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Literature Review of Artificial Intelligence in Augmented Reality for Adaptive Learning

Bintang Eka Putera[1], Julia Fajaryanti[2]

[1] Faculty of Computer Science and Information Technology, Gunadarma University, Indonesia

[2] Faculty of Industrial Engineering, Gunadarma University, Indonesia

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ABSTRACT

Although Artificial Intelligence (AI) and Augmented Reality (AR) have attracted increasing attention in education, their combined role in adaptive learning remains fragmented across existing studies. This review examines how AI is applied in AR-based learning environments, the benefits of AI–AR integration, and the associated challenges. The reviewed studies show that AI supports personalization through intelligent tutoring systems, adaptive feedback, learning analytics, and generative AI, while AR enhances visualization, engagement, and immersive learning experiences. This review synthesizes the complementary roles of AI and AR, highlights current research trends and gaps, and provides insights for educators and researchers developing adaptive learning environments.

Corresponding Author:

Bintang Eka Putera,
Faculty of Computer Science and Information Technology
Gunadarma University
Jl. Margonda Raya Number. 100, Depok 16424, West Java, Indonesia
Email : bintang_ep@staff.gunadarma.ac.

1. INTRODUCTION

The growing use of digital technology has transformed the design and delivery of education, increasing interest in interactive and learner-centered approaches. Among these technologies, Augmented Reality (AR) has attracted considerable attention because it combines digital information with the physical environment. Through this capability, AR helps learners visualize abstract concepts, interact with contextualized learning materials, and engage in experiences that may be difficult to achieve through conventional instruction (Koumpouros, 2024); (Li et al., 2025). However, AR-based learning environments generally provide the same instructional content to all learners and have limited capability to adapt learning experiences according to individual learner characteristics and progress.

At the same time, Artificial Intelligence (AI) has become an important component of modern educational systems. AI can analyze learner data, support personalized learning pathways, provide adaptive feedback, and assist educational decision-making. Recent advances in AI-driven adaptive systems and intelligent tutoring technologies have expanded its potential to support adaptive learning (Yuensook et al., 2025); (Lampropoulos, 2025b). These capabilities enable AI to address the adaptive limitations of conventional AR applications by providing personalized learning support based on learner needs and performance.

The integration of AI and AR creates new opportunities for adaptive learning. AR provides interactive and immersive learning experiences, while AI personalizes learning activities and recommendations. Their integration has therefore attracted increasing attention for improving learner experiences and educational outcomes (Lampropoulos, 2025a).

Although research in this area continues to grow, findings related to AI in AR-based adaptive learning remain scattered across different educational contexts and disciplines. Existing reviews have discussed the integration of AI and AR; however, they have provided limited attention to their complementary roles in adaptive learning. This gap limits a comprehensive understanding of current developments and research directions. A literature review is therefore needed to synthesize existing knowledge and identify current trends, benefits, challenges, and future opportunities related to the use of AI in AR for adaptive learning environments. By synthesizing recent evidence, this review also identifies research trends, complementary roles of AI and AR, and current research gaps to support future studies and educational practice.

This study reviews the application of Artificial Intelligence in Augmented Reality for adaptive learning. The review is guided by the following research questions: (1) How is AI applied in AR-based learning environments? (2) What benefits does the integration of AI and AR provide for adaptive learning? and (3) What challenges and future opportunities exist in the development of AI-powered AR learning systems?

2. BACKGROUND OF THE STUDY

Adaptive learning is an educational approach that adjusts learning content, instructional strategies, and learning experiences based on learners' characteristics, preferences, and performance. In this review, adaptive learning is defined as the ability of educational systems to personalize learning experiences according to learners' needs, progress, and learning behaviors. Its objective is to improve learning effectiveness through more personalized instruction (Yuensook et al., 2025).

Augmented Reality (AR) has been adopted in various educational settings because it allows learners to interact with digital content within real-world contexts. By combining virtual information with real-world environments, AR enables learners to visualize abstract concepts more concretely and contextually, thereby supporting conceptual understanding, learning motivation, and student engagement across disciplines including mathematics, science, and higher education (Anugrah et al., 2023); (Koumpouros, 2024); (Ratnasari et al., 2025); (Li et al., 2025).

Artificial Intelligence (AI) has also become an important part of educational technology. Its role in adaptive learning can be seen in learning analytics, intelligent tutoring systems, automated feedback, and personalized learning recommendations. Recent advances in Generative AI and AI-powered pedagogical agents further enhance personalized learning by responding to learners' needs and progress (Lampropoulos, 2025b).

Recent studies have highlighted the potential of combining AI with AR and other immersive technologies. Through this integration, educational systems can present learning materials through AR while adapting learning experiences using AI-based analysis and recommendations. This growing integration reflects the increasing demand for intelligent and immersive learning environments. Consequently, AI and AR are increasingly regarded as complementary technologies that support adaptive learning (Lampropoulos, 2025a); (Lampropoulos, 2025b); (Rangel-de Lázaro & Duart, 2023).

3. METHODS

This study employed a structured literature review approach to examine the use of Artificial Intelligence in Augmented Reality for adaptive learning environments. The approach was chosen because research on AI and AR is developing rapidly, with findings scattered across different disciplines and publication venues, requiring existing evidence to be synthesized (Graser & Böhm, 2022); (Sakr & Abdullah, 2024). The review consisted of four stages: identifying relevant literature, selecting articles, analyzing their content, and synthesizing the findings. Literature was collected from Google Scholar, Scopus, and ScienceDirect because these databases provide broad coverage of peer-reviewed publications in educational technology and computer science. The search used combinations of the keywords "Artificial Intelligence", "Augmented Reality", "adaptive learning", "learning analytics", and "intelligent tutoring systems". The review primarily focused on peer-reviewed studies published between 2021 and 2026 to capture recent developments in AI-driven educational technologies, while earlier foundational studies were included when they provided essential evidence on AR or AI applications in education. The inclusion criteria comprised studies discussing AI, AR, and adaptive learning in educational contexts, whereas studies outside this scope were excluded. The selected articles were analyzed to identify the AI methods, AR implementation, educational outcomes, and recurring themes related to personalization, learning effectiveness, technical constraints, and implementation challenges. Finally, the findings were synthesized using a thematic narrative approach to identify recurring themes, similarities and differences among studies, research trends, and existing research gaps regarding the contribution of AI to adaptive AR-based learning environments (Li et al., 2025); (Sakr & Abdullah, 2024).

4. RESULTS AND DISCUSSIONS

The reviewed studies indicate that Artificial Intelligence (AI) and Augmented Reality (AR) play complementary roles in adaptive learning. AI supports adaptive learning through learning analytics, personalized learning pathways, intelligent tutoring systems, and data-driven instructional support. whereas AR enhances learning through interactive visualization, contextual learning, and immersive educational activities. The literature consistently shows that AI primarily enables personalization, while AR enriches learning experiences, demonstrating a complementary pattern across educational contexts. Together, these technologies support adaptive and learner-centered educational environments, reflecting growing interest in their combined use within educational practice and research (Sakr & Abdullah, 2024); (Yuensook et al., 2025); (Lampropoulos, 2025a). However, the synthesis also indicates that fully integrated AI–AR adaptive learning environments remain limited, highlighting an important direction for future research.

4.1. Research Trends on AI and AR in Education

Research on Augmented Reality in education has expanded considerably over the past decade. Bibliometric and systematic review studies show that AR has been applied across disciplines, including mathematics, science, engineering, and higher education (A et al., 2025); (Li et al., 2025). The wider availability of mobile devices and digital learning platforms has also contributed to the growth of AR-based learning applications. Overall, AR research has evolved from improving visualization toward supporting more interactive and technology-enhanced learning experiences.

Artificial Intelligence has become an increasingly important technology in adaptive learning. Educational systems incorporating AI utilize learning analytics, intelligent tutoring systems, and personalized learning mechanisms to support individualized

learning experiences. Recent developments in AI-driven adaptive systems have expanded opportunities to create learning environments that are more responsive to learners' needs, preferences, and progress (Yuensook et al., 2025); (Lampropoulos, 2025b). This trend reflects the growing role of AI in enabling personalized and data-driven learning.

A related trend can be seen in the growing number of studies that integrating AI with immersive technologies such as Augmented Reality and Virtual Reality. This development increasing interest in educational systems that combine intelligent adaptation with interactive learning experiences (Lampropoulos, 2025a); (Rangel-de Lázaro & Duart, 2023). However, the limited number of fully integrated AI–AR learning systems suggests that current research remains focused on combining existing technologies rather than developing mature adaptive learning ecosystems, highlighting opportunities for future research and educational implementation.

4.2. Applications of AI and AR for Adaptive Learning

Artificial Intelligence and Augmented Reality support adaptive learning in complementary ways. AI contributes through learner data analysis, personalized recommendations, intelligent tutoring systems, and learning analytics, enabling educational systems to provide instructional support aligned with individual learner characteristics (Yuensook et al., 2025); (Lampropoulos, 2025b). The synthesis indicates that AI primarily supports adaptive learning by enabling data-driven personalization and instructional decision-making.

Augmented Reality serves as an interactive medium that supports visualization and contextual learning. Studies have reported that AR improves conceptual understanding, practical skill development, and immersive learning experiences across various educational settings (Anugrah et al., 2023); (Vidak et al., 2024); (Yoo et al., 2023). The reviewed studies consistently identify learner engagement and visualization as the primary educational contributions of AR.

The reviewed literature points to the value of combining AI and AR within adaptive learning environments. AI contributes personalization and adaptive decision-making, whereas AR enhances interactive and context-rich learning experiences (Lampropoulos, 2025a); (Lampropoulos, 2025b). This complementary relationship suggests that effective adaptive learning depends not only on intelligent adaptation or immersive visualization alone, but on their integration to support learner-centered instruction.

Table 1. Literature Synthesis of AI Applications in AR-Based Adaptive Learning

Authors	Research Focus	AI Component	AR Component	Key Findings
(Anugrah et al., 2023)	AR as a learning medium in mathematics education	-	Augmented Reality	AR improves mathematical concept visualization and learning engagement.
(Çetinkaya Özdemir & Akyol, 2021)	AR for reading activities and comprehension	-	Augmented Reality	AR enhances reading comprehension and learner participation
(Upadhyay et al., 2023)	Collaborative AR in higher education	-	Collaborative AR	AR supports collaboration and improves learning outcomes.
(Yoo et al., 2023)	AR for psychomotor skill development	-	Augmented Reality	AR facilitates the mastery of complex psychomotor skills.
(Vidak et al., 2024)	AR in physics education	-	Augmented Reality	AR assists learners in understanding abstract scientific concepts.
(Rangel-de Lázaro & Duart, 2023)	AI and Extended Reality in online higher education	Artificial Intelligence	Extended Reality (XR)	AI and XR increase flexibility and effectiveness in digital learning.
(Koumpouros, 2024)	Potential and prospects of AR in education	-	Augmented Reality	AR improves engagement, motivation, and interactive learning experiences.
(Sakr & Abdullah, 2024)	AR, VR, and learning analytics in education	Learning Analytics	AR/VR	Learning analytics enhances adaptive and data-driven learning processes.

(Ratnasari et al., 2025)	AR-based learning media and learning outcomes	-	Augmented Reality	AR positively influences student learning outcomes.
(Graser & Böhm, 2022)	Technology acceptance of AR in education and training	-	Augmented Reality	User acceptance significantly influences successful AR implementation.
(Yuensook et al., 2025)	AI-driven adaptive learning systems	Adaptive AI	-	AI effectively supports adaptive and personalized learning.
(Lampropoulos, 2025a)	Combining AI with AR and VR in education	Artificial Intelligence	AR/VR	AI and immersive technologies enhance learning experiences and personalization.
(Lampropoulos, 2025b)	Intelligent tutoring systems with AR and VR	Intelligent Tutoring Systems	AR/VR	Intelligent tutoring systems support individualized learning.
(Li et al., 2025)	AR in higher education: systematic review and meta-analysis	-	Augmented Reality	AR has a positive impact on learning outcomes and learner engagement.
(A et al., 2025)	Bibliometric analysis of AR-based learning research	-	Augmented Reality	Research on AR in education continues to grow globally.
(Ikram et al., 2026)	AI in personalized learning	Adaptive AI	-	AI improve personalized learning, adaptive feedback, and instructional decision-making
(Ebadi & Ashrafabadi, 2022)	AR impact on EFL reading comprehension		Augmented Reality	AR improved reading comprehension and engagement, but lacked AI-driven personalization for adaptive learning.
(Sagita et al., 2025)	Augmented reality books for EFL reading comprehension improvement	-	Augmented Reality	AR books improved reading comprehension and attitudes through interactive multimedia features supporting more engaging learning.
(Putri et al., 2024)	Augmented reality media for early reading literacy development	-	Augmented Reality	AR learning media improved cognitive skills, letter recognition, and early literacy through interactive visual experiences.
(Abedin et al., 2026)	Responsible GenAI in higher education	Generative AI	-	GenAI improves personalized feedback, adaptive instructional support, and content generation for learning
(Liu et al., 2026)	Intelligent digital systems and adaptive support	Artificial Intelligence	-	GenAI improves personalized feedback, adaptive instructional support, and content generation for learning
(Boulhrir et al., 2026)	Technology-supported adaptive online learning	Partial AI		Adaptive digital learning improves learner autonomy, engagement, and instructional flexibility
(El Dandachi, 2026)	Augmented reality applications for language learning	Adaptive AI	Augmented Reality-	AR improves contextual language learning, engagement, vocabulary, and reading through immersive experiences with emerging AI adaptation
(Pallavicini & Anesa, 2026)	Theory-informed review of AR applications in education	-	Augmented Reality	AR enhances visualization, engagement, contextual learning, and conceptual understanding through interactive and immersive educational experiences.
(Abubakar et al., 2024)	AI-enhanced augmented reality applications in education	Adaptive AI	Augmented Reality	AI enhances AR through personalization, adaptive feedback, and analytics, while AR improves engagement, visualization, and interactive learning

A significant observation from the examined literature is the limited number of investigations that directly combine Artificial Intelligence and Augmented Reality into a unified adaptive educational framework. Current research primarily explores AR-

enhanced environments or AI-managed adaptive systems as independent entities. This pattern suggests that the development of comprehensive AI-integrated AR instructional systems remains an emerging area within adaptive learning research.

Table 1 indicates that Augmented Reality is predominantly used to enhance visualization, learner engagement, and learning outcomes. In contrast, Artificial Intelligence is more commonly applied to support adaptive learning through personalization, learning analytics, intelligent tutoring systems, and generative AI. Recent studies also demonstrate an increasing interest in integrating AI and AR through intelligent learning agents and generative AI technologies that provide more personalized feedback and adaptive learning support. Overall, the literature indicates a transition from using AR mainly for immersive visualization and AI mainly for personalization toward integrated AI–AR learning environments that create more flexible, adaptive, and learner-focused educational experiences.

4.3. Educational Benefits

Augmented Reality (AR) has demonstrated its potential to improve visualization, learner engagement, and conceptual understanding. Studies show that AR supports interactive learning experiences while enhancing reading comprehension, psychomotor skill and learning outcomes across various educational contexts ((Anugrah et al., 2023); (Çetinkaya Özdemir & Akyol, 2021); (Yoo et al., 2023); (Vidak et al., 2024); (Li et al., 2025)).

Artificial Intelligence (AI) supports adaptive learning through personalized instruction, intelligent feedback, and data-driven decision-making. AI-based approaches, including adaptive learning pathways, learning analytics, intelligent tutoring systems, predictive analysis, and Generative AI, enable learning environments to respond more effectively to individual learner needs (Sakr & Abdullah, 2024); (Yuensook et al., 2025); (Lampropoulos, 2025b); (Ikram et al., 2026); (Abedin et al., 2026).

The integration of AI and AR extends these benefits by combining immersive learning experiences with intelligent personalization. Recent studies indicate that AI-supported AR systems provide adaptive feedback, contextual learning support, and more responsive learning experiences (Rangel-de Lázaro & Duart, 2023); (Lampropoulos, 2025a); (Pallavicini & Anesa, 2026).

Table 2. Educational Benefits of Artificial Intelligence and Augmented Reality for Adaptive Learning

Educational Benefit	Description	Supporting References
Improved Learning Outcomes	AR and AI Improves learning outcomes and academic performance.	(Ratnasari et al., 2025); (Li et al., 2025); (Ikram et al., 2026)
Enhanced Learner Engagement	AR-based immersive Increases learner engagement and participation.	(Koumpouros, 2024);; (Li et al., 2025)
Improved Conceptual Understanding	AR Enhances visualization and conceptual understanding.	(Anugrah et al., 2023); (Vidak et al., 2024); (Çetinkaya Özdemir & Akyol, 2021)
Increased Learning Motivation and Interest	Interactive AR Increases learner motivation and interest.	(Çetinkaya Özdemir & Akyol, 2021); (Koumpouros, 2024); (Sagita et al., 2025)
Development of Practical and Psychomotor Skills	AR supporting Develops practical and psychomotor skills..	(Yoo et al., 2023)
Personalized Learning Experiences	AI delivers personalized and adaptive learning experiences.	(Yuensook et al., 2025); (Ikram et al., 2026)

Intelligent Learning Support	AI-driven systems provide adaptive feedback and intelligent assistance.	(Lampropoulos, 2025b); (Pallavicini & Anesa, 2026)
Data-Driven Instructional Improvement	AI-based analytics and predictive approaches supports data-driven instructional decisions.	(Sakr & Abdullah, 2024); (Ikram et al., 2026)
Adaptive and Responsive Learning Environment	The integration of AI and AR creates adaptive and responsive learning environments.	(Rangel-de Lázaro & Duart, 2023); (Lampropoulos, 2025a)

As shown in Table 2, synthesizes the educational benefits identified across the reviewed studies rather than merely listing individual findings. The evidence consistently shows that AR primarily enhances learner engagement, visualization, conceptual understanding, and practical skills, whereas AI strengthens personalization, intelligent learning support, and data-driven instructional decisions. This complementary pattern suggests that meaningful improvements in adaptive learning are achieved through the integration of immersive learning experiences with intelligent instructional support, reinforcing learner-centered learning approaches while highlighting opportunities for more adaptive educational systems.

4.4. Challenges and Opportunities

The implementation of Artificial Intelligence (AI) and Augmented Reality (AR) in adaptive learning environments still faces challenges related to technological readiness, system complexity, and responsible implementation. AR-based learning requires adequate infrastructure, accessible devices, and user acceptance to ensure effective adoption. Meanwhile, AI introduces concerns regarding data privacy, ethical use, and adaptive decision-making processes (Graser & Böhm, 2022); (Ikram et al., 2026); (Abedin et al., 2026).

A further challenge lies in combining AI-driven personalization with the immersive capabilities of AR. The reviewed studies show that most AI and AR applications remain separately implemented, with relatively few providing fully integrated adaptive learning environments. This gap highlights opportunities to develop AI–AR systems that adapt learning experiences according to learner characteristics, behaviors, and progress (Ebadi & Ashrafabadi, 2022); (Li et al., 2025); (Lampropoulos, 2025a).

Nevertheless, the integration of AI and AR offers opportunities to develop more adaptive and personalized learning environments. Recent advances in Generative AI, intelligent tutoring systems, and learning analytics support more contextual feedback and flexible learning pathways. This trend suggests a shift from immersive visualization toward intelligent immersive learning ecosystems that combine AR interaction with AI-driven adaptation (Lampropoulos, 2025b); (Pallavicini & Anesa, 2026).

Table 3. Challenges and Future Opportunities of AI and AR Integration in Adaptive Learning

Aspect	Challenges	Future Opportunities	Supporting References
Technology Infrastructure	Limited infrastructure restricts AI–AR implementation.	Cloud technologies improve scalability and accessibility.	(Graser & Böhm, 2022); (Lampropoulos, 2025a)
Data Privacy and Ethical Management	Privacy and ethical issues in learner data management.	Improved governance enables responsible personalized learning.	(Sakr & Abdullah, 2024); (Abedin et al., 2026); (Ikram et al., 2026)
User Acceptance and Digital Readiness	Limited digital literacy hinders AI–AR adoption.	Training improves user readiness and technology adoption.	(Graser & Böhm, 2022); (Koumpouros, 2024)

AI–AR System Integration	Complex integration of AI personalization and AR.	Integrated frameworks enable adaptive immersive learning.	(Ebadi & Ashrafabadi, 2022); (Li et al., 2025); (Lampropoulos, 2025a)
Adaptive Decision-Making Accuracy	Accurate adaptive recommendations remain challenging.	Advanced AI improves personalization accuracy.	(Yuensook et al., 2025); (Ikram et al., 2026)
Adaptive Learning Content Development	Adaptive AR content requires significant expertise and resources.	Generative AI accelerates adaptive content development.	(Pallavicini & Anesa, 2026)
Intelligent Learning Support	Real-time personalized support remains challenging.	GenAI tutors provide adaptive learning support.	(Lampropoulos, 2025b);
Educational Implementation and Scalability	Institutional barriers limit large-scale AI–AR adoption.	Digital transformation expands intelligent learning ecosystems.	(Rangel-de Lázaro & Duart, 2023); (A et al., 2025); (Pallavicini & Anesa, 2026)

Table 3 synthesizes the key challenges and future opportunities for integrating Artificial Intelligence (AI) and Augmented Reality (AR) in adaptive learning. The reviewed studies indicate that current challenges extend beyond technological infrastructure to include ethical, organizational, and pedagogical readiness, suggesting that successful AI–AR implementation depends on balancing intelligent adaptation with effective educational practice. At the same time, advances in Generative AI, intelligent tutoring systems, and learning analytics highlight a transition from standalone AI or AR applications toward integrated, learner-centered adaptive learning ecosystems, providing a clear direction for future research and educational innovation (Graser & Böhm, 2022); (Sakr & Abdullah, 2024); (Lampropoulos, 2025a); (Yuensook et al., 2025); (Pallavicini & Anesa, 2026).

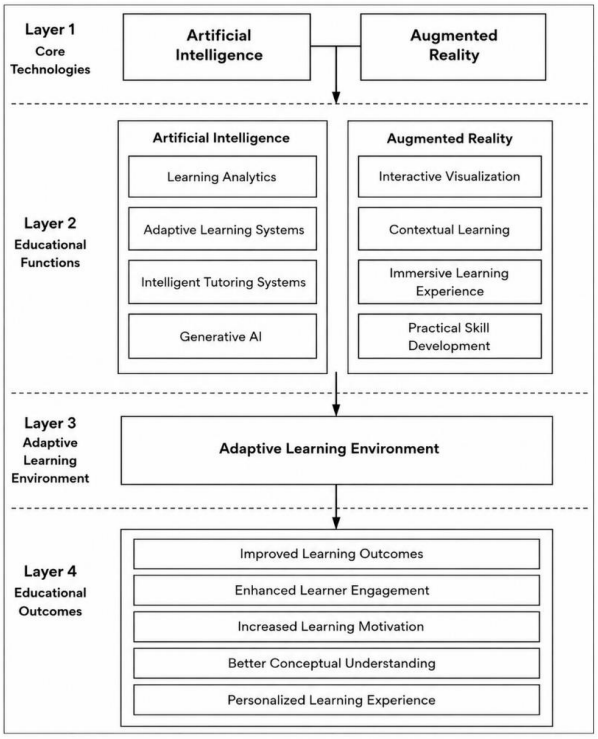

Figure 1. Conceptual Framework Derived from the Literature Review

5. CONCLUSION

The findings of this literature review demonstrate that the integration of Artificial Intelligence (AI) and Augmented Reality (AR) supports the development of more adaptive and learner-centered educational environments. The synthesis shows that AR primarily enhances immersive learning experiences, whereas AI enables personalization through adaptive feedback, learning analytics, and intelligent instructional support. Rather than functioning independently, both technologies provide complementary capabilities that support adaptive learning. Although AI–AR integration still faces challenges related to infrastructure, ethics, privacy, user readiness, and system integration, advances in Generative AI and intelligent learning technologies create new opportunities for developing adaptive learning ecosystems. The novelty of this review lies in synthesizing recent evidence to clarify the complementary roles of AI and AR while identifying the current gap in fully integrated AI–AR adaptive learning environments. The findings contribute theoretically by providing a synthesized understanding of AI–AR integration, practically by informing the design of adaptive educational technologies, and educationally by supporting learner-centered instructional practices. Future research should prioritize the design and empirical evaluation of integrated AI–AR learning systems in authentic educational settings involving diverse learners.

6. LIMITATIONS AND FUTURE WORKS

This review is limited to studies published between 2021 and 2026 on Artificial Intelligence, Augmented Reality, and adaptive learning. Accordingly, the findings reflect the scope and quality of the available literature during this period and may not capture more recent developments. Future research should investigate integrated AI–AR systems in authentic educational settings, with Particular attention to Generative AI, intelligent tutoring systems, and learning analytics. Empirical studies are also needed to evaluate their effectiveness across diverse educational contexts and learner populations.

REFERENCES

A, S., Hasan, Y., Taufik, M., & Hikmawati, H. (2025). Literature Review: Tren Pembelajaran Berbasis Augmented Reality (AR) Berdasarkan Analisis Bibliometrik Menggunakan Dimensions AI. *Lambda: Jurnal Ilmiah Pendidikan MIPA Dan Aplikasinya*, *5*(3), 940–949. https://doi.org/10.58218/lambda.v5i3.1968

Abedin, M. Z., Hayajneh, A., & Raahemi, B. (2026). Pedagogical Use of Responsible Generative AI in Higher Education; Opportunities and Challenges: A Systematic Literature Review. *AI in Education*, *2*(2), 11. https://doi.org/10.3390/aieduc2020011

Abubakar, A., Amosa, I., Adeniyi SOBOWALE, O., & Mosunmola, F. (2024). A SYSTEMATIC REVIEW OF ARTIFICIAL INTELLIGENCE (AI) ENHANCING TEACHING THROUGH AUGMENTED REALITY APPLICATION. In *INTERNATIONAL JOURNAL OF INNOVATIVE TECHNOLOGY INTEGRATION IN EDUCATION pg* (Vol. 165, Number 1).

Anugrah, M. F., Dasari, D., & Juandi, D. (2023). Systematic Literatur Review : Pemanfaatan Augmented Reality Sebagai Alternatif Media Pembelajaran Matematika. *Jurnal Ilmiah Komputasi*, *22*(2), 161–168.

Boulhrir, T., Ghreir, H., Hamash, M., & Robert, M. (2026). Artificial Intelligence in Education: Mapping Adaptive Learning and Learning Analytics in K-12 Online, Virtual, and Distance Learning scoping review AI in Education: Mapping Adaptive Learning and Learning Analytics in K-12 Online, Virtual, and Distance Learning. In *International Review of Research in Open and Distributed Learning* (Vol. 27).

Çetinkaya Özdemir, E., & Akyol, H. (2021). Effect of Augmented Reality-Based Reading Activities on Some Reading Variables and Participation in Class. *International Journal of Progressive Education*, *17*(4), 135–154. https://doi.org/10.29329/ijpe.2021.366.9

Ebadi, S., & Ashrafabadi, F. (2022). An exploration into the impact of augmented reality on EFL learners' Reading comprehension. *Education and Information Technologies*, *27*(7), 9745–9765. https://doi.org/10.1007/s10639-022-11021-8

El Dandachi, I. (2026). Augmented Reality Applications and Tools in Language Education. In *The Palgrave Encyclopedia of Computer-Assisted Language Learning* (pp. 1–6). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-51447-0_290-1

Graser, S., & Böhm, S. (2022). *A Systematic Literature Review on Technology Acceptance Research on Augmented Reality in the Field of Training and Education*. https://doi.org/https://doi.org/10.48550/arXiv.2411.13946

Ikram, M., Hanefar, S. B. M., Saleem, S. M. U., & Zulfiqar, F. (2026). Artificial intelligence in education: a systematic review of personalized learning trends and future directions. In *Frontiers in Education* (Vol. 11). Frontiers Media SA. https://doi.org/10.3389/feduc.2026.1782626

Koumpouros, Y. (2024). Revealing the true potential and prospects of augmented reality in education. In *Smart Learning Environments* (Vol. 11, Number 1). Springer. https://doi.org/10.1186/s40561-023-00288-0

Lampropoulos, G. (2025a). Augmented Reality, Virtual Reality, and Intelligent Tutoring Systems in Education and Training: A Systematic Literature Review. In *Applied Sciences (Switzerland)* (Vol. 15, Number 6). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/app15063223

Lampropoulos, G. (2025b). Combining Artificial Intelligence with Augmented Reality and Virtual Reality in Education: Current Trends and Future Perspectives. In *Multimodal Technologies and Interaction* (Vol. 9, Number 2). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/mti9020011

Li, G., Luo, H., Chen, D., Wang, P., Yin, X., & Zhang, J. (2025). Augmented Reality in Higher Education: A Systematic Review and Meta-Analysis of the Literature from 2000 to 2023. In *Education Sciences* (Vol. 15, Number 6). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/educsci15060678

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*. https://doi.org/10.1016/j.caeai.2025.100523

Pallavicini, F., & Anesa, P. (2026). A Narrative Review on Augmented Reality in Education. *Education Sciences*, *16*(2), 261. https://doi.org/10.3390/educsci16020261

Putri, A. A. V. W., I Wayan Widiana, & Maria Goreti Rini Kristiantari. (2024). Media Augmented Reality Belajar Membaca untuk Menumbuhkan Kemampuan Kognitif dan Literasi Membaca Awal Anak Usia Dini. *Journal of Education Action Research*, *8*(3), 504–512. https://doi.org/10.23887/jear.v8i3.83973

Rangel-de Lázaro, G., & Duart, J. M. (2023). You Can Handle, You Can Teach It: Systematic Review on the Use of Extended Reality and Artificial Intelligence Technologies for Online Higher Education. In *Sustainability (Switzerland)* (Vol. 15, Number 4). MDPI. https://doi.org/10.3390/su15043507

Ratnasari, Y. M., Fakhruddin, F., Ahmadi, F., Subali, B., & Widiarti, N. (2025). A Systematic Literature Review: Augmented Reality-based Learning Media to Improve Student Learning Outcomes. *Edunesia : Jurnal Ilmiah Pendidikan*, *6*(2), 917–933. https://doi.org/10.51276/edu.v6i2.1236

Sagita, M., Yuliasri, I., Faridi, A., & Pratama, H. (2025). Ar-Enhanced Reading Instruction: Impact on Indonesian EFL Learners' Comprehension and Attitudes. *DIB JOURNAL*, *28*(1), 2025.

Sakr, A., & Abdullah, T. (2024). Virtual, augmented reality and learning analytics impact on learners, and educators: A systematic review. *Education and Information Technologies*, *29*(15), 19913–19962. https://doi.org/10.1007/s10639-024-12602-5

Upadhyay, B., Brady, C., Madathil, K. C., Bertrand, J., & Gramopadhye, A. (2023). *Collaborative Augmented Reality in Higher Education Settings – Strategies, Learning Outcomes and Challenges*. *67*(1). https://doi.org/https://doi.org/10.1177/21695067231192199

Vidak, A., Šapić, I. M., Mešić, V., & Gomzi, V. (2024). *Augmented Reality Technology in Teaching about Physics: A systematic review of opportunities and challenges*. https://doi.org/https://doi.org/10.48550/arXiv.2311.18392

Yoo, D. W., Reza, S., Wilson, N., Jona, K., & Moghaddam, M. (2023). *Augmenting Learning with Augmented Reality: Exploring the Affordances of AR in Supporting Mastery of Complex*

Psychomotor Tasks. https://doi.org/https://doi.org/10.48550/arXiv.2305.09875Focustolearnmore

Yuensook, T., Jantakoon, T., & Limpinan, P. (2025). AI-Driven Adaptive Learning Systems in Higher Education: A Systematic Review. *Journal of Education and Learning*, *15*(2), 117. https://doi.org/10.5539/jel.v15n2p117