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Personalized Learning Through Artificial Intelligence: A Literature Review

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Abstract

Artificial intelligence (AI) offers pedagogical solutions to address the global learning crisis, but the literature specifically examines its application to learning personalization is limited. This study aims to examine how AI technology can personalize students' learning experiences and why AI needs to be mastered as an educational productivity tool, not avoided. The method used is a literature review with a search through Google Scholar using the combined keywords "Artificial Intelligence", "Personalized Learning", and "Literature Review", with publication inclusion criteria for 2021–2025. Of the 50 articles found, eight passed the inclusion and exclusion selection for analysis. The results of the review show that adaptive AI systems have been shown to improve learning outcomes by 14–30% compared to conventional methods through three main mechanisms: real-time content adaptation, automatic misconception detection, and targeted feedback. AI acts as a teacher's tool, not a substitute. The main implementation challenges include data privacy, algorithm bias, and teacher readiness gaps. It was concluded that AI is a productivity tool that must be gradually integrated with the support of teacher training, ethical regulations, and cross-stakeholder collaboration so that its benefits can be felt equally.

INTRODUCTION

The acceleration of technological progress is currently unprecedented in the history of human civilization. One of the latest cutting-edge technologies, which is predicted to change the role of humans in several sectors, namely artificial intelligence (AI), has become a reality and has taken on roles such as virtual assistants, consultants, and algorithm-based medical diagnoses. These developments have surpassed the speed of human adaptation to AI and created the Industrial Revolution 4.0, a wave of transformation that is changing not only the way humans work but also the way they learn (Schwab, 2017).

This fact has caused some people to view AI with concern and suspicion, especially in the world of education. Many education practitioners worry that AI will replace teachers, encourage student dependence, or even undermine academic integrity. This is understandable, but an important fact that many people overlook is that AI is a tool that has no human will. The usefulness and value of AI is entirely determined by how humans use it. Similarly, in education, the presence of AI can be used as a tool to expand the role of teachers in facilitating students' learning experiences.

The urgency of integrating AI into education is driven not only by technological trends, but also by the real crisis facing the global education system. The World Bank et al. (2022) global learning crisis is worsening, with an estimated 70% of 10-year-olds in low- and middle-income countries unable to read and understand simple texts—an indicator of the systemic failure of conventional learning approaches to reach a diverse range of students' needs equally. In Indonesia, data from the International Student Assessment Programme (OECD, 2023) puts the science literacy of 15-year-olds at 383—well below the OECD average of 485—indicating that current science learning approaches are not effective enough to develop students' conceptual understanding and scientific thinking skills equally. This is where AI offers a solution that is not only technological, but also pedagogical: a solution to reach each student individually within the same classroom.

One of AI's biggest contributions to education is its ability to massively personalize learning experiences—something previously only one-on-one tutoring could do. Bloom's (1984) landmark study, known as the "2 Sigma Problem," showed that students who received individualized tutoring consistently performed two standard deviations higher than students in a traditional classroom setting. AI, through adaptive learning systems and personalized learning paths, now provides a bridge that makes quality individualized tutoring accessible to all students—regardless of their location and resources. Furthermore, for teachers, AI serves as an assistant, taking over repetitive tasks—formative assessment, progress tracking, misunderstanding identification—so that teachers can redirect their energy and attention to what is most valuable and irreplaceable: building meaningful relationships, inspiring curiosity, and facilitating in-depth discussions that tap into the human dimension of learning.

Science learning at the junior high school level is one of the most urgent contexts to benefit from this transformation. At this stage, students aged 12–15 are undergoing a cognitive transition from concrete thinking to formal operational

thinking. However, in reality, many students fail to build this foundation due to undetected misunderstandings, uniform and forced learning pace, and lack of targeted feedback (Tomlinson, 2014). Vosniadou (2019) emphasizes that misconceptions in science that are formed at this age tend to be very resistant to change if not addressed early and personally. In this case, AI can act as a teacher's assistant, reaching the learning needs of each student simultaneously, automatically, and continuously (Tresno Sejati et al., 2025).

The concept of personalized learning paths is the most concrete manifestation of how AI can multiply learning productivity. Instead of forcing all students to follow the same sequence of content at the same pace, adaptive AI systems can analyze each student's learning profile, including prior knowledge, learning style, comprehension speed, interests, and a history of errors—then dynamically design the optimal learning path for each individual (Brusilovsky & Peylo, 2003). In the context of junior high school science, where the material includes abstract concepts such as force and energy in physics, chemical reactions, and life systems in biology, this kind of personalization is not just a convenience—but a fundamental necessity to ensure that no student is left behind because the pace of the class does not match their speed of thinking.

Despite the growing global interest in AI in Education (AIEd), the literature specifically examining the application of AI to personalized learning pathways in science teaching at the junior high school level is still very limited. Most of the existing reviews focus on higher education or mathematics, thus leaving a significant knowledge gap in one of the most critical phases of education. Furthermore, the discourse on AI in Indonesian education discussions is too often mired in normative debates about whether or not it is permissible, while a much more productive question remains unanswered: how AI can be optimally utilized for the educational goals we all aspire to. This literature review article aims to answer these questions. This article explicitly takes the position that AI is a powerful productivity tool that should be mastered, not avoided—and that AI literacy among educators and students is a 21st-century competency that is no less important than reading or numeracy literacy.

METHOD

This study uses a literature review approach, a research method that involves searching, reading, understanding, and analyzing various sources of scientific literature relevant to the topic being studied. In this context, a literature review is not just a summary of sources, but an attempt to critically and analytically synthesize findings from various previous studies to build a comprehensive understanding of an issue (Marzali, 2017).

Library searches are conducted using Google Scholar as the primary database. The main criteria for library selection include (1) the 2021–2025 publication period and (2) the use of keywords ("Artificial Intelligence" OR "AI" OR "Machine Learning") AND ("Personalized Learning" OR "Adaptive Learning") AND "Literature Review". Although traditional literature reviews do not use as rigorous selection protocols as systematic reviews, the selection criteria are carefully selected to maintain the focus and quality of the research. These criteria serve as a guide in determining which libraries are worth including and which are not, ensuring that the review process remains focused and accountable. Table 1 presents the criteria used.

Table 1. Inclusion and exclusion criteria

Yes	Inclusions	Exclusion
1	Discuss the application or potential of AI in the context of education/learning.	Not related to AI or learning technologies.
2	Relevant to personal learning or learning paths.	Focuses on AI technology outside of the context of education (industry, medicine, etc.).
3	Available in Indonesian or English.	Not available in both languages.
4	Published between 2021–2025.	Published before 2021.

Literature analysis was carried out in three successive stages. First, the critical reading stage: each source is read thoroughly, focusing on the research objectives, methods, key findings, and limitations acknowledged by the author. At this stage, analytical records are developed for each source to facilitate comparisons between studies.

Second, the thematic categorization stage: findings from across the literature are grouped by recurring themes, including: (a) the type of AI technology used, (b) the personalization aspects studied, (c) the impact on student learning outcomes and experiences, and (d) implementation challenges and opportunities. This categorization is done inductively—the themes are allowed to emerge from the literature data, rather than imposed from a predetermined framework.

Third, the interpretive synthesis stage: findings that have been categorized are synthesized to produce a coherent and argumentative narrative. This synthesis not only summarizes, but also interprets patterns, identifies consensus and tensions across various studies, and connects the empirical findings with the article's main

argument: that AI is a productivity tool with significant potential to improve the quality of science learning in junior high school and should be utilized, not avoided..

RESULTS AND DISCUSSION

Results

A literature search yielded 50 articles related to ("Artificial Intelligence" OR "AI" OR "Machine Learning") AND ("Personalized Learning" OR "Adaptive Learning") AND "Literature Review". After the inclusion and exclusion process was carried out, 8 articles were obtained that were suitable for review regarding the flow of personalization of learning through AI. The analysis of this article is presented in Table 2 as follows:

Table 2. The results of the analysis of 8 articles that have gone through the inclusion and exclusion process

Yes	Title	Results
1	Effects of AI-based personalized adaptive learning system in higher education (Cho, 2022)	Adaptive AI systems have proven to be effective not only at the undergraduate level, but also at the graduate level which has been rarely researched. Good integration between AI systems and lectures is the key to success — not just its technical sophistication. Increased user satisfaction and loyalty contribute to better customer relationship management in higher education institutions. Adaptive AI systems need to constantly improve content and features to be more relevant for different types of classes beyond math and statistics.
2	Machine Learning Approach for an Adaptive E-Learning System Based on Kolb Learning Styles (Waladi et al., 2023)	An adaptive e-learning system model that combines three machine learning algorithms in stages where K-Means is used to group learners based on interaction patterns in the system, Artificial Neural Network (ANN) to predict learning styles automatically and in real-time, and Decision Tree to recommend learning content that matches Kolb's learning style profile. The system is also equipped with an auto-adaptation mechanism in the form of continuous assessment, feedback, and

		dynamic content sequencing. This hybrid approach has proven to be more effective and efficient than traditional questionnaire methods, although the model is still in the conceptual design stage and has not been empirically tested on real e-learning platforms.
3	An adaptive learning environment for programming based on fuzzy logic and machine learning (Chrysafiadi et al., 2023a)	The adaptive Intelligent Tutoring System (ITS) was developed for learning computer programming in C by gradually combining two AI approaches, namely distance weighted k-nearest neighbor (KNN) which is used to detect the initial level of knowledge and ability of learners and fuzzy logic which is applied to identify the current level of knowledge and misconceptions of students, as well as determining the most appropriate learning material and sequence based on dependencies between concepts. The system was evaluated using a t-test, and the results showed that the combination of machine learning and fuzzy logic was able to produce a more personalized learning experience, increase student active participation, and reduce dropout rates.

4	AI-Powered Personalized Learning: Advancing Language Education in the Digital Era (Hussain et al., 2024)	This research discusses how AI is changing the way language learning in the digital era. Through technologies such as adaptive learning, natural language processing (NLP), and real-time feedback, AI is able to tailor learning materials to the needs of each individual, provide interactive conversation exercises, and correct errors directly. Platforms such as Duolingo and Rosetta Stone are real examples of its application, proven to increase student engagement, motivation, and learning outcomes compared to conventional methods. However, the application of AI also presents challenges such as data privacy risks, potential algorithm bias, and changes in teacher roles that need to be anticipated. This research confirms that AI is not a substitute for teachers, but a tool that must be used ethically and equitably. Collaboration between educators, technologists, and policymakers is needed so that the benefits of AI in language education can be felt by all groups in a fair and inclusive manner.

5	Enhancing personalized learning: The impact of artificial intelligence in education (Iman et al., 2024)	This study examines the impact of AI on personalized learning in the world of education, focusing on three main technologies: *Intelligent Tutoring Systems* (ITS), adaptive learning platforms, and *machine learning* algorithms. These three technologies are able to analyze student performance data in real-time, adjust the material to each individual's abilities, and provide instant feedback. The results are quite significant — students who use AI-based systems on average recorded an increase in scores of up to 30% compared to conventional learning methods, while also showing higher levels of engagement and motivation. However, the application of AI also brings a number of serious challenges, especially regarding data privacy, algorithmic bias, and the need for ethical oversight in AI-based decision-making. This research emphasizes that AI should not replace the role of teachers, but should be a tool that strengthens teaching skills. Therefore, the continuous professional development of teachers, the development of a clear ethical framework, and collaboration between educators, technology developers, and policymakers are key to ensuring that AI can be applied equitablely, inclusively, and effectively for all students.

6	Improving Educational Outcomes Through Adaptive Learning Systems using AI (Sari et al., 2024)	This study empirically proves that AI-based adaptive learning systems are able to significantly improve student learning outcomes — the average post-assessment score increased from 68.4 to 82.7, far exceeding the improvement achieved by conventional methods. Platforms like Smart Sparrow, IBM Watson Education, and OpenEssayist have been shown to improve course completion, student engagement, and writing skills, with participant satisfaction rates reaching 85%. However, the study, which involved 300 students and 50 educators from elementary to tertiary level, also underscored a number of real challenges, such as institutional infrastructure readiness, teacher training needs, and algorithmic bias and data privacy issues, so further research is needed to measure the long-term impact and ensure the equitable and inclusive application of AI for all groups.

7	Artificial intelligence as an effective tool for personalized learning in modern education (Kovalchuk et al., 2025)	This research from Ukraine examined the role of AI as a personalized learning tool in vocational education, involving 45 educators and 120 students from four universities. The results show that around 70% of students are already actively using AI technologies such as chatbots, automated assessment systems, and adaptive learning platforms — with 60% of them rating AI to be effective for personalizing learning — while on the educator side, only 40% are actively using it because they are hampered by lack of technical training (60%), limited funding (50%), and ethical and legal concerns (40%). However, 55% of educators recognize the great potential of AI and express readiness to develop its competencies, so this study concludes that the use of AI in education needs to be supported by adequate teacher training, expanded access to infrastructure, and a clear ethical framework so that AI can truly improve the quality and equity of learning.

8	Transforming Education with AI: The Development of a Personalized Learning Algorithm for Individual Learning Styles (Jafari & Yazdi, 2024)	The research from the University of Tehran introduced a new algorithm called *the Artificial Intelligent Personal Recommender System* (AIPRS), a learning recommendation system based on AI, *machine learning* (ML), and *the Internet of Things* (IoT) designed to tailor learning materials to each student's unique style and preferences. The system works by collecting student data—from academic history, learning styles (visual, auditory, kinesthetic), to real-time learning behaviors through IoT devices—and then analyzing it to continuously recommend the best combination of content until students reach the expected level of competence. While it offers great potential in improving the efficiency, accessibility, and quality of education, the study also recognizes a number of challenges that need to be addressed, such as data privacy concerns, the risk of algorithmic bias, and the dangers of relying too heavily on quantitative data, so an ethical, holistic, and transparent approach is needed in its future implementation.

Discussion

The results of a review of eight articles that passed the inclusion and exclusion selection reveal a consistent pattern: artificial intelligence technologies have significant potential to personalize students' learning experiences, while presenting implementation challenges that cannot be ignored. The following discussion is prepared based on four main themes that arise inducively from the literature analysis.

1. The Effectiveness of AI in Improving Learning Outcomes and Engagement

Findings across studies consistently show that AI-based learning systems produce more significant improvements in learning outcomes than conventional methods. Sari et al. (2024) reported an increase in the average post-assessment score from 68.4 to 82.7 in the group using an AI-based adaptive platform, with a participant satisfaction rate of 85%. In line with that, a review by the researcher in the fifth article noted an average increase in scores of up to 30% in students who used AI-based systems. These findings are in line with the premise built in the introduction to this article, that AI is capable of massively delivering Bloom's (1984) "2 Sigma" effect, something that could only be achieved through individual guidance.

This improvement in learning outcomes is inseparable from the real-time feedback mechanism which is the main advantage of AI-based systems. In contrast to conventional learning where feedback is often delayed until the end of the exam, AI systems such as the Intelligent Tutoring System (ITS) are able to detect misconceptions directly and dynamically adjust the order of the material (Chrysafiadi et al., 2023b). This is particularly relevant to the challenges of science learning in junior high school mentioned in the introduction, where Vosniadou (2019) asserts that misconceptions that are not detected early tend to be very difficult to change.

2. Various AI Technology Approaches to Personalize Learning

The eight articles reviewed show the diverse technical approaches used to realize learning personalization. First, the multi-algorithm hybrid approach has proven to be the most effective. The second article describes an e-learning system that combines K-Means for grouping, Artificial Neural Network (ANN) for learning style prediction, and Decision Tree for content recommendations a more accurate and efficient approach than traditional questionnaires.

The third article combines K-Nearest Neighbor (KNN) with fuzzy logic to detect the initial level of knowledge while adapting the order of programming learning materials.

Second, real-time behavioral data-driven integration is becoming a growing trend. The eighth article introduces an AIPRS algorithm that combines AI, machine learning, and the Internet of Things (IoT) to collect student learning data on an ongoing basis—from academic history to visual, auditory, and kinesthetic learning styles—and then recommends the most optimal combination of content. This approach operationalizes the concept of a "personalized learning path" outlined in the introduction: each student gets a custom-designed sequence of content based on his or her unique learning profile, rather than just the pace of learning.

Third, commercial platforms such as Duolingo, Rosetta Stone, Smart Sparrow, and IBM Watson Education prove that AI personalization technology is not only at a conceptual level, but has been implemented in real terms and resulted in improved course completion and measurable student engagement (Hussain et al., 2024; Sari et al., 2024).

3. The Role of AI as a Teacher Tool, Not a Substitute

One of the most consistent common threads in the entire literature reviewed is the assertion that AI is not meant to replace teachers. The fourth, fifth, and seventh articles explicitly state that AI plays a role as a tool that strengthens teachers' teaching capacity, not displaces it. This view is consistent with the argument built in the introduction: AI takes over repetitive tasks such as formative assessments and progress tracking, so teachers can direct attention to what matters most—building relationships, inspiring curiosity, and facilitating in-depth discussions with a human dimension.

The findings of the seventh article, which is based on a survey in Ukraine, provide an important nuance: although about 70% of students have actively used AI technology, only 40% of educators have done the same. The top reported barriers include lack of technical training (60%), limited funding (50%), and ethical concerns (40%). These data show that the gap between AI's potential and its realization on the ground is more due to human resource readiness factors than to the limitations of the technology itself—a finding that has direct implications for education policy in Indonesia, where normative debates around AI often ignore questions about implementable readiness.

4. Challenges and Opportunities: Towards Ethical and Inclusive Implementation

Behind its measurable benefits, the entire literature reviewed consistently identifies three key challenges that must be addressed to ensure responsible AI implementation. First, data privacy: an effective AI system relies on the collection of large and continuous student data, which poses a risk of misuse if not managed with an adequate legal framework. Second, algorithmic bias: if the training data used to build the AI model is not representative, the system can generate unfair recommendations for a particular group of students—which exacerbates the educational gap it seeks to address. Third, overreliance on quantitative data: the eighth article explicitly warns of the dangers of reducing students' learning profiles only to numerically measurable parameters, while the affective and contextual dimensions of learning still require human judgment.

Nonetheless, the opportunities offered by AI still outweigh the challenges, provided that the development of AI systems is carried out collaboratively between educators, technology developers, and policymakers. The first article also highlights an often overlooked dimension: the success of adaptive AI systems is not solely determined by their technical sophistication, but rather by the quality of integration between AI systems and existing teaching practices. No amount of advanced technology will produce optimal impact without a well-thought-out pedagogical design and teachers trained to use it effectively.

CONCLUSION

Based on the results of a review of eight articles that met the inclusion criteria, it can be concluded that artificial intelligence has been proven to be able to effectively personalize students' learning experiences through three main mechanisms: real-time content adaptation based on individual learning profiles, automatic detection of misconceptions, and the provision of targeted feedback. The adaptive AI systems studied resulted in a significant improvement in learning outcomes compared to conventional methods, with an average increase in scores of between 14–30%, accompanied by increased student engagement and learning motivation. These findings confirm that AI is not a threat to educators, but rather a productivity tool that expands teachers' capacity to reach the learning needs of each individual student—something that was previously only possible through one-on-one tutoring. Thus, AI literacy is a competency that needs to be mastered by educators and students, not avoided.

The results of this study provide contributions and suggestions for three parties. For educators, it is recommended to start gradually integrating AI-based adaptive learning platforms in teaching practices, particularly for science subjects at the

junior high school level that require personalized feedback. For policy developers, clear regulations are needed related to the protection of student data privacy and teacher professional development programs in the field of AI literacy equally. For the next researcher, empirical research that specifically examines the application of AI for personalization of science learning at the junior high school level in Indonesia is needed, considering that most of the available literature still focuses on higher education and contexts outside Indonesia.

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