AG EDITOR

REVIEW

Integrating Artificial Intelligence in Education: Advancing Personalized Learning Within Ethical Frameworks: An Overview

Integración de la inteligencia artificial en la educación: promoción del aprendizaje personalizado dentro de marcos éticos: una visión general

Sachin Gupta[1] ✉, Pragya Sharma[1] ✉, Krishna Reddy Vajrala[1] ✉, Ambreen Fatima[1] ✉, Neetu Sharma[2] ✉

[1]Galgotias University, School of Allied Health Sciences, Department of Physiotherapy, Greater Noida, India, 203201.
[2]Galgotias University, School of Computer Science and Engineering, Greater Noida, India, 203201.

ABSTRACT

Introduction: Artificial Intelligence (AI) is reshaping education by facilitating adaptive, personalized, and data-informed learning experiences. Through intelligent tutoring systems, predictive analytics, and AI-powered feedback mechanisms, educators can tailor instruction to meet diverse learner needs while enhancing efficiency and engagement across both traditional and digital learning environments.
Objective: this study aims to examine the effective use of artificial intelligence (AI) in education for promoting personalized learning, while upholding key ethical standards.
Method: a short communication methodology was employed to synthesize recent developments in AI applications in education. Relevant literature published between 2018 and 2025 was identified through searches of databases including PubMed, Scopus, ResearchGate, and Google Scholar. Studies were selected based on criteria related to the use of AI in personalized learning, assessment, instructional design, and administrative automation. Data were thematically analyzed to evaluate the benefits, implementation strategies, and challenges associated with AI integration.
Results: AI-driven tools were found to significantly enhance educational outcomes by enabling proactive (e.g., curriculum design, predictive enrollment analysis) and reactive (e.g., real-time tutoring, automated grading) engagement. Platforms like adaptive learning systems, intelligent tutoring tools, and AI-driven assessment software have enabled personalized learning experiences and eased administrative tasks. However, significant challenges persist, including concerns over data privacy, algorithmic bias, digital literacy gaps, and unequal access to technological infrastructure.
Conclusion: AI technologies hold substantial promise in creating more personalized, inclusive, and effective educational ecosystems. By streamlining teaching processes and supporting learner-centered models, AI enhances both pedagogical impact and academic performance. However, ethical concerns and infrastructural barriers must be addressed to ensure responsible and sustainable adoption. Future efforts should focus on aligning AI development with equity, transparency, and accessibility in education.

Keywords: Artificial Intelligence; AI in Education; Personalized Learning; Adaptive Learning Systems; Intelligent Tutoring Systems; Learning Analytics; Digital Pedagogy; Educational Technology; Ethical Considerations with AI.

RESUMEN

Introducción: la Inteligencia Artificial (IA) está transformando la educación al facilitar experiencias de

aprendizaje adaptativas, personalizadas y basadas en datos. Mediante sistemas de tutoría inteligente, análisis predictivo y mecanismos de retroalimentación basados en IA, los educadores pueden adaptar la instrucción para satisfacer las diversas necesidades de los estudiantes, a la vez que mejoran la eficiencia y la participación en entornos de aprendizaje tanto tradicionales como digitales.

Objetivo: este estudio busca examinar el uso efectivo de la inteligencia artificial (IA) en la educación para promover el aprendizaje personalizado, respetando al mismo tiempo los estándares éticos clave.

Método: se empleó una metodología de comunicación breve para sintetizar los desarrollos recientes en aplicaciones de IA en la educación. Se identificó la literatura relevante publicada entre 2018 y 2025 mediante búsquedas en bases de datos como PubMed, Scopus, ResearchGate y Google Scholar. Los estudios se seleccionaron con base en criterios relacionados con el uso de IA en el aprendizaje personalizado, la evaluación, el diseño instruccional y la automatización administrativa. Los datos se analizaron temáticamente para evaluar los beneficios, las estrategias de implementación y los desafíos asociados con la integración de IA.

Resultados: se observó que las herramientas basadas en IA mejoran significativamente los resultados educativos al permitir una participación proactiva (p. ej., diseño curricular, análisis predictivo de la matrícula) y reactiva (p. ej., tutoría en tiempo real, calificación automatizada). Plataformas como los sistemas de aprendizaje adaptativo, las herramientas de tutoría inteligente y el software de evaluación basado en IA han facilitado experiencias de aprendizaje personalizadas y simplificado las tareas administrativas. Sin embargo, persisten desafíos significativos, como la preocupación por la privacidad de los datos, el sesgo algorítmico, las brechas en la alfabetización digital y el acceso desigual a la infraestructura tecnológica.

Conclusión: las tecnologías de IA son muy prometedoras para crear ecosistemas educativos más personalizados, inclusivos y eficaces. Al optimizar los procesos de enseñanza y apoyar modelos centrados en el alumno, la IA mejora tanto el impacto pedagógico como el rendimiento académico. No obstante, es necesario abordar las preocupaciones éticas y las barreras infraestructurales para garantizar una adopción responsable y sostenible. Los esfuerzos futuros deben centrarse en alinear el desarrollo de la IA con la equidad, la transparencia y la accesibilidad en la educación.

Palabras Clave: Inteligencia Artificial; IA en Educación; Aprendizaje Personalizado; Sistemas de Aprendizaje Adaptativo; Sistemas de Tutoría Inteligente; Analítica del Aprendizaje; Pedagogía Digital; Tecnología Educativa y Consideraciones Éticas con IA.

INTRODUCTION

Artificial Intelligence (AI) is transforming education by introducing adaptive and personalized learning systems that respond to the Learning Pace, Learning Styles, Academic Levels, Language Proficiency, Cognitive and Physical Abilities, Interests and Motivation, and Cultural Backgrounds of individual learners.[1] Through tools such as intelligent tutoring systems, automated grading platforms, learning analytics dashboards, and real-time feedback mechanisms, AI empowers educators to monitor progress, identify learning gaps, and deliver customized instruction.[2] These applications not only enhance student engagement but also allow educators to adjust pedagogical strategies by analyzing behavioral patterns and academic performance.[1,2]

For students, AI-driven applications offer personalized learning environments with tailored content, adaptive pacing, and intelligent recommendations. These tools—ranging from "chatbot tutors" (e.g., "such as ChatGPT Edu or Khan Academy's Khanmigo) to immersive "virtual simulations"—extend learning opportunities beyond the classroom, promoting accessibility, autonomy, and continuous support.[3] In parallel, AI simplifies numerous educational workflows for teachers, including curriculum planning, grading, and performance tracking, thereby allowing them to devote more time to instructional innovation and student mentorship.[4]

The integration of digital technologies into education has accelerated over the past two decades, especially in the wake of global digitalization and post-pandemic learning shifts.[5] While traditional education has relied heavily on human-to-human interaction—through lectures, mentorship, and text-based resources—the present era is witnessing a significant transition toward human-computer interaction. Human-computer interaction (HCI) is transforming pedagogy by shifting it from traditional teacher-centered approaches to more learner-centered, adaptive, and interactive models. Through intuitive interfaces, intelligent tutoring systems, and adaptive learning platforms, HCI facilitates personalized instruction, real-time feedback, and data-driven assessment while promoting active engagement and collaboration. It enables educators to transition from content deliverers to facilitators, supports inclusive learning through accessible designs, and manages cognitive load by structuring digital content effectively. This evolution enhances motivation, retention, and equity in education, making pedagogy more dynamic, responsive, and aligned with diverse learner needs.[5,6] Learning is increasingly shaped by engagements with AI-powered systems that simulate or augment cognitive and instructional functions.[6] These developments necessitate a deeper understanding of how AI not only facilitates but also transforms learning processes.

AI's ability to interpret large volumes of learner data and deliver timely, individualized feedback marks a shift from standardized teaching models to learner-centric paradigms. Through machine learning and data analytics, AI identifies patterns in learning behavior and adjusts content delivery to optimize outcomes. [1,7] For example, platforms can dynamically alter question difficulty, present alternative explanations, or recommend supplementary resources based on a student's learning trajectory. [2,3] Such personalization supports differentiated instruction, addresses equity in learning, and enhances educational outcomes, especially for students with diverse needs and learning styles.

However, the rapid adoption of AI in education also raises critical ethical concerns. Issues related to data privacy, algorithmic bias, transparency, consent, and the role of human agency must be addressed to ensure the responsible use of AI tools in educational environments. [8] Algorithmic bias occurs when AI systems produce unfair or discriminatory outcomes due to imbalanced or unrepresentative data. For example, racial bias in online exam proctoring systems has been documented, where facial recognition algorithms perform less accurately for individuals with darker skin tones, leading to false flagging of misconduct or technical difficulties during assessments. Such cases highlight the ethical need for diverse, representative datasets and transparent testing to ensure fairness and inclusivity in AI-driven educational tools. [8,9] The potential for AI to unintentionally perpetuate inequality—through biased datasets or opaque decision-making—poses a significant risk if not adequately governed. [9] Thus, educational institutions must establish clear ethical frameworks that define acceptable uses of AI, ensure data protection, and promote fairness and inclusivity.

Despite the technological promise, there remains a significant research gap in understanding how AI can be effectively leveraged in education without compromising ethical standards. Existing literature often focuses on the capabilities of AI systems but lacks comprehensive discussion on the long-term impacts on pedagogy, equity, and learner autonomy. Moreover, while many AI applications claim to support personalization, few studies critically evaluate their efficacy or address the ethical trade-offs involved.

Therefore, this study aims to explore how AI can be strategically integrated into educational practices to enhance personalized learning while aligning with ethical principles. It investigates the balance between innovation and responsibility, emphasizing the need for transparency, accountability, and learner-centered design in AI-enabled education. By examining both the opportunities and challenges of AI integration, this research contributes to building a framework for the ethical and effective use of AI in contemporary learning environments.

METHOD

This study explores the evolving role of Artificial Intelligence (AI) in education, with a specific focus on its impact on personalized learning and the associated ethical frameworks. An overview was chosen for its flexibility in synthesizing a broad scope of interdisciplinary evidence, spanning technological, pedagogical, and ethical domains.

Research Design

A literature review methodology was adopted to gather, analyze, and synthesize data from peer-reviewed articles, policy documents, and case-based research. This qualitative approach enables thematic exploration of the key applications of AI in education and the ethical challenges posed by its integration.

Data Sources and Search Strategy

A comprehensive and structured literature search was conducted between January 2018 and April 2025 using the following academic databases: PubMed, Scopus, and Google Scholar.

Keywords and Boolean search combinations included: "Artificial Intelligence" AND "Education", "AI in Teaching and Learning", "Personalized Learning" AND "AI", "Intelligent Tutoring Systems" AND "Ethics", "Learning Analytics" AND "Equity", "Digital Pedagogy" AND "Ethical Considerations" Manual searching of references from key papers was also performed to ensure completeness.

Inclusion and Exclusion Criteria

Inclusion Criteria**:**

- Studies published in English between January 2018 and April 2025

Research focused on AI applications in education, including:

- Personalized/adaptive learning
- Intelligent tutoring systems
- Automated assessment and feedback
- AI-supported curriculum planning
- AI ethics in education

Exclusion Criteria**:**
- Studies unrelated to the educational sector (e.g., AI in healthcare or industry)
- Non-peer-reviewed publications, opinion articles, or editorials
- Conference proceedings or abstracts lacking sufficient data
- Studies not addressing personalization or ethics in educational AI

Data Extraction
The included studies were assessed for the following variables: Type of AI tools (e.g., intelligent tutoring systems, chatbots, recommendation engines), Implementation level (institutional vs. individual), Impact on learning outcomes (e.g., engagement, academic performance, motivation), Ethical concerns (e.g., privacy, data protection, algorithmic fairness). Patterns, innovations, limitations, and gaps were identified across studies to draw comprehensive conclusions.

DEVELOPMENT
AI-Based Teaching and Learning Systems
AI-based teaching can take various forms, such as information processing, the creation of imaginative learning environments, and predictive analysis of information. The role of AI in education is becoming increasingly significant.[1] An AI-driven educational system provides timely, personalized training and assessments for both educators and learners. To achieve this, such systems incorporate a variety of computer technologies, including machine learning and cognitive learning theories, to enhance learning outcomes and efficiency. AI-powered systems employ diverse strategies for learning assessment, recommendations, active learning, and data collection, all of which are based on machine learning techniques. Educational standards in AI are typically divided into two components: the system, which encompasses the learner model, teaching model, and knowledge model, and the AI technology that supports them.[2]

AI Tools in Education
AI tools are revolutionizing education by supporting content creation, personalized learning, assessment, and student engagement. Tools like ChatGPT, Google Gemini, and Microsoft Copilot assist in lesson planning and content generation. Adaptive platforms such as Century Tech and Knewton Alta personalize learning. Assessment tools like Gradescope and Turnitin streamline grading and ensure academic integrity. Learning Management Systems (LMS) like Moodle and Canvas integrate AI for enhanced content delivery. For practice and tutoring, apps like Quizlet and Duolingo Max offer interactive support. Creativity tools like Canva Magic Write and ThingLink help create engaging materials. Additionally, platforms like Brightspace Insights and Ecree monitor student progress, making learning more efficient and engaging.[3]

Phases of AI Integration in the Teaching Process
The integration of AI into the end-to-end teaching process can be categorized into two distinct phases. The first is "PROACTIVE ENGAGEMENT", which entails the strategic design, curation, and optimization of educational resources to enhance learning outcomes. The second is "REACTIVE ENGAGEMENT", which involves leveraging AI to monitor student progress, ensure the effective acquisition of knowledge and skills, and provide timely, data-driven feedback based on their learning experiences (figure 1).[4]
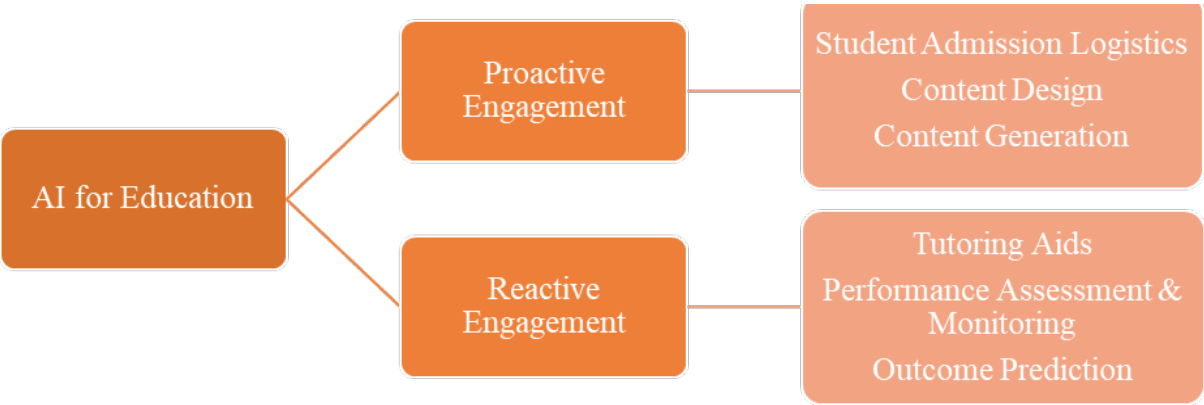

Figure 1. Application of AI in education: Proactive and Reactive Engagement Approaches

Proactive Engagement
Machine learning has been employed to predict student enrollment decisions, enabling institutions to make strategic admissions choices aimed at improving yield rates and optimizing resource allocation.[5]

Learning content design plays a crucial role before the commencement of the learning process. Educators and administrators are responsible for selecting appropriate course offerings for a curriculum, defining relevant content for each course, and choosing suitable questions for standardized assessments.[4]

When designing standardized tests such as the TOEFL, SAT, or GRE, it is essential to ensure that the difficulty level of questions remains consistent across different versions of the test to facilitate fair evaluation. This principle is equally applicable in classroom settings, where educators may wish to generate multiple test versions to reduce plagiarism or to design assignments and exams that progressively increase in difficulty.

This can be achieved using Question Difficulty Prediction (QDP) or Question Difficulty Estimation (QDE), which aim to estimate the skill level required to correctly answer a question. Traditionally, QDP relied on student pretesting or expert judgment, methods that are often costly, time-consuming, subjective, and susceptible to question leakage.[6]

Timetable design, which governs factors such as the number of courses per semester, lectures per day, and available free time slots, significantly influences student attendance patterns and academic outcomes.[7]

Artificial Intelligence (AI) is now extensively used to generate and refine learning content prior to instruction. For example, Automatic Question Generation (AQG) from instructional materials supports student comprehension, facilitates the assessment of knowledge retention, and assists educators in integrating supplementary content from external resources without the burden of manually crafting new assessments.

Moreover, automatically producing problems that match the difficulty level of a given example helps educators deliver personalized practice materials, reduce plagiarism, and ensure equitable assessment for all students.[8]

Reactive Engagement

Interactive tutoring systems have evolved to analyze a student's real-time interactions with the system in order to infer their learning status and deliver tailored feedback or guidance accordingly.[4] When students actively engage with educators or course materials, they tend to remain involved in the learning process for longer periods.[9] Given the uniqueness of each learner, customizing instructional methods and content can enhance individual learning outcomes.[10] Tutoring platforms that support such customization are classified as personalized learning systems or adaptive tutoring aids.

Artificial intelligence-based tools for performance assessment and learning analytics have seen significant development for use by both students and instructors. Systems such as Automatic

Essay Scoring

(AES) and Automatic Short Answer Grading (ASAG) have been designed to objectively evaluate student-written responses using models trained on extensive datasets previously rated by human experts.[11] Additionally, educators can leverage AI to predict academic performance and identify students at risk of dropping out, by analyzing patterns of interaction with course content alongside demographic data.[4]

Table 1. Applications and Impacts of AI in Education			
AI Tool/Theme	**Application in Education**	**Reported Benefits**	**Challenges/Limitations**
Intelligent Tutoring Systems (ITS)	Personalized instruction based on learner responses and behavior tracking	Improved engagement, tailored content delivery, enhanced performance	Requires large datasets, potential bias in content generation
Learning Analytics & Predictive Modeling	Analysis of student data to forecast performance and personalize interventions	Early identification of at-risk students, proactive support	Ethical concerns on data use, student privacy issues
Automated Assessment & Feedback	Real-time feedback, grading essays or MCQs, detecting learning gaps	Saves teacher time, consistent feedback, faster assessment cycles	Limited in evaluating creativity or critical thinking; transparency in scoring mechanisms
AI Chatbots and Virtual Assistants	24/7 student support, answering queries, navigating learning platforms	Increased access to help, reduced administrative burden	May misinterpret context-sensitive queries; requires training in diverse student dialects
Adaptive Learning Platforms	Dynamic adjustment of difficulty level, pacing, and learning path	Boosts individualized learning pace and retention	High cost of development and implementation
AI-Supported Curriculum Design	Assists educators in customizing and updating curriculum content	Aligns curriculum with learner needs and outcomes	Dependence on teacher AI-literacy for meaningful integration
Ethical Frameworks in AI Use	Ensuring fairness, transparency, and data privacy	Promotes responsible AI use and builds trust	Implementation complexity; requires regulatory frameworks and constant review

Challenges of AI-Driven Educational Tools

AI-driven educational tools present several significant challenges. One key issue is the black box algorithms of many AI systems, which hinders educators and learners from fully understanding the rationale behind automated decisions and may undermine confidence in the technology. Furthermore, critical functions such as assessment and grading continue to require human judgment and expertise, emphasizing the necessity for sustained human oversight in the implementation of AI within educational environments.[12] The integration of AI into educational settings raises important concerns regarding its potential impact on student creativity and critical thinking. The increasing reliance on automated tools may limit opportunities for students to engage in deep, independent learning and original thought.

Additionally, as AI assumes more responsibilities traditionally carried out by educators, there is a risk of diminishing the essential human connection between teachers and students (e.g., in mentorship's impact on retention), an element widely recognized as fundamental to effective education. Moreover, there is growing awareness among students and educators of the disparities in access to AI technologies, which could exacerbate existing educational inequalities. Another significant concern is the potential rise in academic dishonesty, particularly plagiarism, facilitated by the ease of information access and task automation, thereby posing challenges to maintaining academic integrity.[13]

Ethical Consideration of AI in Education

The utilization of artificial intelligence in the assessment of student performance presents a range of complex ethical considerations pertaining to equitable evaluation in educational evaluation. While AI technologies have the potential to enhance the efficiency, objectivity, and reliability of assessment processes, their use also introduces significant risks, including algorithmic bias, discriminatory outcomes, and potential infringements on student privacy when not applied with due diligence and ethical oversight.[14,15,16]

It is incumbent upon educational stakeholders to undertake a rigorous examination of these ethical implications, particularly in relation to algorithmic transparency, fairness, accountability, and the potential effects on student motivation, engagement, and overall well-being. Addressing these challenges necessitates the development and implementation of comprehensive ethical frameworks and governance structures that emphasize inclusivity, equity, and fairness. Furthermore, it is essential to establish continuous monitoring and evaluation mechanisms to identify, mitigate, and rectify biases and discriminatory practices within AI-driven assessment systems.[15]

Comparison with Previous Studies

The growing body of literature strongly supports the transformative potential of AI in education, particularly for personalized learning, performance monitoring, and adaptive content delivery. Other systematic reviews have demonstrated outcomes similar to those observed in this review.

The previous studies share common ground with this review in demonstrating the effectiveness of AI for personalized learning, adaptive feedback, and engagement through tools like intelligent tutoring systems, learning analytics, and chatbots. They provide strong evidence that AI can replicate or enhance traditional instruction, as seen in Holmes et al.[21] and Luckin et al.[22] However, they differ in their scope and focus: while many focused on specific domains (e.g., STEM subjects or individual platforms), this review adopts a broader perspective that includes ethical considerations, governance challenges, and equity concerns. Some of these studies were not included in detail because they either lacked a comprehensive analysis of ethical implications or focused narrowly on technical efficacy rather than integrating pedagogical and ethical dimensions. This review builds on their findings by combining evidence of AI's educational impact with a critical lens on its challenges, particularly regarding algorithmic bias, privacy, and the preservation of human-centric learning approaches.

For instance, Holmes et al.[21] found that intelligent tutoring systems significantly improved learner performance across STEM subjects by delivering real-time feedback and adjusting to student needs—closely paralleling the adaptive platforms like Century Tech and Knewton Alta discussed here. Their meta-analysis reported gains equivalent to one-on-one tutoring in some contexts, emphasizing AI's potential to replicate high-quality instruction at scale.

Similarly, Luckin et al.[22] highlighted how AI systems like learning analytics platforms and chatbots support learner engagement and foster metacognitive skills by offering timely, context-aware prompts. These findings reinforce the advantages noted in this review regarding the use of systems like Ecree or Brightspace Insights for progress tracking.

However, some research voices caution. Selwyn[23] critically examined the pedagogical value of AI tools, questioning whether over-reliance on algorithmically curated content diminishes creativity and problem-solving skills. This aligns with the present review's identification of risks related to student creativity and critical thinking due to the automation of cognitive tasks.

Moreover, studies by Williamson and Eynon[24] stressed concerns about data privacy, algorithmic bias, and unequal access, noting that predictive analytics can unintentionally marginalize vulnerable student populations. These concerns directly mirror the current review's emphasis on ethical limitations and the necessity for governance frameworks in AI integration.

In terms of assessment, the findings of Burrows et al.[25] on Automatic Essay Scoring systems echo the utility described here—particularly in efficiency and consistency—but also echo caution about lack of transparency and susceptibility to bias if training datasets are not representative.

Finally, Zawacki-Richter et al.[26], in their systematic review of AI in education, categorized existing research into four areas: profiling and prediction, intelligent tutoring, content generation, and ethical considerations.[26] The current review similarly identifies these domains, reaffirming their relevance and confirming that ethical oversight and continuous evaluation remain underexplored in many implementations.

While there is strong consensus on the benefits of AI in adaptive learning and real-time feedback, significant gaps remain in the ethical governance, equity of access, and preservation of human-centric pedagogy. Addressing these issues requires continuous cross-disciplinary dialogue, robust policy frameworks, and careful implementation rooted in educational equity and learner well-being.

Limitations of the Review

This review is limited by the variability in study designs, with most evidence derived from recent literature (2018-2025), potentially excluding foundational work. Long-term impacts of AI on learning, creativity, and

equity remain underexplored, and ethical considerations such as algorithmic bias and data privacy lack robust empirical validation. Furthermore, the predominance of studies from well-resourced settings limits generalizability to low-resource or marginalized educational contexts.

CONCLUSION

Artificial intelligence offers transformative potential for enhancing educational systems by enabling personalized learning, optimizing instructional design, and improving the accuracy and efficiency of assessments. When strategically implemented, AI can empower educators to deliver more targeted instruction and support students in achieving better learning outcomes through adaptive and data-informed approaches.

However, the integration of AI in education must be approached with thoughtful deliberation and a critical understanding of its inherent limitations. Issues related to transparency, ethical use, data privacy, and equitable access must be addressed to avoid unintended consequences such as bias, academic dishonesty, and the marginalization of essential human interactions in the learning process.

To fully realize the benefits of AI in education, it is imperative to adopt a balanced and inclusive approach that combines technological innovation with the irreplaceable value of human engagement. Ongoing collaboration among educators, developers, policymakers, and learners is essential to ensure that AI tools are designed and applied in ways that are pedagogically sound, ethically responsible, and socially equitable. With appropriate governance, ethical safeguards, and continued research, AI can serve as a powerful complement to traditional educational practices fostering a more effective, accessible, and engaging learning environment for all.

REFERENCES

1. Lin MH, Chen HC, Liu KS. A study of the effects of digital learning on learning motivation and learning outcome. Eurasia J Math Sci Technol Educ. 2017;13(7):3553-64.

2. Mallik S, Gangopadhyay A. Proactive and reactive engagement of artificial intelligence methods for education: a review. Front Artif Intell. 2023;6.

3. Mei XY, Aas E, Medgard M. Teachers' use of digital learning tool for teaching in higher education: Exploring teaching practice and sharing culture. J Appl Res High Educ. 2019;11(3):522-37.

4. Ahmad SF, Alam MM, Rahmat MK, Mubarik MS, Hyder SI. Academic and Administrative Role of Artificial Intelligence in Education. Sustainability. 2022;14.

5. Glickman M, Sharot T. AI-induced hyper-learning in humans. Curr Opin Psychol. 2024;60.

6. Knox J. Artificial intelligence and education in China. Learn Media Technol. 2020;45(3):298-311.

7. Zhai X, Shi L, Nehm RH. A Meta-Analysis of Machine Learning-Based Science Assessments: Factors Impacting Machine-Human Score Agreements. J Sci Educ Technol. 2021;30:361-79.

8. Salih S, Husain O, Hamdan M, Abdelsalam S, Elshafie H, Motwakel A. Transforming education with AI: A systematic review of ChatGPT's role in learning, academic practices, and institutional adoption. Results Eng. 2025;25.

9. Jamison J. Applying machine learning to predict Davidson College's admissions yield. In: Proceedings of the Conference on Integrating Technology into Computer Science Education, ITiCSE. ACM; 2017. p. 765–6.

10. Benedetto L, Cremonesi P, Caines A, Buttery P, Cappelli A, Giussani A, et al. A Survey on Recent Approaches to Question Difficulty Estimation from Text. ACM Comput Surv. 2023;55(9).

11. Larabi-Marie-Sainte S, Jan R, Al-Matouq A, Alabduhadi S. The impact of timetable on student's absences and performance. PLoS One. 2021;16(6).

12. Ahmed UZ, Gulwani S, Redmond M. Automatically generating problems and solutions for natural deduction. Available from: https://www.researchgate.net/publication/262257012

13. Jackson GT, McNamara DS. Motivation and performance in a game-based intelligent tutoring system. J Educ Psychol. 2013;105(4):1036–49.

14. Walkington CA. Using Adaptive Learning Technologies to Personalize Instruction to Student Interests: The Impact of Relevant Contexts on Performance and Learning Outcomes. J Educ Psychol. 2013;105(4):932–45.

15. Dikli S, Russell M. An Overview of Automated Scoring of Essays. Learn Assess. 2006;5. Available from: http://www.jtla.org

16. Chaushi BA, Ismaili F, Chaushi A. Pros and Cons of Artificial Intelligence in Education. Int J Adv Nat Sci Eng Res. 2024;8(2):51–7. Available from: https://www.researchgate.net/publication/379020574

17. Abou Karroum S, Elshaiekh NEM, AlHijji K. Exploring the Role of Artificial Intelligence in Education: Assessing Advantages and Disadvantages for Learning Outcomes and Pedagogical Practices. Int J Innov Res Multidiscip Phil Soc Sci. 2024;12. Available from: https://www.ijirmps.org

18. Cope B, Kalantzis M, Searsmith D. Artificial intelligence for education: Knowledge and its assessment in AI-enabled learning ecologies. Educ Philos Theory. 2021;53(12):1229–45.

19. Kibor JJ. Use of AI tools in assessing student performance in institutions of higher learning: a systematic review of literature. Int J Econ Commer Manag. Available from: https://ijecm.co.uk/

20. Yanisky-Ravid S, Hallisey SK. Artificial Intelligence and Predictive Algorithms: Why Big Data Can Lead To Big Problems. Fordham Urban Law J. 2019;46(2). Available from: https://ir.lawnet.fordham.edu/ulj/vol46/iss2/5

21. Holmes W, Bialik M, Fadel C. Artificial Intelligence in Education: Promises and Implications for Teaching and Learning. Boston, MA: Center for Curriculum Redesign; 2019.

22. Luckin R, Holmes W, Griffiths M, Forcier L. Intelligence Unleashed: An Argument for AI in Education. London: Pearson Education; 2016.

23. Selwyn N. Should robots replace teachers? AI and the future of education. 1st ed. Cambridge: Polity; 2019.

24. Williamson B, Eynon R. Historical threads, missing links, and future directions in AI and education. Learn Media Technol. 2020;45(3):223–35.

25. Burrows S, Gurevych I, Stein B. The eras and trends of Automatic Essay Scoring. Int J Artif Intell Educ. 2021;31(4):1–30.

26. Zawacki-Richter O, Marín V, Bond M, Gouverneur F. Systematic review of research on artificial intelligence applications in higher education – where are the educators? Int J Educ Technol High Educ. 2019;16(1):39.

FINANCING

CONFLICT OF INTEREST

There are no financial conflicts of interest to disclose. The authors declare no conflict of interest.

AUTHORSHIP CONTRIBUTION

Conceptualization: Sachin Gupta, Pragya Sharma, Krishna Reddy Vajrala, Ambreen Fatima, and Neetu Sharma.

Data curation: Sachin Gupta, Pragya Sharma, Krishna Reddy Vajrala, Ambreen Fatima, and Neetu Sharma.

Formal analysis: Sachin Gupta, Pragya Sharma, Krishna Reddy Vajrala, Ambreen Fatima, and Neetu Sharma.

Research: Sachin Gupta, Pragya Sharma, Krishna Reddy Vajrala, Ambreen Fatima, and Neetu Sharma.

Methodology: Sachin Gupta, Pragya Sharma, Krishna Reddy Vajrala, Ambreen Fatima, and Neetu Sharma.

Project management: Sachin Gupta, Pragya Sharma, Krishna Reddy Vajrala, Ambreen Fatima, and Neetu Sharma.

Resources: Sachin Gupta, Pragya Sharma, Krishna Reddy Vajrala, Ambreen Fatima, and Neetu Sharma.

Software: Sachin Gupta, Pragya Sharma, Krishna Reddy Vajrala, Ambreen Fatima, and Neetu Sharma.

Supervision: Krishna Reddy Vajrala, Neetu Sharma, Sachin Gupta, Pragya Sharma, and Ambreen Fatima.

Validation: Krishna Reddy Vajrala, Neetu Sharma, Sachin Gupta, Pragya Sharma, and Ambreen Fatima.

Display: Sachin Gupta, Pragya Sharma, Krishna Reddy Vajrala, Ambreen Fatima, and Neetu Sharma.

Drafting - original draft: Sachin Gupta, Pragya Sharma, Krishna Reddy Vajrala, Ambreen Fatima, and Neetu Sharma.

Writing - proofreading and editing: Sachin Gupta, Pragya Sharma, Krishna Reddy Vajrala, Ambreen Fatima, and Neetu Sharma.