ijonse International Journal on Studies in Education
www.ijonse.net

Artificial Intelligence in Educational Technology: A Systematic Review of Pedagogical Opportunities, Implementation Challenges, and Ethical Considerations

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Article Info

Article History

Received:
15 August 2025

Revised:
3 November 2025

Accepted:
20 November 2025

Published:
1 January 2026

Keywords

Artificial intelligence
Educational technology
Generative AI
Ethics in AI
Pedagogical opportunities
Higher education
Systematic review

Abstract

This systematic review examines the role of artificial intelligence (AI) in educational technology through an analysis of peer-reviewed literature published between 2020 and 2025. Drawing on 65 empirical, theoretical, and review studies retrieved from Web of Science, Scopus, and ERIC, the review explores three core dimensions: the opportunities AI offers for enhancing teaching and learning, the challenges associated with its integration, and the ethical standards required for responsible implementation. The findings reveal that AI has significantly advanced educational practice through personalized and adaptive learning systems, intelligent tutoring, automated assessment, and content generation tools. However, the integration of AI also presents substantial challenges, including data privacy concerns, algorithmic bias, inequitable access, and insufficient faculty preparedness. Ethical considerations, such as transparency, accountability, and fairness, are considered critical for ensuring the trustworthy and sustainable deployment of AI in educational contexts. Overall, the review underscores that while AI has transformative potential to redefine learning and teaching, its benefits can only be fully realized through ethically grounded and pedagogically sound adoption strategies.

Citation: Alshammari, S.H., Alshammari, A.E.A., Alghamdi, B.A., Alrashidi. M.E., Rosli, M.S., & Risdianto, E. (2026). Artificial intelligence in educational technology: A systematic review of pedagogical opportunities, implementation challenges, and ethical considerations. *International Journal on Studies in Education (IJonSE), 8*(1), 17-37. https://doi.org/10.46328/ijonse.5974

ISSN: 2690-7909 / © International Journal on Studies in Education (IJonSE).

Introduction

The rapid growth of computing and information technologies has dramatically transformed the educational experience because of the considerable level of development in artificial intelligence (AI) technology in educational applications (Kyambade et al., 2025). With this development, AI in education (AIEd) transcends the theory stage to move into the applied stage. This is seen in the operation of intelligent tutors, adaptive learning environments, and complex dashboards of learning analytics (Kyambade et al., 2025; Merino-Campos, 2025). Contemporary developments in the area of AIEd derived from advances in machine learning, natural language processing, and cognitive computing have provided refreshing opportunities for the emergence of applications such as chatbots designed for student engagement, forms of automated feedback, and predictive analytics of student success (Bond et al., 2024; Merino-Campos, 2025). The health crisis in 2020 caused by the advent of the global pandemic greatly enabled an effective movement into the radical application of technology, which caused the enhancement of the active participatory role of AI in education to be further heightened, thereby initiating a stronger learner-centric approach to the educational enterprise (Akhmadieva et al., 2024; Mustafa et al., 2024).

Generative AI (GenAI) and adaptive learning technologies have changed the educational landscape with their ability to enable teachers and students to use new ways to engage with technology through a variety of educational mediums and tools. With GenAI technologies, students are able to create new avenues of text, images, code, etc. using advanced prompts (Lee & Moore, 2024; Weng et al., 2024). Through creating customized, personalized formats for instructional modes and creating interactive learning environments, GenAI technologies are also enabling students to develop and process information in different ways than they could previously in an educational setting (Lee & Moore, 2024).

The combination of GenAI and adaptive learning technologies enables machines to tailor assessments, content delivery, and methodologies to meet the specific needs of each student in real time (Merino-Campos, 2025; Gligorea et al., 2023). Likewise, intelligent tutoring systems (ITS) make use of students' unique characteristics, knowledge, and preferences to provide highly individualized educational experiences and adaptive feedback (Awang et al., 2025; Mustafa et al., 2024). These have been shown to assist students' academic performance and involvement in various disciplines (Merino-Campos, 2025).

Despite the growing interest in and rapid development of AIEd, a full synthesis of studies (2020–2025) on its possibilities, challenges, and ethical implications remains underdeveloped (Mustafa et al., 2024). Although there is a great deal of literature on the different aspects of AIEd, there is a lack of understanding of the interdependent relations of AI technologies, established educational theories, and their implications for the quality of instruction (Kyambade et al., 2025). Early reviews have noted a gap in addressing the pedagogical and ethical issues regarding AI systems (Kyambade et al., 2025), which is still part and parcel of the call to have this field focus more on the ethical aspects of present-day AIEd research (Bond et al., 2024). As there are many relevant critical issues, such as data privacy, algorithmic bias, academic integrity, lack of transparency in systems, vagueness of accountability, and the need for proper teacher training, an up-to-the-date and cohesive review of the totality of this area is needed (Bond et al., 2024; García-López and Liñán, 2025; Merino-Campos, 2025).

Research Questions and Objectives

This systematic review aims to address these critical gaps by systematically synthesizing the extant literature from 2020 to 2025 on AI in educational technology (EdTech). Specifically, this systematic review aims to answer the following research questions:

- What opportunities do AI present for enhancing teaching and learning within EdTech?
- What are the primary challenges associated with the integration and implementation of AI in educational settings?
- What ethical issues and standards need to be considered for the responsible deployment of AI in EdTech?

For achieving this, the objectives of this review are as follows:

- Identify the key opportunities offered by AI which include GenAI, adaptive learning, and ITS.
- Examine and categorize the challenges encountered in integrating AI into educational practices.
- Analyze the ethical considerations and propose standards for the responsible use of AI in EdTech.

Methodology

This systematic review of the literature adhered to the preferred reporting items for systematic reviews and meta-analysis guidelines so that methodological consistency, transparency, and replicability are assured (Almasri, 2024; Mustafa et al., 2024). The review process included the (i) identification of research questions, (ii) development of the search protocol, (iii) intense search of the literature, (iv) systematic screening of papers in the reviews obtained, (v) extraction of relevant data, and (vi) synthesis of reviewed papers (Almasri, 2024).

Search Strategy

A thorough search was performed across three major databases: Web of Science, Scopus, and ERIC. These databases were selected because they cover a large amount of peer-reviewed literature in the fields of EdTech, computer science, and the social sciences (Awang et al., 2025; Mustafa et al., 2024). The method used for the search involved keywords and Boolean operators to discover relevant literature.

The main strings of the search were developed to identify articles on AI and the different areas in which it is used in EdTech. Examples of the keywords used are as follows:

- **AI:** “Artificial intelligence” OR “AI” OR “machine learning” OR “deep learning” OR “generative AI” OR “generative artificial intelligence” OR “intelligent tutoring system*” OR “adaptive learning system*” OR “neural network”
- **EdTech:** “Education*” OR “educational technology” OR “higher education” OR “learning environment*” OR “teaching practice*” OR “instructional method*”

The complete search string was modified for each database to maximize the results achieved, which were broad yet targeted, in the retrieval of useful literature. Filters were applied to restrict the results to peer-reviewed articles.

Inclusion and Exclusion Criteria

The inclusion and exclusion criteria of the reviewed studies were established to ensure their relevance and quality.

Inclusion Criteria

- Date of Publication: This review considered all studies published between January 2020 and December 2025. This restriction guaranteed that the current discoveries and tendencies in AIEd would be analyzed.
- Type of Publication: Peer-reviewed journal article.
- Language: Published and written in English.
- Focus: Studies that specifically treat the application of, the opportunities for, the difficulties to be expected with regard to, and the ethical aspect of AI as applied to EdTech.
- Contents: Empirical studies, theoretical studies, and systematic reviews providing substantial insights into AIEd.

Exclusion Criteria

- Type of Publication: Conference abstracts, opinion pieces, book chapters, editorials, or dissertations.
- Focus: Studies in which AI is not the primary focus or those focusing on AI applications outside the educational context.
- Methodology: Studies without a clearly identifiable methodology section or those deemed critically low quality.

After applying these criteria, 65 studies met the inclusion requirements and were selected for in-depth analysis in this systematic review.

Data Extraction and Synthesis Procedures

After the initial search, all identified titles and abstracts were screened independently to eliminate irrelevant studies and duplicates. Studies from which a full text was potentially relevant were subsequently retrieved and checked for eligibility against specific predefined inclusion and exclusion criteria. A standardized form of data extraction was designed in which the relevant data from each included study were prospectively recorded (Bond et al., 2024; Kyambade et al., 2025). The following data were included in this pro forma: publication data, aims of study, AI technology involved, education situation, methodology, main results as regards opportunities and challenges, and ethics determined (Kyambade et al., 2025; Liang et al., 2025). Essentially, data synthesis included a “thematic” type of analysis (Kyambade et al., 2025; Liang et al., 2025). The first type of coding was descriptive but was derived from segments of meaningful extracted data, which identified particular applications and advantages and disadvantages, and from ethical problems posed by AI in EdTech (Awang et al., 2025; Liang et al., 2025). These codes were subsequently compared in pairs and larger groups and then developed into broad themes that aligned with the questions in the study, namely opportunities, challenges, and ethical standards (Awang et al., 2025; Liang et al., 2025). This coding enabled a greater understanding of how the coding aligned

with each of the diverse AI applications and how issues were managed in relation to the literature (Kyambade et al., 2025). All authors checked the coding results, final synthesis, and interpretation of themes to ensure correct coding and consistency (Liang et al., 2025).

Results

The Evolution of AI in EdTech

The incorporation of AI into EdTech is a rapidly moving and ongoing process representative of advances in computer science and the changing theories in education. This evolution has converted teaching methods from simple automated instruction into highly intelligent, responsive, and generative learning environments. This can be traced back to the early origins of AI in education for many decades, and these initial efforts were aimed at introducing automation into the instructional process (Bond et al., 2024). The first applications, for example, the "teaching machines" of the mid-20th century, aimed to present structured knowledge and immediate feedback in accordance with behaviorist theories of learning (Misiejuk et al., 2025). These early AI-based systems operated on the principle of rule-based systems and probabilistic analysis and created the paradigm of AI-guided learning. ITSs were the other main application of the early days, presented as a personalized approach to the problem of instruction and feedback, which persisted along predetermined paths, such as the ACT Programming Tutor (Awang et al., 2025; Bond et al., 2024). These methods, which continued through the 1990s and 2000s, were characteristic of the early days of AIEd, being mainly concerned with skill acquisition and error correction in environments that were somewhat structured (Bond et al., 2024; Kyambade et al., 2025). They established a methodology that created some understanding of how AI should be enabled to manage and adapt instruction along paths determined by input from the learner, but they lacked the basic foundations to allow the use of engagement (i.e., learning from others) or mental engagement (e.g., creative or critical thought) (Kyambade et al., 2025).

The AIEd landscape has undergone a fundamental change due to the emergence and maturing of machine learning (ML) and deep learning (DL) technology. In the past decade, particularly since 2020, the use of such algorithms has been expanding the application of AIEd from more simple, rule based systems into more sophisticated, adaptive systems (Bond et al., 2024; Kyambade et al., 2025) The ability to analyze large data sets, find complex patterns in how learners interact with a system, create predictive models, and provide learner-specific recommendations are all made possible by the use of ML and DL (Kyambade et al., 2025). Thus, there is now a greater variety of adaptive learning systems, sophisticated, and learning analytics dashboards available which could adjust the educational resources and teaching methodologies offered to individual students (Merino-Campos, 2025). Since 2019, considerable advances in deep learning and natural language processing technology have resulted in a massive increase in the potential of AI technology, especially in terms of personal learning systems and precision education (Akhmadieva et al., 2024; Mustafa et al., 2024). These technological advances have made it possible to create information for curricula and instructional materials in real time, thus increasing student performance and engagement (Mustafa et al., 2024).

The most recently developed and socially significant factor in AIEd is the all-embracing phenomenon of GenAI. GenAI tools, such as ChatGPT from OpenAI and other similar large language models, laid claim to a wide

audience in 2022, ushering in a new phase of AI technology capable of generating new and human-like content from raw data (Lee & Moore, 2024; Ogunleye et al., 2024). These systems, based on huge amounts of pre-trained text data, were able to generate linguistic outputs of a coherent and contextually appropriate nature that goes far beyond the analysis of data, as in the past, to an extent in which this AI becomes creative producers of new material (Grassini, 2023; Lee & Moore, 2024). Therefore, the GenAI phenomenon can be seen to influence many educational activities in education work, such as lesson planning, generating teaching material, formative assessment, and self-learning (Lee et al., 2025). GenAI may act as a personal assistant, for example, by bringing students into the learning situation and individually catering to them using an educational process tailored to their requirements, which provides personalized learning opportunities in which teaching materials are produced to meet special student needs and immediate feedback is given to all students (Lee & Moore, 2024). The rapid adoption and incorporation of GenAI in the school setting has been the clearest signal of a pedagogical transition—a remarkable transformation—toward new educational methodologies that depend on AI adjunct to them to aid learning experiences offered to students, which conform with the capabilities of the individual students' abilities (Mustafa et al., 2024). The shift shows how the role of AI is evolving from a tool that just guides students on their educational journey to an active encourager of students to experience learning through interactive education and create personally tailored educational paths (Kyambade et al., 2025).

Current Applications of AI in EdTech

The AI in the field of EdTech has stimulated the creation of a series of applications that have radically changed educational processes and the efficiency of administration in many educational environments. These applications have resulted in individualized learning processes, sophisticated content creation, and administrative applications for educational organizations.

Personalized and Adaptive Learning

Adaptive and personalized learning systems using AI to assist meeting the educational needs of students have dramatically changed how students learn and how teachers teach (Kyambade et al., 2025; Merino-Campos, 2025). These systems are able to tailor the content, the learning environment, and the instructional delivery of the learning process to fit each learners own unique needs and characteristics (Merino-Campos, 2025; Kyambade et al., 2025). AI can be used in an advanced manner such as through machine learning or predictive models so the system can modify the learning experience to improve student engagement and produce greater student productivity (Kyambade et al., 2025). For instance, many of the adaptive learning systems provide instant feedback, and will alter the content they deliver based on the degree to which the student understands and retains the information (Kyambade et al., 2025).

When research has been conducted on the impact of teachers using AI to design custom instruction for each learner, the research has found that this practice produces positive outcomes for both teaching and learning. Some studies have indicated simultaneous improvement in teaching efficiency and student satisfaction (Liang et al., 2025). These systems tend to do well in facilitating the assessment of student progress and adaptation to their

changing needs, resulting in students taking charge of their own educational experiences (Eden et al., 2024; Gligorea et al., 2023).

Intelligent Tutoring Systems

ITSs show a more mature application of AI in education designed for personalized instruction and adaptive human-style feedback, akin to one-on-one tutoring (Awang et al., 2025; Kyambade et al., 2025). ITS can detect, analyze, and monitor learners' psychological states, knowledge, and preferences to provide highly individualized support (Bond et al., 2024; Mustafa et al., 2024). Some of the more widely available ITSs, such as ALEKS, PAT2Math, GeoGebra Tutor, and MATHia, have greatly assisted in fields such as mathematics education by providing adaptive learning opportunities (Awang et al., 2025). ITSs are useful for providing personalized feedback and decreased workloads of tutors, but their application seems to be in the medical and scientific areas in which they are used as tutors for virtual patients and for programming education (Bond et al., 2024). Although beneficial, whether AIEd (e.g., ITSs) positively affects learning achievement needs further inquiry as to how better cooperation among teachers, pupils, and AI can achieve educational aims (Mustafa et al., 2024).

Automated Assessment and Feedback

The incorporation of AI into assessment substantially enhances assessment procedures by automating assessment and short feedback and assessment tools by grading essays (Kyambade et al., 2025; Liang et al., 2025). AI systems are effective in developing students' tasks and generalizing assessable alternatives, and they forecast assessable outputs and projects. Other systems built on AI evaluate the tests given by students, even those given by teachers. AI assessments reduce the effects of heavy loads on teachers through the automated evaluation of tests, systems tests, or small tasks with immediate feedback (Kyambade et al., 2025). By using interesting scores for students when using AI principles to examine topics, these AI systems provide interest in questions that require frequent support for assessment from the instructor (Liang et al., 2025).

AI-Assisted Content Creation

GenAI tools, such as ChatGPT, Copilot, and Bard, have made a major impact on content creation in education. These tools can assist in generating discussion questions, adapting materials to different proficiency levels, creating writing samples, developing handouts and explanations, and generating rubrics (Lye & Lim, 2024). GenAI can support the creation of classroom scenarios, instructional materials, and presentations, and it can potentially save educators considerable time (Nikolic et al., 2024). For students, GenAI can support problem-solving and enhance creativity (Garcia-Lopez & Linan, 2025; Ogunleye et al., 2024). This includes developing learning experiences tailored to a student's specific interests and learning goals through the use of adaptive assessments, and through the creation of customized educational materials that address the students' interests and learning objectives. While this presents numerous benefits of GenAI, the extent of acceptance regarding the value of GenAI is split, especially concerning brainstorming/outline applications of GenAI for generating content as opposed to the final output, largely due to concerns of hallucination or incorrectness of answer (Grassini, 2023; Nikolic et al., 2024).

Institutional Management Systems

The AI used in educational settings extends into the operations side of running a university with many different types of operational functions including scheduling, resources, and admissions. It will also include how AI can assist to make the academic experience more streamlined with AI chatbots that assist academics and create a more efficient institutional operation (Merino-Campos, 2025). Additionally, AI has been found to be beneficial in predicting or creating profiles to aid in gathering student information or academic performance, and to identify students who are struggling academically so they may receive additional assistance (Agherai et al., 2025). AI can relieve administrative staff from performing repetitive tasks. However, there exists a concern with potential biases in AI, i.e., in the admissions process, an applicant from a certain area may have an unfair disadvantage due to their location (Bond et al., 2024). While the use of AI in the administrative aspects of research appears to be limited when compared to the uses of AI in teaching and learning, it is essential in creating a better overall University experience (Bond et al., 2024).

Impact of AI on Educational Stakeholders

AI in EdTech impacts a variety of stakeholders, including learners, teachers, educational organizations, developers and policymakers. While AI is offering many advantages to each group, it will also create several challenges and concerns about ethics that require both thoughtful consideration and intentional action.

Learners: Motivation, Engagement, and Academic Performance

The primary influences of AI on learners are mainly reflected in an increase in motivation, participation and achievement of educational objectives through the development of learning experiences tailored to individual needs (Merino-Campos, 2025). Furthermore, both ITS's and adaptive learning systems have greatly enhanced the success of students, with students reporting that they enjoyed utilizing tools that incorporate AI, experienced greater confidence and motivation during testing and reported greater overall satisfaction (Merino-Campos, 2025). Adaptive AI systems have been shown to positively impact learner motivation and completion rates for courses in higher education (Merino-Campos, 2025). Additionally, AI supported tools, such as ChatGPT, provide effective and credible academic guidance and produce informative and supportive responses to a variety of questions, including those that are open-ended and those that pertain to future career choices (Akhmadieva et al., 2024). Furthermore, recent research indicates that some learners prefer AI over instructors and co-learners in regards to their ability to provide expert commentary in relation to the provision of feedback (Akhmadieva et al., 2024). However, it is essential that AI be used ethically, since there is concern regarding the potential negative impacts of AI on academic integrity in that students may potentially utilize AI to create academic work with questionable authorship (Kyambade et al., 2025).

Educators: Professional Development, Teaching Practices, and Workload

There are two main impacts of AI in education on educators. AI offers both professional development and better instruction, but it also increases teacher workloads and requires new learning to be effective at using AI within

the instructional design of their classroom. For teachers to successfully incorporate AI into their instructional designs, there must be professional development related to AI to develop a technology savvy, and innovative group of teachers (Akhmadieva et al., 2023). AI can potentially automate some of the time-consuming aspects of repetitive administration and preparation of materials for class, and suggest materials and methodologies (Brandão et al., 2024). However, few educators have had the appropriate training and support to effectively utilize AI.

Furthermore, this lack of training may lead to educators being resistant to technology or incorrectly utilizing technology. Therefore, there is no doubt that extensive training will promote AI literacy among educators, educator's knowledge of what AI can or cannot do, and the ethics of AI (Mikeladze et al., 2024; Xia et al., 2024). Ultimately, how well educators are able to use AI for education purposes is dependent upon their ability to be ready to use AI, and their active participation in the teaching-learning process (Mikeladze et al., 2024).

Institutions: Curriculum Design, Digital Infrastructure, and Governance

AI has significant effects on how to develop curricula for courses, digital infrastructures, and governance structures of education. Learning experiences can be designed in ways that allow frequent productive engagement in activities and the development of technology-enhanced learning environments (Peláez-Sánchez et al., 2024). The strategic use of AI can provide societies with a higher degree of performance by streamlining bureaucracy in internal administrative activities, such as scheduling and resource availability (Merino-Campos, 2025).

Institutions will have to respond to the impact of GenAI on educational practice in teaching and assessing, necessitating comprehensive training and professional development in AI as well as data and digital literacy for teachers and students (Xia et al., 2024). Issues around data privacy, transparency, accountability, and the security of AI in education have to be dealt with (Xia et al., 2024). Above all, the curricula must be realigned to include more degrees of digital interactivity as elements at the core of teaching and learning, and flexible frameworks must also be provided for various learners (Merino-Campos, 2025).

Policymakers and Developers: Ethical Regulation, Data Standards, and Innovation Strategies

Developers and policymakers are responsible for expanding the use of AI technologies in education through ethical regulations, data standards, and innovation strategies. Regulatory systems require a careful balance between encouraging technological innovations and protecting individual rights (García-López & Liñán, 2025). This requires a framework that is legally valid, includes stakeholders (e.g., teachers and developers) in decision-making, and is adaptable to movements in existing technologies (García-López & Liñán, 2025). There has been a call to include ethical reasoning in the design and implementation of AI systems to support the educational values and rights of learners with regard to data use, privacy, and academic honesty (García-López & Liñán, 2025; Kyambade et al., 2025).

Policymakers are advised to create inter-sector forecasts for job change regarding GenAI automation and enhance the future-proofing of skills at all levels of education (García-López & Liñán, 2025). This includes building gender

equality concerning the development of advanced competencies in AI and the pool of gender-equal professionals (García-López & Liñán, 2025). There has been a convergence of research on the need to have flexible and updatable regulations and ethical frameworks in order to ensure equitable and accessible use of technology in education through the alignment of technological responses and promoting responsible innovation (Kyambade et al., 2025; García-López & Liñán, 2025).

Challenges and Ethical Considerations

Even though AI use in EdTech offers significant potential benefits, it also introduces the necessity for considerable critical analysis of a variety of ethical and implementation problems. For ensuring the greatest benefit from its vast undertaking in an ethical and equitable manner, the important aspects listed below must be considered.

Data Privacy and Security

When it comes to the implementation of AI in EdTech, data privacy and confidentiality are critical concerns (Kelley & Wenzel, 2025). AI applications generally tend to rely heavily on the collection, processing, and use of volumes of personal student data, which raises considerable doubts about fairness and autonomy (Kelley & Wenzel, 2025). The private nature of such information means that powerful protocols are needed to avoid misuse and to provide security of data (Eden et al., 2024). Many users, including students, do not necessarily understand how extensive the systems for collecting and sharing personal information are or how personal information could be used by AI systems (Kelley & Wenzel, 2025).

There is an urgent need for full disclosure of such practices in data collection and use. Thus, it is necessary to find a balance between security practices and availability for various stakeholders in the smart classroom environment (Dimitriadou & Lanitis, 2023). Institutions must establish clear policies and protocols on the protection of students' privacy with a view to alleviating some of the burden imposed on teachers regarding the management of these complex issues (Kelley & Wenzel, 2025).

Algorithmic Bias

Another key ethical issue is the significant likelihood of algorithmic bias, which may further perpetuate and intensify disparities in education (Kelley & Wenzel, 2025; Kyambade et al., 2025). Biases in AI algorithms may arise from many sources, including skewed training data, algorithmic frameworks, and existing societal prejudices present in the data used to train AI models (Eden et al., 2024). For example, numerous AI systems exhibit gender and racial prejudices, probably stemming from the underrepresentation of certain societal cohorts in the development of technology and the data training thereof (Kelley & Wenzel, 2025). To illustrate, case studies have shown how algorithmic bias results in unduly harsh punishments for students from low-income communities within automated evaluative systems, as well as biased recommendations of courses to take on e-learning platforms that favor male students with references to STEM education, for example (García-López & Liñán, 2025). To address the previous errors, the elements of fairness, accountability, and transparency need to be used

when developing and implementing AI. This includes an assessment of the training data used by AI, the use of fairness-aware machine learning methods, and auditing of AI systems (Eden et al., 2024).

Teacher Role Transformation

A seismic shift in how teachers view their own role is needed once AI is incorporated into an educational environment. While integrating AI in education can assist in relieving the teacher's administrative burdens and locking in instruction planning (Kelley & Wenzel, 2025), AI also fundamentally alters what it means to be a "teacher" as "content deliverer" (Lee et al., 2025). This total role requires a reassessment of the relationships between teachers, students, and technology (Lee et al., 2025). Today's educators still find it difficult to get the necessary orientation and support that they need to use AI tools effectively, which leads to manifest behavior or negative outcomes (Lee et al., 2025; Mikeladze et al., 2024). Thus, professional development that will provide the tools and know-how required for effective AI integration is needed, resulting in a more technology-ready and creative workforce (Kyambade et al., 2025). For this to be achieved, however, teachers need training in the technical aspects of the use of AI, pedagogy in terms of the integration of AI tools, and commitment to lifelong learning to keep up with the frenzied pace of AI development (Burneo-Arteaga et al., 2025).

Digital Equity

Digital equity is an important implementation consideration, as all students and schools do not have equal access to AI-influenced tools and resources (Kelley & Wenzel, 2025). Unequal access to internet connectivity, computing devices, and digital literacy skills can exacerbate the existing divide, especially in low socioeconomic communities, rural areas, and traditionally marginalized groups. Students with disabilities may also face obstacles to the use of AI technologies if they are not designed for their needs (Eden et al., 2024).

In addition to existing barriers, the digital divide also creates new obstacles that hinder the ability of students with inadequate hardware and insufficient digital skills from accessing the technical infrastructure required for AI-based learning which limits their opportunities to compete in educational opportunity (Denny et al., 2024). Therefore, there is a need for a collaborative effort to support digital equity by increasing affordability of accessible and available internet, along with accessible computers, and provide institutional education in digital literacy to students, and create partnerships between government, educational organizations, and technology sectors (Eden et al., 2024).

Governance Frameworks and International Perspectives

Due to the numerous technical and theoretical challenges involved in introducing AI technologies to education, there has been a need for a broad set of frameworks to support international governance and collaboration on the development of AI based solutions for education. For example, UNESCO emphasizes the importance of creating strategic planning and ethical standards to utilize AI effectively in an educational setting (Kyambade et al., 2025). Therefore, the regulatory frameworks that enable the advancement of technology while protecting individual

rights should be capable of adapting to rapid changes in technology (García-López & Liñán, 2025). International frameworks like the IEEE ethically aligned design can be used as a model for the responsible and transparent application of AI that can be governed by human oversight (García-López & Liñán, 2025).

Alongside regulation regarding the use of data, privacy, and academic integrity, there exists a need for ethics guidelines governing the actions of AI in educational environments to respect the rights of students (Buele & Llerena-Aguirre, 2025; Eden et al., 2024). As such, there is a clear need for an interdisciplinary and collaborative effort toward the creation of governance frameworks for the development of AI-based solutions for education that include representation from educators, learners, researchers, developers, and policymakers to develop contextually appropriate and socially acceptable policy (Pinho et al., 2025). Frameworks for the development of AI-based solutions for education will form the basis for international cooperation, transparency and accountability for the prevention of the abuse of AI and the assurance that new technologies align with social values (García-López & Liñán, 2025).

Future Trends and Emerging Directions

As an evolving process, AI is about to revolutionize the EdTech field, as well as create a new era in the learning environment, pedagogy, assessment, and in policy making over the course of the next decade. Improved AI has created many new trends that indicate the near future will include better personalization, smarter analytics, greater transparency, cooperative intelligence, and robust systems for life-long learning.

Hyper-Personalization and Adaptive Pathways

While AI in EdTech continues to evolve, hyper-personalization will be the focus of what is considered to be an area of differentiation from traditional adaptive learning technology, which focuses on delivering high levels of individualized educational experiences (Kyambade et al., 2025). Hyper-personalization AI systems are expected to go beyond simply adjusting content and timing for students to fully grasp the cognitive styles, emotional states and preferences of students in order to create highly customized educational experiences (Liang et al., 2025). As a result, this type of system will represent a new phenomenon referred to as "AI-driven Personalized Learning" that allows learners to have full ownership over their educational journey through self-directed learning and exploration along with critical engagement with content (Eden et al., 2024; Liang et al., 2025).

The AI systems used in these types of programs will utilize advanced AI technologies, such as machine learning and dynamic formation of new understandings through the use of AI-based modeling (i.e. real-time modeling, predictive modeling), that will continuously adapt and alter educational strategies based on the changing needs of each learner's academic identity, motivation and academic requirements in order to improve motivation and academic success (Eden et al., 2024; Kyambade et al., 2025). Ultimately, as education continues to move towards a human-centered approach using AI, it will redefine how individuals interact with technology and will enable technology to continually support the ability of AI to enhance educational experiences and facilitate continued adaptation (Kyambade et al., 2025).

Advanced Learning Analytics

The learning analytics field continues to grow as it becomes increasingly advanced in the analysis of learning processes and potential pedagogical intervention strategies (Gardner et al., 2021). The future of adaptive learning systems will utilize a multitude of contextual data points, such as, wearable devices, environmental sensors etc., to further enhance personalized learning (Gligorea et al., 2023). Thus, predictive models can identify students at risk of disengaging or dismissing their course/program and allow educators to enact timely, effective interventions (Kyambade et al., 2025). The next phase for learning analytics is to make visible previously obscure self-regulated learning processes, even in collaborative situations, by tracking multifaceted affective, social, and cognitive indicators (Gardner et al., 2021). With its online analytic and feedback provisions, learning analytics will still have a positive influence on the self-regulation of students while offering a variety of formative assessments personalized for individual learners.

Explainable AI (XAI)

There will be an increasing demand for XAI as AI systems become more sophisticated. XAI aims to provide explanations for how AI systems make decisions and recommendations in understandable and transparent ways for learners and educators. This fosters trust, accountability, and a responsible and ethical use of AI technologies (Gligorea et al., 2023). A clear understanding of why AI does what it does is important for educators so that they can use AI tools effectively in their teaching and for learners to understand the outcomes of adaptive learning (Kyambade et al., 2025). A balanced development of procedures for assessment that corresponds with transparent AI systems and human interaction is probably the most likely to result in either the highest quality of assessment or the greatest acceptability of the results of assessments (Grassini, 2023). Transparency will be the focus for building confidence in AIEd, as well as to ensure that AI tools support educators instead of diminishing them (Kyambade et al., 2025).

Human–AI Collaboration

The future of education will increasingly center on a human–AI cooperative approach using AI as a tool to supplement human intelligence instead of using it to replace that intelligence (Kyambade et al., 2025). This collaborative relationship will promote teamwork among students, teachers, and technology, facilitating further engagement and the development of critical thinking skills and those for lifelong learning (Kyambade et al., 2025). These collaboratively developed systems illustrate the importance of achieving a balance within the arts between the efficiency of computation and the opportunity for the full deployment of human faculties, such as creativity, critique, social awareness, and ethics (Kyambade et al., 2025). Teachers will be able to guarantee that the cooperative system integrates human values and long-term educational purposes and to adequately address apprehensions over too much dependence on algorithmically controlled systems (Kyambade et al., 2025). This change demonstrates the need for research into how to best craft the integration of AI to guarantee a balance between the development of AI skills and human skills, as well as how best the students will interact with those skills and the regulation of such interactions (Mustafa et al., 2024).

Lifelong Learning Ecosystems

AI is on the verge of reshaping lifelong learning experiences in ways that are personalized, contextualized, and readily available (Weng et al., 2024). The changing nature of the labor market toward new forms of work requiring new types of knowledge will allow GenAI to support an individual's growth based upon the relevant competence that they have acquired during their career (Weng et al., 2024). An additional aspect of this concept will be the establishment of a lifelong learning environment in which AI will enable individuals to continuously develop professionally on their own (Kyambade et al., 2025). The ability to develop and maintain skills such as a professional agent, leader and learner through an open collaborative system of humans and computers throughout an individual's life span with the assurance that education will always remain accessible and relevant to all people (Kyambade et al., 2025).

Reshaping Pedagogy, Assessment, and Policy

These emerging trends will significantly change pedagogy, assessment, and policy over the coming decade.

- Pedagogy. When transitioning from an educator to a facilitator, creating new and engaging lesson plans while giving individualized guidance (Grassini, 2023), the direction of using more flexible and responsive instructional methods will be directed by the learner's needs and how the learner is progressing through their education journey. Therefore, AI can provide additional support to learners in the decision-making process (Kyambade et al., 2025).
- Assessment. Traditional assessment methods will continue to reflect evolution with GenAI, contributing to the remodeling of assessment policies (Xia et al., 2024). Mixed methods will prevail so that the assessment methods include those generated by AI and human-based assessment, with a focus on higher-order thinking skills that are not easily reproduced by AI (Xia et al., 2024).
- Policy. Educational policies will require realignment to address the new technologies, provide equitable access to AI, and establish issues of data privacy, algorithms, and their biases, and continuous professional development for educators (Eden et al., 2024, García-López & Liñán, 2025, Nikolic et al., 2024). Therefore, flexible, adaptable, and frequently changing guidelines based on ethical behavior and legal requirements will be essential in conforming to and acting as catalysts for responsible innovation.

Discussion

This systematic review examined the many-faceted world of AIEd technology, putting together various facts about the historical background, present uses, effects on the main parties, and large ethical and practical problems involved. A broad range of studies from 2020 to 2025 was conducted, and the common assumption shows the power of AI to transform education and the complexities inherent in AI adoption in education.

Synthesis of Opportunities, Challenges, and Ethics

The evolution of EdTech and AI is linear in development, from ITSs to their present form in GenAI, revealing a

common obsession with the quest to find personalized, flexible, and efficient forms of instruction (Bond et al., 2024; Kyambade et al., 2025; Lee & Moore, 2024). There are many potentials, particularly in terms of hyper-personalization and adaptive learning, to increase student motivation, interest, and academic results through a greater individualized and personalized program of delivery of objects and instruction (Kyambade et al., 2025; Merino-Campos, 2025). AI text-generated materials and automated opportunities for assessment represent a significant increase in the efficiency of the task to be completed by instructors and educational institutions, thereby diminishing effort and vastly enhancing the speed of feedback given (Kyambade et al., 2025; Lye & Lim, 2024). The efficiency through which AI can improve institutional efficiency through more accurate predictive analytics or provide administrative assistance more accurately represents the most systematic means of developing and reinforcing its fundamental universal importance and utility, that is, its inviting use and application in a universal manner (Merino-Campos, 2025).

However, these advantages are accompanied by major challenges and ethical concerns. One of the most important topics here is information privacy and security, as the demands of AI access and the use of large amounts of sensitive information about students necessitate discussions about autonomy and misutilization, among others (Kelley & Wenzel, 2025). Algorithmic bias, which may be exhibited through bias at the source of the training data, may prolong and reinforce existing inequalities in education that warrant continued vigilance and mitigation strategies (Eden et al., 2024). The transition of the role of the teacher from content deliverer to facilitator of learning will require considerable development training in light of the pedagogical changes and effects on content meaning, as so many teachers are ill-prepared for the utilization strategies employed in AI (Lee et al., 2025; Mikeladze et al., 2024). In addition, digital equity issues are addressed as the unequal availability of AI applications widens the gap between the digital divide and the economically affected groups of learners (Kelley & Wenzel, 2025).

Among the criticisms of AI applications are their main requirements, openness concerning accountability, fairness, and justice in the development and use of AI products (Bond et al., 2024; Garcías-López and Liñán, 2025). International governing frameworks from organizations, such as UNESCO, suggest that significant governing frameworks must provide a balance between the need to develop and the need to protect the rights of individuals and the rights and values related to education (Fu and Weng, 2024). The emergence of AI is a welcome development that seeks to engender faith by explaining how AI concludes its various analyses, thus allowing educators and students to question these kinds of technologies (Kyambade et al., 2025).

Contribution to Current Discourse

This systematic review makes important contributions to the discussions in both EdTech and AI implementation fields through its comprehensive, modern, and multi-faceted, and complex depiction of the relationship between AI in education and education itself. Through addressing joint limitations and ethics of separate parties, the literature review has provided ideas that could have been developed separately, thus illustrating AI's potential as both an innovative technology and as a disruptive system that necessitates transformation of the values, systems, policies, and structures of education (Pinho et al., 2025; Grassini, 2023). The principles described above are

indicative of the necessity for a human-centered ethical approach to the development and use of AI in order to promote human enhancement and human values over the opposite (Kyambade et al., 2025). This study also offers direction for productive areas of research and inquiry to researchers that will be engaged in horizon scanning on the innovations of XAI, digital equity and the transformative professional development of key educators to support those innovations. As such, this study is a guide to the intelligent, reflective thinking regarding the responsible, adaptable and collaborative incorporation of AI into realizing the future of learning for both practitioners and policymakers.

Conclusions

This systematic review offers an overview of AI development in EdTech, current uses of AI in education, and possible implications of AI in education for all parties involved. In addition to discussing current applications of AI in education, this study discusses both the ethical problems and challenges of implementing AI in education. By combining the AI's transformative capabilities and acknowledging the complex issues that need to be resolved before AI can responsibly be integrated into education, we believe that this study will contribute to the collective body of knowledge. AI-based systems in education have progressed from simple, rule-based ITS, to increasingly sophisticated types of capabilities, to most recently Generation-AI, which represents the progress of AIEd as offering better levels of customization of education (e.g., personalized instruction, individualized learning pathways) and easier administrative processes (Bond et al., 2024; Kyambadde et al., 2025).

According to this systematic review, AI is likely to generate numerous positive effects on student's motivation, student's engagement, and student's performance through personalized learning experience, as well as new opportunities for teachers' assistance with administration of tasks, development of new content, providing immediate feedback for teachers (Kelley & Wenzel, 2025; Kyambade et al., 2025; Merino-Campos, 2025; Nikolic et al., 2024; Eden et al., 2024). In addition to the above-mentioned potential benefits for both teachers and students, there is also potential for institutions to allocate resources more effectively, and for students to make decisions based on data when making decisions related to curriculum and academic work (Agherai et al., 2025; Merino-Campos, 2025). However, these opportunities do not exist in isolation from the substantial challenges associated with the implementation of AI, which include concerns with respect to data quality, controlling for bias in algorithms, and the necessity of a major redesign of the roles of faculty members and ongoing concern with the issue of digital equity (Buele & Llerena-Aguirre, 2025; Kelley & Wenzel, 2025; Lee et al., 2025). A number of important ethical considerations will need to be addressed in order to use AI in ways that enhance human capabilities and values, and do not diminish them, including transparency, accountability, and effective governance (Kyambade et al., 2025).

Recommendations

As a result of synthesizing the results of the study, there are the following recommendations based on evidence for key stakeholders to assist ensuring the appropriate and effective integration of AI within EdTech.

For educators

- *Invest in training and continuous education:* Educators need comprehensive training about the capabilities of educational AI and the built-in limitations and ethics of AI (Kyambade et al., 2025; Mikeladze et al., 2024), to assist them transform from the roles of content providers to facilitate an AI-enhanced learning environment. Educators' first-hand experiences will allow them to develop new lesson plans based upon their own experience and to deliver individualized coaching (Mena-Guacas et al., 2023).
- *Treat AI as a partner:* Educators are required to view AI as an educational assistant to assist with administrative tasks, provide multiple sources of instructional information and communication, and to provide immediate feedback (Kelley & Wenzel, 2025; Kyambade et al., 2025; Nikolic et al., 2024), to allow teachers to be able to focus on pedagogical higher-order functions and to have enhanced communication with students.

For policymakers and institutions

- *Establish healthy governance frameworks:* Derive legal, flexible, and updated ethical and regulatory guidelines that are updated continuously for the deployment of AIEd, giving more relevance to the privacy and safety of data and transparent data collection and usage practices (Eden et al., 2024).
- *Minimize algorithmic biases and advocate for digital equality:* Audit AI systems must consider bias in the analysis and use available machine learning algorithms for fairness awareness in the use of technology while increasing the training dataset to become representative (Dimitriadou & Lanitis, 2023; García-López & Liñán, 2025). The policies already mentioned must also advocate for digital equality to extend the necessary infrastructures to obtain their ultimate goals of affordable internet connections, inexpensive computing devices, and training for digital literacy, as educational inequities must not be aggravated (Denny et al., 2024, Kelley & Wenzel, 2025).
- *Create interdisciplinary cooperation:* Initiate the co-design of governance mechanisms implicated in the case of educators, learners, researchers, developers, and policymakers to ensure that the developed frameworks are contextually legitimate and socially acceptable (Bond et al., 2024; Pinho et al., 2025).

For researchers

- *Focus on human-centered AI design:* Direct research could be conducted on developing AI systems that focus on openness, fairness, and the enhancement of human cognition rather than its replacement. This requires developing systems which incorporate both technology enhancement and human-oriented values for an environment that fosters collaboration between learners, teachers, and technology (Buele & Llerena-Aguirre, 2025).
- *Assess long-term effects:* Following multiple years of experimental data and longitudinal studies, it is expected that researchers will need to assess long-term usage of AI applications as well as the efficiency of AI in learning outcomes, social and emotional development and the nuances of human-AI interaction. The purpose for this assessment would be to understand the effectiveness of AI-based applications within

various types of educational environments and learner populations (Mustafa et al., 2024; Raitskaya & Tikhonova, 2025; Xiaoyu et al., 2025).

- *Investigate pedagogical and ethical norms:* Expand the understanding of "how" and "why" AI is changing or has changed the methods and ideas in teaching that have been used previously or are currently being used because of the ambiguous relationship between AI technology and the current pedagogy and its moral justification for using such technology (Almasri, 2024; Bond et al., 2024; Kyambade et al., 2025; Lee et al., 2025; Mustafa et al., 2024).

Future Research Directions

The progressive development of AI in terms of EdTech necessitates a vibrant and commanding research agenda. Future research will need to explore the following:

1. *Longitudinal and experimental studies:* There is a great need for thorough longitudinal and experimental studies to grasp the continued effects resulting from interventions that aim to produce cognitive development, creativity, and problem solving in students to whom they are intended, rather than mere short-term follow-ups (Mustafa et al., 2024; Raitskaya & Tikhonova, 2025; Xiaoyu et al., 2025).
2. *AI in educational contexts:* A big step is warranted in terms of building and training XAI models that can be investigated immeasurably in terms of their connection with educational contexts. This means tests that transparent AI models can have to produce trust or reduce imparted stereotypical ideas or biases and an increase in critical thought on the part of students and teachers so that they can critically engage in decisions on AI matters (Buele & Llerena-Aguirre, 2025; Kalota, 2024; Kyambade et al., 2025).
3. *Dynamics of cooperation between human beings and AI:* An avenue worth examining is the best policies regarding cooperation between human beings and AI, particularly in light of teaching AI as a partner of teachers and students, as an intelligent assistant to teachers, and as a cognitive partner of students, balancing calculated efficiencies with respect to human agency, creativity, and thought (Mena-Guacas et al., 2023).
4. *Digital equity and AI models responsive to diversity:* Further investigation of the possibilities to close the digital gap of people who are laggards in the advanced AI tool areas could be productive. This is to ensure that the AI technologies in question are socially conscious, designed for accessibility, and considerate of the requirement of mindful inclusiveness, that is, all people who are disadvantaged or have disabilities (Denny et al., 2024; García-López & Liñán, 2025; Kelley & Wenzel, 2025).
5. *Adaptive ethical frameworks:* There is a need to further study the development thus far and the use of adaptive and anticipatory ethical frameworks and policies of governance to keep up with the present rapid development of AI and its adaptabilities regarding attempts at social control, ethical analysis, and responsible development of AI solutions, considering equality, justice, and inclusiveness in AI ethical solutions (Mustafa et al., 2024; Pinho et al., 2025).

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