Artificial Intelligence (AI) in Personalized Learning

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ABSTRACT

Artificial intelligence (AI) is revolutionizing education by enabling personalized learning tailored to individual student needs, especially in STEM fields. Tools like adaptive learning platforms and intelligent tutoring systems enhance engagement, understanding, and academic success through real-time feedback and targeted interventions. However, challenges such as unequal access to technology, data privacy concerns, and teacher readiness must be addressed. Examining case studies and ethical considerations highlights both opportunities and hurdles in AI integration. Collaborative efforts among educators, policymakers, and technologists are vital to ensure equitable access, robust infrastructure, and effective implementation, preparing all students for a technology-driven future.

1. INTRODUCTION

In today's education systems, personalized learning represents a pivotal shift from one-size-fits-all instruction toward adaptive, learner-centred models (Du Plooy et al., 2024). Rooted in data-driven pedagogy and powered increasingly by AI technologies, personalized learning addresses students' unique needs, interests, and goals (Naseer et al., 2024). This approach fosters engagement, supports self-paced learning, and enhances academic outcomes. This chapter critically explores both the promise and limita-

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tions of AI-enabled personalization, with a focus on its application in STEM education. In recent years, the educational landscape has witnessed a remarkable shift towards personalized learning models, which hold significant promise for enhancing student outcomes. Research underscores the potential of these approaches to foster greater engagement and motivation among learners, allowing them to master subjects more effectively. By empowering students to take ownership of their educational journeys, personalized learning creates a dynamic environment where individual needs and preferences can be addressed. This is particularly crucial in the realm of STEM education, covering Science, Technology, Engineering, and Mathematics, where the complexity of content can often pose challenges for students. Personalized approaches are especially impactful in these areas, as they offer tailored instructional methods that cater to each learner's unique strengths and weaknesses.

For example, adaptive learning platforms and intelligent tutoring systems leverage real-time analytics to pinpoint gaps in knowledge. They provide immediate, targeted interventions that help students build a strong foundation in key concepts. Such innovative technologies not only facilitate a deeper understanding but also encourage a sense of agency in learners, reinforcing their confidence as they navigate complex subjects. Studies conducted by organizations such as the RAND Corporation have shown that students in personalized learning environments frequently outperform their peers (Andhika et al., 2024). However, it is important to consider that many of these studies are conducted in controlled, high-resource environments and often rely on data from edtech companies with commercial interests. There is limited discussion around the methodological rigor, generalizability, or long-term impact of these findings, particularly in diverse or low-resource contexts (Pane et al., 2015). As such, while the benefits of personalized learning are compelling, they should be interpreted alongside a critical appraisal of the existing literature. The promise of personalized learning lies in its ability to meet diverse educational needs, ultimately leading to superior academic achievements and a more engaged student body. Delving deeper into the intricacies of personalized learning reveals that this educational model is not just a trend, but a transformative approach with the potential to redefine the way of thinking about teaching and learning in the 21st century.

Personalized learning equips students with critical thinking, problem-solving, and self-regulation skills, all of which are essential for thriving in a technology-driven and rapidly evolving world (Motorina et al., 2025). Moreover, as educational technologies continue to evolve, this approach has emerged as a cornerstone of inclusive education. It supports diverse learning profiles, including those of students with disabilities, by providing customized accessibility tools tailored to individual needs. Despite the numerous advantages, the implementation of this approach presents several challenges. Ethical concerns surrounding data privacy and the digital divide, ensuring equitable access to essential technology, must be addressed to achieve effective and fair adoption (Yang, 2025). When integrated thoughtfully within frameworks such as the Technological Pedagogical Content Knowledge (TPACK) model, personalized learning has the potential to greatly enhance educational practices and outcomes. In conclusion, personalized learning is reshaping traditional education by focusing the learner on the instructional process. By leveraging advancements in artificial intelligence and data analytics, this approach offers a transformative pathway for education systems to create more equitable, effective, and future-ready learning environments.