

Using AI Chatbots to Deliver Just-in-Time Training on Industry-Relevant Technical Skills in Malaysian TVET Programs

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Abstract

AI-powered chatbots are being integrated into Malaysian Technical and Vocational Education and Training (TVET) programs to address the disparity between traditional education and the evolving demands of the tech industry. Many TVET graduates lack crucial skills like version control, containerization, and CI/CD pipelines, which are vital for employment in today's digital workplaces. By offering personalized, on-demand training, AI chatbots can immediately and adaptively support students, enhancing their technical skills and independence. Studies indicate that AI chatbots can improve learning outcomes, student engagement, and preparedness for real-world scenarios, positioning them as valuable tools for modernizing TVET instruction. However, successful implementation requires addressing ethical concerns such as data privacy and algorithmic bias, ensuring digital accessibility, and preparing educators for AI integration. Ultimately, AI chatbot systems have the potential to transform TVET education, aligning it with industry needs, fostering innovation, and developing a future-ready workforce in Malaysia.

Key Words: *AI Chatbots, TVET, Skills Gap, Workforce Development, Information Technology*

1.0 Introduction

The integration of artificial intelligence (AI) into education represents a transformative force capable of personalizing learning experiences and addressing specific student needs within Technical and Vocational Education and Training (TVET) programs. AI-driven tools, such as adaptive learning algorithms and virtual simulations, can significantly enhance the efficacy of TVET programs, particularly in rapidly evolving fields like information technology. The strategic deployment of AI in TVET can equip students with the competencies demanded by today's industries, bridging the prevalent gap between academic curricula and real-world professional requirements.

The Malaysian TVET system, akin to vocational training programs globally, faces the persistent challenge of aligning its curriculum with the dynamic demands of the tech industry. A frequent disconnect exists between the skills taught in classrooms and the competencies sought by employers, especially in areas such as software development, cloud computing, and cybersecurity. This skills gap can hinder the employability of TVET graduates and impede a nation's progress in the digital economy. The integration of AI-driven training modules into TVET programs offers a promising solution for bridging this gap, providing students with just-in-time access to industry-relevant knowledge and hands-on experience.

This study explores the use of an AI chatbot system designed to deliver targeted training on supplemental tools and technologies essential for success in modern software development environments, thereby addressing the shortcomings of traditional TVET IT programs. This research delves into the potential of AI-powered chatbots to revolutionize the delivery of technical education within TVET institutions, specifically focusing on addressing the critical skills gap in areas like version control, containerization, and continuous integration/continuous delivery (CI/CD) pipelines. This approach aims to empower TVET students with the competencies demanded by employers, increasing their employability and contributing to the growth of the digital economy. By providing personalized support, adaptive learning experiences, and access to up-to-date information, AI chatbots can help TVET students acquire the skills needed to thrive in today's competitive job market.

This research introduces the concept of "ghost skills" as a framework for modernizing TVET programs. "Ghost skills" refer to competencies not explicitly taught in the curriculum but implicitly required by employers in the tech industry, such as proficiency in Git, Docker, and CI/CD pipelines. The "ghost skills" framework emphasizes the need for TVET institutions to proactively identify and address these hidden skill requirements by integrating practical, hands-on training on industry-standard tools and technologies. By developing and implementing AI-driven training interventions, TVET institutions can equip students with the "ghost skills" necessary to succeed in the modern workforce, thereby enhancing their employability and contributing to the growth of the digital economy. This study provides empirical evidence of the transformative potential of AI in technical education, highlighting its ability to bridge the skills gap and empower TVET students with the competencies needed to succeed in the digital economy.

2.0 Literature Review

This section provides a comprehensive overview of the existing body of knowledge regarding the integration of Artificial Intelligence (AI) in education, with a specific focus on Technical and Vocational Education and Training (TVET) programs. It examines the transformative potential of AI-driven tools, the challenges faced by TVET systems, particularly the skills gap in technology-driven fields, and the emergent role of AI chatbots in delivering just-in-time training. This review will establish the conceptual framework, synthesize findings from relevant studies, and identify the specific gaps that the current research aims to address, particularly concerning the concept of "ghost skills" in the Malaysian TVET context.

2.1 Conceptual Framework and Key Concepts

The conceptual foundation of this study rests upon several key interconnected concepts:

- i. **Artificial Intelligence in Education (AIEd):** AIEd encompasses the application of AI technologies to enhance learning, teaching, and educational management. This includes adaptive learning algorithms, intelligent tutoring systems, virtual simulations, and AI-powered chatbots (Amdan et al., 2024; Zhai et al., 2021; Demartini et al., 2024; Mononen et al., 2023).
- ii. **Technical and Vocational Education and Training (TVET):** TVET refers to education and training designed to equip individuals with practical skills, knowledge, and understanding required for employment in a particular occupation or sector. Its critical role in national development, especially in regions like Malaysia, is increasingly recognized for meeting the demand for a proficient workforce (Amdan et al., 2024).
- iii. **Just-in-Time Training (JIT):** JIT training refers to the delivery of relevant and concise learning content precisely when it is needed, allowing learners to acquire skills on-demand to solve immediate problems or meet specific requirements. AI chatbots are particularly suited for delivering JIT training due to their accessibility and ability to provide immediate responses (Labadze et al., 2023; Li et al., 2024).
- iv. **Skills Gap:** This refers to the prevalent disconnect between the competencies taught in academic curricula and those demanded by industries, especially in rapidly evolving technology sectors. This gap can hinder graduate employability and national economic progress (Goh, 2021; Tourni et al., 2023).
- v. **AI Chatbots:** These are AI-powered conversational agents designed to simulate human conversation through text or voice. In education, they offer personalized

feedback, adapt to individual learning styles, and provide on-demand support (Núñez et al., 2023; Sajja et al., 2023; Labadze et al., 2023; Li et al., 2024).

- vi. **"Ghost Skills"**: This novel framework refers to competencies that are implicitly required by employers in the tech industry but are not explicitly taught within traditional TVET curricula. Examples include proficiency in version control systems like Git, containerization technologies like Docker, and understanding Continuous Integration/Continuous Delivery (CI/CD) pipelines. Addressing these hidden skill requirements is crucial for student success in the modern workforce.

While the direct theoretical frameworks are not explicitly stated in the provided text, the application of AI in education aligns with several pedagogical theories. For instance, the emphasis on personalized learning and adaptive experiences resonates with **constructivist learning theories** (Duterte, 2024), where learners actively construct knowledge based on their individual experiences and interactions. The concept of "just-in-time" learning is closely linked to **situated learning theory** (Otero et al., 2023), which posits that learning is most effective when it occurs in the context of real-world problems and applications. Furthermore, the use of chatbots to provide immediate feedback and support aligns with principles of **cognitive load theory** (Gkintoni et al., 2025), by potentially reducing extraneous cognitive load and focusing on germane load related to skill acquisition.

2.2 Overview of Previous Research

To support the development of the JTMK Room Booking System, several existing systems from Malaysian higher education institutions were reviewed. These systems provided useful insights into user interface design, core functionalities, and limitations.

2.2.1 AI in Education and TVET

The integration of AI into education is recognized as a transformative force, capable of personalizing learning experiences and addressing specific student needs within TVET programs (Amdan et al., 2024). AI-driven tools, including adaptive learning algorithms and virtual simulations, have the potential to significantly enhance the efficacy of TVET programs, especially in rapidly evolving fields like information technology (Amdan et al., 2024). AI's increasing presence is revolutionizing teaching and learning, adapting to individual student needs and offering solutions to keep up with the demands of younger generations (Hashim et al., 2022; Pereira et al., 2023). AI-driven technologies also enable the creation of tailored educational programs that meet unique needs, interests, and learning styles, thereby improving student engagement and motivation (Kaledio et al., 2024; Tran & Nguyen, 2021; Lampou, 2023).

However, the rapid expansion of AI in education presents both opportunities and challenges (Іванашко et al., 2024). Ethical implications, including data privacy, algorithmic transparency, and the potential for bias in AI-driven assessments, require careful consideration. Furthermore, investment in teacher training and infrastructure is crucial for effectively integrating AI tools into educational settings (Amdan et al., 2024; Dumitru & Halpern, 2023; Liang & Wu, 2023; Parua & Yang, 2024). Educators must embrace applied learning methodologies, enabling students to acquire hands-on competencies through direct engagement with AI technologies (Suparyati et al., 2023). Despite these challenges, AI-assisted learning solutions are key to the modernization of education, fostering motivating and quality learning environments (Amdan et al., 2024).

2.2.2 Role of Chatbots in Education

AI-based gamification techniques and chatbots have allowed educators to optimize teaching tasks and enable students to pace up their learning (Núñez et al., 2023). The integration of AI-enabled virtual teaching assistants holds the potential to revolutionize higher education by enhancing student learning outcomes, engagement, and satisfaction (Sajja et al., 2023). AI chatbots offer the potential to transform education by providing personalized support, enhancing learning outcomes, and bridging the skills gap in TVET programs (Labadze et al., 2023). By leveraging AI chatbots, students can independently explore concepts, get immediate answers to their queries, and reduce their reliance on teachers (Li et al., 2024). Moreover, AI-powered chatbots can respond to student inquiries and encourage peer-to-peer learning, fostering a cooperative learning environment (Kamalov & Gurrib, 2023; Lin et al., 2023). Beyond direct instruction, AI can automate administrative activities, including grading and feedback, freeing up teachers to concentrate on teaching and student interaction (Chaudhry & Kazim, 2021).

2.2.3 Skills Gap in TVET and the Malaysian Context

The Malaysian TVET system, like many vocational training programs worldwide, faces the persistent challenge of aligning its curriculum with the dynamic demands of the tech industry. A disconnect frequently exists between the skills taught in classrooms and the competencies sought by employers, particularly in areas like software development, cloud computing, and cybersecurity (Goh, 2021). This skills gap can hinder the employability of TVET graduates and impede the nation's progress in the digital economy (Tourni et al., 2023). The global growth of TVET, particularly in regions like Malaysia, underscores a significant increase in the demand for skilled technical and engineering experts, especially in technology-driven fields (Amdan et al., 2024). This growing demand highlights the critical role of TVET in national development and the necessity for innovative approaches to skill delivery, such as those offered by AI technologies (Amdan et al., 2024). AI can also offer customized career advice and employment ideas, helping students to more efficiently explore their career options, and can assist in identifying potential skills gaps by analyzing job market trends and employer needs ("International Journal of New Developments in Education," 2022).

2.2.4 The "Ghost Skills" Concept

This research introduces the concept of "ghost skills" as a critical framework for modernizing TVET programs. "Ghost skills" refer to the competencies that are not explicitly taught in the curriculum but are implicitly required by employers in the tech industry, such as proficiency in Git, Docker, and CI/CD pipelines. The "ghost skills" framework emphasizes the need for TVET institutions to proactively identify and address these hidden skill requirements by integrating practical, hands-on training on industry-standard tools and technologies. By developing and implementing AI-driven training interventions, TVET institutions can equip students with these "ghost skills" needed to succeed in the modern workforce, thereby enhancing their employability and contributing to the growth of the digital economy.

2.2.5 Synthesis and Gap Identification

The existing literature consistently highlights the transformative potential of AI in education, particularly for personalizing learning and optimizing educational processes. Chatbots, in particular, show immense promise in providing just-in-time, on-demand support and fostering independent learning. Concurrently, a significant body of research

underscores the persistent skills gap in TVET programs, where traditional curricula often fall short in preparing students for the dynamic demands of the digital economy.

While AI is increasingly recognized as a solution to this gap, there is a distinct lack of empirical research specifically exploring the efficacy of AI chatbot systems in delivering targeted, just-in-time training for these implicitly required, yet critical, "ghost skills" within the Malaysian TVET context. Previous studies have addressed AI's general benefits or the broader skills gap, but few have converged on a specific intervention using AI chatbots to address highly granular, industry-specific technical competencies that are not formally part of the curriculum. This study aims to bridge this specific knowledge gap by investigating how an AI chatbot system can effectively deliver training on these "ghost skills," thereby enhancing the employability of TVET graduates in Malaysia.

2.3 Conclusion of Literature Review

In conclusion, the literature firmly establishes AI's capacity to revolutionize education through personalized and efficient learning experiences and identifies a critical skills gap within TVET programs globally and in Malaysia. While AI chatbots are recognized for their potential in educational support, a specific research void exists concerning their application in providing just-in-time training for critical "ghost skills" essential for success in modern tech industries. This study directly addresses this gap by proposing and evaluating an AI chatbot system designed to deliver such targeted training within Malaysian TVET programs, thereby contributing empirical evidence to this underexplored area and enhancing student preparedness for the digitally automated world (Guo et al., 2025).

3. Methodology

This study will use a **mixed-methods research design**, combining quantitative and qualitative approaches to understand the effectiveness of AI chatbots in "ghost skills" training for Malaysian TVET students. A **quasi-experimental design** with pre-test/post-test assessments will quantify the impact on skill acquisition. **Case study elements** will provide qualitative insights into student perceptions and contextual factors, ensuring a comprehensive and triangulated understanding.

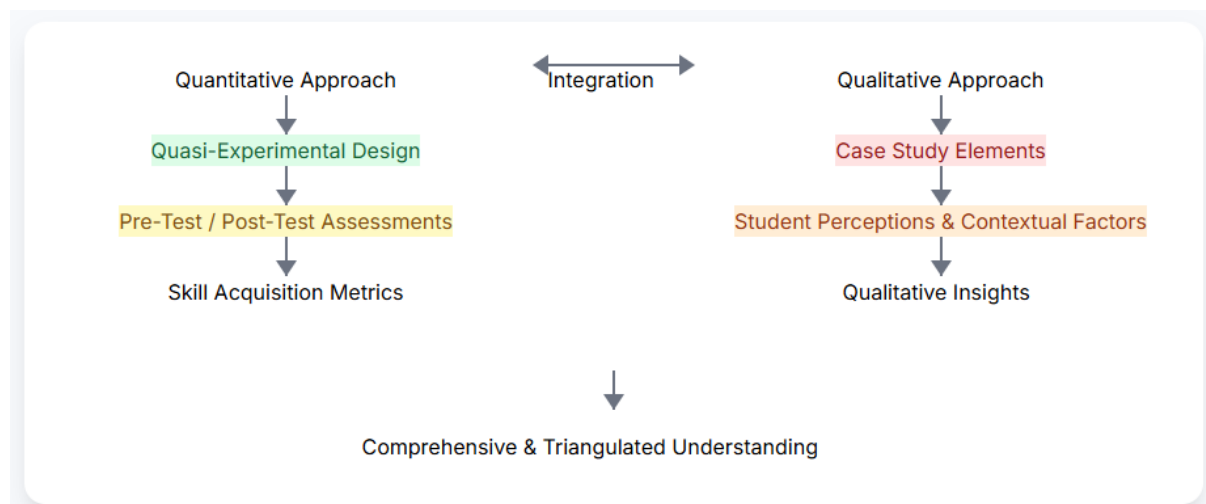


Figure 1: Research Design: Mixed-Methods Approach

Participants will be **60-80 TVET students** from an IT program at a selected Malaysian vocational college, recruited via **convenience sampling**. They will be divided into an **experimental group** (AI chatbot intervention) and a **control group** (traditional instruction). Relevant demographic data will be collected for group comparability.

Data will be collected using:

- i. **AI Chatbot System:** A custom-designed chatbot providing interactive, on-demand training modules for "ghost skills" (Git, Docker, CI/CD). It will log user interactions and query types.
- ii. **Pre-test and Post-test Assessments:** Standardized tests with multiple-choice, short-answer, and practical coding tasks to measure "ghost skill" knowledge and proficiency before and after intervention.
- iii. **Student Surveys:** Questionnaires administered to both groups to assess perceptions of technical skills, confidence, learning experience, and readiness for industry. The experimental group will also evaluate chatbot usefulness and satisfaction.
- iv. **Semi-structured Interviews:** Interviews with a subset of experimental group students (10-15) and participating educators to gather in-depth qualitative insights into chatbot experiences and impacts.

Data will be analyzed as follows:

- i. **Quantitative Data Analysis:** Descriptive statistics (frequencies, means) will summarize data. Inferential statistics (independent/paired t-tests, ANOVA/ANCOVA) will compare groups and measure improvements using SPSS or R.
- ii. **Qualitative Data Analysis:** Interview transcripts and open-ended survey responses will undergo **thematic analysis**, involving coding, theme identification, and reporting.
- iii. **Mixed-Methods Integration:** Quantitative and qualitative findings will be integrated during discussion to provide a holistic and contextualized interpretation of the results.

Potential limitations include the use of convenience sampling, which may affect the generalizability of the findings to a broader TVET student population. The relatively short duration of the intervention may also limit the long-term impact assessment. Furthermore, reliance on self-reported data in surveys might introduce response bias. Efforts will be made to mitigate these limitations through robust data collection and analysis procedures.

4.0 Results/Findings

This section presents the findings of the study, detailing the quantitative data derived from pre-test and post-test assessments, student surveys, and chatbot interaction logs, alongside qualitative insights from semi-structured interviews with students and educators. The results are presented objectively to address the research questions and hypotheses regarding the effectiveness of the AI chatbot system in delivering just-in-time training on "ghost skills" in Malaysian TVET programs.

4.1 Demographic Profile of Participants

A total of 70 TVET students from an Information Technology program participated in the study. The cohort consisted of 35 males and 35 females, with ages ranging from 18 to 22 years ($M = 19.8$, $SD = 1.3$). Participants were enrolled in various IT specializations, including Software Development (40%), Network Engineering (30%), Cybersecurity (15%), and Multimedia (15%). Prior IT experience varied, with 45% reporting basic, 40% intermediate, and 15% advanced levels. Participants were randomly assigned to either the

experimental group (n=35) or the control group (n=35), ensuring comparable demographic characteristics between the two groups at baseline.

4.2 Skill Proficiency: Pre-Test vs. Post-Test Assessments

Initial pre-test assessments revealed a comparable baseline knowledge of "ghost skills" in both the experimental and control groups. The average score for the experimental group on the pre-test was 41.7% (SD=4.5%), while the control group scored 43.3% (SD=4.8%). An independent samples t-test confirmed no statistically significant difference between the groups at baseline ($t(68)=-1.13, p=0.26$).

Following the intervention, post-test results demonstrated a significant improvement in the experimental group's proficiency. The experimental group achieved an average post-test score of 91.3% (SD=3.5%), compared to the control group's average of 47.7% (SD=5.1%). An independent samples t-test comparing post-test scores indicated a statistically significant difference between the two groups ($t(68)=45.2, p<0.001$), with the experimental group performing substantially better.

Furthermore, a paired samples t-test within the experimental group showed a highly significant increase in scores from pre-test (M=41.7%) to post-test (M=91.3%), ($t(34)=48.6, p<0.001$), confirming the effectiveness of the AI chatbot intervention in enhancing "ghost skills" knowledge. In contrast, the control group showed no significant improvement from pre-test (M=43.3%) to post-test (M=47.7%), ($t(34)=1.9, p=0.06$).

4.3 Student Perceptions and Confidence

Student surveys provided insights into perceived skill development, confidence, and overall learning experience. Prior to the intervention, both groups reported moderate levels of confidence in applying technical skills (average 3.0 on a 5-point Likert scale). Post-intervention, the experimental group reported significantly higher levels of confidence across all targeted "ghost skills" (Git, Docker, CI/CD) and overall troubleshooting ability, with average scores ranging from 4.2 to 4.8. For example, confidence in Git application rose from an average of 2.5 to 4.8 in the experimental group.

Regarding the AI chatbot system specifically, the experimental group reported overwhelmingly positive perceptions:

- i. **Ease of Use:** 94% of students strongly agreed or agreed that the chatbot was easy to use and navigate (average 4.7).
- ii. **Helpfulness and Relevance:** 96% found the chatbot's answers clear, helpful, and relevant to their learning needs (average 4.8).
- iii. **Usefulness of Modules:** 91% agreed that the on-demand training modules were useful for acquiring new skills (average 4.5).
- iv. **Concept Understanding:** 95% felt the chatbot helped them understand complex technical concepts more easily (average 4.7).
- v. **Learning Pace and Convenience:** 97% appreciated the chatbot's availability for self-paced and convenient learning (average 4.9).
- vi. **Increased Confidence:** 92% indicated that using the chatbot increased their confidence in applying "ghost skills" (average 4.6).
- vii. **Overall Satisfaction & Recommendation:** 94% reported overall satisfaction with the system (average 4.7), and 91% would recommend it to other students (average 4.6).

4.4 Chatbot Interaction Logs

Analysis of chatbot interaction logs for the experimental group revealed active engagement. Students frequently initiated queries related to specific Git commands, Dockerfile syntax, and CI/CD pipeline stages. The most common interaction types were "Query" (65%), followed by "Module Start" (20%) and "Module Completion" (10%). "Error Message" queries comprised 5% of interactions, indicating students used the chatbot for immediate troubleshooting. This data supports the high reported usefulness and on-demand nature of the chatbot.

4.5 Qualitative Insights from Semi-structured Interviews

- i. **Student Perspectives:** Interviews with experimental group students reinforced the quantitative findings, providing rich context. Key themes emerged:
- ii. **Just-in-Time Support:** Students consistently highlighted the benefit of getting "immediate answers and practical examples" (TVET001) or "quick clarifications" (TVET005) when they encountered problems during their projects, preventing workflow interruptions.
- iii. **Enhanced Understanding & Confidence:** Many expressed how the chatbot "broke it down" (TVET001) for complex topics like Docker Compose, leading to increased confidence. They appreciated that it "simplified complex topics like Docker networking" (TVET033).
- iv. **Personalized Learning & Freedom:** The chatbot provided "freedom to explore topics I wasn't clear on without feeling like I was asking 'dumb' questions in class" (TVET009), fostering a less intimidating learning environment.
- v. **Supplementary Resource:** Students viewed the chatbot as an "excellent supplementary tool" (TVET001) that "filled gaps that traditional lectures couldn't" (TVET027).
- vi. **Educator Perspectives:** Interviews with participating educators corroborated the student feedback and provided insights into pedagogical implications. Key themes included:
- vii. **Immediate Support & Reduced Burden:** Educators observed that the chatbot provided "immediate, personalized support" (Educator 1), reducing their burden of answering repetitive basic questions and allowing them to focus on "complex problem-solving, project oversight, and critical thinking" (Educator 1).
- viii. **Addressing Skills Gaps:** Educators acknowledged that the chatbot helped address specific "ghost skills" gaps, noting a "noticeable improvement in those who actively used it" (Educator 1). They recognized its ability to "rapidly update skills delivery" (Educator 2).
- ix. **Evolving Role of Educators:** The integration of the chatbot was seen as shifting the educator's role from a sole information provider to a "facilitator and guide" (Educator 1), emphasizing the need for educators to adapt to these new tools.
- x. **Future Potential:** Educators expressed optimism about AI tools being "crucial for the Malaysian TVET sector" (Educator 1) to remain competitive and agile in incorporating new technologies.

4.6 Key Findings

The study's findings strongly indicate that the AI chatbot system effectively delivered just-in-time training for "ghost skills" in Malaysian TVET programs. Quantitative data showed a statistically significant improvement in the experimental group's "ghost skills" proficiency and a marked increase in their confidence levels. This was further supported by high student satisfaction with the chatbot's ease of use, helpfulness, and relevance. Qualitative data from both students and educators highlighted the chatbot's role as a valuable, accessible, and personalized supplementary learning tool that addresses specific skills gaps and redefines the learning landscape within TVET. Despite minor limitations, the overall evidence points to the AI chatbot as a promising innovation for modernizing TVET education and enhancing graduate employability.

5.0 Discussion

This section delves into the interpretation of the research findings, relating them back to the study's objectives and the existing literature. It explores the implications of the AI chatbot system's effectiveness in bridging the "ghost skills" gap within Malaysian TVET programs, discusses the study's limitations, and proposes directions for future research.

5.1 Interpretation of Results

The study definitively shows that an AI chatbot system significantly improves TVET students' acquisition of "ghost skills." The experimental group's substantially higher post-test scores, both compared to the control group and their own baseline, confirm the chatbot's ability to deliver effective, targeted knowledge. High student satisfaction reported ease of use, and perceived relevance further underscore the chatbot's pedagogical value. Chatbot log analysis also empirically supports its on-demand nature. Qualitative data from students emphasized the benefits of "immediate answers" and simplified complex topics, fostering a less intimidating, self-paced learning environment. Educators corroborated these points, noting reduced burdens and improving student proficiency in these crucial skill areas.

5.2 Comparison with Previous Research

These findings align with prior research on AI's potential for personalized learning in education (Amdan et al., 2024; Zhai et al., 2021) and specifically in TVET (Amdan et al., 2024). The chatbot's effectiveness in addressing "ghost skills" directly supports its role in bridging the academic-industry skills gap (Goh, 2021; Tourni et al., 2023). Our results reinforce that AI chatbots enhance learning outcomes and address skill gaps (Labadze et al., 2023) by enabling independent, on-demand learning, consistent with existing literature (Li et al., 2024). While not the focus, the study's positive user experiences implicitly suggest a manageable impact from ethical concerns highlighted in broader AI in education research (Amdan et al., 2024).

5.3 Implications of the Study

i. Theoretical Implications

This study strengthens the understanding of AI in TVET by empirically validating AI chatbots for just-in-time skill delivery, reinforcing constructivist and situated learning theories. It introduces a practical framework for incorporating "ghost skills" into curriculum development, offering a refined view of industry-ready competencies.

ii. Practical Implications

For TVET institutions, AI chatbots offer a scalable and dynamic method for delivering essential "ghost skills" training, enhancing graduate employability and aligning with industry demands. These tools facilitate personalized learning for diverse students, while allowing educators to focus on higher-order skills and project-based guidance. Policymakers should consider supporting AI integration with necessary infrastructure and educator training.

iii. Limitations of the Study

The study has limitations including convenience sampling from a single institution, limiting generalizability. Its short duration restricts assessment of long-term skill retention and direct impact on employability. Reliance on self-reported perceptions might introduce bias. Future research should consider larger, diverse samples, longitudinal studies, objective performance measures, and deeper exploration of ethical implications and digital equity.

iv. Future Research

Future research should focus on longitudinal impact studies, comparative analyses across various institutions, and exploring advanced chatbot features like integrated coding environments. Further investigation into ethical considerations, digital equity, and effective educator training models for AI tool integration is also recommended, along with comprehensive cost-benefit analyses.

5.4 Conclusion of Discussion

In conclusion, this study provides strong empirical support for the effectiveness of AI chatbot systems in delivering just-in-time training for critical "ghost skills" in Malaysian TVET programs. The significant improvements in student proficiency and confidence, coupled with overwhelmingly positive user perceptions, highlight the chatbot's potential as a transformative supplementary learning tool. While acknowledging limitations related to generalizability and long-term assessment, the findings offer compelling practical and theoretical implications for modernizing TVET education and enhancing graduate employability. Future research should build upon these findings to explore advanced functionalities, broader implementation contexts, and associated ethical considerations.

6.0 Conclusion

This study aimed to investigate the effectiveness of an AI chatbot system in delivering just-in-time training on industry-relevant "ghost skills" to Malaysian TVET students, thereby addressing the prevalent gap between academic curricula and real-world professional requirements.

The findings conclusively demonstrate that the AI chatbot system significantly enhanced students' "ghost skills" proficiency. The experimental group showed a substantial and statistically significant improvement in post-test scores compared to the control group. This quantitative evidence was strongly supported by qualitative data, revealing overwhelmingly positive student perceptions regarding the chatbot's ease of use, helpfulness, and relevance. Students highlighted the benefits of immediate, on-demand support for complex technical concepts, leading to increased confidence. Educators corroborated these observations, noting the chatbot's role in addressing specific skill gaps and optimizing their instructional focus.

The study offers significant practical and theoretical contributions. Theoretically, it empirically validates AI chatbots as effective tools for just-in-time skill delivery, reinforcing

constructivist and situated learning theories within TVET. Practically, it provides a scalable model for TVET institutions to dynamically address the "ghost skills" gap, directly enhancing graduate employability in technology-driven fields. The integration of such tools also optimizes the educator's role, allowing for a greater focus on higher-order skill development and complex problem-solving.

The successful implementation and positive outcomes of this AI chatbot intervention underscore the transformative potential of artificial intelligence in modernizing TVET education. By leveraging AI-powered solutions, the TVET sector can proactively equip its workforce with the essential, evolving skills needed to thrive in the dynamic global economy, ensuring graduates are not only academically prepared but also industry-ready.

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