

## Utilization of Artificial Intelligence in Personalized Learning

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### ABSTRACT

The rapid advancement of artificial intelligence (AI) over the past decade has driven significant transformations in educational practices, particularly through the implementation of personalized learning. This article aims to comprehensively examine the utilization of AI in supporting adaptive, learner-centered personalized learning and to identify the opportunities and challenges associated with its implementation. This study adopts a literature review approach by analyzing relevant peer-reviewed journal articles retrieved from Google Scholar published between 2015 and 2025. The findings indicate that the application of Intelligent Tutoring Systems, Adaptive Learning Management Systems, and Generative AI enables the dynamic adaptation of learning content, pacing, and learning pathways based on individual learner profiles, thereby enhancing learner engagement, learning efficiency, and academic achievement. Furthermore, the role of educators is shifting from content delivery toward facilitation and mentoring of the learning process. Nevertheless, the integration of AI in education also presents critical challenges, including data privacy concerns, algorithmic bias, AI hallucinations, and the risk of depersonalization in learning environments. This article underscores the importance of adopting a human-centered and ethical approach to AI integration to ensure that personalized learning is implemented effectively, equitably, and sustainably.

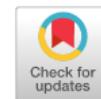
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## INTRODUCTION

The integration of artificial intelligence (AI) in education has accelerated significantly in the past decade, along with advances in intelligent computing and the increasing demand for flexible, adaptive, and student-centered learning. This transformation was further accelerated by the COVID-19 pandemic which prompted a massive shift towards online and hybrid learning. However, pedagogical practices in distance learning are still dominated by a uniform approach that is less able to accommodate the diversity of students' abilities, motivations, and learning styles, resulting in low learning engagement and inequality in academic achievement. The integration of artificial intelligence (AI) technology in education today is no longer just an option, but rather a need to create a flexible and customized learning environment. AI is able to collect and interpret data from a variety of sources to build comprehensive student learning profiles, a capability that is difficult to achieve in conventional methods (Hashim et al. 2022)

In this case, personalized learning is seen as a strategic approach to overcome the limitations of conventional learning models. This approach emphasizes content adjustments, learning tempos, instructional strategies, and assessments based on the individual characteristics of learners. AI acts as a pedagogical enabler that is able to process learning data in real-time, model student learning profiles, and produce adaptive recommendations that support more autonomous and meaningful learning paths. In line with the Education 4.0 paradigm, the use of AI marks a fundamental shift from a *one-size-fits-all* approach to a learning ecosystem that values the uniqueness and potential of each individual.

Artificial Intelligence acts as a transformative force capable of automatically customizing educational content by analyzing student interaction data to meet their individual needs and preferences as described by Mimoudi (2024). Theoretically, AI-based personalized learning has a strong affinity with constructivism theory, which places learners as active actors in the process of knowledge construction. In addition, this approach is also supported by *Self-Determination Theory* which emphasizes the role of autonomy, competence, and social connectedness in building intrinsic motivation. The implementation of technologies such as *Intelligent Tutoring Systems (ITS)* and *Generative AI (GenAI)* shows the potential to optimize cognitive load through adjusting the level of material complexity and providing adaptive feedback, so that the learning process becomes more efficient and directed.

The adoption of AI marks a paradigm shift from a 'one size fits all' approach to a more inclusive model. In this ecosystem, the role of educators evolves from key content presenters to facilitators, while AI handles administrative tasks such as student progress tracking and automated assessments, allowing teachers to focus more on instructional interactions (Alashwal, 2024).

However, high expectations for AI in education have not been fully offset by a critical understanding of its pedagogical, ethical, and technical implications. Various studies identified the risk of algorithmic bias, the vulnerability of student data privacy, as well as digital surveillance practices that have the potential to reduce the autonomy and agency of learners. In addition, over-reliance on AI systems risks encouraging superficial learning and weakening critical thinking skills if not integrated with proper instructional design. Empirical findings also show that the effectiveness of AI is highly dependent on infrastructure readiness, educators' AI literacy, and alignment between technology and pedagogical goals.

The urgency of this study lies in the need to bridge the gap between the transformational potential of AI and the reality of its implementation in educational practice. Although research on AI in education continues to grow, studies that comprehensively synthesize the theoretical foundations, utilization models, ethical challenges, and pedagogical implications of personalized learning are still limited. Therefore, this article aims to systematically examine the use of AI in personalized learning, identify its opportunities and limitations, and formulate evidence-based recommendations for educational institutions. The main contribution of this article lies in the preparation of an analytical framework that integrates pedagogical, technological, and ethical perspectives, so that it can be a reference for the development of effective, equitable, and sustainable AI-based learning.

## METHODS

This study uses a traditional literature review approach (narrative literature review) to critically examine the development of theories, concepts, and empirical findings related to the use of artificial intelligence (AI) in personalized learning. This approach was chosen to gain a comprehensive and conceptual understanding of research trends, educational practices, and key issues that have developed in the past decade.

The literature search was conducted through Google Scholar with a focus on scientific journal articles published in the period 2015–2025. Search keywords are developed iteratively and include terms such as artificial intelligence in education, personalized learning, adaptive learning, intelligent tutoring systems, and generative AI. Literature sources were selected based on the topic's relevance, academic quality, and contribution to the development of pedagogical and technological understanding of AI-based learning.

The selected articles were analyzed using thematic analysis, by grouping the findings into several main themes, including theoretical foundations and conceptual models, operationalization and measurement approaches, the application of AI in various aspects of education, and implementation challenges and limitations. Through this narrative synthesis, the research aims to map the state-of-the-art study of AI in personalized learning and identify

the direction of development and opportunities for further research in the field of educational technology.

## RESULTS AND DISCUSSION

### The Mechanism of Technology in Personalized Learning

The results of a literature review from 13 journal references show that the implementation of artificial intelligence (AI) in education has driven a paradigm shift in learning from a teacher-centered approach to a learner-centered learning model. This shift is mainly mediated by the use of Intelligent Tutoring Systems (ITS) and Adaptive Learning Management Systems (ALMS) which are designed to dynamically adjust the content, tempo, sequence, and level of complexity of learning based on the individual characteristics, needs, and performance of learners. As stated in the previous study, one of the main implementations of AI is through *Intelligent Tutoring Systems (ITS)* which uses *Deep Learning algorithms* and *Fully Connected Neural Networks*. This system is able to act as a 'digital teacher' who is available 24/7, providing up to 98% accurate responses in accompanying students to complete practice questions independently (Rosalina & Sen 2022). Architecturally, AI-based learning systems are generally built on four main components, namely a learner profile model that represents abilities, preferences, and learning styles; a domain model that contains the structure and relationships of knowledge; a pedagogical or expert model that regulates instructional strategies; and an interaction interface that facilitates human-machine communication. Furthermore, the integration of Multi-Agent Systems (MAS) and Case-Based Reasoning (CBR) approaches allows AI systems to model learners more adaptively and precisely through comparisons between actual learning conditions and similar learner success patterns in previous experiences. This mechanism not only improves the accuracy of learning activity recommendations, but also strengthens the relevance and accuracy of the pedagogical interventions provided, thereby supporting a more personalized, effective, and sustainable learning process.

Table 1. Literature Review of the Utilization of AI for Personalized Learning

Source	Findings	Impact
Mehlan et al. (2025)	Personalization of career goals significantly increased session duration and NPS score (9.02), as well as reduced study duration by 7.51% even though exam scores remained similar.	Aligning content with professional aspirations bridges academic knowledge and application in the workplace.
Lamya et al. (2024)	The integration of CBR and MAS allows ITS to dynamically adapt to the unique profile of learners using past knowledge.	This framework improves the quality of learning scenarios and the efficiency of time management for teachers and learners.
Mimoudi (2024)	AI increases engagement through tailored content, but faces the risk of data bias and depersonalization if the role of teachers is reduced.	The application of AI must be managed with attention to ethical considerations and a balance between technology and human interaction.
Alashwal (2024)	AI facilitates a shift toward student-centered learning and democratizes access to education through online platforms.	Educators need ongoing professional development to stay up-to-date with the evolving capabilities of AI tools.
Wei et al. (2025)	GAI demonstrates an exceptional ability to provide adaptive experiences, especially in programming and mathematics education.	Teachers must switch roles to become facilitators and supervisors of GAI output to avoid overdependence.
Xia (2023)	Smart technology allows for accurate portraits of learners to recommend personalized learning paths and reduce the workload.	Schools should integrate a digital homework management system to increase efficiency without overburdening students.

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Tavakoli et al. (2022)	The system achieved an F1-score of 89% for skill recommendations and 93% for educational materials, demonstrating high potential in dynamic environments.	AI can automate content quality assessments, while crowdsourcing ensures scalability and expert input.
Zheng (2022)	The proposed hybrid algorithm achieves an accuracy of 0.89 and an AUC of 0.97, providing a reliable solution for individual lesson plans.	Teachers can more easily manage the potential of students by knowing the specific characteristics of each group through intelligent methods.
Rosalina & Sen (2022)	The system achieves 98% accuracy in predicting the next question that is appropriate for students based on their performance.	Digital teachers can be available 24/7 to help students learn at their individual pace.
Hashim et al. (2022)	Personalized learning focuses on training according to specific needs, but its implementation in Malaysia still needs strengthening.	These findings guide developers in creating better adaptive learning systems.
Soler Costa et al. (2021)	Adaptive technology improves graduation rates and reduces course friction through instant feedback and scaffolding.	Administrative support and instructor training are essential for successful adoption of adaptive technologies.
Li et al. (2020)	Research is shifting from theory to big data- and AI-based applications, with a focus on cognitive diagnosis and learning paths.	The importance of integrating online and offline learning, as well as improving the construction of learning models in primary education.
Yu et al. (2017)	AI can optimize the division of assistant work and use Virtual Learning Companions (VLCs) for large-scale interactions.	MOOCs can be transformed into a testing ground to advance educational research through behavioral analytics.

**Generative AI Innovation and Purpose-Based Haltualization**

Recent literature findings confirm that the emergence of *Generative AI* (GenAI), such as GPT-4, has expanded the capacity of learning personalization through the ability to generate exercise materials, feedback, and haltual simulations in real-time. One of the important innovations that emerged was career goal-based personalization, where learning content was tailored to the professional aspirations of learners. Empirical studies on AI-based learning platforms, such as Syntea, show that haltualization of materials based on career goals contributes to increased duration of learning engagement and learner satisfaction levels. This approach significantly bridges the gap between academic knowledge and the competency needs of the world of work. In addition, GenAI supports dialogical interactions based on heuristic and Socratic approaches that encourage high-level thinking processes, so that learning does not stop at the reproduction of information, but leads to deeper conceptual understanding.

**Impact on Learning Effectiveness and Transformation of Educator Roles**

Consistently, the literature shows that AI-based personalized learning has a positive impact on students' intrinsic motivation, learning time efficiency, and academic achievement. Personalization of learning paths allows learners to achieve learning objectives with shorter study durations without sacrificing the quality of learning outcomes. In this case, AI does not replace the role of educators, but rather transforms them. The role of teachers shifts from delivering material to facilitators, mentors, and learning companions. The automation of administrative tasks and routine assessments by AI provides space for educators to focus on social-emotional aspects, critical thinking coaching, and reflective support—dimensions of learning that are humanistic in nature and cannot be fully replicated by intelligent systems. Determining learner profiles can be done by referring to Kolb's experiential learning model which emphasizes four unique learning styles: *concrete and experiential*, *reflective and observant*, *abstract and theoretical*, and *pragmatic and purposeful* (Anoir Lamy, et al. 2024).

**Ethical, Technical Challenges and the Risk of Depersonalization**

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Behind its transformative potential, the results of the study also identified a number of significant challenges in the use of AI for personalized learning, namely:

*Data Privacy*

AI's reliance on extensive collection of personal data sparked concerns regarding consent and the risk of misuse of students' sensitive information.

*Bias Algorithmic*

AI risks reinforcing discrimination if the data used to train it contains systemic bias, which can harm marginalized student groups.

*AI Hallucinations*

Especially in subjects such as mathematics, GenAI sometimes generates inaccurate or misleading solutions ("hallucinations"), which require close supervision from educators.

*Depersonalization*

Excessive reliance on technology is feared to reduce human interaction which is essential for the holistic development of students.

## CONCLUSION

The use of artificial intelligence (AI) in personalized learning has the potential to transform educational practices by driving a shift from a uniform learning approach to adaptive and student-centered learning. Through the application of Intelligent Tutoring Systems, Adaptive Learning Management Systems, and Generative AI, learning systems are able to dynamically adjust content, learning paths, and pedagogical interventions based on individual learners' characteristics and performance. AI-based personalization has been proven to increase engagement, learning time efficiency, and academic achievement, while changing the role of educators from material presenters to facilitators and companions of the learning process. However, the effectiveness of AI utilization is highly dependent on alignment between technology, pedagogical design, and human resource readiness. The study also identified important challenges, such as the risk of data privacy breaches, algorithmic bias, hallucinations in Generative AI, and the potential for depersonalization of learning if human interaction is significantly reduced. Therefore, the integration of AI in personalized learning needs to be done through a human-centered and ethical approach, with policy support, increased AI literacy of educators, as well as advanced research focused on the long-term impact and sustainability of its implementation.

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