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AI in Technical and Vocational Education: A Comprehensive Mini Review

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Abstract

Artificial Intelligence (AI), as a phenomenon in education, is progressively considered as a revitalizing power, but little has been said about its application in Technical and Vocational Education and Training (TVET) despite the mounting pressure on institutions to meet the needs of Industry 4.0. This mini review is a synthesis of existing evidence that investigates the use of AI in teaching and learning, workforce development, as well as curriculum design. Defined keywords were used to search the Scopus as well as Google Scholar (August 2025) literature; it included studies related to AI in vocational education settings and excluded the grey or non-English literature. The results show that AI can substantially contribute to workforce preparedness by analyzing predictive skills gaps, micro-credentialing, as well as industry-oriented curricula; to teaching and learning by supporting adaptive platforms, intelligent tutoring, and simulations; alongside redesigning curriculum through flexible and responsive paths in alignment with changing labor markets. However, it remains highly constrained by other factors such as, the digital divide, unequal institution readiness, ethical and data privacy, as well as lack of longitudinal evidence regarding the long-term impact. These issues of conflicting technological innovation and human-related mentoring as well as threats of overdependence on automation are also found in other discourses. AI must be applied to the future in a way that is ethically and policy sound, scalable and fair, as well as as a hybrid that does not replace human teachers. Its applications include AI-based analysis and certification, industry education collaboration, the notions of lifetime learning, inclusiveness, as well as moral responsibility. As mentioned in this review, one must focus on the issues that are yet to be resolved and make use of the opportunities that are available so that the TVET systems can be modified in a manner that would enable them to become equitable, flexible, as well as responsive to the needs of the new workforce.

Keywords: Artificial Intelligence, Technical and Vocational Education, Workforce Development, Curriculum Design, Teaching and Learning

Introduction

Artificial Intelligence (AI) has become one of the most revolutionary technologies of the 21st century that has changed economies, industries, as well as educational systems globally. In this regard, Technical and Vocational Education and Training (TVET) must provide people with the ability to work and to achieve sustainable development (Aljohani et al., 2022; Liu et al., 2022; Tuli et al., 2022). In particular, the decision to implement AI in TVET is particularly timely because vocational education organizations are currently forced to cope with the increasing pressure to re-design their coursework to suit the needs of Industry 4.0, as well as with the rapidly expanding labor market (Omar et al., 2023). Employing AI systems, such as intelligent tutoring technologies, intelligent learning platforms, predictive analytics, as well as others, can help to improve personalized learning, quality of training, and increase employability preparedness (Jemetz and Motschnig, 2024; Liu et al., 2022; Matsunaga and Miyata, 2024). Although there is an increasing interest, the application of AI in TVET is underutilized relative to its application in general education as well as higher education. Our knowledge regarding the relevance of AI-based solutions in the workplace, the possibility to apply it in various socio-economic conditions as well as impact the competencies certifying the corresponding skill and labor market remains to be incredibly large (Muchira et al., 2023). Furthermore, the literature is split, some researchers assume that AI would contribute to the democratization of the access to high-quality vocational training, on the other hand, there are those who fear that the humanization of learning is going to be reduced, the digital divide will become even greater, alongside inequities will continue to increase due to the dependence on some technologies. It also does not address ethical considerations, information privacy, whether TVET institutions, particularly in third world countries, desire to be run on this scale, and so on (Hearn et al., 2023). The main focus of the mini review is to present an overall picture of the current situation in the field of AI in TVET and answer these unanswered questions and identify the opportunities and limitations. The review includes four thematic areas: (i) applications of AI in the teaching and learning process, (ii) AI-enabling assessment and certification, (iii) AI in bridging training to workforce demands, as well as (iv) risks, barriers, and ethical considerations (Mahesh, 2025; Mittoor and Putteti, 2025; Regula, 2025). Together with the new results, this review shows that AI can help make vocational learning more responsive and industry-responsive, but its deployment will need infrastructure, a policy-enabling environment, as well as human capabilities. Ultimately, this mini-review offers insights not only for researchers in education and technology but also for policymakers and practitioners seeking to modernize vocational training for a digital and inclusive future (Gangoda et al., 2023; Mittoor & Putteti, 2025).

Objective

This mini-review aims to:-

Provide a comprehensive overview of AI applications in TVET

Identify existing gaps, and highlight both opportunities and challenges.

This study offers insights for researchers, policymakers, and practitioners seeking to modernize TVET systems in a digital and inclusive era.

Methods

A comprehensive literature search was conducted using Scopus, Google Scholar. Keywords such as ("artificial intelligence" OR "ai" OR "machine learning" OR "deep learning") AND ("technical education" OR "vocational education" OR "career training" OR "skills development") AND ("e-learning" OR "online learning" OR "distance education" OR "digital education") AND ("curriculum" OR "instruction" OR "teaching" OR "training") AND ("assessment" OR "evaluation" OR "feedback" OR "performance") AND ("student engagement" OR "motivation" OR "learning outcomes" OR "success").

Date of searched : 25 August 2025

Inclusive Criteria

- Studies discussing AI's role in workforce development, teaching and learning, and curriculum design within TVET contexts.
- Studies focusing on the application of AI tools (e.g., ChatGPT, intelligent tutoring systems, predictive analytics, generative AI) in vocational and technical education.
- Studies analyzing the strengths (personalization, efficiency, workforce alignment), limitations (equity gaps, ethical concerns, technological dependency), and potential applications (adaptive curricula, skills gap analysis, job-matching, immersive simulations) of AI in TVET.
- Studies published in English.

Exclusion Criteria

- Studies published in languages other than English.
- Studies addressing vocational education or workforce development without explicit reference to Artificial Intelligence or related technologies.
- Grey literature such as conference abstracts, dissertations, and unpublished reports, to ensure quality and reliability.

Discussion and Result

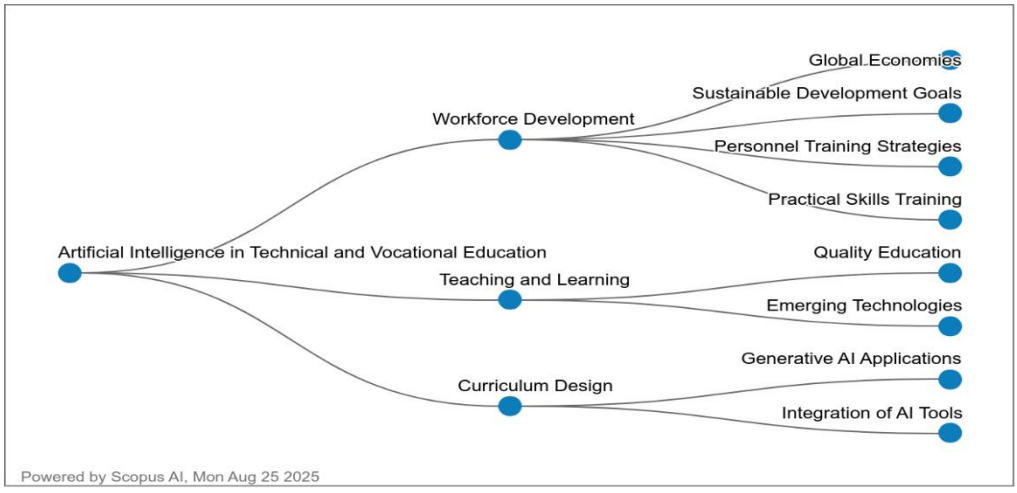

Figure 1 AI in Technical and Vocational Education generated by scopus AI Analyzer

Workforce development in education has become increasingly vital in preparing learners for dynamic global economies, addressing both labor market demands and broader social objectives. Its relevance is underscored by links to the Sustainable Development Goals (SDGs), particularly those promoting quality education, decent work, and reduced inequalities, as well as the need to integrate digital and green skills for sustainable industries (Richter et al., 2025). Current strategies emphasize competency-based curricula, apprenticeships, and lifelong learning, which enhance employability and industry alignment but raise debates over balancing job-specific training with transferable skills and civic education (Keawtavon et al., 2023; Kimura et al., 2022; Renganayagalu et al., 2021; Yamauchi et al., 2023). Practical skills training demonstrates clear benefits in improving workforce readiness, yet longitudinal evidence on its long-term adaptability remains limited. The rise of key technologies including artificial intelligence, big data, and immersive simulations has expanded opportunities for personalized learning and predictive skills gap analysis, though concerns over digital divides, data privacy, and technological dependency persist (Husain et al., 2020; Mian et al., 2020). Practical applications, such as industry partnerships, micro-credentialing, and public–private collaborations, have shown promise in improving workforce readiness, though scalability and sustainability remain challenges, especially in low-resource contexts (Selwyn et al., 2025). As a whole, the literature shows that workforce development bolsters national competitiveness as well as employability, but there has been a gap and inconsistencies in need of inclusivity, ground ethical, and scalable approaches (De Masi et al., 2025). Future research should focus on evaluating long-term outcomes, embedding sustainability in training models, and developing policies that ensure equitable access to workforce-oriented education globally.

Current status of Artificial Intelligence in Technical and Vocational Education based on teaching and learning

Artificial Intelligence (AI) is increasingly shaping teaching and learning in Technical and Vocational Education and Training (TVET), offering new opportunities to enhance quality education and leverage emerging technologies for workforce readiness. In terms of quality education, AI supports adaptive learning, intelligent tutoring, and predictive analytics that personalize instruction and improve assessment, though debates continue over whether such tools risk diminishing the human-centered mentoring essential to vocational learning (Adarkwah, 2025). While AI can democratize access, unequal infrastructure and digital divides threaten to widen disparities across institutions and regions. At the same time, AI's convergence with emerging technologies such as big data analytics, virtual and augmented reality, and the Internet of Things enables immersive simulations, real-time skills gap analysis, and smarter job-matching systems, strengthening the connection between training and labor markets (Creely & Blannin, 2025). However, challenges related to ethical use, data privacy, and the scalability of advanced tools in resource-constrained contexts remain unresolved, and gaps persist in longitudinal research assessing the sustained impacts of AI in vocational education (El Khayati et al., 2025). Collectively, current evidence suggests that AI has the potential to modernize TVET and prepare learners for Industry 4.0, but future research must prioritize equitable access, robust policy frameworks, and hybrid teaching models that balance technological innovation with human-centered learning (Montalbo, 2022; Othman et al., 2022; Rodzalan et al., 2022).

Current status of Artificial Intelligence in Technical and Vocational Education based on curriculum design

Artificial Intelligence (AI) is reshaping curriculum design in Technical and Vocational Education and Training (TVET), making learning more adaptive, relevant, and aligned with the demands of Industry 4.0 (Modiba, 2025). The latest developments revolve around the AI integration in the curriculum to help students develop flexible and skills-based careers that equip them to operate in dynamic labor markets. Applying generative AI to create content on demand, provide intelligent tutoring, as well as create adaptive assessment systems have proven to positively impact personalized learning experiences and distributed the instructors' workload, but it has also been noted that this technology raises several issues of academic integrity, excessive reliance on automation, along with the risk of losing human judgment in vocational training (Dahake et al., 2025; Faisal et al., 2025; Mohamad et al., 2024; Razia et al., 2023). Likewise, the curriculum can be responsive in the context of the introduction of the AI applications, i.e., simulation platforms, predictive analytics, while recommendation systems has progressed curriculum responsiveness by determining skills gaps, tailoring instruction, as well as bolstering connections between workplace needs and classroom training (Jaiswal et al., 2025). However, several issues persist in ensuring fair accessibility by Artificial Intelligence, data privacy, as well as application of AI in an ethical way in different learning environments. Current gaps include limited longitudinal evidence on the sustained impact of AI-driven curricula and insufficient exploration of how generative AI can balance innovation with inclusivity (Ahmed et al., 2025). Future research should focus on developing hybrid models where AI complements human educators, policy frameworks that regulate responsible integration, and context-sensitive strategies that ensure curriculum design remains learner-centered, ethical, and sustainable (Irish et al., 2025).

Results and Findings

Document by year generated by scopus

Figure 2 shows documents generated by Scopus. Output rises from 6 (2020) to 21 (2023), then peaks at 41 (2024) before a provisional decline to 18 (2025, likely partial-year). The field records a ~62% CAGR (2020–2024); 2024 almost doubles 2023 (+95% YoY) and contributes ~37% (41/111) of all items in the series clear evidence of a take-off phase. Early years (2020–2021) reflect exploratory work introducing AI for TVET; growth in 2022–2023 signals consolidation around applied studies (adaptive tutoring, predictive analytics for placement, automated assessment, competency tracking). The 2024 spike aligns with the mainstreaming of generative AI in education, rapid diffusion of LLM-enabled tools, and a wave of special issues/policy discussions on adoption, pedagogy, and ethics in skills training. The apparent 2025 dip (−56% vs. 2024) is still above 2022 levels and is plausibly explained by indexing lags/partial-year coverage rather than contraction. Implications for field maturity. AI-in-TVET has moved from emergence to early maturity: topic breadth widens (GenAI for simulation/digital twins, adaptive micro-credentials, OJT analytics; integrity, bias, and data-privacy safeguards), while methods shift toward comparative trials and real-world evaluations. We anticipate a normalization of volume post-2024 with greater emphasis on quality multi-site studies, longitudinal outcomes (employability/readiness), teacher upskilling, and cost-effectiveness marking a transition from enthusiasm to evidence-based implementation.

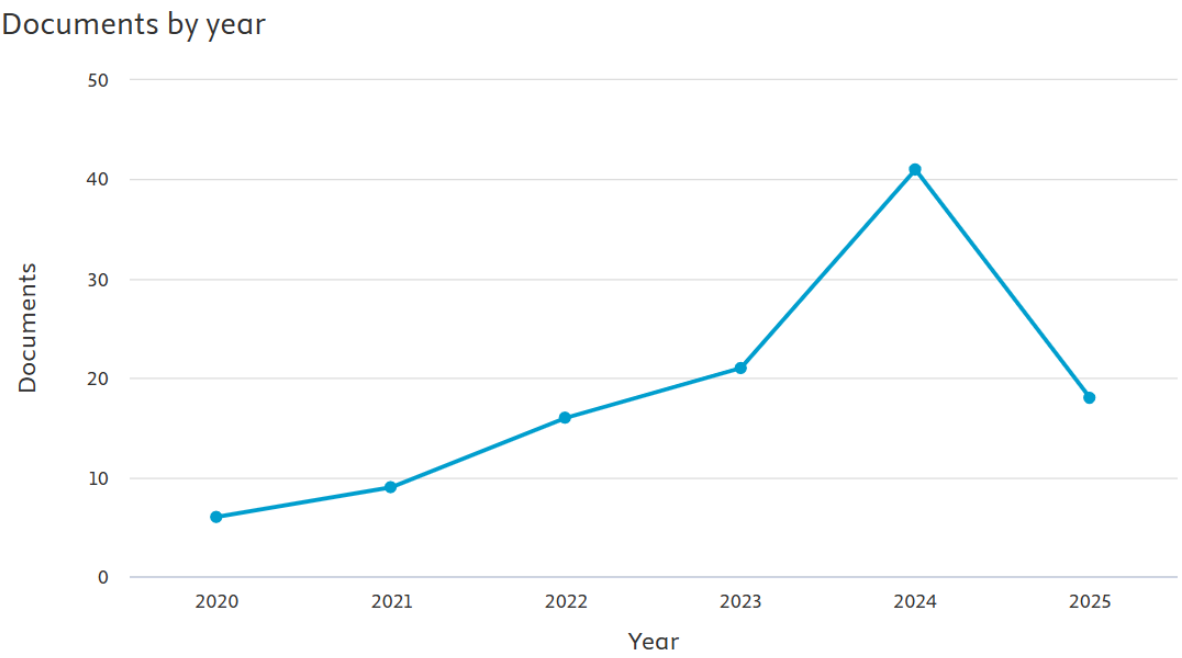

Figure 2 Document by year generated by scopus

Most recent research article journal on Artificial Intelligence in Technical and Vocational Education

The 2025 literature signals a mature pivot from "can AI help education?" to how systems, curricula, and workplaces operationalise GenAI. Policy pieces (Africa-wide outlook; China's AI–metaverse stance) and administrative adoption (records management) indicate system readiness the governance, data, and interoperability foundations that TVET needs for scalable implementation (e-portfolios/skills passports, secure assessment, audit trails). Pedagogical studies (constructivist integration, creative partnerships, scenario building) align naturally with competency-based TVET via task simulation, digital-twin labs, and AI-assisted feedback. Workforce-facing contributions (UK skills-gap analysis; GenAI pedagogy for work; adult-learning frameworks) sharpen the employability lens, underscoring micro-credentials co-designed with employers, predictive OJT matching, and authentic assessment tied to job tasks. However, the evidence base remains light on TVET-specific outcomes: most papers are policy, conceptual, or qualitative, with few multi-site trials quantifying competency mastery, placement quality, cost-effectiveness, or instructor upskilling. In short, 2025 research provides the scaffolding; TVET now needs rigorous, outcomes-driven studies that prove value at the workshop floor and workplace.

Table 1
Most recent research article journal on Artificial Intelligence in Technical and Vocational Education

Authors	Year	Contribution Area
Ahmed A.-B.; King B.D.; Hiran K.K.; Dadhich M.; Malcalm E.	2025	Trends, opportunities, challenges, and future directions of AI in education in Africa
Jaiswal K.; Kuzminykh I.; Modgil S.	2025	Understanding the skills gap between higher education and industry in the UK in artificial intelligence sector
Modiba M.	2025	Adoption of AI to enhance records management practices in South Africa's Department of Education
El Khayati M.; Courr A.; Kich I.; Hibbi F.-Z.	2025	Integration of AI into Morocco's high-school computer science curriculum
Creely E.; Blannin J.	2025	Creative partnerships with generative AI. Possibilities for education and beyond
Michael; Agyemang; Adarkwah	2025	GenAI-Infused Adult Learning in the Digital Era: A Conceptual Framework for Higher Education
Irish A.L.; Gazica M.W.; Becerra V.	2025	A qualitative descriptive analysis on generative artificial intelligence: bridging the gap in pedagogy to prepare students for the workplace
De Masi V.; Di Q.; Li S.; Song Y.	2025	China's AI and metaverse policies: implications for academic research
Selwyn N.; Kaviani F.; Strengers Y.; Dahlgren K.; Cumbo B.; Wagner M.	2025	Supporting students' construction of future school scenarios with AI
Richter S.; Giroux M.; Piven I.; Sima H.; Dodd P.	2025	Constructivist approaches to integrating AI into marketing education

Conclusion

This mini review highlights that Artificial Intelligence holds significant potential to transform Technical and Vocational Education and Training (TVET) by strengthening workforce development, enhancing teaching and learning, and reshaping curriculum design to meet the demands of Industry 4.0. Evidence suggests that AI can support competency-based training, adaptive instruction, and responsive curricula that better align with labor market needs, thereby improving employability and national competitiveness. However, critical limitations remain, including uneven infrastructure, digital divides, ethical concerns, and limited longitudinal evidence on the sustained impact of AI-driven solutions. Ongoing controversies also persist regarding the balance between technological innovation and human-centered learning, as well as the risks of over-reliance on automation in vocational training. Addressing these gaps requires future research that prioritizes equity, sustainability, and policy frameworks that enable responsible AI integration. Practical directions include the development of hybrid teaching models, scalable AI-enabled assessment tools, and stronger industry–education partnerships. Ultimately, capitalizing on the opportunities of AI in TVET depends on fostering inclusive, ethical, and context-sensitive approaches that ensure technology complements, rather than replaces, the vital human elements of vocational education.

Theoretical and Contextual Contributions

This study makes both theoretical and contextual contributions to the growing body of knowledge on Artificial Intelligence (AI) in Technical and Vocational Education and Training (TVET). From a theoretical perspective, the review extends existing frameworks of technology-enhanced learning by integrating AI within the specific context of competency-based and workforce-oriented education. It synthesizes fragmented literature into a structured understanding of how AI supports teaching and learning, workforce alignment, and curriculum innovation in TVET, thereby contributing to the conceptualization of AI as a catalyst for adaptive, industry-responsive education systems. Furthermore, the study highlights the need for hybrid pedagogical models that balance AI-driven automation with human-centered instruction, enriching theoretical discussions on the intersection between educational technology, employability, and skills development. On the other hand, contextual perspective, provides timely insights into the implementation of AI in TVET systems, particularly within emerging and resource-constrained environments where digital readiness and infrastructure remain uneven. It identifies critical challenges such as the digital divide, institutional capacity, and ethical considerations, offering a nuanced understanding of how AI adoption varies across socio-economic contexts. The findings are especially relevant for policymakers, educators, and practitioners seeking to modernize TVET systems in alignment with Industry 4.0 while ensuring inclusivity and sustainability. By bridging global AI trends with the practical realities of vocational education, this study contributes to the development of context-sensitive strategies that support equitable and scalable AI integration in TVET.

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