

ARTIFICIAL INTELLIGENCE IN EDUCATION: A SYSTEMATIC LITERATURE REVIEW OF APPLICATIONS, CHALLENGES, AND FUTURE RESEARCH DIRECTIONS

Maftuhul Ilma Wiratama¹, Muhammad Naraya Januarso², Callista Ayu Putri Shafira³,
Andhini Lestary Alexa Vare⁴, Attalia Putri Ramadhani⁵, Rachmah Fiina Mahdiah⁶

¹ STAI Ma'had Aly Al-Hikam Malang, Indonesia

² Universitas Negeri Surabaya, Indonesia

³ Universitas Negeri Surabaya, Indonesia

⁴ Universitas Negeri Surabaya, Indonesia

⁵ Universitas Negeri Surabaya, Indonesia

⁶ Universitas Negeri Surabaya, Indonesia

ABSTRACT

Artificial Intelligence (AI) has increasingly transformed educational practices, creating new opportunities for personalized learning, intelligent tutoring, automated assessment, learning analytics, and instructional support. However, the rapid adoption of AI, particularly Generative AI and Large Language Models, also raises concerns regarding privacy, algorithmic bias, academic integrity, technological dependence, and teacher readiness. This study aims to systematically review the existing literature on Artificial Intelligence in Education (AIED) by examining its major applications, benefits, challenges, and future research directions. A Systematic Literature Review (SLR) was conducted using the Scopus database and guided by the PRISMA 2020 framework. Relevant studies were identified, screened, and analyzed using thematic synthesis. The findings indicate that AI applications are primarily concentrated in personalized and adaptive learning, intelligent tutoring systems, teaching support, assessment and feedback, learning analytics, and educational content generation. The review also highlights significant challenges related to data privacy, algorithmic fairness, transparency, academic integrity, digital inequality, and AI literacy. Research gaps remain in K–12 education, developing countries, inclusive education, culturally diverse contexts, and longitudinal evaluation of AI's educational impacts. The study recommends strengthening AI literacy, responsible AI governance, teacher professional development, and human-AI collaboration. Future research should prioritize evidence-based, ethical, inclusive, and human-centered approaches

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to ensure that AI contributes meaningfully to educational quality and learning outcomes.

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Corresponding Author:

Maftuhul Ilma Wiratama, dewihn@gmail.com

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I. INTRODUCTION

The development of Artificial Intelligence (AI) in recent years has brought about significant changes across various sectors of life, including education. Advancements in machine learning, deep learning, natural language processing, large language models (LLMs), generative AI (GenAI), intelligent tutoring systems (ITS), and learning analytics have expanded the possibilities for utilizing digital technology in the educational process. AI is no longer positioned merely as a technology for administrative support; it has begun to play a role in learning, teaching, assessment, feedback provision, the prediction of learner outcomes, personalized learning, and even the management of educational institutions. These developments have established Artificial Intelligence in Education (AIED) as a rapidly growing, multidisciplinary field of research. Zawacki-Richter et al. (2019) demonstrated that AIED research has evolved through various application forms, particularly profiling and prediction, assessment and evaluation, adaptive systems and personalization, and intelligent tutoring systems.

These changes have intensified with the emergence of generative AI, which can interactively produce text, images, code, summaries, translations, and various other forms of content. The arrival of applications like ChatGPT has transformed how learners seek information, draft written work, receive feedback, and interact with learning resources. Simultaneously, teachers and lecturers can leverage AI to design learning materials, create learning activities, develop assessment instruments, provide feedback, and handle various administrative tasks. Recent systematic reviews indicate that the surge in AIED research was particularly evident in 2023 and 2024, coinciding with the widening access to GenAI and LLMs (Mustafa et al., 2024). Furthermore, Wang et al. (2024)—through an analysis of 2,223 research articles and a content analysis of 125 articles—found that AIED research encompasses adaptive learning and personalized tutoring, intelligent assessment and management, profiling and prediction, as well as various AI products emerging within the educational landscape.

In the context of learning, one of AI's key contributions is its ability to provide more adaptive and personalized learning experiences. AI-based systems can leverage data on learners' activities, responses, capabilities, and progress to tailor materials, difficulty levels, recommendations, and the types of support provided. Consequently, learning does not have to rely on a one-size-fits-all approach for all students. Systematic reviews of AI-driven intelligent tutoring

systems (ITS) in K–12 education indicate that ITS are emerging as a significant application of AI in support of learning, while research on self-regulated learning shows that chatbots, ITS, adaptive learning systems, e-books, and educational games are being used to support various stages of student self-regulation. These developments demonstrate AI's potential to evolve from a mere information provider into a system capable of offering more adaptive and responsive learning support.

Beyond the learning process itself, AI is increasingly being used to support educators in their work. AI systems can assist teachers and lecturers with material preparation, lesson planning, assessment design, learning outcome analysis, feedback provision, and the identification of students at risk of learning difficulties. In their systematic review, Zawacki-Richter et al. (2019) found that the majority of AIED research in higher education focuses on technology and application development, while the involvement and perspectives of educators receive relatively little attention. This finding is significant because the effectiveness of AI in education is determined not solely by technological sophistication, but also by the educator's ability to integrate that technology into pedagogical goals and strategies.

Regarding assessment, AI offers the potential for faster evaluation, automated feedback, learner response analysis, and the identification of error patterns and competency gaps. These developments could reduce the administrative burden on educators while accelerating the delivery of feedback to learners. Through a systematic literature review of AIED research from 2012 to 2021, Cheng et al. (2023) identified various roles AI plays in learning, teaching, assessment, and administration, as well as seven types of learning outcomes associated with AI implementation. However, the study also highlighted ten key challenges requiring attention during the development and implementation of AIED. Consequently, the use of AI in assessment should not be viewed solely through the lens of efficiency; it must also be evaluated based on validity, reliability, transparency, fairness, and pedagogical consequences.

While offering numerous opportunities, the integration of AI into education also gives rise to complex issues. A primary concern is data privacy and security. Educational AI systems require vast amounts of data for personalization, prediction, and evaluation. This data may encompass learning activities, academic performance, learner characteristics, interaction patterns, and even information regarding behavior and emotional states. The more extensive the data collection,

the greater the need for robust data protection mechanisms, transparency in data usage, user consent, and responsible governance. Holmes et al. (2022) emphasize that AIED ethics cannot be separated from issues such as data ownership and control, privacy, transparency, algorithmic bias, fairness, accountability, and learner agency.

Another issue concerns the potential for algorithmic bias and inequity. AI operates based on specific data and computational models; thus, its outputs depend heavily on the quality, representativeness, and context of the data used. If training data fails to reflect learner diversity, AI systems risk generating recommendations or decisions that are unfair to certain groups. In an educational context, this issue is critical, as decisions made or supported by AI can impact learners' educational experiences, assessments, predictions of success, and even their educational opportunities. Holmes et al. (2022) identify fairness, accountability, transparency, bias, autonomy, agency, and inclusion as fundamental issues in AIED ethics.

Furthermore, the development of generative AI has raised new concerns regarding academic integrity. The ability of GenAI to generate answers, essays, code, and various forms of academic assignments complicates the distinction between technological assistance and the learner's own work. This situation compels educational institutions to re-evaluate their assessment approaches, academic policies, AI literacy, and educator competencies. Research on GenAI in higher education indicates that the technology has influenced teaching, learning, and institutional activities, while simultaneously presenting challenges related to academic integrity, AI competence, and institutional readiness to develop appropriate policies (Tlili et al., 2024).

Another challenge concerns the readiness of educators. The mere presence of AI technology does not automatically lead to improved learning quality if teachers and lecturers lack the competence to select, evaluate, and pedagogically integrate AI. Mouta et al. (2024) indicate that while AIED literature frequently highlights the benefits of technology for learning and teaching, issues regarding ethics, inclusion, cultural differences, and educator capacity still require greater attention. They also emphasize the importance of teacher capacity building to ensure that AI usage is not solely focused on technical skills but also considers pedagogical and ethical consequences. This demonstrates that the successful implementation of AI in education is fundamentally a socio-technical issue,

involving the interaction between technology, educators, learners, institutions, policies, and social contexts.

The rapid pace of AIED research has also resulted in an increasingly vast and fragmented knowledge landscape. Research on AI in education spans various educational levels, disciplines, countries, user groups, and technology types. Wang et al. (2024) show that AIED literature is multidisciplinary in nature, employing diverse theories, research methods, and educational contexts. Mustafa et al. (2024) identified as many as 143 literature reviews on AIED published between 2012 and 2024. They found that AIED research largely focuses on higher education and is concentrated in specific geographic regions, whereas special education, stakeholders other than teachers and learners, and certain aspects of AIED theory remain relatively under-researched. This situation highlights the need for a more comprehensive synthesis of knowledge to understand AIED developments across technologies, educational levels, functions, benefits, challenges, and research directions.

This need is increasingly critical as AIED research continues to evolve alongside technological advancements. For instance, studies conducted prior to the emergence of Generative AI (GenAI) naturally differ in focus from research undertaken after the advent of ChatGPT and Large Language Models (LLMs). While earlier reviews focused heavily on ITS, adaptive learning, learning analytics, profiling and prediction, and automated assessment, recent research increasingly explores GenAI, LLMs, chatbots, AI-assisted writing, AI-powered feedback, and human-AI collaboration. A 2025 systematic review found that AI integration in education largely targets personalized learning, enhanced engagement, and teaching effectiveness; however, issues regarding accuracy, data privacy, algorithmic bias, and the need for educator training remain significant challenges. Meanwhile, a 2025 study synthesizing 102 systematic reviews on K–12 education identified four major categories of challenges: technological limitations, pedagogical barriers, ethical risks, and systemic obstacles. That study also emphasized that AI literacy among teachers and students, as well as the development of AIED theory, lags behind the rapid evolution of AI applications.

Consequently, there is a need for a Systematic Literature Review (SLR) that not only catalogs the types of AI technologies used in education but also integrates findings regarding applications, benefits, challenges, implementation contexts, and future research agendas. An SLR is crucial because AIED research is advancing rapidly, employing diverse terminologies and approaches, and

yielding findings scattered across various disciplines and educational levels. A comprehensive SLR can help identify research trends, categorize AI applications based on educational functions, compare their benefits and limitations, and reveal unresolved research gaps. Cheng et al. (2023) previously demonstrated that AIED research can be mapped across the domains of learning, teaching, assessment, and administration, while Wang et al. (2024) highlighted the breadth of application categories and the diversity of research approaches within the field.

Furthermore, the current Systematic Literature Review (SLR) holds significant importance as the field of AI in Education (AIED) enters a new phase characterized by the widespread adoption of Generative AI (GenAI) and Large Language Models (LLMs). Research has moved beyond merely questioning whether AI can be utilized in education; the focus has shifted toward more complex inquiries: for which educational purposes is AI most effective? How should AI be integrated with pedagogy? Who benefits, and what risks arise? How can the readiness of educators and institutions be fostered? And how can AI be deployed in ways that are equitable, safe, transparent, and human-centric? Recent studies on AI and personalized learning indicate that research is gravitating toward identifying more systematic AI integration models while simultaneously pinpointing implementation gaps. Consequently, there is a need for a knowledge mapping exercise that goes beyond description to generate a research agenda aligned with contemporary AIED developments.

Against this backdrop, this study—titled “Artificial Intelligence in Education: A Systematic Literature Review of Applications, Challenges, and Future Research Directions”—was conducted. It aims to systematically synthesize research on AI applications in education, identify the various forms and functions of AI in learning, teaching, assessment, and educational management, analyze the benefits and challenges of implementation, and formulate future research directions. In doing so, the study seeks to make a theoretical contribution by clarifying the structure of AIED knowledge, as well as a practical contribution by assisting educators, researchers, technology developers, and policymakers in designing AI implementations that are effective, pedagogically sound, inclusive, ethical, and learner-oriented.

II. LITERATURE REVIEW

Artificial Intelligence in Education

Artificial Intelligence in Education (AIED) refers to the application of artificial intelligence technology to support learning, teaching, assessment, and educational management processes. The evolution of AIED encompasses machine learning, natural language processing, learning analytics, intelligent tutoring systems, adaptive learning, chatbots, and generative artificial intelligence (GenAI). Zawacki-Richter et al. (2019) identified several key applications of AI in higher education: profiling and prediction, assessment and evaluation, adaptive systems and personalization, and intelligent tutoring systems. Subsequent developments have expanded the use of AI to include learning, teaching, assessment, and educational administration (Cheng et al., 2023; Wang et al., 2024).

AI has the potential to enhance learning personalization by analyzing learner characteristics and progress, while providing more adaptive materials, recommendations, and feedback. Furthermore, AI can assist educators in designing materials, creating assessments, analyzing learning outcomes, and delivering feedback. The emergence of GenAI and large language models has further broadened these capabilities, as they can interactively generate text, questions, learning materials, code, and various forms of educational content (Wang et al., 2024; Yusuf et al., 2024).

Challenges of Artificial Intelligence in Education

Despite offering numerous opportunities, the implementation of AI in education faces technical, pedagogical, ethical, and institutional challenges. Data privacy and security are major concerns, as AI systems require vast amounts of learner data. Additionally, issues such as algorithmic bias, a lack of transparency, fairness, and accountability can impact the quality of decisions generated by AI (Holmes et al., 2022; Mouta et al., 2024).

The rise of GenAI also introduces new issues regarding academic integrity, technological dependency, assessment validity, and educator readiness. Therefore, AI implementation must take into account AI literacy, educator competence, pedagogical design, and human-centered AI principles to ensure the technology serves to support—rather than replace—the human role in education (Bond et al., 2024; Mustafa et al., 2024).

Although AIED research is expanding rapidly, the literature remains fragmented across various technologies, educational levels, functions, and research perspectives. Previous studies have largely addressed specific AI applications, higher education, GenAI, or ethical aspects in isolation (Zawacki-Richter et al., 2019; Cheng et al., 2023; Wang et al., 2024; Mustafa et al., 2024). Furthermore, there is a need to integrate evidence regarding AI applications, benefits, challenges, ethical considerations, and research gaps into a comprehensive synthesis. Addressing this gap, this study conducts a Systematic Literature Review to map the evolution of AIED research, identify the forms and functions of AI application in education, analyze the benefits and challenges of implementation, and formulate directions for future research. This study aims to provide a foundation for developing AI utilization that is effective, ethical, inclusive, and oriented toward the needs of both learners and educators.

III. RESEARCH METHODOLOGY

This study employed a Systematic Literature Review (SLR) to examine the applications, benefits, challenges, and future research directions of Artificial Intelligence in Education (AIED). The review followed the PRISMA 2020 framework to ensure a systematic, transparent, and reproducible review process (Page et al., 2021).

The literature search was conducted using the Scopus database, selected because of its extensive coverage of peer-reviewed international publications in education, technology, and related disciplines. The primary search string was TITLE-ABS-KEY ("artificial intelligence" AND education). The search was refined based on publication year, English language, and relevant document types. Journal articles directly addressing the application or implications of AI in educational contexts were prioritized.

The selection process consisted of identification, screening, eligibility assessment, and final inclusion. Studies were included if they focused on AI in education, were published in English in peer-reviewed journals, and provided findings relevant to the research questions. Articles unrelated to education, studies focusing solely on technical AI development without educational implications, and non-journal publications were excluded.

Data were extracted from the selected studies, including publication year, educational context, AI application, research focus, major findings, benefits, challenges, and proposed future directions. The collected data were analyzed using thematic synthesis to identify recurring patterns and organize the literature into major themes, particularly AI applications, personalized learning, assessment, teaching support, ethical challenges, technological limitations, and future research opportunities. The review process and study selection were reported according to PRISMA 2020 guidelines to enhance the transparency and reliability of the findings (Page et al., 2021).

IV. RESULTS AND ANALYSIS

The systematic literature review demonstrates that Artificial Intelligence in Education (AIED) has evolved from a relatively specialized technological field into a broad and multidisciplinary research domain. The literature indicates substantial growth in research addressing AI applications in learning, teaching, assessment, educational management, and academic research. Wang et al. (2024), through a bibliometric analysis of 2,223 research articles and content analysis of 125 selected studies, identified a broad conceptual structure of AIED research encompassing adaptive learning and personalized tutoring, intelligent assessment and management, profiling and prediction, and emerging AI products. Their findings also demonstrate that AIED research increasingly addresses not only the technical development of AI systems but also adoption, educational impacts, and implementation challenges.

The increasing diversity of applications indicates that AI in education should no longer be understood as a single technological intervention. Instead, AIED represents an ecosystem of technologies that perform different educational functions. Earlier research predominantly focused on intelligent tutoring systems, adaptive learning, student profiling, and prediction. More recent research has expanded toward learning analytics, automated feedback, educational chatbots, generative AI, large language models, and multimodal AI. Cheng et al. (2023) identified 13 roles of AI technologies across four major educational domains—learning, teaching, assessment, and administration—and further identified seven learning outcomes and ten major challenges associated with AIED. This indicates

that the contribution of AI extends beyond direct interaction with learners and increasingly encompasses the broader educational system.

Major Applications of Artificial Intelligence in Education

One of the strongest findings from the literature is the increasing application of AI to personalized and adaptive learning. AI systems can process learner data, including academic performance, learning behavior, response patterns, and interaction histories, to identify individual learning needs and provide differentiated learning materials or recommendations. Adaptive systems can modify the difficulty, sequence, and type of learning activities according to learners' progress. This capability is particularly important because conventional educational systems frequently rely on relatively standardized learning experiences despite substantial differences among learners.

The literature suggests that intelligent tutoring systems remain an important foundation of AI-supported personalized learning. These systems can provide explanations, hints, exercises, and feedback based on learner responses. Wang et al. (2024) identified adaptive learning and personalized tutoring as one of the dominant research clusters within AIED. However, the contemporary development of AI suggests a transition from rule-based tutoring toward more flexible systems that can interpret natural language, generate explanations, and respond dynamically to learner questions.

A second major application concerns teaching support and instructional design. AI can assist teachers and lecturers in generating instructional materials, developing questions, preparing lesson plans, providing feedback, summarizing learning resources, and identifying students who may require additional support. This application is particularly significant because educators frequently face substantial workloads related to lesson preparation, assessment, feedback, and administrative activities. AI therefore has the potential to reduce repetitive tasks and allow educators to devote greater attention to pedagogical interaction and higher-order instructional activities.

Nevertheless, the findings indicate that teacher support should not be interpreted as teacher replacement. Earlier AIED research already raised concerns about the limited involvement of educators in AI research. Zawacki-Richter et al. (2019) found that AIED research in higher education was strongly oriented toward technological development, while educators' perspectives and pedagogical roles

received comparatively less attention. This remains relevant in the contemporary GenAI environment because effective AI integration depends on educators' ability to evaluate AI-generated outputs, contextualize them pedagogically, and determine when human intervention is necessary.

A third major application is assessment and automated feedback. AI technologies can support automated grading, formative assessment, essay analysis, feedback generation, and identification of learning difficulties. These applications can potentially accelerate assessment processes and provide students with more immediate feedback. Cheng et al. (2023) identified assessment as one of the four central domains of AIED and demonstrated that AI has increasingly been used to support educational evaluation. However, the literature also indicates that automated assessment should not be treated as inherently objective. AI-generated evaluations may reproduce biases in training data or fail to recognize contextual and qualitative dimensions of student work. Consequently, human oversight remains necessary, particularly for high-stakes assessment. The most appropriate future direction is therefore likely to involve human-AI collaborative assessment, where AI supports data processing and preliminary feedback while educators retain responsibility for interpretation and final judgment.

Another important application is learning analytics, profiling, and prediction. AI can analyze large volumes of educational data to identify patterns associated with student engagement, performance, dropout risk, or learning difficulties. Predictive systems may enable educational institutions to identify students requiring intervention before academic problems become severe. Wang et al. (2024) identified profiling and prediction as a major category in AIED research. This application creates opportunities for early intervention and evidence-based educational decision-making but simultaneously raises significant concerns regarding data privacy, algorithmic bias, and the consequences of predictive labeling.

The Emergence of Generative AI and Large Language Models

One of the most significant findings in the recent literature is the rapid emergence of Generative Artificial Intelligence (GenAI). The introduction of ChatGPT in late 2022 accelerated research and experimentation with AI in educational settings. Unlike many earlier AI applications that were designed for

specific tasks, GenAI can perform a wide range of activities through natural-language interaction, including content generation, summarization, translation, question generation, brainstorming, writing assistance, coding, and tutoring.

Yusuf et al. (2024), through a systematic mapping review of 407 publications indexed in Web of Science, ScienceDirect, and Scopus, identified eight major discursive themes in GenAI research. The dominant themes included applications, impacts and potential, ethical implications and risks, perspectives and experiences, institutional and individual adoption, and performance and intelligence. The review conceptualized GenAI as a tool for pedagogical enhancement, specialized training, writing assistance and productivity, professional development, and interdisciplinary learning.

The rapid growth of GenAI therefore represents a qualitative change in AIED research. AI is no longer only operating behind the scenes through prediction or recommendation algorithms; it increasingly interacts directly with learners and educators. This direct interaction changes the nature of educational technology because users can ask questions, request explanations, revise outputs, and engage in iterative dialogue with AI systems.

Recent systematic research on higher education similarly indicates that GenAI applications are beginning to influence creativity, critical thinking, learner autonomy, and prompt literacy. Qian (2025) found that although many pre-ChatGPT themes remain relevant, newer research increasingly explores the pedagogical possibilities of GenAI and its implications for higher-order learning. Thus, GenAI should not simply be evaluated as a faster information-generation tool; its educational value depends on how it is incorporated into pedagogical processes.

Benefits and Educational Opportunities

The reviewed literature identifies several potential benefits of AI integration. The first is increased personalization. AI can provide learning experiences that are responsive to individual learner characteristics rather than relying exclusively on standardized instructional approaches. This may be particularly beneficial in large classes where teachers have limited capacity to provide individualized feedback. The second benefit is efficiency and productivity. AI can automate repetitive activities such as content generation, question development, preliminary grading, data analysis, and administrative support.

Cheng et al. (2023) demonstrated that AI has roles across learning, teaching, assessment, and administration, indicating that the efficiency benefits extend across multiple educational functions.

The third benefit concerns accessibility and learning support. AI-based systems can potentially provide assistance outside conventional classroom hours, offer repeated explanations, and support learners who require additional practice. Chatbots and conversational systems can function as supplementary learning resources, while generative systems can provide alternative explanations or examples according to learners' requests.

The fourth benefit is the potential enhancement of creative and higher-order learning activities. GenAI can support brainstorming, idea generation, writing revision, coding assistance, and exploration of alternative perspectives. However, the educational value depends heavily on instructional design. If students simply accept AI-generated answers without evaluation, AI may reduce rather than enhance critical thinking. Therefore, AI-supported learning should emphasize questioning, verification, reflection, comparison, and revision. The fifth benefit relates to decision support for educators and institutions. Learning analytics and predictive AI can help identify patterns that may not be immediately visible through conventional classroom observation. Such systems can support early intervention and institutional planning. Nevertheless, the use of predictive systems must remain carefully governed because predictions are probabilistic rather than deterministic and should not become labels that define students' educational trajectories.

Challenges in Technological and Pedagogical Integration

Despite the opportunities, the literature consistently demonstrates that AIED implementation is accompanied by substantial challenges. One important challenge is technological reliability. AI systems can generate inaccurate, incomplete, outdated, or fabricated information. This issue becomes particularly problematic in educational contexts because learners may interpret AI-generated responses as authoritative. The problem is especially visible with GenAI systems that can produce highly plausible but factually incorrect responses.

Another challenge is integration with existing educational infrastructure. AI systems must operate within institutional learning management systems, data environments, assessment systems, and existing pedagogical practices. Poor

integration may create additional workload rather than reducing it. Recent systematic research on ChatGPT implementation identifies technological integration and technological obsolescence as significant concerns and emphasizes the need for scalable and adaptable infrastructures.

Pedagogical integration is an equally important challenge. The presence of AI does not automatically improve learning outcomes. Teachers must determine which activities are appropriate for AI assistance and which require direct human interaction. AI integration therefore requires pedagogical redesign rather than simply adding AI tools to existing instructional practices. Arriazu's systematic review of 52 studies highlights the need to adapt teaching methods and curricula while maintaining an appropriate balance between AI-supported teaching and human interaction. Another challenge concerns teacher readiness and AI literacy. Teachers require more than technical knowledge of how to operate AI tools. They need to understand AI limitations, evaluate generated content, design effective prompts, recognize algorithmic bias, protect student data, and integrate AI into learning objectives. Without adequate professional development, AI adoption may remain superficial or may increase rather than reduce educators' workload.

Ethical Challenges and Responsible AI

Ethical considerations constitute one of the most persistent themes in AIED research. Data privacy and security are particularly important because educational AI systems frequently rely on extensive learner data. Such data may include academic performance, interaction histories, behavioral patterns, and other sensitive information. The use of these data requires clear governance concerning collection, storage, access, processing, and retention.

Algorithmic bias and fairness represent another major concern. AI systems learn from data, and biased or unrepresentative data can lead to biased outcomes. In education, such bias can affect recommendations, predictions, assessments, or access to learning opportunities. Therefore, fairness should be considered throughout the AI lifecycle, from data collection and model development to deployment and evaluation.

Transparency and explainability are also essential. Educators and learners need to understand, at least at an appropriate level, why an AI system produces particular recommendations or decisions. Black-box systems may be difficult to

challenge, especially when their outputs influence high-stakes educational decisions. The literature consequently supports greater attention to explainable and accountable AI. The ethical dimension also includes human agency. Holmes et al. emphasize the importance of privacy, transparency, fairness, accountability, autonomy, and human agency in developing ethical AIED. AI should therefore support rather than undermine the capacity of educators and learners to make informed decisions. Human oversight is particularly important when AI is used for assessment, prediction, or other decisions with significant educational consequences.

Equity, Inclusion, and the Digital Divide

Another important finding concerns equity and inclusion. AI has the potential to reduce educational barriers by providing personalized support and accessible learning resources. However, unequal access to AI technologies may simultaneously reinforce existing educational inequalities. Students with reliable internet connections, modern devices, paid AI services, and technologically skilled educators may benefit more than students in resource-constrained environments. This creates a new dimension of the digital divide in which inequality is no longer limited to access to basic digital technologies but also involves access to advanced AI capabilities. The literature on GenAI further reveals geographic and educational imbalances. Yusuf et al. (2024) identified a relative lack of research on GenAI in K–12 education and limited exploration of cultural dimensions. This suggests that current evidence may not adequately represent educational contexts outside highly developed higher education systems. Consequently, future AIED development should explicitly address inclusive AI, including accessibility, affordability, multilingual support, cultural responsiveness, and the needs of learners with disabilities. AI systems designed primarily around dominant languages and educational cultures may not adequately serve diverse populations.

Research Trends and Emerging Directions

The analysis indicates a clear transition in AIED research. Earlier research concentrated heavily on intelligent tutoring, adaptive systems, profiling, prediction, and automated assessment. More recent research increasingly focuses on GenAI, LLMs, human-AI collaboration, AI literacy, ethical governance, and pedagogical integration. Mustafa et al. (2024), through a systematic review of literature reviews on AIED, emphasized the need for a future research agenda that

responds to the rapid expansion and diversification of the field. Their work demonstrates that AIED research has become sufficiently extensive to require more systematic identification of unresolved issues and emerging directions.

One emerging direction is multimodal AI. Future educational systems are increasingly likely to integrate text, images, audio, video, and behavioral data. Such systems could provide richer forms of feedback and interaction but would also increase the complexity of data governance and ethical concerns. A second direction is human-AI collaboration. Rather than conceptualizing AI as either a replacement for educators or a passive tool, future research increasingly needs to investigate how teachers and AI can work together. This includes determining which tasks should be automated, which should remain under human control, and how responsibility should be distributed. A third direction concerns AI literacy. As AI becomes embedded in everyday educational activities, AI literacy is likely to become a fundamental competence for both educators and learners. Future research should therefore move beyond basic operational skills and examine critical, ethical, pedagogical, and evaluative dimensions of AI literacy. A fourth direction is longitudinal and experimental research. Much of the existing literature focuses on perceptions, attitudes, adoption, or potential benefits. Yusuf et al. (2024) specifically identified limited experimental investigation of GenAI's educational impact as an important research gap. Future studies should therefore investigate whether AI actually improves learning outcomes over time and under which pedagogical conditions.

Future Research Directions

Based on the synthesis, future research should focus on developing evidence-based and human-centered models of AI integration. Researchers should investigate not only whether AI is effective but also under what conditions, for which learners, for which educational tasks, and through which pedagogical mechanisms it produces meaningful benefits. Future studies should also examine the effectiveness of different forms of AI-supported pedagogy. Comparative research could investigate traditional instruction, AI-assisted instruction, and human-AI collaborative instruction to determine their relative effects on academic achievement, engagement, creativity, critical thinking, and self-regulated learning.

Another priority is the development of responsible AI governance in education. Future research should explore institutional policies concerning data privacy, transparency, algorithmic accountability, AI-generated content, academic

integrity, and human oversight. Governance frameworks should be flexible enough to accommodate rapid technological changes while protecting the rights and interests of learners and educators.

Research should also pay greater attention to AI literacy and teacher professional development. Future studies could investigate which professional development models most effectively improve teachers' confidence, competence, and pedagogical ability to integrate AI. This should include not only technical training but also ethical reasoning, prompt literacy, critical evaluation of AI outputs, data protection, and assessment redesign. Finally, future research should address the global and cultural diversity of AIED. Evidence should be expanded beyond dominant research settings to include developing countries, multilingual contexts, culturally diverse communities, rural schools, and underserved populations. Such research would help ensure that AIED does not reproduce existing global inequalities but instead contributes to more equitable and inclusive educational development.

V. CONCLUSION AND RECOMMENDATION

This systematic literature review concludes that Artificial Intelligence in Education (AIED) has become an important and rapidly developing field. AI is increasingly applied in personalized learning, intelligent tutoring, teaching support, assessment, learning analytics, and educational management. The emergence of Generative AI and Large Language Models has further expanded these applications through content generation, interactive tutoring, writing assistance, and automated feedback. Despite its potential to improve learning personalization, efficiency, accessibility, and educational support, AI also presents significant challenges, including data privacy, algorithmic bias, inaccurate information, academic integrity, digital inequality, and limited AI literacy among educators and learners. Therefore, effective AIED requires not only technological innovation but also appropriate pedagogical integration, ethical governance, and human oversight. The review also identifies research gaps, particularly the limited evidence from K–12 education, developing countries, inclusive education, and culturally diverse contexts. More empirical and longitudinal studies are needed to examine the long-term effects of AI on learning outcomes, critical thinking, creativity, learner autonomy, and self-regulated learning.

Educational institutions should develop clear policies for responsible AI use, particularly concerning data privacy, academic integrity, transparency, and human oversight. Teacher professional development should strengthen AI literacy, critical evaluation skills, and pedagogical competencies for AI integration. Assessment practices should also be adapted toward authentic and process-oriented approaches that acknowledge the presence of GenAI. Future research should focus on human-AI collaboration, AI literacy, responsible AI governance, inclusive AI, and the long-term educational impact of GenAI. Greater attention should also be given to underrepresented educational contexts and diverse learner populations. Ultimately, AI should be positioned as a complementary technology that strengthens, rather than replaces, the role of educators and human interaction in education.

REFERENCES

- Arriazu, R. (2025). The daunting challenge of Artificial Intelligence in Education: A systematic literature review. *Journal of e-Learning and Knowledge Society*.
- Bond, M., Khosravi, H., De Laat, M., Bergdahl, N., Negrea, V., & others. (2024). A meta systematic review of artificial intelligence in higher education: A call for increased ethics, collaboration, and rigour. *International Journal of Educational Technology in Higher Education*, 21.
- Bond, M., Khosravi, H., De Laat, M., et al. (2024). A meta systematic review of artificial intelligence in higher education: A call for increased ethics, collaboration, and rigour. *International Journal of Educational Technology in Higher Education*, 21, 4.
- Catatan penting untuk artikel SLR: karena judul Anda menggunakan cakupan yang sangat luas (Artificial Intelligence in Education), saya menyarankan pada tahap berikutnya kita membuat Research Questions (RQ1–RQ5), search string Scopus/WoS, kriteria inklusi-eksklusi, PRISMA 2020, dan tabel sintesis artikel. Ini akan membuat latar belakang di atas benar-benar terhubung dengan metodologi SLR dan tidak sekadar menjadi narrative review.
- Cheng, M., Sun, Y., Sun, Y., & other authors. (2023). Systematic literature review on opportunities, challenges, and future research recommendations of

- artificial intelligence in education. *Computers and Education: Artificial Intelligence*, 4, 100118. <https://doi.org/10.1016/j.caeai.2022.100118>
- Holmes, W., Porayska-Pomsta, K., Holstein, K., et al. (2022). Ethics of AI in education: Towards a community-wide framework. *International Journal of Artificial Intelligence in Education*, 32, 504–526.
- Mouta, A., Pinto-Llorente, A. M., & Torrecilla-Sánchez, E. M. (2024). Uncovering blind spots in education ethics: Insights from a systematic literature review on artificial intelligence in education. *International Journal of Artificial Intelligence in Education*, 34, 1166–1205.
- Mustafa, M. Y., Tlili, A., Lampropoulos, G., et al. (2024). A systematic review of literature reviews on artificial intelligence in education (AIED): A roadmap to a future research agenda. *Smart Learning Environments*, 11, 59.
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, 372, n71. <https://doi.org/10.1136/bmj.n71>
- Qian, Y. (2025). Pedagogical applications of generative AI in higher education: A systematic review of the field. *TechTrends*, 69, 1105–1120.
- Tlili, A., Shehata, B., Adarkwah, M. A., Bozkurt, A., Hickey, D. T., Huang, R., & Agyemang, B. (2024). What if the devil is my guardian angel: ChatGPT as a case study of using chatbots in education. *Smart Learning Environments*.
- Wang, S., Wang, F., Zhu, Z., Wang, J., Tran, T., & Du, Z. (2024). Artificial intelligence in education: A systematic literature review. *Expert Systems with Applications*, 252, 124167.
- Yusuf, A., Pervin, N., Román-González, M., & Noor, N. M. (2024). Generative AI in education and research: A systematic mapping review. *Review of Education*, 12(2), e3489. <https://doi.org/10.1002/rev3.3489>.
- Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education—Where are the educators? *International Journal of Educational Technology in Higher Education*, 16, 39.