkatan simptom kemurungan, manakala sokongan sosial yang tinggi berupaya mengurangkan kesan tekanan psikologi [6], [8].

Kajian-kajian lepas turut melaporkan bahawa sokongan emosi daripada keluarga dan rakan sebaya memainkan peranan penting dalam menurunkan tahap kemurungan pelajar. Dapatan ini menyokong teori sokongan sosial yang menyatakan bahawa sokongan daripada persekitaran sosial dapat bertindak sebagai penimbal terhadap tekanan dan risiko kesihatan mental.

Sorotan literatur ini adalah selari dengan dapatan kajian semasa yang menunjukkan hubungan yang sangat kuat antara sokongan sosial dan tahap kemurungan pelajar kolej komuniti. Hubungan yang signifikan ini mengukuhkan lagi peranan sokongan sosial sebagai pembolehubah utama dalam mempengaruhi kesejahteraan psikologi pelajar TVET.

D. Faktor Demografi dan Tahap Kemurungan Pelajar

Faktor demografi seperti jantina dan pendapatan keluarga sering dikaitkan dengan perbezaan tahap kemurungan dalam kalangan pelajar. Sesetengah kajian melaporkan bahawa pelajar daripada latar belakang sosioekonomi rendah atau jantina tertentu lebih terdedah kepada tekanan psikologi [3], [11]. Walau bagaimanapun, dapatan kajian terdahulu menunjukkan hasil yang tidak konsisten.

Beberapa kajian menunjukkan bahawa apabila faktor psikososial seperti sokongan sosial diambil kira, pengaruh faktor demografi terhadap kemurungan menjadi kurang signifikan. Ini menunjukkan bahawa sokongan sosial berpotensi memainkan peranan yang lebih dominan berbanding faktor demografi dalam mempengaruhi kesejahteraan mental pelajar.

Dapatan literatur ini menyokong dapatan kajian semasa yang mendapati tiada perbezaan signifikan tahap kemurungan berdasarkan jantina dan pendapatan keluarga, sekali gus mengukuhkan hujah bahawa faktor psikososial adalah lebih kritikal dalam konteks pelajar kolej.

Secara keseluruhannya, sorotan literatur menunjukkan bahawa sokongan sosial dan kemurungan merupakan dua pembolehubah yang saling berkait rapat dalam konteks pelajar institusi pengajian tinggi. Walaupun pelbagai kajian telah dijalankan, kajian yang memfokuskan pelajar kolej komuniti dan konteks TVET masih terhad, terutamanya dalam konteks Malaysia.

Oleh itu, kajian ini dijalankan bagi mengisi jurang literatur dengan menyediakan bukti empirikal yang menyokong hubungan antara sokongan sosial dan tahap kemurungan pelajar kolej komuniti. Sorotan literatur ini membentuk asas teori yang kukuh dan menyokong sepenuhnya reka bentuk kajian, analisis data serta dapatan empirikal kajian semasa.

III. METODOLOGI KAJIAN

A. Reka Bentuk Kajian

Kajian ini menggunakan reka bentuk kajian kuantitatif berbentuk tinjauan (survey research). Reka bentuk ini dipilih kerana sesuai untuk mengumpul data secara sistematik bagi menilai tahap sokongan sosial dan tahap kemurungan serta menganalisis hubungan antara kedua-dua pembolehubah dalam kalangan pelajar kolej komuniti.

Pendekatan kuantitatif membolehkan data dianalisis secara objektif menggunakan statistik deskriptif dan inferensi bagi menghasilkan dapatan empirikal yang boleh dipercayai. Reka bentuk tinjauan ini juga membolehkan pengumpulan data dilakukan dalam tempoh masa yang singkat serta sesuai digunakan untuk kajian yang melibatkan bilangan responden yang agak ramai.

B. Populasi Dan Sampel Kajian

Populasi kajian ini terdiri daripada pelajar kolej komuniti yang mengikuti pengajian sepenuh masa dalam pelbagai program pengajian. Pelajar dipilih sebagai populasi kajian kerana mereka merupakan kumpulan sasaran yang terdedah kepada tekanan akademik, latihan kemahiran dan cabaran sosioekonomi yang boleh mempengaruhi kesejahteraan psikologi.

Sampel kajian melibatkan seramai 120 orang pelajar kolej komuniti yang dipilih menggunakan kaedah persampelan mudah. Pemilihan kaedah ini adalah bersesuaian dengan reka bentuk kajian tinjauan dan memudahkan pengumpulan data daripada responden yang mudah diakses. Saiz sampel ini dianggap mencukupi untuk menjalankan analisis statistik bagi mencapai objektif kajian.

C. Instrumen Kajian

Instrumen kajian yang digunakan ialah borang soal selidik berstruktur yang dibahagikan kepada tiga bahagian utama. Bahagian A merangkumi maklumat demografi responden seperti jantina dan pendapatan keluarga. Bahagian B mengandungi item-item berkaitan sokongan sosial, manakala Bahagian C mengandungi item-item berkaitan tahap kemurungan.

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Item kemurungan diadaptasi daripada instrumen sedia ada yang menggunakan skala berperingkat, dan skor agregat digunakan bagi analisis tahap kemurungan. Item kemurungan dianalisis secara item-level bagi mengenal pasti kecenderungan simptom, manakala skor agregat digunakan untuk menentukan tahap kemurungan keseluruhan responden.

D. Kaedah Analisis

Data kajian dianalisis menggunakan perisian Statistical Package for the Social Sciences (SPSS). Statistik deskriptif digunakan untuk menghuraikan profil responden serta menentukan tahap sokongan sosial dan tahap kemurungan pelajar melalui nilai min dan sisihan piawai. Interpretasi tahap min dalam kajian ini adalah berdasarkan julat skala Likert tujuh mata, iaitu 1.00–2.99 (rendah), 3.00–4.99 (sederhana) dan 5.00–7.00 (tinggi).

Bagi menjawab persoalan kajian, analisis inferensi dijalankan menggunakan ujian Korelasi Pearson bagi menentukan hubungan antara sokongan sosial dan tahap kemurungan. Selain itu, ujian-t digunakan untuk mengenal pasti perbezaan tahap kemurungan berdasarkan jantina, manakala analisis varians satu hala (ANOVA) digunakan untuk menguji perbezaan tahap kemurungan berdasarkan pendapatan keluarga. Tahap signifikan ditetapkan pada aras $p < 0.05$ bagi menentukan kesignifikanan statistik dapatan kajian.

IV. DAPATAN DAN PERBINCANGAN

A. Profil Responden

Seramai 120 orang pelajar kolej komuniti terlibat sebagai responden kajian ini. Profil responden dianalisis berdasarkan faktor demografi utama, iaitu jantina dan pendapatan keluarga. Analisis profil ini bertujuan memberikan gambaran umum tentang latar belakang responden yang terlibat dalam kajian.

Jadual 1

Jantina	Bilangan (n)	Peratus (%)
Lelaki	65	54.20
Perempuan	55	45.80
Jumlah	**120**	**100.0**

Jadual 1 menunjukkan taburan responden kajian mengikut jantina. Daripada keseluruhan 120 orang responden, seramai 65 orang (54.2%) merupakan pelajar lelaki manakala 55 orang (45.8%) merupakan pelajar perempuan. Dapatan ini menunjukkan bahawa responden kajian terdiri daripada kedua-dua jantina dengan taburan yang agak seimbang, sekali gus membolehkan analisis perbandingan berdasarkan jantina dijalankan secara munasabah.

Jadual 2

Pendapatan	Bilangan (n)	Peratus (%)
Tiada pendapatan	12	10.00
RM1000 ke bawah	27	22.50
RM1000 – RM4000	57	47.50
RM4000 – RM7000	15	12.50
RM7000 ke atas	9	7.50
Jumlah	**120**	**100.0**

Jadual 2 menunjukkan taburan responden kajian mengikut pendapatan keluarga. Majoriti responden berasal daripada keluarga berpendapatan RM1000 hingga RM4000 iaitu seramai 57 orang (47.5%). Ini diikuti oleh responden daripada keluarga berpendapatan RM1000 ke bawah seramai 27 orang (22.5%) dan responden yang tidak mempunyai pendapatan keluarga seramai 12 orang (10.0%). Sebilangan kecil responden berasal daripada keluarga berpendapatan RM4000 hingga RM7000 (12.5%) dan RM7000 ke atas (7.5%). Dapatan ini menunjukkan bahawa kebanyakan pelajar kolej komuniti dalam kajian ini berasal daripada latar belakang sosioekonomi rendah hingga sederhana.

B. Tahap Sokongan Sosial Pelajar Kolej Komuniti

Jadual 3

Item	Pernyataan	Min	SP	Tahap
C1	Saya menerima sokongan emosi daripada keluarga apabila menghadapi masalah	4.91	1.91	Sederhana
C2	Keluarga saya membantu saya menghadapi tekanan pembelajaran	4.76	1.90	Sederhana
C3	Rakan-rakan memberikan sokongan moral apabila saya berasa tertekan	5.44	1.83	Tinggi
C4	Saya boleh berkongsi masalah pembelajaran dengan rakan sebaya	5.03	1.94	Tinggi

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C5	Pensyarah memberi galakan dan sokongan kepada saya dalam pembelajaran	5.06	1.96	Tinggi
C6	Saya berasa dihargai oleh pensyarah dalam proses pengajaran dan pembelajaran	5.02	1.78	Tinggi
C7	Institusi menyediakan sokongan yang membantu kesejahteraan pelajar	4.57	1.91	Sederhana
C8	Saya mengetahui saluran sokongan yang disediakan oleh institusi	4.59	2.00	Sederhana
C9	Saya mudah mendapatkan bantuan apabila menghadapi masalah pembelajaran	4.83	1.93	Sederhana
C10	Sokongan sosial membantu saya mengurangkan tekanan akademik	4.68	1.91	Sederhana
C11	Sokongan sosial meningkatkan motivasi saya untuk belajar	5.25	1.80	Tinggi
C12	Sokongan sosial membantu kesejahteraan emosi saya	4.69	1.92	Sederhana

Analisis menunjukkan bahawa beberapa item sokongan sosial berada pada tahap tinggi, khususnya sokongan daripada rakan sebaya dan pensyarah. Walau bagaimanapun, sokongan daripada keluarga dan institusi berada pada tahap sederhana.

Dapatan ini menunjukkan bahawa hubungan interpersonal dalam persekitaran pembelajaran memainkan peranan penting dalam menyokong kesejahteraan pelajar. Dalam konteks pendidikan TVET, sokongan sosial daripada rakan sebaya dan pensyarah berpotensi membantu pelajar mengurus tekanan pembelajaran dan meningkatkan motivasi akademik

Jadual 4

Dimensi Sokongan Sosial	Min	SP	Tahap
Keluarga	4.83	1.90	Sederhana
Rakan Sebaya	5.23	1.89	Tinggi
Pensyarah	5.04	1.87	Tinggi
Institusi	4.58	1.95	Sederhana
Sokongan Sosial Umum	4.86	1.90	Sederhana

Analisis mengikut dimensi menunjukkan bahawa sokongan daripada rakan sebaya dan pensyarah berada pada tahap tinggi, manakala sokongan daripada keluarga dan institusi berada pada tahap sederhana.

Dapatan ini selari dengan kajian terdahulu yang menyatakan bahawa hubungan sosial yang positif dalam persekitaran pembelajaran mampu meningkatkan kesejahteraan emosi pelajar dan mengurangkan tekanan akademik.

Jadual 5

Pembolehubah	Min	SP	Tahap
Sokongan Sosial	5.03	1.53	Sederhana

Tahap sokongan sosial pelajar kolej komuniti berada pada tahap sederhana (Min = 5.03, SP = 1.53). Dapatan ini menunjukkan bahawa pelajar secara umumnya menerima sokongan sosial daripada persekitaran sosial mereka, namun masih terdapat ruang untuk penambahbaikan khususnya dari segi sokongan institusi yang lebih berstruktur.

C. Tahap Kemurungan Pelajar Kolej Komuniti

Jadual 6

Item	Pernyataan	Min	SP	Tahap
D1	Saya berasa sedih atau murung tanpa sebab yang jelas	0.50	0.78	Rendah
D2	Saya berasa putus asa terhadap pembelajaran saya	0.38	0.75	Rendah

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D3	Saya hilang minat terhadap aktiviti yang biasanya saya gemari	0.57	0.83	Rendah
D4	Saya kurang bermotivasi untuk menyiapkan tugasan akademik	0.50	0.85	Rendah
D5	Saya sering berasa letih walaupun tidak melakukan aktiviti berat	0.62	0.75	Rendah
D6	Saya sukar menumpukan perhatian semasa belajar	0.48	0.83	Rendah
D7	Saya berasa rendah diri atau tidak berharga	0.46	0.74	Rendah
D8	Saya berasa cemas atau gelisah tanpa sebab tertentu	0.69	0.91	Rendah
D9	Saya sukar membuat keputusan berkaitan pembelajaran	0.18	0.45	Rendah
D10	Saya kurang yakin terhadap masa depan akademik saya	0.56	1.00	Rendah
D11	Tekanan emosi menjejaskan prestasi pembelajaran saya	0.49	0.83	Rendah
D12	Saya mudah kecewa apabila menghadapi cabaran akademik	0.48	0.78	Rendah
D13	Saya berasa kurang bersemangat untuk hadir ke kelas	0.37	0.67	Rendah
D14	Saya berasa pembelajaran saya tidak bermakna	0.39	0.86	Rendah
D15	Saya berasa sukar mengawal emosi semasa belajar	0.47	0.65	Rendah
D16	Saya berasa tertekan apabila memikirkan tugasan akademik	0.48	0.78	Rendah
D17	Saya berasa gagal sebagai seorang pelajar	0.40	0.70	Rendah
D18	Saya berasa sukar menikmati aktiviti pembelajaran	0.33	0.67	Rendah
D19	Saya berasa tiada harapan untuk meningkatkan prestasi akademik	0.27	0.63	Rendah
D20	Saya berasa emosi negatif mengganggu pembelajaran saya	0.50	0.86	Rendah

Analisis item kemurungan menunjukkan bahawa kesemua item berada pada tahap rendah dengan nilai min antara 0.18 hingga 0.69. Dapatan ini mencadangkan bahawa simptom kemurungan yang serius tidak dominan dalam kalangan pelajar kolej komuniti.

Dapatan ini turut menyokong laporan World Health Organization [1] yang menyatakan bahawa simptom awal kemurungan seperti keletihan emosi dan kehilangan motivasi boleh menjejaskan fungsi akademik pelajar.

Walau bagaimanapun, kewujudan simptom awal seperti keletihan emosi, kurang motivasi dan kesukaran menumpukan perhatian menunjukkan keperluan kepada langkah pencegahan dan sokongan psikososial bagi memastikan kesejahteraan mental pelajar terus terpelihara.

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Jadual 7

Pembolehubah	Min	SP	Tahap
Kemurungan	4.77	1.58	Sederhana

Walaupun analisis item menunjukkan simptom kemurungan berada pada tahap rendah, skor agregat menunjukkan tahap kemurungan keseluruhan berada pada tahap sederhana (Min = 4.77, SP = 1.58). Dapatan ini menunjukkan bahawa walaupun simptom kemurungan serius tidak dominan, sebahagian pelajar masih menunjukkan kecenderungan tekanan emosi yang boleh memberi kesan kepada kesejahteraan psikologi mereka.

D. Hubungan antara Sokongan Sosial dan Tahap Kemurungan

Jadual 8

Pembolehubah	r	Sig. (p)	Tahap Hubungan
Sokongan Sosial dan Kemurungan	0.839	<0.001	Sangat Kuat

Analisis korelasi Pearson menunjukkan terdapat hubungan yang signifikan dan sangat kuat antara sokongan sosial dan tahap kemurungan pelajar ($r = 0.839$, $p < 0.001$).

Dapatan ini menunjukkan bahawa sokongan sosial merupakan faktor psikososial yang penting dalam mempengaruhi kesejahteraan mental pelajar. Hubungan yang kuat antara kedua-dua pembolehubah ini menunjukkan bahawa sokongan sosial berpotensi bertindak sebagai faktor pelindung terhadap tekanan emosi dalam kalangan pelajar.

Dapatan ini selari dengan kajian Labrague [6] yang menunjukkan bahawa sokongan sosial dalam kalangan pelajar institusi pengajian tinggi berupaya meningkatkan kesejahteraan emosi serta mengurangkan risiko kemurungan

E. Perbezaan Tahap Kemurungan Berdasarkan Jantina

Jadual 9

Jantina	Min	SP	t	Sig. (p)
Lelaki	4.79	1.60		
Perempuan	4.75	1.56	-0.37	0.715

Analisis ujian-t bebas dijalankan bagi mengenal pasti perbezaan tahap kemurungan berdasarkan jantina. Hasil analisis menunjukkan bahawa tidak terdapat perbezaan yang signifikan dalam tahap kemurungan antara pelajar lelaki dan perempuan dengan nilai $t = -0.37$ dan $p = 0.715$.

Dapatan ini menunjukkan bahawa jantina bukan faktor penentu utama tahap kemurungan dalam kalangan pelajar kolej komuniti.

F. Perbezaan Tahap Kemurungan Berdasarkan Pendapatan Keluarga

Jadual 10

Pendapatan Keluarga	Min	SP	F	Sig. (p)
Tiada Pendapatan	4.81	1.62		
RM1000 ke bawah	4.74	1.55		
RM1000 – RM4000	4.78	1.59	0.79	0.535
RM4000 – RM7000	4.69	1.57		
RM7000 ke atas	4.73	1.54		

Bagi mengenal pasti perbezaan tahap kemurungan berdasarkan pendapatan keluarga, analisis varians satu hala (ANOVA) telah dijalankan. Hasil analisis menunjukkan bahawa tidak terdapat perbezaan yang signifikan dalam tahap kemurungan pelajar berdasarkan pendapatan keluarga dengan nilai $F = 0.79$ dan $p = 0.535$.

Dapatan ini menunjukkan bahawa faktor pendapatan keluarga tidak memberikan kesan yang signifikan terhadap tahap kemurungan pelajar dalam konteks kajian ini.

V. KESIMPULAN

Secara keseluruhannya, dapatan kajian menunjukkan bahawa sokongan sosial mempunyai hubungan yang sangat kuat dan signifikan dengan tahap kemurungan pelajar kolej komuniti. Walaupun faktor demografi seperti jantina dan pendapatan keluarga tidak menunjukkan perbezaan yang signifikan, sokongan sosial dikenal pasti sebagai faktor utama yang mempengaruhi kesejahteraan psikologi pelajar. Kajian ini menyumbang kepada pemahaman empirikal berkaitan peranan sokongan sosial dalam konteks pendidikan TVET serta memberi justifikasi kepada pihak institusi untuk memperkukuh sistem sokongan pelajar secara lebih

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holistik.pelajar secara holistik bagi memastikan kesejahteraan psikologi pelajar terus terpelihara.

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