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Empowering Sustainable Futures: The Teacher-AI-Student Triadic Model in Vocational Education

Wong Siew Ping[1*], Zeng Xi[1,2]

[1]Faculty of Education and Liberal Studies, City University Malaysia, Selangor, Malaysia
[2]Department of Management and Grain and Oil, Guangxi Technology and Business Vocational College, Nanning, China

*Corresponding author: wong.siewping@city.edu.my; ORCID iD: 0000-0002-3096-3276

ABSTRACT

The Teacher–AI–Student Triadic Model is proposed as a conceptual framework for advancing sustainable and human-centred artificial intelligence (AI) integration in vocational education. Responding to the growing demand for work-ready and sustainability-oriented graduates, the model reconceptualises the roles of teachers, students, and AI systems within AI-enhanced learning environments. Developed through a conceptual research methodology, the model draws on an in-depth literature review and synthesises constructivist learning theory, social learning theory, and competency-based education. It emphasises dynamic interactions among teachers, AI, and students as central to fostering adaptive learning, ethical reasoning, and sustainable thinking. Within the triadic structure, teachers function as ethical mentors and learning architects, students as self-regulated and adaptive learners, and AI as an intelligent collaborator supporting personalised learning and formative assessment. The model illustrates potential applications in vocational contexts, including green technology simulations, virtual laboratories, AI-supported assessment, and sustainability-oriented entrepreneurship training. By embedding the Sustainable Development Goals as a core pedagogical capability rather than a peripheral objective, the model offers a vocationally specific, ethically grounded framework aligned with the transition toward Society 5.0. This study contributes a structured foundation for future empirical research, policy development, and responsible AI implementation in vocational education.

Keywords: vocational education; artificial intelligence in education; sustainability; human–AI collaboration; Society 5.0

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1.0 Introduction

Due to the urgent need to address social and economic injustice, resource depletion, and climate change on a global scale, sustainability has become the core focus of policy and practice in the 21st century. In this context, AI can serve as both a facilitator and a disruptor. AI has enormous potential in various markets, including education, in large part because it can examine extensive datasets, discover intricate patterns, and tailor interactions. Moreover, AI can help achieve the Sustainable Development Goals (SDGs) by improving access, efficiency, and learning opportunities (Miao et al., 2025; Vinuesa et al., 2019).

Vocational education and training (VET), an important economic element of our society for many years, is steadily becoming one of the rising components of improving the environment and human well-being. VET prepares students with practical skills to advance inclusive labour markets, eco-friendly industries, and robust economies. This also aligns with the opportunities for transformation and SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), and SDG 9 (Industry, Innovation, and Infrastructure) (UNESCO - UNEVOC, 2025).

AI-enhanced vocational training programs can change the learning environment. Devanaugh (2025), who incorporated AI into sustainable development projects, included vocational education topics such as eco-friendly manufacturing, precision agriculture, and smart energy systems. Although the advantages are limited by persistent issues with infrastructure and efficient human-machine collaborative design, Jaya et al. (2024) found that learning outcomes and teaching efficiency have greatly improved in Indonesia following the adoption of AI. Yusro et al. (2024) added that meaningful AI integration requires not just adaptive learning strategies but also deliberate curriculum restructuring and ethical protections to guarantee that critical soft skills like empathy and creativity are maintained.

Despite these promising advancements, many traditional vocational education models still struggle to keep pace with rapidly changing technologies, environmental sustainability, and labour market demands. This background led to the proposal of the Teacher-AI-Student Triad model in the current study, where human leadership, machine intelligence, and learner initiative are combined to cultivate capabilities for a sustainable future (Ari Alamäki et al., 2024) and the principles of Green VET (UNESCO - UNEVOC, 2025). The model depicts vocational education as a living system for lifelong learning, civic responsibilities, and adaptive resilience, and redesigns the roles of teachers and students in AI-assisted learning environments.

Unlike existing AI-in-education frameworks that primarily emphasise learner autonomy, technological efficiency, or teacher–AI complementarity, the Teacher–AI–Student Triadic Model offers a vocationally grounded, sustainability-oriented framework for AI-mediated learning. Its originality lies in three integrated contributions. First, the model positions the Sustainable Development Goals (SDGs) as a core pedagogical capability rather than a contextual add-on, embedding sustainability thinking directly into learning design, assessment, and competency development. Second, it redefines the role of teachers as ethical mediators and learning architects, responsible not only for instructional orchestration but also for guiding moral reasoning, social-emotional development, and responsible AI use. Third, the model is explicitly tailored to vocational education, aligning AI-supported learning with work-ready competencies while simultaneously cultivating sustainable mindsets and civic responsibility. Through this triadic interaction, the model advances a human-centred approach to AI integration that responds to the demands of Society 5.0 and sustainable workforce development.

2.0 Literature Review

2.1 Evolving Human–AI Collaboration

Artificial intelligence is increasingly well known for its ability to enhance vocational education with personalised learning, adaptive learning platforms, and instant feedback. AI can modify learners' learning paths based on their individual pace and enhance their technical skills to cope with rapidly changing labour markets (Jaya et al., 2024; Dewanto, 2025). Such an environment allows teachers to gain data-driven insights that provide a basis for their teaching decisions, while students benefit from timely support and performance feedback, which helps promote self-regulation and continuous participation (Miao et al., 2025).

However, meaningful and sustainable integration of AI in education goes beyond providing technology. This necessitates a systematic approach: continuous professional development for educators, creation of specific positions such as an AI curriculum designer and a data ethics advisor, among others, coupled with investment in a strong digital infrastructure (Ejjami, 2024; Jiang et al., 2023). Risks associated with privacy leaks, algorithmic bias, and widening usage gaps call for the creation of cross-departmental collaborations among educators, technical experts, and decision-makers (Vinuesa et al. 2019, Kamalov & Gurrib 2023):

Teachers aim to progress from passive adoption of AI tools to active and constructive partnerships that enable them to take the initiative in their instructional decisions while simultaneously strengthening the moral oversight thereof. To accomplish this aim, we must cultivate data literacy, embed ethical frameworks more clearly into our daily practices, and build a professional culture that supports learning for life to stay current in the fast-moving nature of AI (Polat, 2025; Miao et al., 2025). For learners, this type of collaboration affords not only greater personalisation and flexibility but also allows them to see AI as a cognitive partner in addressing real-world problems, particularly those that relate to the Sustainable Development Goals (Vinuesa et al., 2019; Yusro et al., 2024).

In any case, the key is to preserve the balance between human and AI contributions. AI should be viewed as a tool that can enhance human judgment, creativity, and empathy rather than replace these abilities. Teachers provide an explanatory and moral perspective to ensure that the output of AI can meaningfully adapt to the background of the learners (Miao et al., 2025; Msambwa et al., 2025). Therefore, institutional policies and national frameworks should protect the integrity of the teaching profession, promote fair access to opportunities, and enhance students' initiative in AI-enhanced environments. (Tanveer et al., 2020 ; Kamalov et al., 2023).

2.2 Relevant Theories

The Teacher–AI–Student Triadic Model is based on a synthesis of different interdisciplinary learning theories to serve as the ethical and pedagogical foundation for AI use in vocational education. There are three main theoretical viewpoints that are of high importance in this approach: constructivist learning theory, social learning theory, and Competency-Based Education (CBE).

Constructivist learning theory emphasises that learners build knowledge as they interact with their environment rather than receiving it. This is true for vocational education, which offers hands-on, practical experience where skills are honed through real work and problem-solving tasks. AI can assist in the formation of an AI practice, as it can offer real-time simulation and an adjustable platform. It will also provide a rapid response to students. By doing so, students have the chance to try, test, reflect, and think about what happened in a controlled and easy-to-replicate environment. (Jonassen, 1999, Holmes, et.al., 2025). Moreover, AI-driven personalisation supports constructivists' view of learner agency and the role of prior knowledge and context in understanding (Ari Alamäki et al., 2024).

Social learning theory (Bandura, 1986) states that people learn from each other through observation, modelling, and social interaction. Teachers and AI systems are complementary to each other. Teachers display ethical reasoning and their own professional expertise as well as their socio-emotional intelligence, and AI performs tasks, offers scaffolded opportunities for practice of those tasks, and gives repeated but data-guided feedback (Hwang & Tu, 2021). AI can promote peer-to-peer learning by recommending groups and organising and supervising collaboration to consolidate the social component, which is an important component of practice-based vocational learning.

Competency-based education (CBE) is about proof of mastery, not the advancement of time. It is best suited for vocational education, which is all about learning both technical and transferable skills to get a job. AI aids CBE through continuous formative evaluation, distributing micro-credits, and crafting specific learning courses (Jaya et al., 2024). Intelligent tutoring systems can monitor the performance of learners in simulations, provide them with focused micro-lessons to help them overcome weaknesses, and prove their ability using analytics (Yusro et al., 2024). They can also be made smaller, making it more fun and possible for you to see how they work by yourself.

Taken together, they form the basis of the Teacher-AI-Student Triadic Model, which is Constructivism, Social Learning and CBE. These perspectives posit that AI, when implemented thoughtfully and mindfully, is a medium that supports human interaction and fosters vocational learning environments that are better able to adapt to, include, and respond to Society 5.0 and the SDGs (Vinuesa et al., 2020; UNESCO-UNEVOC, 2025). AI integrated into the vocational education system changed the view from static to dynamic, passive to active, and a learning environment to a sustainable learning environment.

3.0 Methods

This study conducted conceptual development, which is composed of a literature review, theory synthesis of existing theories, and peer review, to form the Teacher-AI-Student Triad Model. To make a theory-practice-oriented development that states how we can use human-AI partnerships sustainably to change vocational education. The Google Scholar database was searched for relevant studies. The search terms included "artificial intelligence in education," "vocational education," "sustainability pedagogy," "human-AI collaboration," and "Society 5.0." Journal articles and conference papers published in English from 2018 to 2025 were included. Learning theories were selected based on their relevance to vocational competence development and technology-mediated learning.

Constructivist theory, which stresses the making of knowledge by means of active learning; social learning theory, which emphasis on emulating and peer interaction; and competency-based schooling, which links learning results to real-world performance requirements, are a few of them. The key themes extracted from the literature were grouped through qualitative coding techniques, ultimately forming three main agent roles (teacher, AI, and student), which were organised according to functional dimensions (teaching, technology, and social emotion).

An iterative mapping process was used to visualise the interconnections among roles, responsibilities, and communication processes. The initial concept map was refined through three rounds of development to promote internal validity and adaptability to the context of vocational education. To improve conceptual clarity and professional relevance, the initial model was shared with a group of academic peers, including colleagues in the fields of vocational education and educational technology. Feedback from these colleagues was solicited through informal discussions. This study aims to distinguish between roles that are independent but overlapping for teachers and AI systems, while simultaneously highlighting the important aspects of ethics and social-emotional learning for the teacher's role, and the role of the students to be active participants in their learning experience.

Following feedback from academic peers, the definitions of roles and interaction processes within the model were refined to more closely reflect authentic classroom communication and the practical realities of collaborative implementation in vocational education contexts. This iterative refinement strengthened the conceptual coherence of the model and clarified the ethical, pedagogical, and functional responsibilities of each agent. The stages of model development, including methods, procedures, and outputs, are summarised in Table 1.

Table 1

Stages of Conceptual Teacher-AI-Student Triadic Model Development

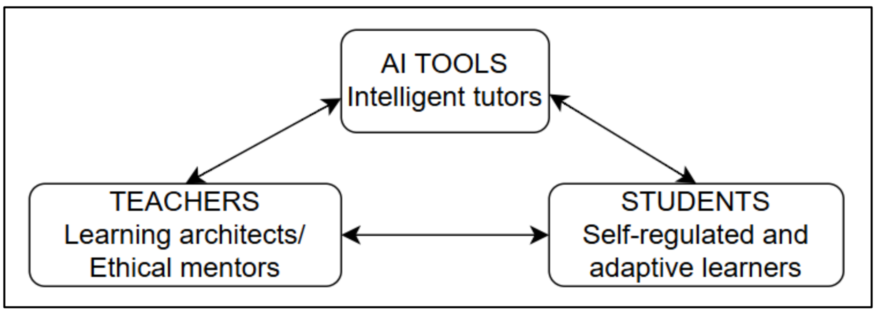
Stage	Process	Output
1. Literature Review	Systematic search of Google Scholar using predefined keywords; inclusion of peer-reviewed studies published between 2018 and 2025	Curated corpus of literature on AI, vocational education, sustainability, and pedagogy
2. Theoretical Selection	Identification and synthesis of relevant learning theories (constructivism, social learning theory, competency-based education)	Theoretical foundation guiding role definition and interaction design
3. Thematic Coding	Qualitative coding of key concepts and recurring themes across the literature	Three agent roles (teacher, AI, student) organised by functional dimensions
4. Mapping and Iteration	Development of a conceptual model through three iterative refinement cycles	Visual representation of interrelationships and communication flows
5. Peer Feedback and Refinement	Consultative review with academic peers in vocational education and educational technology	Refined role definitions with enhanced emphasis on ethics, socio-emotional learning, and student agency

4.0 Results

This study proposes the Teacher-AI-Student Triadic Model, a dynamic, interactive ecosystem of vocational education. The Teacher-AI-Student Triadic Model is a synergistic relationship among three core subjects involved in vocational education: human educators, artificial intelligence (AI) systems, and students. The model does not replace AI but focuses on a collaborative model in which each agent complements the others to promote sustainable, inclusive, and competency-oriented learning. Figure 1 illustrates this triadic structure, with sustainability at its core.

Figure 1

Teacher–AI–Student Triadic Model



4.1 AI Tools as Intelligent Instructors

AI tools work as intelligent instructors that provide tailored feedback, real-time grading, and adaptive output. AI, via data-driven personalised learner paths, can identify and address knowledge gaps and offer simulative practice, which is very important for trade school staff (Zawacki-Richter et al., 2019; DeWanto, 2025). Furthermore, generative AI can scaffold creativity and critical thought through dialogic interaction as part of an iterative problem-solving process (Hwang & Tu, 2021).

4.2 Teachers as Learning Architects and Ethical Mentors

Within the Teacher–AI–Student Triadic Model, teachers assume expanded roles that extend beyond traditional instructional functions. They act as learning architects, curriculum designers, and ethical mentors who situate AI-supported learning within appropriate pedagogical, social, and moral contexts. In AI-enabled classrooms, teachers curate and integrate AI tools by selecting, adapting, and aligning technologies with intended learning outcomes and vocational competencies (Ari Alamäki, 2022; Ari Alamäki, 2024).

Rather than serving as the sole source of knowledge, teachers design and orchestrate learning experiences that connect technical skill development with ethical reasoning and learner diversity. They critically interpret machine-generated outputs, provide meaningful feedback, and foster positive learning dispositions. These responsibilities rely on distinctly human capacities such as moral judgement, contextual reasoning, and socio-emotional sensitivity that cannot be replicated by AI systems (Miao et al., 2025; Vinuesa et al., 2020).

In vocational education contexts, teachers play a central role in cultivating sustainable mindsets and responsible professional identities. Their work shifts from delivering static content to facilitating adaptive, industry-relevant learning experiences framed by principles of sustainable development (Jaya et al., 2024; Dewanto, 2025). Teachers guide learners through ethical dilemmas related to AI use, supporting the development of digital citizenship, accountability, and responsible innovation (Holmes et al., 2025).

Teachers also support students in critically evaluating AI-generated content to determine its accuracy, fairness, and contextual relevance skills that are essential for both vocational practice and sustainability-oriented decision-making (Vinuesa et al., 2020). Alongside technical instruction, teachers nurture key human competencies, including collaboration, creativity, and emotional intelligence, which remain vital for addressing complex social and environmental challenges in the 21st century (Yusro et al., 2024).

In addition, teachers utilise AI-driven analytics to inform personalised instruction, adjust competency pathways, and provide timely interventions (Jaya et al., 2024). These data-informed practices enhance instructional precision while maintaining a human-centred pedagogical approach (Miao et al., 2025). To effectively fulfil these evolving roles, ongoing professional development is required, encompassing AI literacy, sustainability-oriented pedagogy, and socio-technical systems thinking (Dewanto, 2025).

4.3 Students as Self-Regulated and Adaptive Learners

Students become self-directed as they interact with the enriched AI-enhanced platform to explore content at their own pace in authentic competency-based scenarios. Interaction with human and machine facilitators develops technical skills and AI literacy, in addition to improving collaborative skills and ethics. These capabilities are collectively in line with the overall goals of "Society 5.0" and lifelong learning (Yusro et al., 2024; Ari Alamäki et al., 2024).

Students learn to be adaptive by adjusting themselves based on feedback and challenges. AI supports adaptability by creating simulations, performing scenario-based evaluations, and playing decision-making exercises that are similar to real-life scenarios (Dewanto, 2025; Vinuesa et al., 2020). Besides self-study, students in AI-mediated learning contexts also conduct peer teamwork and interdisciplinary problem-solving to enhance their communication, leadership, and intercultural competencies (Yusro et al., 2024). Additionally, students are considered both consumers and producers. By feeding back into

AI systems and suggesting sustainable activities, vocational learning becomes more positive, and learners feel more in control and take on responsibility (Miao et al., 2025).

4.4 Alignment with Sustainable Development Goals and Sustainability-Oriented Applications

The Teacher–AI–Student Triadic Model is well positioned to contribute to several Sustainable Development Goals (SDGs), particularly those related to education, decent work, and innovation. Within vocational education, the model functions as a strategic response to global challenges associated with equity, skills development, and sustainable economic growth, while integrating artificial intelligence within a human-centred pedagogical framework.

The model supports Sustainable Development Goal 4, Quality Education, by enabling personalised, inclusive, and accessible learning experiences. Artificial intelligence facilitates instructional differentiation, real-time feedback, multilingual support, and adaptive content delivery, while teachers maintain responsibility for safeguarding the ethical, cultural, and social dimensions of learning (Vinuesa et al., 2020; Miao et al., 2025). In addition, the model contributes to Sustainable Development Goal 8, Decent Work and Economic Growth, through the use of AI-based simulations that develop industry-relevant competencies in sectors such as manufacturing, automotive services, and green technologies (Dewanto, 2025). These simulations support both technical proficiency and transferable skills, including problem-solving and teamwork. AI-enabled micro-credentialing further enhances graduate employability and workforce mobility (Jaya et al., 2024).

With respect to Sustainable Development Goal 9, Industry, Innovation, and Infrastructure, the triadic model enables resource-limited institutions to expand learning opportunities through virtual laboratories, intelligent tutoring systems, and data-driven forecasting tools (Yusro et al., 2024). These technologies foster innovation and prepare learners to contribute effectively to sustainable industrial development. By increasing access to digital learning resources, the model also supports Sustainable Development Goal 5, Gender Equality, and Sustainable Development Goal 10, Reduced Inequalities, by facilitating the participation of learners from underrepresented groups and rural communities (Ari Alamäki et al., 2024).

Beyond explicit SDG alignment, the model demonstrates broader sustainability applications across vocational contexts. AI-supported simulations in green technology and intelligent production allow learners to engage directly with renewable energy systems, smart grids, and environmentally responsible manufacturing processes. Through these experiences, students apply sustainability-oriented ethical principles while contributing to reduced material waste and lower carbon emissions (Mitchell et al., 2025; Dewanto, 2025). Teachers contextualise these technical activities within wider environmental and social considerations, while industry partners contribute real-world data and applied case examples (Jaya et al., 2024). AI-based performance tracking further supports competency-based learning in areas such as green logistics and sustainable business practices (Miao et al., 2025).

Entrepreneurship education and community-based projects further illustrate the flexibility of the model. Artificial intelligence supports the simulation of market dynamics, environmental impact assessment, and the development of sustainability-oriented business models (Vinuesa et al., 2020). With guidance from teachers, learners apply these tools to innovation in fields such as renewable energy, ecotourism, and sustainable fashion (Jaya et al., 2024). In the context of smart cities and community development, students analyse data related to energy use, waste management, and mobility systems, and collaborate with local stakeholders to design solutions that support sustainable infrastructure development (Yusro et al., 2024; Miao et al., 2025).

5.0 Discussion

5.1 Contribution of Teacher-AI-Student Triadic Model

The Teacher-AI-Student Triadic Model is created through technology development, moral teaching, and the concept of sustainability for a human-oriented and flexible model of education. Unlike other AI-integrated education models that focus mainly on complementation and learner autonomy (Miao et al., 2025; Zawacki-Richter et al., 2019; Luckin et al., 2016), this model focuses on the sustainability of core competences. This aligns with the global call for socially responsible and effective pedagogies (UNESCO, 2022; OECD, 2021). This clear integration of sustainability distinguishes the Triadic model from earlier methods and positions it as a future-oriented vocational education framework, as shown in Table 2.

Table 2

Comparison of Existing AI-in-Education Frameworks and the Teacher–AI–Student Triadic Model

Framework	Key Features	Limitations	Unique Contribution of Triadic Model
Holmes et al. (2025)	Focus on teacher-AI complementarity	Limited integration of sustainability dimensions	Embeds sustainability as a core competency, linking AI use to SDGs and vocational relevance
Luckin et al. (2016)	Learner autonomy and AI scaffolding	Primarily cognitive focus: socio-emotional and ethical aspects are underexplored	Positions teachers as ethical mentors and students as co-creators, not just autonomous learners
Zawacki-Richter et al. (2019)	Systematic review of AI in education, mapping research areas	Descriptive rather than prescriptive; no model proposed	Provides a structured, practice-oriented model with defined roles and sustainability alignment
Teacher–AI–Student Triadic Model	Collaborative roles of teacher, AI, and student; explicit SDG integration	Still conceptual; needs empirical validation	The originality

5.2 Challenges and Ethical Considerations

5.2.1 Equitable Access to Artificial Intelligence and Digital Infrastructure

One of the foremost challenges in implementing AI-enhanced vocational education is ensuring equitable access to digital infrastructure and AI technologies. Many rural or economically disadvantaged regions, including parts of Guangxi Province in China and several areas of Southeast Asia, continue to face significant barriers to adopting AI-supported learning environments. These barriers include limited internet connectivity, inadequate or outdated hardware, low levels of digital literacy among both teachers and students, and insufficient technical support (Mhlanga & Moloi, 2020; Tanveer et al., 2020).

Addressing these disparities requires coordinated action among multiple stakeholders. Governments play a central role in expanding broadband infrastructure and providing affordable digital devices to learners. Educational institutions must adopt inclusive and resource-efficient system designs that enable AI tools to function effectively in low-resource contexts (Jiang et al., 2024). In addition, industry partners and non-governmental organisations can contribute through technology donations, capacity-building initiatives, and community-based training programmes. Collectively, these efforts help reduce the digital divide and promote more equitable access to AI-enabled educational opportunities (Ejjami, 2024; Msambwa et al., 2025).

5.2.2 Ethical Governance and Data Protection

AI-supported educational environments require the collection and processing of large volumes of learner data, raising concerns related to privacy, informed consent, algorithmic bias, and surveillance. When deployed without appropriate governance frameworks, such systems risk reinforcing existing social inequalities and undermining trust in educational institutions (Bircan et al., 2025; Miao et al., 2025).

Vocational education institutions should therefore establish robust AI governance and data protection frameworks aligned with international standards, including the General Data Protection Regulation. Regular awareness-raising activities are also necessary to strengthen understanding of AI ethics, digital rights, and responsible technology use among both students and educators (Vinuesa et al., 2020; Ejjami, 2024).

5.2.3 Teacher Preparedness and Professional Development

Teacher preparedness represents a critical challenge in the effective integration of AI into vocational curricula. Many educators lack the technical competencies and pedagogical frameworks required to meaningfully incorporate AI tools into teaching and learning processes. As a result, some AI applications remain underutilised and fail to enhance learning outcomes (Miao et al., 2025).

Sustainable implementation therefore depends on continuous professional development focused on AI literacy, socio-technical systems thinking, and sustainability-oriented pedagogy (Polat, 2025). Effective training programmes should combine hands-on experience with AI platforms, interdisciplinary curriculum design, and strategies that support human–AI collaboration in vocational settings (Dewanto, 2025). Peer learning communities and mentoring initiatives can further support educators in adapting to evolving instructional roles and technologies (Jaya et al., 2024).

5.2.4 Pedagogical Balance and Human-Centred Learning

Maintaining a balance between technological efficiency and human-centred learning represents a key pedagogical challenge. Overreliance on AI systems risks reducing learning to a transactional process, potentially marginalising emotional intelligence, creativity, and ethical reasoning (Miao et al., 2025; Msambwa et al., 2025).

The Teacher–AI–Student Triadic Model addresses this concern by positioning educators as ethical stewards of the learning environment. Within this framework, AI enhances personalised instruction and formative feedback but does not replace human interaction. Teachers remain responsible for fostering social-emotional development, collaborative learning, and civic responsibility, thereby ensuring that technological innovation supports rather than diminishes human agency (Vinuesa et al., 2020; Kamalov et al., 2023).

5.2.5 Sustainability of AI Systems and Environmental Impact

Although AI is frequently promoted as a tool for advancing sustainability, its development and deployment raise environmental concerns. The computational resources required to train and operate large-scale AI systems contribute to increased energy consumption and carbon emissions (Tanveer et al., 2020).

If vocational education is to meaningfully align AI adoption with sustainability goals, institutions must prioritise energy-efficient algorithms and encourage the use of renewable energy-powered cloud services. In addition, environmental and sustainability awareness should be integrated into core digital and AI literacy curricula. Learners should be encouraged to critically evaluate the environmental implications of technological innovation, fostering an integrated understanding of digital transformation and environmental responsibility (Jaya et al., 2024). When AI implementation aligns with institutional and national sustainability objectives, technological advancement can support, rather than undermine, long-term environmental goals.

5.2.6 Cultural and Contextual Adaptation

The global application of the Teacher–AI–Student Triadic Model requires careful adaptation to diverse cultural and institutional contexts. Vocational education systems vary widely in terms of industry priorities, pedagogical traditions, and community values. As a result, AI tools and instructional models must be tailored to reflect local needs and conditions.

Effective adaptation may involve collaboration with local stakeholders in the co-development of AI-supported curricula, the localisation and translation of learning resources, and the integration of culturally responsive pedagogical approaches (Dewanto, 2025; Yusro et al., 2024). Ongoing feedback mechanisms, such as structured consultations with students, educators, and community partners, are essential to ensure that implementation remains contextually relevant, inclusive, and responsive to evolving educational and societal needs.

5.3 Limitations and Future Directions

Despite the benefits of the Teacher–AI–Student triadic model, there are still some significant limitations. To date, it has not been empirically verified, and its effectiveness in different occupational environments remains unknown (Dewanto 2025; Alamäki 2024). The amount of evidence on how this model works in cross-cultural settings is also limited, where changes in pedagogy, language, and workplace practices may impact the outcomes (Yusro et al., 2024; Dewanto, 2025). There is also a research gap in assessment; the current tools are not designed to gauge the effectiveness of students' learning of sustainable development–related skills within an AI-supported environment. Effective and reliable documentation should be created for this purpose.

Thus, further research should focus on three directions. First, longitudinal and experimental studies could evaluate the workplace performance, contribution to the Sustainable Development Goals, and involvement in innovation of graduates from this model (Miao et al., 2025; Jaya et al., 2024). Second, comparative and cross-cultural studies are needed to test how this model operates in different occupations and educational systems across countries. Third, methodological work is needed to develop indicators and frameworks for assessment that can capture qualities such as the use of ethical AI, social and emotional development, and the ability to solve problems aimed at sustainable development.

To address these gaps, collaboration between researchers, industry, and other policymakers is essential. This collaboration can work together to develop AI-supported syllabuses, assessments, and micro-certifications that respond to the changing needs of the labour market while embedding the principles of sustainable development (Jiang et al., 2024; Kamalov & Gurrib, 2023).

To ensure the long-term viability of this model, digital and AI literacy must be prioritized. Teachers will have the opportunity to enhance their sociotechnical understanding and implement pedagogies focused on sustainability, while students will develop the ability to use ethical AI and adapt to technology (Polat, 2025; Ejjami, 2024). However, to empirically confirm capacity-building needs, additional research must be conducted to explore which forms of training and support are the most efficacious.

Originally conceived as a tool for vocational education, the triadic model must also be examined in a wider context, such as secondary education, higher education, lifelong learning, and corporate retraining. Although its adaptive structure suggests broad applicability, further research is needed to provide empirical evidence of its efficacy at various stages of education and career development (Holmes et al., 2023; Vinuesa et al., 2020). By contributing to the stated research prompts, our 'Triadic model of a teacher-AI-student' may be able to move from a conceptual proposal to a sustainable, proven (evidence-based), and well-prepared structural framework for the education space of a feasible society 5.0.

6.0 Conclusion

The Triadic teacher-AI-student model is distinctive because it considers sustainability as one of its three core capabilities alongside technology and social-emotional learning. Unlike existing models developed by Holmes, Luckin, or Zawacki-Richter, this model integrates the vocational education field with the United Nations Sustainable Development Goals. The Triadic model is both socially responsible and innovative with respect to pedagogy. Its particular contribution is how it formally connects digital transformation capability with sustainability requirements using a balanced, people-centered framework. From a practice and policy perspective, the model has clear implications for educators, policymakers, and researchers: Educators can use it to facilitate ethical reasoning about how to integrate AI responsibly into curricula. Policymakers can use it as a metric for their professional learning program designs and as a fair calculator for program infrastructure support. Researchers can use it for empirical testing and iterate towards an application for a continent and professional context, including developing tools for assessing sustainability capabilities. Overall, the Triadic model provides a practical, adaptable framework for education systems and practice in an emergent Society 5.0 reality–an education framework that does not shy away from practice.

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The author(s) declare (s) no conflict of interest.

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Author Biography

Wong Siew Ping is a Senior Lecturer at the Faculty of Education and Liberal Studies, City University, Malaysia. Her research interests include teaching, learning, and educational psychology.

Zeng Xi is a postgraduate student from City University, Malaysia. His research interests include educational information technology and educational psychology.

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