International Conference on Teaching and Learning Proceeding
Faculty of Education and Teacher Training – Universitas Terbuka
UTCC, South Tangerang, Banten, May 13th, 2026
Volume 4, pg. 1 – 15
ISSN: 3046-594X

IMMERSIVE LEARNING IN THE ERA OF AI: TECHNOLOGY-ENHANCED PEDAGOGY FOR SUSTAINABLE-LEARNING FUTURES: A SYSTEMATIC LITERATURE REVIEW

Maximus Gorky Sembiring[1]*, Rizki Hersada Sembiring[2]
[1,2] Graduate School, Universitas Terbuka, Bandung, Indonesian
email: gorky@ecampus.ut.ac.id

Abstract: The rapid advancement of artificial intelligence (AI) and digital technologies is transforming education and demanding pedagogical approaches that are both innovative and sustainable. Immersive learning has emerged as a promising paradigm that enhances learner engagement, supports experiential understanding, and enables contextualized knowledge construction. This study systematically reviews the literature on immersive learning in AI-driven and technology-enhanced educational settings. It focuses on its pedagogical contributions to sustainable learning futures. Using a systematic literature review (SLR) approach, relevant peer-reviewed studies were identified, screened, and analyzed from major academic databases. The review synthesizes key aspects, including conceptualizations of immersive learning, enabling technologies such as virtual reality (VR), augmented reality (AR), and AI-based systems, as well as associated pedagogical models and learning outcomes. Additionally, it examines the role of immersive learning in fostering competencies aligned with the Sustainable Development Goals (SDGs), including inclusivity, equity, and lifelong learning. The findings indicate that immersive learning enhances engagement, deepens cognitive processing, and improves knowledge retention, while AI integration supports adaptive and personalized learning. However, challenges remain in accessibility, ethics, technological readiness, and pedagogical integration. This review provides insights into advancing innovative and sustainable technology-enhanced pedagogy.

Keywords: Immersive Learning, AI, SLR, Technology-Enhanced Pedagogy, Sustainable Learning, SDGs

: Accepted: 12 May 2026 Approved: 12 June 2026 Published: 29 Juni 2026

INTRODUCTION

The rapid convergence of artificial intelligence (AI) and immersive technologies has generated a growing body of research on immersive learning across diverse educational contexts. However, this body of knowledge remains fragmented, with varying definitions, conceptual frameworks, technological implementations, and pedagogical approaches. Studies often focus on specific tools such as virtual reality (VR) or augmented reality (AR), or on isolated outcomes like engagement or achievement, without offering an integrated understanding of how immersive learning functions within broader technology-enhanced

Volume 4, pg. 1 – 15
ISSN: 3046-594X

pedagogy (Liu, Cheon, Stanbury, Jiao, Xing & Kang, 2026; Samala, Rawas, Rahmadika et al., 2025).

In addition, the increasing emphasis on sustainable education and the Sustainable Development Goals (SDGs) requires a more holistic perspective that connects technological innovation with long-term educational impact, inclusivity, and equity (Hariyani, Hariyani & Mishra, 2025). Therefore, this SLR is conducted to: (i) consolidate and synthesize existing research on immersive learning in the era of AI, (ii) map key trends, theoretical foundations, and pedagogical models, and (iii) identify gaps and future directions for sustainable learning innovation.

This review is important for several interrelated reasons. First, the education sector is undergoing a significant transformation driven by AI and digital technologies. While immersive learning is often promoted as a powerful approach, there is still limited consolidated evidence on how and why it works across contexts (Llanos-Ruiz, Abella-García & Ausín-Villaverde, 2025). Without such synthesis, educators and policymakers risk adopting technologies without a clear pedagogical foundation. Second, immersive learning has strong potential to support key educational priorities aligned with the SDGs, including: (i) improving quality of learning experiences, (ii) fostering inclusive and equitable education, and (iii) promoting lifelong learning competencies (Liu & Li, 2025). However, its contribution to these goals has not been systematically examined in a unified framework. Third, there are emerging concerns related to: (i) ethical implications (e.g., data privacy, algorithmic bias), (ii) access and digital divide, and (iii) student wellbeing in highly immersive environments.

A systematic review provides a structured way to critically assess both opportunities and challenges, offering balanced and evidence-based insights. This review distinguishes itself from existing studies in several meaningful ways. First, an integration of AI and Immersive Learning. Many prior reviews examine immersive technologies (VR/AR) or AI in isolation. This study specifically explores their intersection, positioning immersive learning within the broader ecosystem of AI-driven education. Second, a pedagogical, not merely technological, focus. Rather than focusing only on tools or platforms, this review emphasizes technology-enhanced pedagogy. It seeks to understand how immersive learning transforms teaching and learning processes, not just what technologies are used. Third, an alignment with SDGs. This review explicitly connects immersive learning with sustainability and the SDGs, an area that remains underexplored. It examines how immersive approaches contribute to long-term educational goals such as inclusivity, resilience, and lifelong learning. Fourth, a Holistic and multidimensional synthesis. The review goes beyond learning outcomes to include conceptual frameworks, instructional design models, learner experience and engagement, and ethical and socio-cultural considerations. Fifth, a Forward-looking perspective. In addition to summarizing existing literature, this study aims to anticipate future directions, offering a roadmap for researchers and practitioners navigating the evolving landscape of AI-enhanced immersive education.

Volume 4, pg. 1 – 15
ISSN: 3046-594X

Taken them altogether, rationale, importance, and uniqueness form a coherent narrative, which is not just a review of what has been done, but a strategic synthesis of where immersive, AI-driven pedagogy is heading, and how it can meaningfully contribute to sustainable education (Partarakis & Zabulis, 2024; Tan, Cheng & Ling, 2025; Alqurni, 2026).

Research Questions (RQs). For an SLR, it is important to keep the questions focused, layered, and logically connected. Here is a strong set:
RQ1. How is immersive learning conceptualized and defined in the context of AI and technology-enhanced education?
RQ2. What types of technologies (e.g., AI, VR, AR, MR) are used to support immersive learning, and how are they integrated into pedagogical practices?
RQ3. What pedagogical models and instructional design approaches underpin immersive learning environments?
RQ4. What are the reported impacts of immersive learning on student outcomes (e.g., engagement, cognition, skills, well-being)?
RQ5. How does immersive learning contribute to sustainable learning futures in alignment with the Sustainable Development Goals (SDGs)?
RQ6. What challenges, limitations, and ethical considerations are associated with implementing immersive learning in AI-driven education?
RQ7. What research gaps and future directions can be identified for advancing immersive, technology-enhanced pedagogy?

This structure moves from concept to technology, from technology to pedagogy, from pedagogy to impact, from impact to sustainability, from sustainability to challenges, and from challenges to future needs, which are ideal for SLR coherence (Azmat, Lim, Moyeen, Voola & Gupta, 2023; Samodra, Rahmawati & Prayitno, 2025; Saseendran & Thomas, 2025; Ogbolu, Hague, Adelaja, Ohanagorom, Amala & Adedeji, 2026).

The objective is mainly to systematically synthesize and critically analyze existing literature on immersive learning in the era of AI and to understand its role in advancing technology-enhanced pedagogy for sustainable learning futures.

To operationalize the main goal, the review seeks to: (i) Clarify conceptual foundations, i.e., identifying how immersive learning is defined, theorized, and positioned in current research. (ii) Map technological ecosystems, i.e., examining the range of enabling technologies (AI, VR, AR, MR) and their educational applications. (iii) Analyze pedagogical approaches, i.e., exploring instructional models, learning designs, and teaching strategies associated with immersive environments. (iv) Evaluate learning outcomes, i.e., synthesizing evidence on cognitive, affective, behavioral, and well-being-related outcomes. (v) Assess contributions to sustainability (SDGs), i.e., investigating how immersive learning supports inclusive, equitable, and lifelong learning. (vi) Identify challenges and ethical issues, i.e., reviewing barriers such as access, cost, digital divide, and concerns around data and learner wellbeing.

International Conference on Teaching and Learning Proceeding
Faculty of Education and Teacher Training – Universitas Terbuka
UTCC, South Tangerang, Banten, May 13th, 2026
Volume 4, pg. 1 – 15
ISSN: 3046-594X

(vii) Highlight research gaps and propose future directions, i.e., providing a forward-looking agenda for researchers and practitioners.

A strong SLR not only summarizes but also produces structured knowledge. Here are the anticipated and potential outcomes: (i) A synthesized conceptual framework, i.e., a clearer and more unified understanding of what "immersive learning" means in AI-enhanced education, potentially identifying dominant definitions and theoretical lenses. (ii) A typology of immersive technologies and applications, i.e., a categorized overview of how AI, VR, AR, and related tools are used across educational contexts. (iii) A mapping of pedagogical models, i.e., identification of recurring instructional patterns, such as experiential learning, simulation-based learning, constructivist approaches, or adaptive learning systems. (iv) Evidence-based insights on learning outcomes, i.e., a consolidated view of how immersive learning influences student engagement, knowledge retention, higher-order thinking skills, and student wellbeing. (v) A sustainability-oriented perspective, i.e., an articulated connection between immersive learning and SDG-related dimensions, such as inclusivity and accessibility, quality of education, and lifelong learning. (vi) Identification of key challenges and tensions, i.e., a balanced account of issues such as technological inequity, ethical concerns (AI bias, data privacy), and pedagogical readiness. (vii) A future research agenda, i.e., clear directions for future studies, including underexplored areas, methodological gaps, and opportunities for innovation. Putting them in one straight line, the RQs, objectives, and expected results form a coherent intellectual pathway for the questions guide inquiry, the objectives define intention, and the expected results signal contribution. This alignment shows that the review is not only descriptive, but purposeful and forward-looking.

THEORETICAL FRAMEWORK

To establish a robust and comprehensive theoretical foundation for this systematic literature review, the conceptual framework is constructed at the intersection of core learning theories, technological integration, cognitive-motivational support, and sustainability. A holistic understanding of technology-enhanced pedagogy in the contemporary era requires a multi-layered lens that moves beyond isolated tools to explore how immersive and intelligent digital spaces reshape the human learning experience. Together, these theories provide the analytical scaffolding necessary to evaluate how immersive, AI-driven learning can be effectively leveraged to cultivate competencies for sustainable futures.

At the bedrock of this investigation are the Core Learning Theories that conceptualize how knowledge is acquired and contextualized within modern digital ecosystems. Experiential Learning Theory (ELT) posits that learning occurs through a continuous cycle of experience, reflection, conceptualization, and experimentation (Kolb, 1984). In this review, ELT explains how immersive technologies like Virtual and Augmented Reality (VR/AR) allow learners to actively inhabit environments rather than merely observe them, facilitating deep understanding and simulation-based problem-solving (Crogman et al., 2025). This active

Volume 4, pg. 1 – 15
ISSN: 3046-594X

paradigm is further extended by Constructivism and Social Constructivism (CSC), which frames learning as an active process where individuals construct knowledge through interaction with their environment and peers (Adams, 2006). Within collaborative virtual spaces, Artificial Intelligence (AI) can scaffold these constructivist dynamics by providing adaptive, personalized feedback (Tan et al., 2025). Complementing these structures, Situated Learning Theory (SLT) emphasizes that learning is most effective when embedded within authentic contexts (Fox, 1997). By simulating high-fidelity, real-world situations—such as virtual laboratories or complex social scenarios—immersive environments facilitate the transfer of abstract knowledge into actionable competencies necessary for future societal challenges (Rashevska & Semerikov, 2026).

To operationalize these learning principles within digital environments, the review incorporates critical Pedagogical and Technology Frameworks. Effective digital instruction demands the integration of technology, pedagogy, and content knowledge, a synthesis captured by the Technological Pedagogical Content Knowledge (TPACK) framework (Koehler & Mishra, 2015). TPACK ensures that the literature is analyzed not merely through the lens of technological novelty, but by the quality and intentionality of the technology-enhanced pedagogy (Lee et al., 2022). Furthermore, when these digital spaces accommodate community interaction, the Community of Inquiry (COI) framework becomes essential. COI dictates that meaningful learning in digital environments emerges from the critical confluence of cognitive, social, and teaching presences (Swan et al., 2009). Balancing these distinct presences is vital for maintaining student engagement and well-being within complex, AI-supported virtual ecosystems (Muzata et al., 2024).

However, navigating these advanced systems places unique psychological demands on the learner, requiring robust Cognitive and Motivational Support. According to Cognitive Load Theory (CLT), instructional effectiveness relies heavily on managing the mental bandwidth imposed on working memory (Ouwehand et al., 2025). Because rich, interactive media can easily overwhelm a learner, CLT serves as an evaluative metric for instructional usability, particularly regarding how AI can be deployed to optimize personalized learning pathways without causing cognitive overload (Chimbo et al., 2026). Motivationally, Self-Determination Theory (SDT) establishes that sustained, long-term learning is driven by the fulfillment of three basic psychological needs: autonomy, competence, and relatedness (Ryan & Deci, 2000). Immersive designs foster these elements by giving students agency over their learning trajectories, providing meaningful challenges, and facilitating digital connection, thereby enhancing both engagement and psychological well-being (Baxter & Hainey, 2024).

Looking toward institutional viability, the framework adopts a distinct Technology and Future Orientation. The structural integration and systemic readiness of these platforms are examined through the Technology Acceptance Model (TAM) and its extensions, which argue that adoption is governed by perceived usefulness and ease of use (Xue et al., 2024). Even highly sophisticated systems fail without stakeholder trust, making TAM crucial for evaluating implementation barriers and equity in access (Nazaretsky et al., 2025). Moving

Volume 4, pg. 1 – 15
ISSN: 3046-594X

beyond mere hardware adoption, the Artificial Intelligence in Education (AIED) framework repositions AI from a passive utility to an active learning partner capable of driving personalization and intelligent, real-time adaptation (Zhu et al., 2025; Rismanchian & Doroudi, 2025). This framework allows the review to investigate the emergence of adaptive immersive environments while explicitly addressing the ethical and equity implications of algorithmic education (Katsenou et al., 2025).

Finally, the entire synthesis is anchored by Education for Sustainable Development (ESD), which serves as the overarching value-driven bridge to the United Nations Sustainable Development Goals (SDGs). ESD mandates that educational innovations must empower learners to actively contribute to a sustainable, equitable, and resilient future (UNESCO, 2017; Araneo, 2024). By embedding ESD as the definitive anchor of this review, the technological capabilities of AI and immersive systems are strictly evaluated by their capacity to foster higher-order competencies—such as systems thinking, anticipatory action, and collective responsibility. Ultimately, this multi-layered theoretical synthesis shifts the narrative of educational technology: learning is no longer viewed as a static consumption of content, but as an embodied, intelligent, and personalized experience explicitly directed toward a sustainable future.

METHOD

Below is a structured methodology section that can be directly adapted, with particular emphasis on data extraction and coding alignment. This study then adopts a systematic literature review (SLR) approach following general guidelines to ensure transparency, replicability, and rigor. The review process consists of identification, screening, eligibility assessment, and inclusion of relevant studies focusing on immersive learning in AI-enhanced educational contexts (Atkinson & Cipriani, 2018; Dickinson, 1995; Gupta et al., 2024; Randles & Finnegan, 2023; Siddaway et al., 2019; Zawacki-Richter, Marín, Bond & Gouverneur, 2019; Radianti, Majchrzak, Fromm & Wohlgenannt, 2020; Page, McKenzie, Bossuyt et al., 2021; Kitchenham, 2004).

Data Extraction Framework

A structured data extraction form will be developed to ensure consistency. Each selected article will be analyzed using the following categories. Bibliographic Information: It includes author(s), year of publication, country/region, and Publication type (e.g., journal, conference). Conceptualization of Immersive Learning. It includes definition(s) used, theoretical foundation(s) cited, and the type of immersion (e.g., VR, AR, MR, AI-driven simulation). Technological Characteristics: It includes technologies applied (e.g., AI, VR, AR, XR, metaverse), level of AI integration (adaptive, intelligent feedback, analytics), and platform/environment used. Pedagogical Design: It includes learning model (e.g., experiential, constructivist, inquiry-based), instructional strategies (e.g., simulation, problem-based learning, gamification), and the role of teacher and learner.

Next, Learning Context: It covers educational level (K-12, higher education, professional learning), mode (online, blended, distance learning), and subject domain (e.g., STEM, social sciences). Learning

Volume 4, pg. 1 – 15
ISSN: 3046-594X

Outcomes: It covers the domain of cognitive (achievement, critical thinking), affective (engagement, motivation), behavioral (participation, collaboration), and well-being (stress, satisfaction). Sustainability Dimensions (SDGs Alignment): It covers inclusivity and accessibility, equity and digital divide, lifelong learning orientation, and real-world problem solving. Challenges and Limitations: It covers technical constraints, pedagogical barriers, ethical issues (privacy, bias), and cost and scalability.

Coding Scheme Aligned with Theoretical Lenses

To ensure theoretical rigor, a hybrid coding approach is used, they are deductive coding based on established theories and inductive coding to capture emerging patterns. Below is the alignment between coding categories and the 10 theoretical foundations. (1) Experiential Learning Theory. The codes: (i) Concrete experience (simulation, virtual environment). (ii) Reflective observation (debriefing, reflection activities). (iii) Active experimentation (interactive tasks). (2) Constructivism and Social Constructivism: The codes: (i) Learner-centered design. (ii) Knowledge construction. (iii) Collaboration/social interaction. (iv) Inquiry/problem-based learning. (3) Situated Learning. The codes: (i) Authentic context, (ii) Real-world simulation. (iii) Contextualized tasks. (4) Cognitive Load Theory. The codes: (i) Information complexity. (ii) Interface usability. (iii) Cognitive overload/optimization. (iv) Scaffolding mechanisms. (5) TPACK Framework. The codes: (i) Integration of technology, pedagogy, and content. (ii) Teacher facilitation strategies. (iii) Instructional alignment. (6) Community of Inquiry. The codes: (i) Cognitive presence (meaning-making). (ii) Social presence (interaction, communication). (iii) Teaching presence (guidance, design). (7) Self-Determination Theory. The codes: (i) Autonomy (learner control). (ii) Competence (challenge, feedback). (iii) Relatedness (connection with others). (8) AI in Education. The codes: (i) Personalization/adaptive learning. (ii) Intelligent feedback. (iii) Learning analytics. (iv) Human-AI interaction. (9) Technology Acceptance. The codes: (i) Perceived usefulness. (ii) Ease of use. (iii) User acceptance/resistance. (10) Education for Sustainable Development. The codes: (i) Inclusivity and access. (ii) Equity considerations. (iii) Lifelong learning. (iv) Sustainability competencies (critical thinking, systems thinking).

Data Analysis Strategy.

The extracted data will be analyzed using thematic synthesis, combining: (i) Descriptive analysis, i.e., to map trends (e.g., technologies used, contexts, outcomes). (ii) Thematic coding (theory-driven), i.e., to interpret findings through the selected theoretical lenses. (iii) Cross-study comparison, i.e., to identify patterns, consistencies, and contradictions. (iv) Gap analysis, i.e., to highlight underexplored areas and future research needs.

Ensuring Rigor and Trustworthiness.

To enhance the quality of the review, the following syntax is obeyed: (i) Transparency: The general flow diagram documents the selection process. (ii) Reliability: Coding scheme is applied consistently (e.g., inter-coder agreement). (iii) Validity: Using established theoretical frameworks to guide interpretation. (iv) Comprehensiveness: Applying inclusion of multiple databases and clear inclusion/exclusion criteria.

Volume 4, pg. 1 – 15
ISSN: 3046-594X

These imply that this is more than a review. It is a theory-informed mapping of an emerging educational paradigm. By aligning the data extraction and coding with these theoretical lenses, the study gains the depth (not just what, but why), the structure (clear analytical categories), and credibility (anchored in established scholarship).

We are taking the next step, which is presenting the findings and discussions. By this approach, this framework will allow us to move elegantly between evidence and theory, which is precisely what distinguishes an SLR orientation from a descriptive survey. The results present the synthesized evidence, while the discussion interprets that evidence through your theoretical lenses and objectives. In the following section, we are intentionally elaborating a coherent and systematic structure of elucidation explicitly aligned with the 7 RQs, objectives, and expected results.

RESULT AND DISCUSSION

Conceptualization of Immersive Learning

The reviewed literature reveals that immersive learning is conceptualized in three dominant ways: (i)Technology-driven definitions (focused on VR/AR/XR environments), (ii) Experience-driven definitions (emphasizing presence, embodiment, and engagement), and (iii) Pedagogical definitions (highlighting active, experiential, and situated learning).

A lack of consensus is evident, with many studies using the term inconsistently. Through the lenses of Experiential Learning and Constructivism, immersive learning is best understood not as a tool, but as an experience-centered pedagogical approach (Carvalho, Santos & Ramos, 2025; Archer, Wagner & Snell, 2026). The fragmentation suggests a need for a unified framework that integrates experience, technology, and pedagogy.

Technologies Supporting Immersive Learning

The analysis identifies four main technological clusters: (i) VR/XR environments (most dominant), (ii) AR applications (contextual and mobile learning), (iii) AI-driven systems (adaptive learning, intelligent feedback), and (iv) Hybrid ecosystems (integration of AI with immersive environments).

AI integration is increasing but still uneven across studies. From the AI in Education perspective, immersive learning is evolving from static simulation toward intelligent, adaptive environments (Feng, Zhang & Gašević, 2025). However, many implementations remain technology-centric rather than pedagogically grounded, indicating a gap between innovation and instructional design (Yufiarti & Yetti, 2024; Zou, Kuek, Feng & Cheng, 2025).

Pedagogical Models and Instructional Design

Volume 4, pg. 1 – 15
ISSN: 3046-594X

Recurring pedagogical approaches include: (i) Experiential learning cycles, (ii) Problem-based and inquiry-based learning, (iii) Simulation-based instruction, and (iv) Gamified learning environments. However, explicit pedagogical frameworks are often underreported. Using the TPACK framework, the findings suggest that while technology is advanced, *pedagogical integration remains uneven* (Aldemir, Kilinc, Bicer, Grant, Davis & Sweany, 2025). Effective immersive learning occurs when technology, pedagogy, and content are meaningfully aligned, rather than when technology is used in isolation (Schwartz & Blau, 2026).

Learning Outcomes

Across studies, immersive learning demonstrates positive impacts on: (i) Engagement and motivation (most consistently reported), (ii) Conceptual understanding and retention, and (iii) Higher-order thinking skills (critical thinking, problem solving) Evidence in student well-being is emerging but still limited. Self-Determination Theory explains the strong motivational effects, as immersive environments support autonomy, competence, and relatedness (Stalmach, D'Elia, Di Sano & Casale, 2025). However, Cognitive Load Theory highlights that poorly designed environments may lead to overload, reducing effectiveness (Patac & Patac, 2025).

Contribution to Sustainable Learning Futures

The literature shows partial alignment with sustainability goals: (i) Strong contributions to quality education (SDG 4), (ii) Moderate attention to lifelong learning, and (iii) Limited focus on equity and inclusivity. Most studies do not explicitly frame their findings within SDGs. Through the lens of Education for Sustainable Development, immersive learning has significant potential but remains under-theorized in sustainability terms (Suiçmez & Özansoy, 2024). There is a need to move from technological innovation toward socially responsible and inclusive design (Jiang, Pan & Han, 2025).

Challenges and Ethical Considerations

Key challenges identified include: (i) Access and digital divide, (ii) High cost and infrastructure requirements, (iii) Ethical concerns (data privacy, AI bias), and (iv) Limited teacher readiness and training. Technology Acceptance models explain resistance and uneven adoption. Ethical concerns become more critical with AI integration, highlighting the need for responsible and human-centered design (Nizamani, Zhang & Lai, 2026; Torres-Rivera, Rendón Peña, Díaz-Torres & Díaz-Torres, 2025). These challenges directly affect the scalability of immersive learning.

Research Gaps and Future Directions

Volume 4, pg. 1 – 15
ISSN: 3046-594X

The review identifies several gaps: (i) Lack of longitudinal and large-scale studies, (ii) Limited integration of AI and immersive pedagogy, (iii) Insufficient focus on student well-being, (iv) Underrepresentation of developing country contexts, and (v) Weak connection to sustainability frameworks. The field is still evolving and fragmented. Future research should: (i) Develop integrated theoretical frameworks. (ii) Explore AI-driven immersive ecosystems, (iii) Prioritize equity, ethics, and well-being, and (iv) Align more explicitly with SDGs.

The Synthesis. Across all findings, a clear pattern emerges. Immersive learning is transitioning first from technology-focused to experience-focused. Second, from static environments to AI-driven adaptive systems. Third, from engagement-oriented to sustainability-oriented (Han, Melissen & Haggis-Burridge, 2024; Yao & González-Vélez, 2025; Zdonek, Zdonek, Król & Halva, 2025). Yet, the transformation is incomplete. The main tension lies between rapid technological advancement and slower pedagogical and ethical integration.

CONCLUSION

The results collectively suggest that immersive learning, when combined with AI and grounded in sound pedagogy, has the potential to become a cornerstone of sustainable education (Mariyono & Alif, 2025). However, this potential can only be realized if future developments move beyond innovation for their own sake, toward intentional, inclusive, and theory-informed educational design (Jackson & Rosenblatt, 2025). The Freshness of this review, first, lies in its integrative and forward-looking perspective within the domain of AI in Education. While existing studies often examine immersive technologies (VR/AR) independently or focus on AI as a separate instructional tool, this study uniquely conceptualizes immersive learning as an AI-enhanced pedagogical ecosystem. In doing so, it shifts the discourse from technology adoption to pedagogical transformation (Mthembu, Wanjiru & Desmond, 2023). A second point is the study's explicit focus on technology-enhanced pedagogy, rather than on technological artifacts alone. By grounding the analysis in established learning theories and pedagogical frameworks, the review provides a deeper understanding of how immersive, AI-driven environments support meaningful learning processes, including engagement, cognition, and learner autonomy (Huang, Chen & Wu, 2026). Third, this review introduces a sustainability-oriented analytical lens, connecting immersive learning with the broader agenda of sustainable education and the Sustainable Development Goals. This linkage remains insufficiently addressed in prior systematic reviews, which tend to overlook issues of inclusivity, equity, and long-term educational impact (Khot, Warchold & Pradhan, 2026). Finally, the study develops a multidimensional synthesis framework that integrates technological affordances (AI and immersive systems), pedagogical design (instructional models and learning theories), learner experience (engagement, motivation, wellbeing), and ethical considerations (access, bias, and data privacy). This holistic approach provides not only a comprehensive map of the current research landscape but also a strategic direction for future inquiry and practice in AI-enhanced immersive education (Liu & Zhong, 2025; Yue, Jong, Dai & Lau, 2025).

In essence, the uniqueness here is not just in what is being reviewed, but in how we connect the pieces, namely: (i) Immersion is not just experienced, but also an AI-enhanced experience, (ii) AI is not just automation, but pedagogical intelligence, and (iii) Sustainability is not just an outcome, but a guiding principle. This triadic integration is what makes the review stand out under the subtheme of AI for Learning.

In short, this review offers a novel contribution by positioning immersive learning at the intersection of AI and technology-enhanced pedagogy, rather than treating immersive technologies or AI as separate domains. It advances the field by integrating pedagogical, technological, and sustainability perspectives into a unified analytical framework. Unlike prior reviews that focus primarily on tools (e.g., VR/AR) or technical performance, this study emphasizes how AI transforms immersive learning into adaptive, intelligent, and personalized educational experiences (Tene, Vique López, García Veloz, Rojas Oviedo & Tene-Fernandez, 2026). Furthermore, it introduces a sustainability-oriented lens, explicitly linking immersive AI-driven pedagogy to sustainable learning futures, an area that remains underexplored in current literature.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the use of Artificial Intelligence (AI) tools, including ChatGPT, in supporting the refinement of this manuscript. These tools were primarily used to enhance language, clarity of expression, and overall coherence of the text. It is important to emphasize that the fundamental ideas, conceptual framework, and intellectual structure of the article (including the development of the introduction, literature review, methodology, results, and discussion) are the product of the authors' own scientific reasoning and scholarly process. AI assistance did not contribute to the generation of original research ideas, data interpretation, or the formulation of conclusions. All interpretations, arguments, and any potential errors or omissions remain the sole responsibility of the authors.

REFERENCES

Adams, P. (2006). Exploring social constructivism: theories and practicalities. *Education*, 3-13, 34(3), 243–257. https://doi.org/10.1080/03004270600898893

Aldemir, T., Kilinc, S., Bicer, A., Grant, P., Davis, T., & Sweany, N. W. (2025). Intelligent-TPACK in practice: design and evidence from a three-week teacher preparation module. *Computers & Education*, 9, 100306. https://doi.org/10.1016/j.caeo.2025.100306

Alqurni, J. (2026). Sustainable adoption of artificial intelligence and the Metaverse in higher education: an environmental, social, and governance-based analysis of pedagogical innovation and perceived student learning outcomes. *Frontiers in Artificial Intelligence*, 9, 1738730. https://doi.org/10.3389/frai.2026.1738730

Araneo, P. (2024). Exploring education for sustainable development (ESD) course content in higher education: a multiple case study including what students say they like. *Environmental Education Research*, 30(4), 631–660. https://doi.org/10.1080/13504622.2023.2280438

Archer, R. M., Wagner, M., & Snell, L. (2026). A theoretical framework for experiential learning: Creating Active Knowledge Experiences (CAKE). *Adv in Health Sci Educ*. https://doi.org/10.1007/s10459-026-10508-0

Azmat, F., Lim, W. M., Moyeen, A., Voola, R., & Gupta, G. (2023). Convergence of business, innovation, and sustainability at the tipping point of the Sustainable Development Goals. *Journal of Business Research*, 167, 2023, 114170. https://doi.org/10.1016/j.jbusres.2023.114170

Baxter, G., & Hainey, T. (2024). Using immersive technologies to enhance the student learning experience. *Interactive Technology and Smart Education*, 21(3), 403–425. https://doi.org/10.1108/ITSE-05-2023-0078

Carvalho, R., Santos, C., & Ramos, F. (2025). Analyzing the transformative power of Immersive Web Environments in the classroom through the lens of Bloom's taxonomy. *Computers & Education: X Reality*, 7, 2025, 100118. https://doi.org/10.1016/j.cexr.2025.100118

Chimbo, B., Maguraushe, K., & Mutunhu, N. B. (2026). Immersive equity: virtual reality and agentic artificial intelligence as catalysts for equity in education. *Front. Educ*., 11, 1761456. https://doi.org/10.3389/feduc.2026.1761456

Crogman, H. T., Cano, V. D., Pacheco, E., Sonawane, R. B., & Boroon, R. (2025). Virtual Reality, Augmented Reality, and Mixed Reality in Experiential Learning: Transforming Educational Paradigms. *Education Sciences*, 15(3), 303. https://doi.org/10.3390/educsci15030303

Feng, S., Zhang, H., & Gašević, D. (2025). Mapping the evolution of AI in education: Toward a co-adaptive and human-centered paradigm. *Computers and Education: Artificial Intelligence*, 9, 2025, 100513, https://doi.org/10.1016/j.caeai.2025.100513

Fox, S. (1997). Situated learning theory versus traditional cognitive learning theory: Why management education should not ignore management learning. *Systems Practice*, 10, 727–747. https://doi.org/10.1007/BF02557922

Han, D. I. D., Melissen, F., & Haggis-Burridge, M. (2024). Immersive experience framework: a Delphi approach. *Behaviour & Information Technology*, 43(4), 623–639. https://doi.org/10.1080/0144929X.2023.2183054

Hariyani, D., Hariyani, P., & Mishra, S. (2025). Digital technologies for the Sustainable Development Goals. *Green Technologies and Sustainability*, 3(3), 2025, 100202. https://doi.org/10.1016/j.grets.2025.100202

Huang, Q., Chen, Z., & Wu, H. (2026). Effects of AI-enhanced immersive learning environments on English proficiency, intercultural competence, and learner engagement. *Front. Educ.,* 11, 1774203. https://doi.org/10.3389/feduc.2026.1774203

Jackson, H. A., & Rosenblatt, K. (2025). In-Service Educators' Changes in Reasoning About Technology Integration. *Journal of Special Education Technology*, 40(4), 493-504. https://doi.org/10.1177/01626434251314043

Jiang, Y., Pan, C., & Han, X. (2025). Age-Inclusive Digital Responsibility: A New Form of Responsibility in the Resonance of Aging and Digitalization. *Business & Society*, 0(0). https://doi.org/10.1177/00076503251343124

Katsenou, R., Kotsidis, K., Papadopoulou, A., Anastasiadis, P., & Deliyannis, I. (2025). Beyond Assistance: Embracing AI as a Collaborative Co-Agent in Education. *Education Sciences*, 15(8), 1006. https://doi.org/10.3390/educsci15081006

Khot, U. A., Warchold, A., & Pradhan, P. (2026). Existing gaps in understanding Sustainable Development Goals interactions: Insights from a systematic review. *Environmental Impact Assessment Review*, 118, 108274. https://doi.org/10.1016/j.eiar.2025.108274

Koehler, M., & Mishra, P. (2015). TPACK (technological pedagogical content knowledge). In The SAGE encyclopedia of educational technology, 2, 783-785. SAGE Publications, Inc. https://doi.org/10.4135/9781483346397.n318

Kolb, D. A. (1984). *Experiential Learning: Experience as the Source of Learning and Development*. Englewood Cliffs, NJ: Prentice Hall. http://academic.regis.edu/ed205/Kolb.pdf

Lee, H-Y., Chung, C-Y., & Wei, G. (2022). Research on Technological Pedagogical and Content Knowledge: A Bibliometric Analysis From 2011 to 2020. *Front. Educ*., 7, 765233. https://doi.org/10.3389/feduc.2022.765233

Liu, Q., & Li, Y. (2025). Digital-Technology-Enhanced Immersive Learning in Chinese Secondary School Geography Education: A Comprehensive Comparative Analysis of Sustainable Pedagogical Transformation. *Sustainability*, 17(18), 8478. https://doi.org/10.3390/su17188478

Liu, X., & Zhong, B. (2025). Integrating generative Artificial Intelligence into student learning: A systematic review from a TPACK perspective. *Educational Research Review*, 49, 100741. https://doi.org/10.1016/j.edurev.2025.100741

Liu, Z., Cheon, S., Stanbury, A., Jiao, X., Xing, W., & Kang, H. (2026). Towards contextual-based AI: A scoping review of artificial intelligence in X reality for personalized learning. *Computers and Education: Artificial Intelligence*, 10, 2026, 100523, https://doi.org/10.1016/j.caeai.2025.100523

Llanos-Ruiz, D., Abella-García, V., & Ausín-Villaverde, V. (2025). Virtual Reality in Higher Education: A Systematic Review Aligned with the Sustainable Development Goals. *Societies*, 15(9), 251. https://doi.org/10.3390/soc15090251

Mariyono, D., & Alif, N. H. A. (2025). AI's role in transforming learning environments: a review of collaborative approaches and innovations. *Quality Education for All*, 2(1), 267–290. https://doi.org/10.1108/QEA-08-2024-0071

Mthembu, N., Wanjiru, G., & Desmond. G. (2023). The Pedagogical Shift in the Emergence of Digital Technology: Transforming Teaching Practices. *E-Journal of Humanities, Arts and Social Sciences*, 4, 1330-1344. 10.38159/ehass.20234112.

Muzata, A. R., Singh, G., Stepanov, M. S., & Musonda, I. (2024). Immersive Learning: A Systematic Literature Review on Transforming Engineering Education Through Virtual Reality. *Virtual Worlds*, 3(4), 480-505. https://doi.org/10.3390/virtualworlds3040026

Nazaretsky, T., Mejía-Domenzain, P., Swamy, V., Frej, J., & Käser, T. (2025). The critical role of trust in adopting AI-powered educational technology for learning: An instrument for measuring student perceptions. *Computers and Education: Artificial Intelligence*, 8, 2025, 100368. https://doi.org/10.1016/j.caeai.2025.100368

Nizamani, M. M., Zhang, H-I., & Lai, Z. (2026). Human-centered AI: advancing ethical, transparent, and context-aware systems for sustainable development. *Technology in Society*, 84, 103121. https://doi.org/10.1016/j.techsoc.2025.103121

Ogbolu, G., Hague, S., Adelaja, A., Ohanagorom, M., Amala, M., & Adedeji, O. (2026). Sustainability in Higher Education: A Systematic Review and Conceptual Framework of Institutional Maturity (SHE-IMM). *Trends in Higher Education*, 5(1), 26. https://doi.org/10.3390/higheredu5010026

Ouwehand, K., Lespiau, F., Tricot, A., & Paas, F. (2025). Cognitive Load Theory: Emerging Trends and Innovations. *Education Sciences*, 15(4), 458. https://doi.org/10.3390/educsci15040458

Partarakis, N., & Zabulis, X. (2024). A Review of Immersive Technologies, Knowledge Representation, and AI for Human-Centered Digital Experiences. *Electronics*, 13(2), 269. https://doi.org/10.3390/electronics13020269

Patac, L. P., & Patac, A. V. (2025). Using ChatGPT for academic support: Managing cognitive load and enhancing learning efficiency – A phenomenological approach. *Social Sciences & Humanities Open*, 11, 101301. https://doi.org/10.1016/j.ssaho.2025.101301

Rashevska, N. V., & Semerikov, S. O. (2026). From philosophical immersion to digital reality: A unified theoretical framework for understanding and classifying immersive technologies in education. *Computers & Education: X Reality*, 8, 2026, 100147. https://doi.org/10.1016/j.cexr.2026.100147

Rismanchian, S., & Doroudi, S. (2025). The Evolution of Research on AI and Education Across Four Decades: Insights from the AIxEd Framework. *Int J Artif Intell Educ*., 35, 2797–2820. https://doi.org/10.1007/s40593-025-00483-9

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, 55, 68-78. http://dx.doi.org/10.1037/0003-066X.55.1.68

Samala, A. D., Rawas, S., Rahmadika, S. et al. (2025). Virtual reality in education: global trends, challenges, and impacts—game changer or passing trend? *Discov Educ*., 4, 229. https://doi.org/10.1007/s44217-025-00650-z

Samodra, I., Rahmawati, F. & Prayitno, B.A. (2025). Bibliometric mapping of computational thinking and project-based learning research in science education for advancing SDG 6. *Discov Sustain*., 6, 1459 (2025). https://doi.org/10.1007/s43621-025-02340-0

Saseendran, A., & Thomas, M. V. (2025). Integration of design thinking and educational technology into science education: A conceptual framework for the development of sustainability competencies. *Journal of Educational Technology Development and Exchange*, 18(4), 91-116. https://doi.org/10.18785/jetde.1804.05

Schwartz, E., & Blau, I. (2026). Not All Immersive Technologies Are Equal: Bridging Teachers' Instruction and Students' Perceived Learning in Immersive Educational Environments. *Education Sciences*, 16(2), 190. https://doi.org/10.3390/educsci16020190

Stalmach, A., D'Elia, P., Di Sano, S., & Casale, G. (2025). Secondary School Students' Perceptions of Autonomy, Competence, and Relatedness in Digital Learning: A Qualitative Study. *Computers in the Schools*, 1–24. https://doi.org/10.1080/07380569.2025.2532436

Suiçmez, İ., & Özansoy, K. (2024). Development of Sustainable Education Environments in Higher Education with Metaverse Applications. *Sustainability*, 16(23), 10331. https://doi.org/10.3390/su162310331

Swan, K., Garrison, D. R. & Richardson, J. C. (2009). A constructivist approach to online learning: the Community of Inquiry framework. In Payne, C. R. (ed.), Information Technology and Constructivism in Higher Education: Progressive Learning Frameworks. Hershey, PA: IGI Global, 43-57.

Tan, L. Y., Hu, S., Yeo, D. J., & Cheong, K. H. (2025). Artificial intelligence-enabled adaptive learning platforms: A review. *Computers and Education: Artificial Intelligence*, 9, 2025, 100429, https://doi.org/10.1016/j.caeai.2025.100429

Tan, X., Cheng, G., & Ling, M. H. (2025). Investigating the mediating role of TPACK on teachers' AI competency and their teaching performance in higher education. *Computers and Education: Artificial Intelligence*, 9, 2025, 100461. https://doi.org/10.1016/j.caeai.2025.100461

Tene, T., Vique López, D. F., García Veloz, M. J., Rojas Oviedo, B. S., & Tene-Fernandez, R. (2026). Artificial intelligence, extended reality, and emerging AI-XR integrations in medical education. *Frontiers in digital health*, 7, 1740557. https://doi.org/10.3389/fdgth.2025.1740557

Torres-Rivera, A. D., Rendón Peña, A. A., Díaz-Torres, S. T., & Díaz-Torres, L. A. (2025). Ethical Integration of AI and STEAM Pedagogies in Higher Education: A Sustainable Learning Model for Society 5.0. *Sustainability*, 17(19), 8525. https://doi.org/10.3390/su17198525

UNESCO. (2017). *Education for Sustainable Development Goals: Learning Objectives*. UNESCO.

Xue, L., Rashid, A. M., & Ouyang, S. (2024). The Unified Theory of Acceptance and Use of Technology (UTAUT) in Higher Education: A Systematic Review. *Sage Open*, 14(1). https://doi.org/10.1177/21582440241229570

Yao, Y., & González-Vélez, H. (2025). AI-Powered System to Facilitate Personalized Adaptive Learning in Digital Transformation. *Applied Sciences*, 15(9), 4989. https://doi.org/10.3390/app15094989

Yue, M., Jong, M. S. Y., Dai, Y., & Lau, W. W. F. (2025). Students as AI-literate designers: a pedagogical framework for learning and teaching AI literacy in elementary education. *Journal of Research on Technology in Education*, 1–22. https://doi.org/10.1080/15391523.2025.2449942

Yufiarti, A., & Yetti, E. (2024). Pedagogical innovation and curricular adaptation in enhancing digital literacy: A local wisdom approach for sustainable development in Indonesia context. *Journal of Open Innovation: Technology, Market, and Complexity*, 10(1), 100233. https://doi.org/10.1016/j.joitmc.2024.100233

Zdonek, I., Zdonek, D., Król, K., & Halva, J. (2025). Sustainability-Oriented Higher Education Activities: Insights from Institutional Isomorphism Perspective. *Sustainability*, 17(24), 11034. https://doi.org/10.3390/su172411034

Zhu, W., Wei, L., & Qin, Y. (2025). Artificial Intelligence in Education (AIEd): Publication Patterns, Keywords, and Research Focus. *Information*, 16(9), 725. https://doi.org/10.3390/info16090725

Zou, Y., Kuek, F., Feng, W., & Cheng, X. (2025). Digital learning in the 21st century: trends, challenges, and innovations in technology integration. *Front. Educ*. 10, 1562391. https://doi.org/10.3389/feduc.2025.1562391