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Ethical Issues and Challenges of Artificial Intelligence (AI) in TVET Teaching towards Enhancing Student Competences

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ABSTRACT

This study aims to conduct a Systematic Literature Review (SLR) on the ethical issues and challenges of artificial intelligence (AI) implementation in Teaching and Learning within Technical and Vocational Education and Training (TVET), as well as its implications for enhancing student competencies. A total of 20 Scopus-indexed articles published between 2022 and 2025 were analysed using a thematic synthesis approach. The article search and initial screening processes were supported by the AI-based research tool Elicit, while the thematic analysis and synthesis were conducted manually to ensure academic rigour. The findings indicate that AI has strong potential to enhance TVET student competencies, particularly in technical skills, self-directed learning, and critical thinking. However, significant challenges remain, including data privacy concerns, algorithmic bias, information security risks, and the readiness of educators and institutional infrastructure. Although several reviewed studies focus on higher education contexts, their findings are considered transferable to TVET settings due to similarities in pedagogical structures, competency-based assessment, and digital learning environments.

1. Research Background

The rapid advancement of Artificial Intelligence (AI) has significantly transformed the global education landscape, including Technical and Vocational Education and Training (TVET). AI technologies such as adaptive learning systems, educational chatbots, learning analytics, and automated assessment tools are increasingly adopted to support teaching and learning processes. These developments are closely aligned with the Sustainable Development Goal 4 (SDG 4), which emphasises inclusive, equitable, and quality education as well as lifelong learning opportunities for all [21]. At the international level, UNESCO highlights the importance of ethical and responsible AI

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integration in education, particularly in ensuring fairness, transparency, data privacy, and human-centred learning [21]. In the Malaysian context, initiatives such as Malaysia Education Blueprint and national digital education strategies underscore the role of digital transformation and emerging technologies, including AI, in strengthening workforce readiness and future skills development within TVET institutions. These policy directions reflect the growing expectation that AI should not only enhance learning efficiency but also support sustainable, ethical, and inclusive educational practices. Within TVET settings, AI is perceived to have strong potential in enhancing student competencies, particularly technical skills, self-directed learning, critical thinking, and employability. However, the integration of AI extends beyond technological benefits and raises significant ethical and implementation challenges. Key concerns include student data privacy, algorithmic bias, unequal access to digital infrastructure, and educator readiness to effectively integrate AI into pedagogy. These challenges are especially critical in TVET, where competency-based assessment and hands-on practical training are central to student evaluation. Any weaknesses in ethical governance or implementation may directly affect the validity, fairness, and reliability of skills assessment. Although much of the existing literature focuses on higher education contexts, the ethical principles and implementation challenges identified are largely transferable to TVET due to similarities in digital learning environments and competency-based assessment structures. Therefore, this study conducts a Systematic Literature Review (SLR) to examine ethical issues, implementation challenges, and the potential contribution of AI in enhancing student competencies within TVET education.

At the global level, the integration of Artificial Intelligence (AI) in education aligns with Sustainable Development Goal 4 (SDG 4), which emphasises inclusive and equitable quality education as well as lifelong learning opportunities for all [22]. UNESCO further highlights that the adoption of AI in education must be guided by ethical principles, particularly fairness, transparency, data privacy, and human-centred learning, to ensure responsible and sustainable educational practices [21].

In the Malaysian context, national digital education initiatives, including the Blue Education Malaysia agenda, emphasise the role of emerging technologies in strengthening future-ready skills, sustainability awareness, and workforce preparedness within Technical and Vocational Education and Training (TVET) institutions. These policy directions reinforce the expectation that AI adoption should not only enhance learning efficiency but also support ethical, inclusive, and sustainable educational practices.

Based on the identified research gap, this Systematic Literature Review is guided by the following research questions:

Question 1: What ethical issues are associated with the use of artificial intelligence (AI) in TVET teaching and learning?

Question 2: What implementation challenges are reported in integrating AI within TVET education contexts?

Question 3: How does AI contribute to enhancing student competencies in TVET education?

To synthesize the Key Ethical Issues and Implementation Challenges identified in the reviewed literature, Table 1 summarises the main aspects and supporting references.

Table 1

Key ethical issues and implementation challenges of AI in TVET

Aspect	Description	Supporting References
Data Privacy	Risks related to collection and use of student data	Marín <i>et al.</i> , [11]; Ismail <i>et al.</i> , [8]
Algorithmic Bias	Potential reinforcement of inequality	Kamali <i>et al.</i> , [9]; Holmes and Porayska-Pomsta [6]
Educator Readiness	Limited skills and training in AI integration	Pitchan and Azmi [13]; Abdelaal and Al Sawi [1].
Infrastructure & Access	Digital divide and resource limitations	Sun and Pratt [17]; Ocen <i>et al.</i> , [12]

Overall, the table highlights that data privacy, algorithmic bias, educator readiness, and infrastructure limitations are the most frequently discussed concerns, underscoring the need for ethical governance and institutional preparedness in TVET institutions. Some ethical issues are derived from higher education studies, as ethical principles such as fairness, data privacy, and algorithmic transparency are applicable across educational contexts, including TVET.

2. Methodology

This study adopted a Systematic Literature Review (SLR) approach to examine ethical issues, implementation challenges, and the implications of artificial intelligence (AI) integration in Technical and Vocational Education and Training (TVET). The SLR method was employed to ensure a transparent, replicable, and rigorous synthesis of existing literature related to AI applications in TVET education.

2.1 Identification

A systematic literature search was conducted using the Scopus database as the primary source. The search process was supported by the AI-based research tool *Elicit* to assist in identifying potentially relevant studies; however, all decisions regarding study selection were made by the researchers. The initial search yielded 50 records.

2.2 Screening

Prior to screening, 5 duplicate records were removed. The remaining 45 records were screened based on their titles and abstracts. During this stage, 17 records were excluded because they were not related to AI implementation in TVET, did not address ethical or implementation issues, or were not relevant to student competency development. As a result, 28 full-text articles were retained for further assessment.

2.3 Eligibility

The full texts of the 28 articles were assessed for eligibility using predefined inclusion and exclusion criteria. Studies were included if they:

1. Focused on AI integration in education, particularly within TVET contexts.

2. Addressed ethical issues and/or implementation challenges of AI use.
3. Examined the impact of AI on student competencies or learning outcomes.
4. Were peer-reviewed journal articles indexed in Scopus and published between 2022 and 2025.

Following this assessment, 8 articles were excluded for the following reasons: not focusing on ethical or implementation issues ($n = 4$), not related to the TVET context ($n = 3$), and being conceptual papers without relevant empirical discussion ($n = 1$).

2.4 Quality Assessment of Included Studies

To ensure the methodological quality and relevance of the included studies, a quality assessment was conducted prior to data synthesis. Each article was evaluated using four criteria adapted from established SLR guidelines: (1) clarity of research objectives, (2) appropriateness of research methodology, (3) relevance to AI implementation in education (TVET or transferable contexts), and (4) discussion of ethical or implementation-related issues. Each criterion was scored as Yes (1) or No (0). Studies with a total score of three or above were considered of acceptable quality and included in the final synthesis. All 20 selected studies met the minimum quality threshold.

2.5 Data Extraction and Thematic Synthesis

Data were extracted manually using a structured framework focusing on study characteristics, AI applications, ethical considerations, implementation challenges, and reported impacts on student competencies. A thematic synthesis approach was employed to identify recurring patterns and themes across the included studies. Although AI tools were used during the identification stage, all data extraction, analysis, and interpretation were conducted manually to ensure analytical rigour and academic integrity.

The study selection process followed the PRISMA 2020 guidelines to ensure transparency and replicability. The identification, screening, eligibility, and inclusion stages are summarised in the PRISMA flow diagram (Figure 1).

2.6 Included Studies

A total of 20 articles met all inclusion criteria and were selected for thematic synthesis and analysis. The study selection process is illustrated in Figure 1 based on the PRISMA 2020 guidelines.

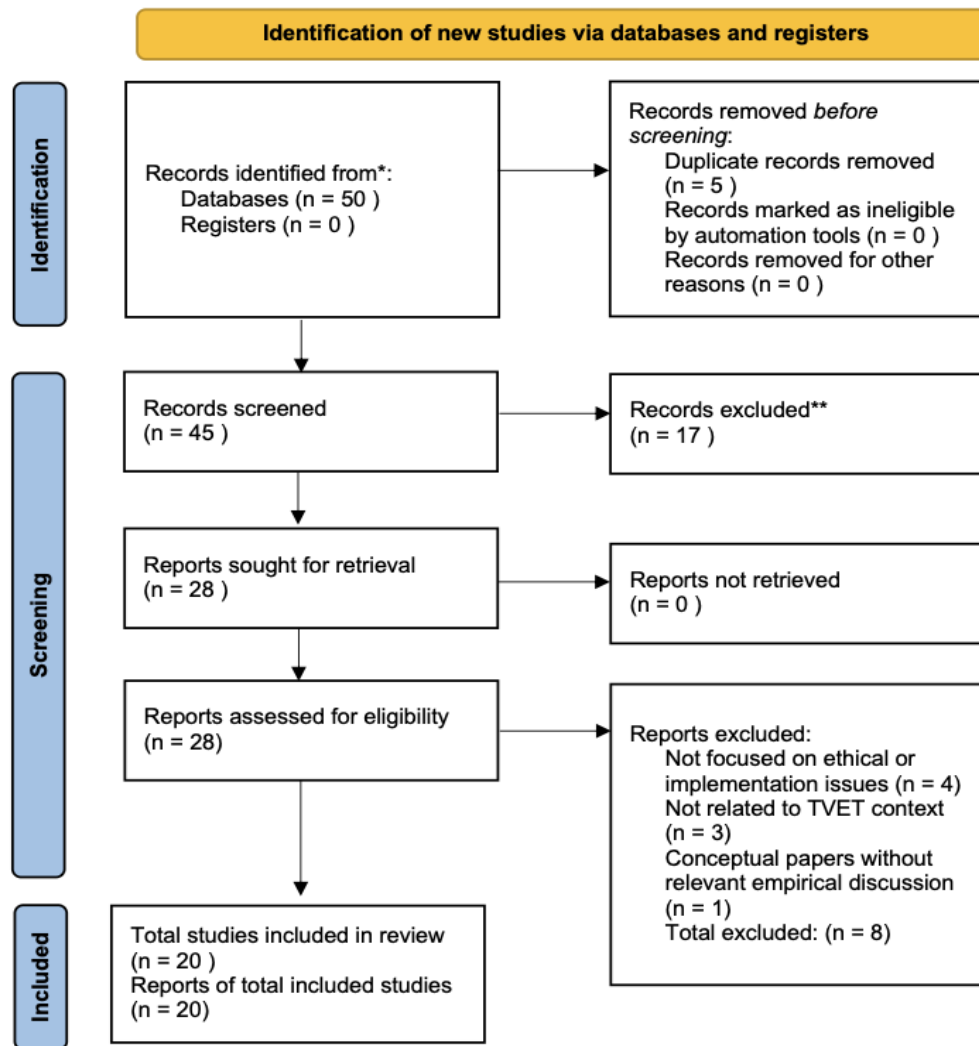


Fig. 1. PRISMA 2020 flow diagram – Scopus database

Table 2 presents the search keywords used in the systematic literature review to ensure comprehensive coverage of studies related to artificial intelligence, TVET education, ethical issues, and student competencies.

Database	Keywords
Scopus	Search keywords included combinations of “artificial intelligence,” “AI in education,” “TVET,” “technical and vocational education,” “ethics,” “implementation challenges,” and “student competencies.”

The use of broad and targeted keywords allowed for the identification of relevant and recent studies addressing both technological and ethical dimensions of AI integration in education.

3. Data Matrix of AI Studies Relevant to TVET and Higher Education Context (20 Articles)

NO	Title	Population / Sample	Method	AI tools / Focus	Key themes	Main findings
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1	Perceptions, challenges, and prospects: University professors' use of AI in education [1]	University professors	Survey / Qualitative	General AI	Perceptions, challenges, prospects	Positive views but face AI integration challenges
2	Impact of artificial intelligence in lifelong learning cyberogy: Islamic and Western perspectives [18].	Not specified	Literature review / Conceptual	AI in lifelong learning	Islamic & Western perspectives, AI impact	AI enhances lifelong learning but needs ethical guidance
3	Experience and challenges of UKM lecturers using AI as teaching support [13]	6 lecturers	Qualitative, semi-structured interviews	Generative AI	Educators' experience, teaching enhancement, challenges	AI improves teaching efficiency, creativity, student engagement
4	Navigating ethical dilemmas in the implementation of AI-driven educational technologies [8]	Systematic literature review	SLR	AI-driven educational technologies	Ethics, fairness, transparency	Main ethical dilemmas identified
5	Artificial intelligence in education: Ethical considerations and insights from ancient Greek philosophy [10]	Not applicable	Conceptual / Philosophical analysis	General AI	Ethics, philosophical lens	Ethics informed by ancient philosophy
6	Ethical challenges associated with the use of AI in university education [11]	University educators / students	Literature review	AI in higher education	Ethics, implementation challenges	AI adoption poses ethical challenges
7	Artificial intelligence in higher education institutions: review of innovations, opportunities and challenges [12]	Literature / HE institutions	SLR	AI in higher education	Innovations, opportunities, challenges	AI adoption supports innovation
8	Trends and Security Challenges of AI Use in Higher Education: A Systematic Review [20]	Literature (32 articles)	Systematic review	AI in higher education	Security, ethics, stakeholder perception	Highlighted ethical and security challenges
9	A comprehensive AI policy education framework for university teaching and learning [3]	Survey respondents	Mixed-methods	Generative AI / policy	Policy, pedagogy, governance	Developed AI Ecological Education Policy Framework
10	Navigating the Ethical Challenges of AI in Higher Education: An Analysis of Seven Global AI Ethics Policies [16]	7 AI ethics policies	Discourse analysis	AI policy / ethics	Ethical challenges, bias, human displacement	Responsible AI deployment necessary

11	Considerations for Adapting HE Technology Courses for AI Large Language Models: A Critical Review of ChatGPT [19]	Case studies	Critical review	ChatGPT / LLMs	Impact on learning, teaching, ethics	ChatGPT offers benefits but presents challenges
12	AI ethics as a complex and multifaceted challenge: Decoding educators' AI ethics alignment [9]	37 educators	Qualitative: metaphor elicitation + semi-structured interviews	AI ethics	Educators' beliefs, ethics alignment	Diverse and inconsistent ethical perspectives
13	The Ethics of Artificial Intelligence in Education [6]	Not applicable	Theoretical / Conceptual framework	AI in education	Socio-cultural bias, fairness, digital divide	Highlighted moral dilemmas, bias, equity concerns
14	Impact of AI in TVET and STEM Education among Higher Learning Students in Malaysia [2]	10 students	Qualitative, semi-structured interviews	AI in TVET/STEM	Learning, performance, career preparedness	AI enhances learning efficiency and critical thinking
15	Navigating AI Integration in Career and Technical Education: Diffusion Challenges, Opportunities, Decisions [17]	Literature / educators	Literature review, Diffusion of Innovations theory	AI in CTE	Adoption challenges, opportunities, systemic barriers	AI adoption hindered by infrastructure
16	The role of AI in transforming education: A systematic review of trends [14]	Literature review	Systematic review	AI in higher education	AI applications, benefits, challenges	AI transforming teaching, learning, admin processes
17	Integration of AI technologies into the digital transformation of professional HE in technical fields [5]	Literature / institutions	Literature review / conceptual	AI technologies	Digital transformation, AI adoption	AI adoption supports digital transformation
18	Adaptive learning systems in higher education: Challenges, trends, outcomes [4]	Literature review / case studies	Review / Empirical	Adaptive learning / AI	Learning personalization, outcomes	Adaptive learning enhances personalized learning & competency
19	Artificial intelligence in TVET: Empirical evidence, implementation challenges, future directions [23]	Literature review + case studies	Literature review / Empirical synthesis	AI in TVET	Implementation challenges, benefits	AI supports learning and skill development
20	Added new adaptive AI learning focus – Čep, Bernik & Tomicic, 2025 (same as 18 for Theme 3 emphasis) [4]	Literature review / Empirical	Review / Empirical	Adaptive learning / AI	Personalized learning, competency improvement	AI adaptive learning improves student competency

4. Results

4.1 Ethical Issues of AI Use in TVET Teaching

The findings indicate that ethical issues are among the primary concerns in AI implementation in education. Studies by Marín *et al.*, [11] and Kamali *et al.*, [9] emphasize that algorithmic bias and student data privacy can affect learning equity if not properly managed. Additionally, Holmes and Porayska-Pomsta [6] highlighted the need for a clear ethical framework to ensure AI use does not undermine student autonomy or the role of educators.

In the TVET context, these ethical issues are more complex because student data often involve practical skill assessments and individual performance. If AI systems are not designed transparently and fairly, they may provide biased evaluations for students. Although several studies were conducted in higher education contexts, their findings are considered transferable to TVET due to similarities in competency-based assessment and digital learning environments. To further elaborate on the ethical dimensions of AI integration in TVET teaching, Table 3 summarises the key ethical issues, research focus, and recommendations reported in the selected studies.

Table 3

Summary of ethical issues of AI use in TVET teaching

No	Author(s) & Year	Study Focus	Method	Key Findings / Challenges / Recommendations
1	Abdelaal and Al Sawi, 2024	Lecturer perceptions	Survey / Qualitative	Positive views but ethical challenges & lack of training
2	Surtahman <i>et al.</i> , 2025	AI in lifelong learning	Literature review / Conceptual	Need for ethical guidance & cultural considerations
3	Pitchan and Azmi, 2025	UKM lecturers' experience	Interview Qualitative	/ AI assists teaching but risk of plagiarism
4	Ismail <i>et al.</i> , 2025	Ethics of AI-driven tech	SLR	Data privacy, bias, reduced human interaction
5	Karpouzis, 2024	AI ethics from Greek philosophy	Conceptual	Integration of philosophy into AI ethics policy
6	Marín <i>et al.</i> , 2025	AI ethical challenges	Literature review	Bias, fairness, accountability
7	Tucak-Roguljić and Đurđević Babić, 2025	Security & ethical challenges	SLR	Highlighted ethical & security issues
8	Slimi <i>et al.</i> , 2023	Analysis of global AI ethics policies	Discourse analysis	Algorithmic bias, human displacement
9	Kamali <i>et al.</i> , 2024	Educators' alignment ethics	Semi-structured interviews	Diverse perspectives; ethical need professional development

10	Holmes and Pomsta, 2022	Porayska- AI moral dilemmas	Conceptual Theoretical	/	Ethical required	framework
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Collectively, the studies emphasise that data privacy, algorithmic bias, and the preservation of human-centred values remain central ethical considerations in AI-supported TVET education.

4.1 Challenges of AI Implementation in TVET Teaching

Besides ethical concerns, AI implementation in TVET faces various practical challenges. Studies by Pitchan and Azmi [13] and Abdelaal and Al Sawi [1] found that educator readiness is a major challenge, particularly in terms of technological skills and understanding AI integration in pedagogy. Other studies highlighted challenges related to technology infrastructure, data security, and implementation costs, especially in TVET institutions with limited resources. These constraints can hinder the effective use of AI unless supported by institutional policies and continuous professional development.

Although several studies were conducted in higher education contexts, their findings are considered transferable to TVET due to similarities in competency-based assessment and digital learning environments. Table 4 outlines the primary challenges associated with the implementation of artificial intelligence in TVET teaching and learning, as reported in the reviewed literature.

Table 4
Challenges of AI implementation in TVET teaching

No	Author(s) & Year	Study Focus	Method	Key Findings / Challenges / Recommendations
1	Abdelaal and Al Sawi, 2024	Lecturer perceptions	Survey / Qualitative	Technology barriers, lack of training
2	Pitchan and Azmi, 2025	UKM lecturers' experience	Interview / Qualitative	Lack of policy, low educator readiness
3	Amdan <i>et al.</i> , 2025	AI in TVET Malaysia	Semi-structured interviews	Need for ethical management & skill enhancement
4	Sun and Pratt, 2024	AI in CTE	Literature review	Cost, access, curriculum alignment challenges
5	Chan, 2023	AI policy framework	Mixed-methods	Need for policy adoption & pedagogical framework
6	Tayan <i>et al.</i> , 2024	ChatGPT LLM	Critical review / Case study	Academic integrity & understanding challenges
7	Dmytruk <i>et al.</i> , 2025	Digital transformation HE	Literature review / Conceptual	Training, adoption barriers, institutional guidance needed
8	Čep <i>et al.</i> , 2025	Adaptive learning	Literature review	Technical barriers, limited empirical evidence
9	Zary and Zary, 2025	AI in TVET	Literature review + Case studies	Adoption barriers, training, ethics
10	Ocen <i>et al.</i> , 2025	AI innovations in HE	SLR	Infrastructure, resource distribution, systemic barriers

The challenges identified suggest that limitations in educator readiness, infrastructure, and institutional policy frameworks continue to constrain the effective adoption of AI in TVET contexts.

4.2 AI Potential in Enhancing TVET Student Competency

Despite these challenges, the findings show that AI has significant potential to enhance TVET student competencies. Empirical studies by Amdan *et al.*, [2] and Zary and Zary [23] indicate that AI use can improve technical skills, self-directed learning, and student motivation. The SLR findings based on Elicit indicate measurable improvements in student academic performance, critical thinking, and self-directed learning following AI interventions, as reported in selected empirical studies [2,23]. Although several studies were conducted in higher education contexts, their findings are considered transferable to TVET due to similarities in competency-based assessment and digital learning environments. To examine the potential contribution of artificial intelligence to student competency development, Table 5 summarises the reported impacts of AI integration on learning outcomes in TVET education.

Table 5

AI potential in enhancing TVET student competency

No	Author(s) & Year	Study Focus	Method	Key Findings / Challenges / Recommendations
1	Abdelaal and Al Sawi, 2024	Lecturer perceptions	Survey / Qualitative	AI assists teaching, potential learning enhancement
2	Pitchan and Azmi, 2025	UKM lecturers' experience	Interview / Qualitative	AI enhances creativity & student engagement
3	Amdan <i>et al.</i> , 2025	AI in TVET Malaysia	Semi-structured interviews	AI improves technical skills & self-directed learning
4	Zary and Zary, 2025	AI in TVET	Literature review + Case studies	AI supports skill development, high potential
5	Tayan <i>et al.</i> , 2024	ChatGPT LLM	Critical review / Case study	AI provides new learning opportunities & pedagogical adaptation
6	Dmytruk <i>et al.</i> , 2025	Digital transformation HE	Literature review / Conceptual	AI supports digital transformation, competency improvement
7	Čep <i>et al.</i> , 2025	Adaptive learning	Review / Empirical	AI adaptive learning impacts personalized learning & student competency
8	Sun and Pratt, 2024	AI in CTE	Literature review	AI enables learning personalization opportunities

Overall, the findings indicate that AI-supported learning environments have the potential to enhance technical skills, self-directed learning, and student engagement when aligned with competency-based curricula.

5. Discussion

This systematic literature review synthesises evidence from twenty selected studies on the integration of artificial intelligence (AI) in education, with particular emphasis on Technical and Vocational Education and Training (TVET) contexts and relevant higher education settings. The discussion is structured around the three research questions guiding this review, namely ethical issues, implementation challenges, and the contribution of AI towards enhancing student competencies. Synthesising the three thematic findings AI presents substantial opportunities to improve teaching and learning processes in TVET, its effective adoption remains constrained by ethical, pedagogical, and institutional factors that require careful consideration.

5.1 Ethical Issues in AI Integration within TVET Education

In addressing Research Question 1, the review demonstrates that ethical concerns are consistently highlighted across the literature as a central issue in AI integration. Data privacy and algorithmic bias emerge as the most frequently reported ethical risks. Studies by Marín *et al.*, [11], Ismail *et al.*, [8], and Kamali *et al.*, [9] caution that the collection, storage, and analysis of student data through AI-driven systems may expose learners to privacy breaches and unfair profiling if governance mechanisms are weak. These concerns are particularly pronounced in TVET settings, where learner data often include detailed records of practical performance, skills mastery, and competency-based assessments.

Furthermore, algorithmic bias remains a critical ethical challenge. Holmes and Porayska-Pomsta [6] argue that AI systems trained on incomplete or non-representative datasets may inadvertently reinforce existing inequalities, thereby affecting assessment fairness and learner progression. Within TVET education, such bias may have long-term consequences, as assessment outcomes are closely linked to certification, employability, and career pathways. This finding aligns with Slimi *et al.*, [16], who emphasise that ethical AI deployment must prioritise fairness, transparency, and accountability to prevent marginalisation of certain learner groups.

Beyond technical concerns, several conceptual studies stress the importance of maintaining human-centred values in AI-enhanced education. Karpouzis [10] and Surtahman *et al.*, [18] highlight that ethical considerations should be informed not only by technological standards but also by philosophical, cultural, and moral perspectives. In the context of TVET, where mentorship, apprenticeship, and instructor guidance play a crucial role, excessive reliance on AI may risk reducing meaningful human interaction and learner autonomy. Therefore, ethical AI integration in TVET must ensure that technology supports, rather than replaces, the pedagogical role of educators.

5.2 Implementation Challenges of AI in TVET Teaching and Learning

In relation to Research Question 2, the findings reveal that multiple implementation challenges hinder the effective integration of AI within TVET institutions. Educator readiness consistently emerges as one of the most significant barriers. Empirical studies by Pitchan and Azmi [13] and Abdelaal and Al Sawi [1] indicate that many educators possess limited knowledge and confidence in using AI tools for pedagogical purposes. This lack of readiness extends beyond technical skills to include limited understanding of ethical implications, assessment validity, and curriculum alignment.

Infrastructure and resource constraints further exacerbate these challenges. Studies by Sun and Pratt [17] and Ocen *et al.*, [12] highlight that uneven access to digital infrastructure, high implementation costs, and limited technical support restrict AI adoption, particularly in institutions with constrained funding. These issues are especially relevant in TVET contexts within developing and middle-income countries, including Malaysia, where institutional readiness varies significantly across regions and institutions.

In addition, the rapid diffusion of generative AI tools, such as large language models, introduces new challenges related to academic integrity and assessment practices. Tayan *et al.*, [19] caution that without clear institutional policies, AI-assisted learning may blur the boundaries between legitimate learning support and academic misconduct. This challenge is amplified in TVET education, where competency-based assessment relies heavily on authentic demonstrations of skill proficiency. As such, institutions must establish clear governance frameworks, assessment guidelines, and professional development programmes to support responsible AI use.

5.3 AI Potential in Enhancing TVET Student Competencies

Despite the ethical and implementation challenges identified, the findings addressing Research Question 3 indicate that AI holds considerable potential to enhance student competencies in TVET education. Empirical evidence from studies such as Amdan *et al.*, [2] and Zary and Zary [23] demonstrates that AI-supported learning environments can improve technical skills, self-directed learning, student motivation, and critical thinking. These outcomes are particularly relevant to TVET, where the development of job-ready competencies is a primary educational objective.

Adaptive learning systems receive particular attention in the reviewed literature. Čep *et al.*, [4] report that AI-driven adaptive platforms enable personalised learning pathways that accommodate diverse learner abilities and learning speeds. This is highly beneficial in TVET contexts, which often comprise heterogeneous student populations with varied academic backgrounds and skill levels. By supporting personalised learning, AI can enhance competency development while reducing learner disengagement.

However, the review also suggests that the effectiveness of AI in enhancing student competencies is contingent upon strategic alignment with curriculum objectives and industry needs. Studies emphasise that AI tools must be integrated purposefully within competency-based frameworks rather than used as standalone technological solutions. This finding reinforces the argument that AI adoption should be guided by pedagogical intent and industry relevance to ensure meaningful learning outcomes.

5.4 Towards a Balanced and Ethical AI Integration Framework for TVET

Synthesising the three thematic findings, this review suggests that successful AI integration in TVET education requires a balanced approach that simultaneously addresses ethical governance, educator readiness, and institutional capacity. Ethical frameworks must be embedded within AI policies to safeguard data privacy, fairness, and transparency. At the same time, continuous professional development is essential to equip educators with both technical and ethical competencies necessary for AI-enhanced teaching.

Moreover, maintaining a balanced human–AI relationship is crucial in TVET education. Given the hands-on and practice-oriented nature of TVET programmes, AI should function as a supportive tool that enhances instruction and assessment rather than replacing instructor judgement and

mentorship. This balance is vital to preserving the integrity of competency-based assessment and ensuring that graduates possess both technical proficiency and professional values.

Overall, the discussion highlights that while AI offers transformative opportunities for TVET education, its benefits can only be realised through thoughtful, ethical, and context-sensitive implementation. Without robust governance structures and institutional support, the risks associated with AI adoption may outweigh its potential advantages. These insights provide a foundation for the conclusions and recommendations presented in the following section.

6. Conclusion

This systematic review synthesises evidence from twenty studies on the integration of artificial intelligence (AI) in higher education, with particular emphasis on Technical and Vocational Education and Training (TVET) contexts, revealing both its transformative potential and the challenges associated with its adoption. While AI demonstrates significant capacity to enhance student competency development through personalised learning, increased engagement, and the strengthening of cognitive and technical skills particularly when adaptive and generative AI tools are aligned with curriculum and industry needs its effective implementation remains constrained by ethical concerns related to data privacy, fairness, transparency, and reduced human interaction, as well as practical challenges such as limited infrastructure, insufficient educator training, academic integrity issues, and uneven institutional readiness. These findings indicate that successful and sustainable AI integration in TVET education requires more than technological readiness, necessitating robust ethical frameworks, clear governance structures, continuous professional development for educators, and collaborative policy alignment among institutions, policymakers, and industry stakeholders. However, this review is limited by its reliance on Scopus indexed studies published between 2022 and 2025 and the partial transferability of findings from broader higher education contexts to TVET settings, highlighting the need for future research to expand database coverage, prioritise empirical TVET-focused studies, and adopt meta-analytical approaches to strengthen the generalisability and integrity of research on AI in education. Collectively, the findings discussed in this review highlight that the integration of artificial intelligence in TVET education presents both significant opportunities and complex challenges that must be

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Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this paper.

Data Availability Statement

All data generated or analyzed during this study are included in this published article. Additional datasets are available from the corresponding author upon reasonable request.

Ethics Statement

This study was conducted in accordance with the ethical standards of the institutional and/or national research committee.

References

- [1] Abdelaal, Nouredin Mohamed, and Islam Al Sawi. "Perceptions, Challenges, and Prospects: University Professors' Use of Artificial Intelligence in Education." *Australian Journal of Applied Linguistics* 7, no. 1 (2024): n1. <https://doi.org/10.29140/ajal.v7n1.1309>
- [2] Amdan, Mohammad Aniq Bin, Naldo Janius, Mohd Safwan Bin Saidin, and Mohamad Aidil Hazidi Bin Kasdiah. "Impact of artificial intelligence in TVET and STEM education among higher learning students in Malaysia." *Journal of Research in Mathematics, Science, and Technology Education* 2, no. 1 (2025): 1-14. <https://doi.org/10.70232/jrmste.v2i1.15>
- [3] Chan, Cecilia Ka Yuk. "A comprehensive AI policy education framework for university teaching and learning." *International journal of educational technology in higher education* 20, no. 1 (2023): 38. <https://doi.org/10.1186/s41239-023-00408-3>
- [4] Čep, Andrej, Andrija Bernik, and Igor Tomičić. "Adaptive Learning Systems in Higher Education: Challenges, Trends, and Outcomes." In *Proceedings of the Future Technologies Conference*, pp. 1-17. Springer, Cham, 2026. https://doi.org/10.1007/978-3-032-07992-3_1
- [5] Dmytruk, O., Kovalchuk, V., & Pavlenko, O. (2025). Integration of artificial intelligence technologies into the digital transformation of professional higher education in technical fields. *Education Sciences*, 15(1), Article 48. <https://doi.org/10.3390/educsci15010048>
- [6] Holmes, W., & Porayska-Pomsta, K. (2022). *The ethics of artificial intelligence in education: Practices, challenges, and debates*. Routledge. <https://doi.org/10.4324/9780429329067>
- [7] Ismail, Islam Asim. "Protecting privacy in ai-enhanced education: A comprehensive examination of data privacy concerns and solutions in ai-based learning." *Impacts of Generative AI on the Future of Research and Education* (2025): 117-142. <https://doi.org/10.4018/979-8-3693-0884-4.ch006>
- [8] Ismail, Muhusina, Nisha Thorakkattu Madathil, Meera Alalawi, Shamma Alalawi, and Saed Alrabaa. "Navigating Ethical Dilemmas in the Implementation of AI-Driven Educational Technologies." In *2025 IEEE Global Engineering Education Conference (EDUCON)*, pp. 1-5. IEEE, 2025. <https://doi.org/10.1109/EDUCON62633.2025.11016612>
- [9] Kamali, Jaber, Muhammet Furkan Alpat, and Aras Bozkurt. "AI ethics as a complex and multifaceted challenge: decoding educators' AI ethics alignment through the lens of activity theory." *International Journal of Educational Technology in Higher Education* 21, no. 1 (2024): 62. <https://doi.org/10.1186/s41239-024-00496-9>
- [10] Karpouzis, Kostas. "Artificial intelligence in education: Ethical considerations and insights from Ancient Greek philosophy." In *Proceedings of the 13th Hellenic Conference on Artificial Intelligence*, pp. 1-7. 2024. <https://doi.org/10.1145/3688671.3688772>
- [11] Marín, Yuri Reina, Omer Cruz Caro, Angelica María Carrasco Rituay, Katia Araceli Guimac Llanos, Doris Tarrillo Perez, Einstein Sánchez Bardales, Judith Nathaly Alva Tuesta, and River Chávez Santos. "Ethical challenges associated with the use of artificial intelligence in university education." *Journal of Academic Ethics* 23, no. 4 (2025): 2443-2467. <https://doi.org/10.1007/s10805-025-09660-w>
- [12] Ocen, Samuel, Joseph Elasu, Sylvia Manjeri Aarakit, and Charles Olupot. "Artificial intelligence in higher education institutions: Review of innovations, opportunities and challenges." In *Frontiers in Education*, vol. 10, p. 1530247. Frontiers Media SA, 2025. <https://doi.org/10.3389/feduc.2025.1530247>
- [13] Pitchan, M. A., & Azmi, S. (2025). Pengalaman dan cabaran pensyarah Universiti Kebangsaan Malaysia menggunakan kecerdasan buatan sebagai sokongan pengajaran dan pembelajaran. *Jurnal Komunikasi: Malaysian Journal of Communication*, 41(3), 313–329. <https://doi.org/10.17576/JKMJC-2025-4103-17>
- [14] Ratul, Q. E. A., Zaman, E., Das, S., & Memari, M. (2025). The role of artificial intelligence in transforming education: A systematic review of trends. In *Proceedings of the IEEE Global Engineering Education Conference (EDUCON 2025)* (pp. 1–6). IEEE. <https://doi.org/10.1109/IETC64455.2025.11039329>
- [15] Sellnow, Deanna D. "Reflection-AI: exploring the challenges and opportunities of artificial intelligence in higher education." *Frontiers in Communication* 10 (2025): 1615040. <https://doi.org/10.3389/fcomm.2025.1615040>
- [16] Slimi, Zouhaier, and Beatriz Villarejo Carballido. "Navigating the Ethical Challenges of Artificial Intelligence in Higher Education: An Analysis of Seven Global AI Ethics Policies." *TEM journal* 12, no. 2 (2023). <https://doi.org/10.18421/TEM122-02>
- [17] Sun, Jeffrey C., and Taylor L. Pratt. "Navigating AI integration in career and technical education: Diffusion challenges, opportunities, and decisions." *Education Sciences* 14, no. 12 (2024): 1285. <https://doi.org/10.3390/educsci14121285>
- [18] Saja, Ijlal, Siti Nurul Izza Hashim, Nurul Wardah Nazifah Razali, and Mohd Faizal P. Rameli. "Impak Kecerdasan Buatan (AI) dalam Sibergogi Pendidikan Sepanjang Hayat daripada Perspektif Islam dan Barat: The Impact of

- Artificial Intelligence (AI) in Lifelong Learning Cybergogy from Islamic and Western Perspectives." *Global Journal Al-Thaqafah* 15, no. 1 (2025): 189-208. <https://doi.org/10.7187/GJAT072025-12>
- [19] Tayan, Omar, Ali Hassan, Khaled Khankan, and Sanaa Askool. "Considerations for adapting higher education technology courses for AI large language models: A critical review of the impact of ChatGPT." *Machine Learning with Applications* 15 (2024): 100513. <https://doi.org/10.1016/j.mlwa.2023.100513>
- [20] Tucak-Roguljić, Ivana, and I. Đurđević Babić. "Trends and Security Challenges of Artificial Intelligence Use in Higher Education: A Systematic Review." In *2025 MIPRO 48th ICT and Electronics Convention*, pp. 479-483. IEEE, 2025. <https://doi.org/10.1109/MIPRO65660.2025.11131824>
- [21] UNESCO. (2025). *Artificial intelligence in education: Potential to address educational challenges and accelerate progress towards SDG 4*. UNESCO.
- [22] United Nations. (2023). *Sustainable Development Goal 4: Quality education—Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all*. United Nations.
- [23] Zary, Adam, and Nabil Zary. "Artificial intelligence in technical and vocational education and training: Empirical evidence, implementation challenges, and future directions." (2025). <https://doi.org/10.20944/preprints202504.2173.v1>