

Conceptual Review on Impact of Artificial Intelligence in Education Systems: Positive and Negative Effects on Student Performance

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ABSTRACT

Artificial Intelligence (AI) is rapidly reshaping educational systems through the use of intelligent tutoring systems (ITS), adaptive learning platforms and automated feedback and assessment tools. The remarkable performance of AI models such as ChatGPT on standardized academic assessments has further intensified global interest in its educational potential. The integration of AI into teaching and learning processes has significantly reshaped academic experiences, presenting both promising opportunities and notable challenges for student performance. This conceptual review synthesizes recent empirical and review literature on how artificial intelligence affects student performance in formal education. It maps positive mechanisms (personalized learning, intelligent tutoring, automated feedback, adaptive assessment) and negative mechanisms (academic integrity threats, over-reliance, bias, reduced metacognition), evaluates empirical effect-size evidence from recent meta-analyses and systematic reviews, and discusses contextual moderators (level of education, subject domain, instructor practices, access/inequity). This paper provides a comprehensive review of AI applications in education, examining their influence on students' learning processes and academic outcomes, with particular emphasis on the positive and negative effects arising from AI adoption in the educational system.

1. Introduction

Artificial Intelligence (AI) has rapidly transformed the global education landscape, influencing teaching methodologies, learning processes, assessment systems and overall student performance. AI applications in education present a double-edged sword offering substantial benefits while posing potential challenges to student performance. The rapid evolution of AI technologies has transformed multiple sectors, with education emerging as one of the most significantly impacted. AI systems such as adaptive learning platforms, automated grading tools, virtual tutors, and intelligent learning analytics are increasingly integrated into schools and universities worldwide (Vieriu & Petrea, 2025; Bit et al., 2024; Mallillin, 2024). These technologies aim to personalize instruction, improve teaching efficiency, and enhance overall learning outcomes. Their effectiveness often depends on institutional readiness, implementation strategies, and the transition process from traditional to technology-enhanced learning environments (Mallillin et al., 2020).

AI has become a transformative force in both general and higher education, influencing students' academic development by producing both positive and negative effects on performance (Hwang et al., 2020; Holmes et al., 2019). As educational institutions, particularly in developing nations such as Nigeria, strive to meet the diverse and evolving needs of learners in a rapidly changing digital landscape (Gocen & Aydemir, 2020), AI emerges as a powerful instrument capable of redefining traditional pedagogical paradigms. Despite its numerous benefits, improper management or excessive reliance on AI technologies can lead to detrimental effects on student performance (Zhang & Aslan, 2021). Moreover, the integration of AI in education raises critical concerns regarding equity, data privacy, and the evolving role of human educators (Seo et al., 2021). Hence, while AI holds the promise of innovation and improved learning outcomes, a balanced and thoughtful approach is required to maximize its advantages while mitigating potential drawbacks (Yang et al., 2024).

AI impacts students' academic performance by providing tailored information, real-time feedback, and resources aligned with curricular requirements (Coy et al., 2024). Through the contribution of advanced technologies, information systems, and intelligent algorithms, AI-driven learning environments foster adaptive, student-centered learning experiences (Mallillin & Carag et al., 2020). Information technologies, particularly AI, are revolutionizing modern education, as AI algorithms and educational robots are increasingly embedded within learning management systems (LMS) and training platforms to support diverse teaching and learning activities.

When students encounter assignments that are overly complex or challenging, they may become disengaged or frustrated. However, the integration of AI-driven educational applications has helped to mitigate these challenges. For instance, Khan Academy's Khanmigo, an AI tutor powered by GPT-4, delivers personalized learning support and intelligent feedback across

multiple subjects, including mathematics, programming, and language learning. Similarly, Duolingo employs sophisticated AI systems to adapt language lessons dynamically, improving learner engagement and retention (Bicknell et al., 2023). AI-powered learning management systems such as Absorb LMS and Docebo further extend these capabilities by offering intelligent content generation, administrative automation, and personalized learning pathways (Leh, 2022).

Artificial Intelligence has thus emerged as a defining technology of the 21st century, reshaping industries ranging from healthcare and finance to education (Neha & Sidiq, 2020). Within educational contexts, AI applications including intelligent tutoring systems, adaptive learning environments, automated grading tools, and conversational chatbots are transforming how students learn, interact, and demonstrate understanding (Yang et al., 2024). These innovations promise personalized, flexible, and data-driven learning experiences but also raise ethical, pedagogical, and performance-related concerns. In particular, issues of dependency, equity, data security, and overreliance on algorithmic support warrant careful consideration.

This study therefore examines the application of Artificial Intelligence in education systems, with a focus on its positive and negative effects on student performance. By analyzing current AI tools and pedagogical practices, it seeks to identify how AI can be optimally harnessed to enhance educational outcomes while minimizing potential risks.

2. Literature review

Artificial Intelligence (AI) enhance students' academic performance by improving personalized learning experiences, fostering knowledge integration, and promoting cognitive development (Mallillin et al., 2020). The fundamental objective of AI is to develop intelligent systems, computer programs or machines learning capable of exhibiting intelligent behaviour. Scholars commonly distinguish between strong AI and weak AI. According to Wang et al. (2024), strong AI, also known as artificial general intelligence (AGI), encompasses a wide range of human cognitive abilities, such as reasoning, communication, and emotional understanding, enabling it to perform multiple complex tasks. In contrast, weak AI, or narrow AI, lacks the full array of human-like capabilities but can apply algorithms to reason and solve problems within specific domains, such as fraud detection or chess playing.

Altememy et al. (2023) emphasize that AI significantly enhances students' learning potential, enabling them to maximize their educational experiences. The educational field is particularly well-suited to AI integration, as both teaching and learning are highly cognitive and knowledge-intensive activities. AI applications designed for reasoning and problem-solving through algorithmic and knowledge-based processes can effectively support and augment the capabilities of educators and learners alike (Perrotta & Selwyn, 2020). Since the mid-1950s, AI technologies have been progressively adopted to facilitate education and training across various disciplines, including languages, STEM, and medicine. These technologies have been developed to support multiple educational functions, such as instructional content creation and dissemination, learner interaction and collaboration, and performance evaluation (Perrotta & Selwyn, 2020).

Bećirović (2023) argues that integrating AI into educational contexts can enhance students' cognitive and critical thinking abilities while fostering collaboration among peers. This collaborative environment strengthens overall knowledge acquisition and supports holistic learning development. Similarly, Chen et al. (2020) conducted a comprehensive global study on the implications of AI in education and found that this emerging technology significantly enhances pedagogical processes, leading to notable improvements in students' intellectual growth. Furthermore, AI enables educators to closely monitor students' academic progress, providing valuable insights into learning behaviors and performance trends. As a rapidly evolving technological innovation, AI continues to emerge from academic research environments and is instrumental in driving innovation and transformation within Higher Education Institutions (HEIs) (Okunlaya et al., 2022).

In a meta-analysis, Tlili et al. (2024) examined the effects of AI on learning achievement in computer science education and identified several moderating variables influencing its impact. AI technologies are now transforming education at multiple levels, including classroom instruction, individualized learning, assessment practices, institutional operations, and policy development. The COVID-19 pandemic further accelerated the adoption of AI in education and expanded research interest in its effects on teaching and learning (Mallillin et al., 2020; Coy et al., 2024). Therefore, it is imperative to investigate the role of AI within the educational system, focusing on both its positive and negative effects on student academic performance, while proposing strategies to maximize its benefits and mitigate potential drawbacks.

3. Concept of Artificial Intelligence in Education

Artificial Intelligence (AI) refers to the simulation of human cognitive processes by computer systems or machines, including learning, reasoning, perception, and problem-solving (Russell & Norvig, 2021). In the context of education, AI encompasses a broad range of technologies and applications designed to replicate or augment human intelligence to enhance teaching and learning processes (Zawacki-Richter et al., 2020). The integration of AI in education aims to create adaptive learning environments that respond dynamically to the needs, abilities, and progress of individual learners (Chen et al., 2020).

AI in education can be broadly categorized into two main types: strong AI and weak AI. Strong AI, or Artificial General Intelligence (AGI), aspires to possess human-like reasoning and emotional understanding, capable of performing multiple intellectual tasks autonomously (Wang et al., 2024). In contrast, *weak AI*, also known as narrow AI, focuses on executing specific functions such as grading, personalized recommendations, and tutoring within well-defined parameters (Bates et al., 2024). Most current educational AI applications fall under the category of narrow AI, offering specialized assistance rather than general intelligence. In addition, AI applications such as chatbots, virtual assistants, and recommendation engines facilitate interactive learning and continuous student engagement (Dandachi, 2024; Raza & Iqbal, 2023).

The concept of AI in education extends beyond automation and it seeks to enhance human learning by fostering personalization, engagement, and continuous feedback. AI-driven systems such as Intelligent Tutoring Systems (ITS), Learning Management Systems (LMS), and adaptive assessment tools provide real-time analytics and tailored instructional support to students (Perrotta & Selwyn, 2020; Tlili et al., 2024). These technologies analyze large volumes of educational data to identify learning patterns, predict academic outcomes, and recommend individualized learning pathways (Raza & Iqbal, 2023).

Moreover, AI acts as a collaborative tool for educators by streamlining administrative tasks, assisting with curriculum development, and supporting data-informed decision-making (Zavalevskiy et al., 2024). AI chatbots and virtual assistants facilitate communication between teachers and students, providing instant feedback and promoting interactive learning experiences (Dandachi, 2024). The adoption of AI in education also enables institutions to manage resources more effectively and enhance access to quality education, particularly in remote or underserved areas (Altememy et al., 2023).

However, the concept of AI in education is not limited to technological deployment; it encompasses ethical, pedagogical, and psychological considerations. Bećirović (2023) emphasizes that AI should be viewed as a complement to human teaching rather than a replacement. Its effective integration depends on maintaining human oversight, promoting equity, and safeguarding data privacy. Furthermore, the development of AI literacy has the ability to understand, interact with, and critically evaluate AI tools is increasingly recognized as a fundamental skill for both teachers and learners (Kim, 2023).

In essence, the concept of Artificial Intelligence in education represents a transformative shift toward data-driven, learner-centered, and intelligent educational ecosystems. It redefines the roles of teachers and students, promoting more efficient, inclusive, and personalized learning experiences while highlighting the need for ethical implementation and continuous human engagement.

4. Conceptual Framework: The Connection between Artificial Intelligence and Student Performance

The conceptual framework of this study explains the dynamic relationship between Artificial Intelligence and student performance within the educational system. It highlights how AI technologies act as mediating tools that enhance learning experiences, instructional practices, and academic outcomes. Grounded in constructivist learning theory and technology-enhanced learning frameworks, this model posits that AI-driven tools can facilitate personalized learning, improve cognitive engagement, and support data-driven instructional decisions (Zawacki-Richter et al., 2020).

AI applications such as intelligent tutoring systems, adaptive learning platforms, chatbots, and predictive analytics serve as catalysts that influence student performance through several pathways. These technologies provide personalized feedback, enable individualized learning plans, and support teacher–student collaboration, thereby improving comprehension, critical thinking, and motivation (Chen et al., 2020; Raza & Iqbal, 2023).

4.1 Framework Description

The framework conceptualizes AI as an input variable that operates through learning and teaching processes to produce desired educational outcomes. It consists of three main components:

- **AI-Enabled Inputs:**

These include the deployment of AI systems such as intelligent tutoring systems, automated grading tools, virtual learning assistants, and data-driven learning analytics (Tlili et al., 2024; Dandachi, 2024). These tools enhance the ability of educators to tailor learning experiences according to students' abilities and needs.

- **Learning Process and Mediation:**

AI supports interactive and adaptive learning processes by analyzing students' learning patterns, providing instant feedback, and adjusting content difficulty (Kim, 2023). It fosters engagement through gamification, promotes self-directed learning, and reduces the cognitive load associated with complex topics (Bećirović, 2023).

- **Student Performance Outcomes:**

The final output of AI integration is improved student performance, which can be measured through academic achievement, problem-solving ability, learning efficiency, and motivation (Bates et al., 2024; Altememy et al., 2023).

4.2 Key Components of the Framework

- **Input Variables (AI-Enabled Factors)**

These refer to the AI-driven tools and technologies integrated into the educational process. They include:

- Intelligent Tutoring Systems (ITS) for personalized instruction and real-time feedback.
- Learning Analytics and Predictive Systems that analyze student data to identify learning gaps and predict outcomes.
- Natural Language Processing (NLP) Tools such as chatbots and virtual assistants that facilitate communication and support.
- Automated Assessment Systems that evaluate student performance objectively and efficiently (Tlili et al., 2024; Dandachi, 2024).

- **Process Variables (Learning Mediation and Interaction)**

These represent the mechanisms through which AI influences the learning experience:

- **Personalized Learning:** AI customizes content based on learners' strengths, weaknesses, and pace (Kim, 2023).
- **Feedback and Assessment:** Continuous and adaptive feedback helps learners understand performance gaps.
- **Engagement and Motivation:** Gamification and adaptive challenges enhance participation and motivation.
- **Teacher Support:** AI assists educators in decision-making and classroom management (Zavalevskiy et al., 2024).

- **Output Variables (Student Performance Outcomes)**

Student performance is the ultimate dependent variable influenced by AI integration. It is measured through:

- Academic Achievement (test scores, comprehension levels, grades)
- Cognitive Skills Development (problem-solving, critical thinking)
- Learning Efficiency and Retention
- Emotional and Social Engagement in Learning (Bates et al., 2024).

• Moderating and Mediating Factors

Several factors influence the strength and direction of AI's impact on student performance:

- Teacher Competence and Attitudes Toward AI
- Institutional Readiness and Infrastructure
- Equity and Accessibility of AI Tools
- Ethical and Data Privacy Considerations (Bećirović, 2023; Altememy et al., 2023).

However, this relationship is moderated by external and contextual factors such as teacher competence, institutional infrastructure, accessibility of AI tools, and ethical considerations. These mediating variables determine the effectiveness of AI in influencing learning outcomes (Okunlaya et al., 2022).

4.2.1 Conceptual Flow Illustrative Framework (Textual Description)

In essence, the conceptual framework shown in Figure 1 demonstrates that effective integration of AI technologies enhances student performance by promoting personalization, interactivity, and continuous feedback. Nevertheless, for AI to achieve its full potential, it must be implemented within an equitable, ethical, and pedagogically sound educational environment.

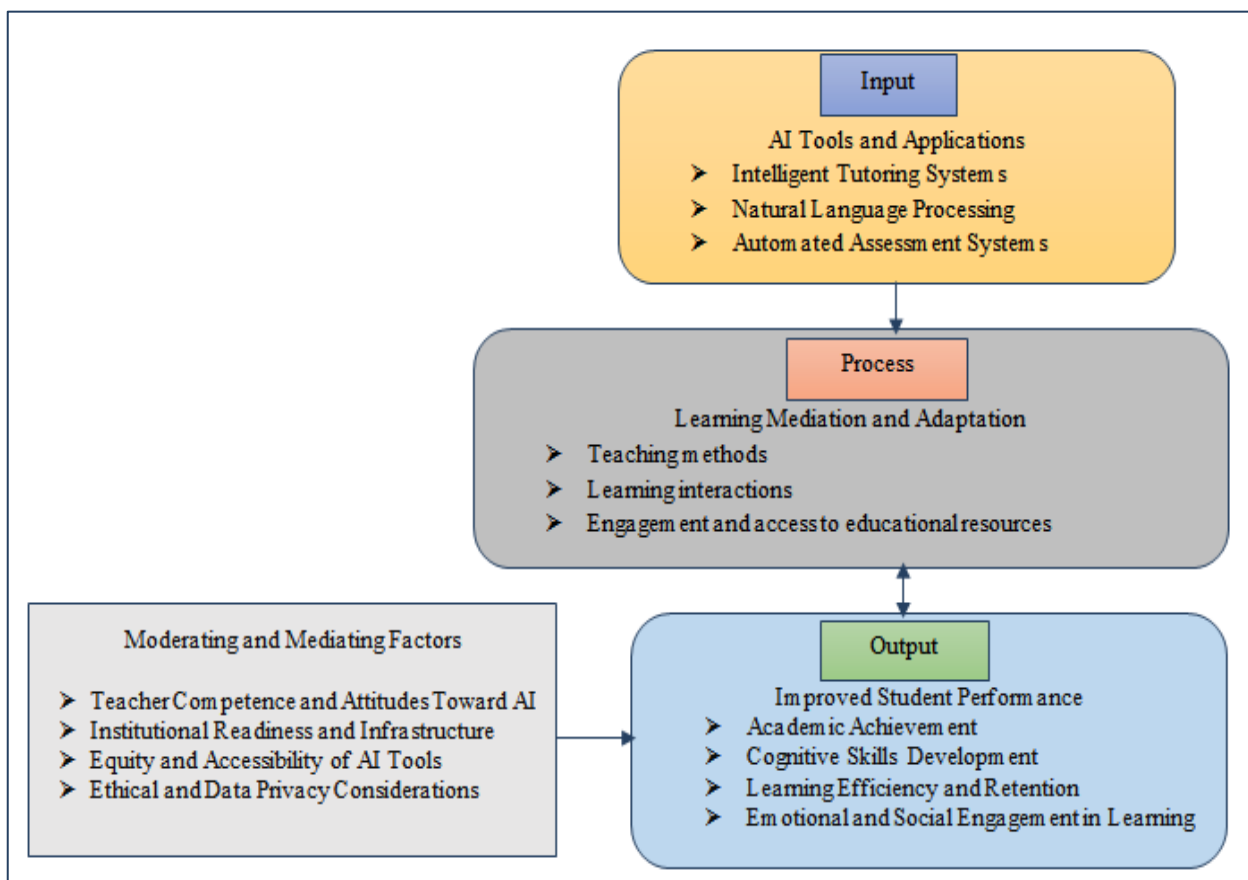


Figure 1: The Conceptual Flow Illustrative Framework

5. Impact of AI on Teacher to Student Relationship

Artificial Intelligence (AI) has the potential to significantly enhance the learning process by fostering collaboration between teachers and students (Dandachi, 2024). Through real-time analytics and data-driven insights, AI can help educators identify individual students' strengths, weaknesses, and learning patterns, allowing them to adapt instructional strategies to meet diverse learning needs (Raza & Iqbal, 2023). Moreover, AI systems can alert teachers when students are struggling and suggest possible interventions or remedial approaches. Beyond analytical functions, AI can also serve as a brainstorming partner for educators, helping generate innovative teaching ideas and strategies to support effective student teaching (Zavalevskyi et al., 2024).

AI technologies further assist educators in addressing a broad spectrum of student questions during instruction. Given that human teachers may be limited by time or subject expertise, students' unexpected or unconventional inquiries can pose challenges in real-time classroom interactions. In such cases, AI tools can bridge knowledge gaps and provide accurate, contextually relevant responses to enhance understanding (Dandachi, 2024; Bates et al., 2024). AI-driven chatbots, for instance, can facilitate instant feedback, foster peer-to-peer learning, and promote a cooperative and interactive classroom environment (Raza & Iqbal, 2023).

According to Kim (2023), cultivating a positive attitude toward AI-enhanced learning is crucial for maximizing its educational benefits. Exposure to AI-based learning tools encourages students to develop adaptive learning skills, critical thinking, and a proactive approach to knowledge acquisition. This evolving mindset strengthens students' engagement with the learning process and promotes continuous improvement in their competencies. Furthermore, understanding students' perceptions and attitudes toward AI provides valuable insights into how such technologies influence motivation, participation, and overall academic development.

5.1 Overall Impact of AI in Education

Artificial intelligence helps to improve student performance by transforming, communicating, and interacting in learning. The benefit of AI on the educational system is multifaceted and transformative, offering both opportunities and challenges. The following outline some key aspects of this impact:

Personalized Learning:

AI enables personalized learning experiences by adapting educational content to meet the needs of individual students. Algorithms can analyze a student's strengths, weaknesses, and learning style to tailor lessons, exercises, and resources. This helps in addressing diverse learning paces and preferences, potentially improving overall learning outcomes (Hennekeuser et al., 2024).

Intelligent Tutoring Systems:

AI-powered tutoring systems provide students with immediate feedback and assistance. These systems can simulate one-on-one tutoring, offering explanations, practice problems, and guidance tailored to the student's level of understanding. This can be particularly beneficial for subjects where students may need extra help outside regular class hours (Coy et al., 2024).

Administrative Efficiency:

AI can streamline administrative tasks such as grading, scheduling, and enrollment management. Automated grading systems can handle multiple-choice tests and even some essay evaluations, freeing up educators to focus more on teaching and student interaction. AI-driven tools can also help in managing school operations and logistics (Seo et al., 2021; Yang et al., 2024).

Data-Driven Insights:

AI can analyze vast amounts of educational data to provide insights into student performance, teaching effectiveness, and curriculum efficacy. This data-driven approach helps educators and administrators make informed decisions, identify trends, and implement strategies to enhance the learning environment (Neha & Sidiq, 2020).

Enhancing Engagement:

AI can be used to create interactive and engaging educational content, such as simulations, virtual reality (VR) experiences, and gamified learning activities. These tools can make learning more immersive and enjoyable, potentially increasing student motivation and engagement (Tili et al., 2024).

Accessibility and Inclusivity:

AI technologies can improve accessibility for students with disabilities. Tools like speech-to-text, text-to-speech, and language translation can help accommodate diverse learning needs and ensure that educational materials are accessible to all students (Hennekeuser et al., 2024; Coy et al., 2024).

Teacher Support and Development:

AI can assist teachers by providing professional development resources, teaching aids, and lesson plans. AI-driven platforms can also analyze classroom interactions and provide feedback to help teachers improve their instructional techniques and classroom management (Krstić et al., 2022).

Ethical and Privacy Concerns:

The use of AI in education raises important ethical and privacy issues. Ensuring data security, protecting student privacy, and addressing biases in AI algorithms are critical concerns that need to be managed. There is also the risk of over-reliance on technology, which could affect the human aspects of teaching and learning (Neha & Sidiq, 2020; Coy et al., 2024).

Equity and Access:

While AI has the potential to democratize education by providing resources and support to underserved areas, there is a risk that it could exacerbate existing inequities. Access to AI tools and technology may be uneven, potentially widening the gap between well-resourced and under-resourced educational settings (Krstić et al., 2022; Huang et al., 2022).

6. Positive and Negative Effects of AI on Education

AI's transformational potential in changing teaching and learning techniques creates exciting opportunities for both students and teachers. However, every innovation has both good and bad repercussions and it is our responsibility as humans to govern and manage these consequences.

The following subsection will look into the beneficial elements of AI and also discuss the possible negative effect of AI in education system.

6.1 Positive Effects of AI on Student Performance

Personalized Learning:

AI-powered platforms like adaptive learning systems (e.g., Knewton, DreamBox) tailor content to individual learning paces and styles. This personalization increases student engagement and comprehension, as learners receive content suited to their strengths and weaknesses (Dandachi, 2024).

Immediate Feedback and Assessment:

Intelligent tutoring systems (ITS) provide instant feedback, enabling students to correct mistakes and reinforce learning in real time. This has been linked to improved retention and academic achievement (Woolf, 2021).

Enhanced Accessibility:

AI supports students with disabilities by providing tools such as speech recognition, text-to-speech, and real-time translation, thus reducing barriers to learning and promoting inclusivity (Al-Azawei et al., 2019).

Data-Driven Insights for Teachers:

Learning analytics powered by AI help educators identify struggling students early, allowing timely interventions. This proactive support has shown to improve overall class performance (Ifenthaler & Yau, 2020).

Gamification and Motivation:

AI-driven gamified platforms foster motivation by turning learning into interactive experiences. This boosts student performance by increasing engagement and reducing dropout rates (Zawacki-Richter et al., 2019).

6.2 Negative Effects of AI on Student Performance**Overreliance on Technology:**

Excessive dependence on AI tutors or automated systems may reduce critical thinking, problem-solving, and independent learning skills (Huang et al., 2021).

Equity and Digital Divide:

Students in underfunded schools or rural areas may lack access to advanced AI tools, exacerbating educational inequality and negatively affecting their performance compared to peers in well-resourced institutions (Sarker et al., 2022).

Bias and Fairness Issues:

AI algorithms may reflect inherent biases in training data, leading to unfair assessments or recommendations, which can disadvantage certain groups of students (Baker & Hawn, 2021).

Privacy and Ethical Concerns:

AI relies heavily on student data collection. Breaches of privacy or misuse of personal data could harm trust and negatively impact students' learning engagement (Williamson & Eynon, 2020).

Reduced Human Interaction:

Human teachers provide emotional intelligence, mentorship, and social interaction, which AI cannot fully replicate. Overuse of AI may weaken teacher–student relationships, affecting motivation and holistic development (Hennekeuser et al., 2024).

7. Conclusion and Future works

The integration of Artificial Intelligence in education presents both significant opportunities and critical challenges for student performance. While AI offers transformative potential in enhancing student performance through personalized learning, accessibility, assessment efficiency, and efficient feedback systems. It simultaneously introduces concerns related to inequality, overreliance, and ethical implications. Nevertheless, its integration must be guided by ethical standards, pedagogical balance, and equitable access to prevent dependency, bias, and exclusion. Maximizing the benefits of AI requires a balanced approach that harmonizes technological innovation with traditional pedagogical practices, emphasizes human oversight, and ensures equitable access for all learners. Therefore, effective collaboration among educators, policymakers, and technologists is essential in developing AI systems that are ethical, inclusive, and conducive to students' long-term cognitive and personal development. Further works can be conducted on longitudinal studies on AI's effects on metacognition and transfer. As well as methodological work on valid assessment of AI-augmented learning (avoiding contamination by AI-generated work).

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