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Artificial Intelligence for Personalized, Adaptive, and Inclusive Learning: A Systematic Literature Review (2022–2026)

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Abstract

Artificial Intelligence (AI) has been advancing rapidly and accelerating the transformation of education toward more personalized, adaptive, and inclusive learning environments. Despite the growing body of research, few studies have examined these three learning approaches in an integrated and holistic manner. This study analyzes the development and application of AI in education and its contribution to personalized, adaptive, and inclusive learning between 2022–2026. A Systematic Literature Review (SLR) based on the PRISMA framework was employed. Data were collected from Scopus, Google Scholar, ERIC, and ScienceDirect. Following screening and eligibility procedures, 312 records were identified, and 25 peer-reviewed articles were selected for analysis. In SLR studies, representativeness depends on the relevance and methodological quality of the selected studies rather than the number of publications. The selected articles covered the review period and captured dominant themes and emerging trends in AI-supported learning. Thematic saturation was achieved, indicating that additional studies did not provide new insights and confirming the adequacy of the sample for synthesizing developments over the five-year period. Data were analyzed using narrative synthesis, research trend analysis, article classification, and thematic analysis. The findings reveal increasing interest in AI-powered chatbots, adaptive learning platforms, Intelligent Tutoring Systems, and learning analytics. AI enhances learning effectiveness, student engagement, academic achievement, accessibility, and personalized instruction. However, challenges remain regarding infrastructure, teacher readiness, data privacy, ethical concerns, and algorithmic bias. The review proposes a holistic framework integrating personalized, adaptive, and inclusive learning and offers theoretical and practical implications for effective, equitable, and responsible AI-supported education.

Keywords: artificial intelligence, personalized learning, adaptive learning, inclusive learning, digital education.

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INTRODUCTION

The advancement of digital technology has induced substantial transformations across multiple sectors, including education. The digital transformation of the Fourth Industrial Revolution is experiencing an increase in the utilization of technologies such as the Internet of Things (IoT), big data, automation and artificial intelligence (AI). These technologies have helped to make learning more efficient and effective, as well as easier to make data-based decisions in the field of education. As technological innovation continues to evolve, the concept of Society 5.0 further strengthens the role of technology by emphasizing human well-being and quality of life. Unlike Industry 4.0, which primarily focuses on technological advancement and automation, Society 5.0 promotes the integration of physical and digital environments to address human needs and societal challenges. In education, this perspective encourages the development of learning systems that place students at the center of educational innovation while leveraging advanced technologies to support learning.

AI is being used more and more in education. Smart tutoring systems, adaptive learning platforms, learning analytics, educational chatbots, and recommendation systems are just a few examples. These systems make sure that each student gets the right learning materials, teachers, and tests (Zahara et al., 2023; Ayeni et al., 2024) . According to Joseph and Uzondu (2024), the widespread use of AI has helped move learning environments away from relying on teachers and toward ones that are more personalized, flexible, adaptive, and open to everyone. Aside from making teaching more effective, AI also makes learning more interactive and personalized, which could boost student motivation, engagement, and long-term learning outcomes (Hu, 2024; Dong et al., 20254).

Despite the continuous development of educational technology, conventional teaching methods still face various challenges that affect the effectiveness of the learning process. Teaching is generally still one-size-fits-all and is therefore unable to accommodate differences in pupils' abilities, interests and learning styles. This situation means that some pupils struggle to fully grasp the subject matter. Furthermore, constraints on time, the number of teachers, and educational resources make it difficult to implement personalized learning, particularly in classes with large numbers of students. Inequalities in access to education also remain a challenge due to differences in economic, geographical, and technological infrastructure conditions (Eden et al., 2024).

Furthermore, conventional teacher-centred teaching methods are considered ineffective in enhancing students' active participation, creativity, and critical thinking skills (Rahayu, 2023). Consequently, many educational institutions have begun to investigate the integration of digital technology to support a more flexible and student-centred learning environment. Therefore,

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technology-based learning innovations that are more personalized, adaptive, and inclusive are needed enhance educational quality and guarantee equitable learning opportunities for all students.

In response to the various limitations of conventional learning, Artificial Intelligence (AI) has emerged as a key innovation in the transformation of modern digital education. In an educational context, AI can be defined as computer technology designed to mimic human cognitive abilities, such as analysing data, recognising patterns, making decisions, and providing automated learning recommendations. The implementation of AI in education seeks to establish a learning process that is more effective, personalized, adaptive, and efficient, customised to the requirements of learners. Through real-time data analysis capabilities, AI can assist educators in monitoring students' learning progress, identifying learning difficulties, and adapting learning materials and methods based on individual abilities (Afrita, 2023).

Beside that, AI also supports the automation of administrative duties, learning evaluations, and delivers expedited and precise feedback (Celik et al., 2022). The integration of AI in education has progressed through diverse technologies, including intelligent tutoring systems, adaptive learning platforms, virtual assistants, educational chatbots, and learning analytics, all aimed at improving the student learning experience (Bilad et al., 2023). Some digital learning platforms have even utilised AI to recommend learning materials, create personalized learning pathways, and assist students in learning independently and interactively (Maola et al., 2024). With these capabilities, AI is viewed as a potential solution to the challenges of digital education, especially in enhancing access, quality, equity, and the efficacy of learning in the contemporary technological landscape.

The advancement of Artificial Intelligence (AI) in education has prompted the rise of diverse contemporary learning methodologies focused on learners' requirements, including personalized learning, adaptive learning, and inclusive learning. Personalized learning emphasises the application of education customised to individual requirements by utilising learner data, recommendation systems, and student-centered methodologies to improve the effectiveness of the learning experience (Ayeni et al., 2024). In this context, it is essential to analyse how AI can customise educational materials, methodologies, and trajectories according to the attributes of each learner. This study examines how the implementation of AI facilitates personalized learning to enhance the quality of individual education.

Furthermore, adaptive learning has become a key innovation in digital education through the creation of adaptive learning systems that autonomously modify content and difficulty levels according to students' learning advancement. The use of intelligent tutoring systems enables the learning process to be more responsive and dynamic, tailored to students' abilities (Kestin et al., 2025). Based on this, this study also examines how AI is applied in adaptive learning and to what extent adaptive systems are effective in supporting modern educational processes. Conversely, AI development fosters inclusive learning with technology-based education that guarantees equal access for all students, including those with special needs. The Features like accessibility, automated learning support, and more flexible and

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accessible education services can make AI technology an enabler to remove learning barriers. Thus, this study challenges how AI helps develop inclusive learning and how this technology contributes to the enhancement of equal access to education for different groups of learners.

Although research on Artificial Intelligence (AI) in education has grown exponentially in recent years, current studies tend to focus on specific aspects of AI implementation rather than combining multiple learner-centred approaches in a comprehensive analysis. Several studies have explored AI-supported personalized learning and its effect on learning outcomes, engagement and effectiveness of instruction. Other studies have focused on adaptive learning systems, Intelligent Tutoring Systems, learning analytics or the broader opportunities and challenges of AI integration in education. Ethical concerns, teacher preparedness, the use of Generative AI, and implications for educational policy have also been addressed in contemporary reviews. However, these studies tend to address these dimensions in isolation, with little discussion on the intersection of personalized learning, adaptive learning and inclusive learning within the context of AI supported educational environments.

This fragmentation represents an important research gap, as personalized, adaptive and inclusive learning are interconnected pillars of learner-centred education. In addition, the emergence of Generative AI technologies including large language models and AI-enabled chatbots has significantly transformed educational practices since 2022. Previous reviews tend to focus on specific AI applications, educational levels, or isolated learning outcomes. Comprehensive syntheses that consider collectively the contribution of AI to personalized, adaptive, and inclusive learning are still scarce. Hence, a systematic literature review is required for the period 2022-2026 to offer an integrated understanding of the recent developments, emerging trends, opportunities, and challenges of AI-supported education and to propose a holistic framework for effective, equitable, and inclusive learning.

Based on the above background and research gaps, this study aims to observe the development of research on Artificial Intelligence (AI) in education in the period 2022-2026. The study aims to identify different ways to implement AI that helps to personalize learning, adapt to learning and include learning in today's educational systems. The objective of this study is to explore the effects of the implementation of AI on the effectiveness of learning, the experience of learners and the enhancement of inclusive and adaptive educational access. This research is centered around the challenges, limitations and possibilities of the advancement of AI with an emphasis on the use of Generative AI in the future of digital education.

METHODS

Research Design

In this study, the Systematic Literature Review (SLR) approach has been used following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The SLR method was chosen as it allows researchers to systematically and transparently identify, appraise and synthesise all relevant empirical evidence. This approach is considered appropriate given the

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abundance of existing literature on the use of Artificial Intelligence (AI) in education, as well as the need to gain a comprehensive and evidence-based understanding of its development, benefits, challenges, and research trends. The SLR approach enables researchers to minimize selection bias, enhance the reproducibility of the review process, and produce stronger, scientifically accountable conclusions compared to conventional literature reviews. Through the PRISMA framework, each stage of the article selection process is explicitly documented, ensuring that the review can be verified and replicated by other researchers.

Data Sources

The data were collected from four well-known international academic databases, which are well-known for their broad coverage, high credibility and relevance to the fields of education and technology. The four databases employed are: (1) Scopus, a multidisciplinary database from Elsevier that covers millions of journal articles, conference proceedings, and scientific documents worldwide, renowned for its strict indexing standards and selection of high-quality journals; (2) Google Scholar, a comprehensive and inclusive academic search engine covering a wide range of scientific literature, including theses, dissertations, technical reports, and preprints; (3) ERIC (Education Resources Information Center), a database dedicated to the field of education managed by the United States Institute of Education Sciences (IES), which serves as a primary source of reliable educational literature; and (4) ScienceDirect, Elsevier's journal platform covering thousands of peer-reviewed journals across various disciplines, including educational technology and computer science.

Search Strategy

The references were systematically selected for the literature search to ensure the topic was covered comprehensively. The primary keywords used include: "Artificial Intelligence in Education," "Personalized Learning," "Adaptive Learning," "Inclusive Learning," and "AI-Based Learning." To expand and refine the search results, Boolean operators were used. The AND operator was used to combine two or more keywords so that only articles containing all specified terms were displayed (e.g., "Artificial Intelligence" AND "Education" AND "Personalized Learning"), while the OR operator is used to broaden the search by including synonyms or variations of those keywords (e.g., "Adaptive Learning" OR "AI-Based Learning" OR "Personalized Learning"). This search strategy was consistently applied across all four databases, with minor adjustments to accommodate each platform's specific search interface and functionality.

Inclusion Criteria

The Articles included in this review must meet all of the following criteria: (1) published between January 2022 and the date of data collection in 2026, including peer-reviewed articles that had been formally published or made available as online-first/early-access publications in the selected databases at the time of the search, to ensure the relevance and timeliness of evidence regarding recent developments in Artificial Intelligence in education; (2) peer-reviewed publications that have been

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rigorously evaluated by experts in the field prior to publication; (3) specifically address the use, integration, or impact of Artificial Intelligence in an educational context; (4) be written in English or Indonesian to ensure the research team's ability to understand and analyze the content in depth; and (5) be available in full-text format to enable comprehensive reading and analysis.

Exclusion Criteria

The Articles are excluded from review if they meet one or more of the following criteria: (1) non-academic articles, such as news, public opinion pieces, blogs, reports from non-scientific organizations, or media content that has not undergone peer review; (2) articles outside the field of education, such as research discussing AI in healthcare, industry, or other fields not directly related to education; (3) articles not available in full-text format, including those providing only an abstract or summary without access to the full content; and (4) duplicate articles appearing in more than one database or search result, which are counted only once to avoid calculation bias.

Data Collection Process

The data collection was carried out according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart, which consists of four main stages. First, the identification stage involved a comprehensive search conducted in the four specified databases (Scopus, Google Scholar, ERIC, and ScienceDirect) using predefined keywords and Boolean operators, yielding a total of 312 initial articles. Second, the Screening stage involves evaluating all identified articles based on their titles and abstracts; articles deemed irrelevant and duplicate records found across various databases are excluded at this stage, resulting in the removal of 198 articles and leaving 114 articles for further evaluation. Third, the Eligibility stage further evaluated the remaining articles based on all established inclusion and exclusion criteria, including full-text availability, language of publication, peer-review status, and relevance to AI in education, resulting in the removal of an additional 89 articles. Fourth, 25 articles that met all criteria were selected at the Included Studies stage as the main data for this systematic literature review and analysed in depth to answer the research questions.

Table 1. PRISMA Based Article Selection Process

PRISMA Stage	Process	Articles Retained	Articles Excluded
Identification	Search of 4 databases using keywords and Boolean operators	312	—
Screening	Selection of titles and abstracts; removal of duplicate records	114	198
Eligibility	Evaluation of full-text articles; inclusion and exclusion criteria	25	89
Included	Articles included for in-depth analysis	25	—

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Data Analysis Technique

Data analysis in this study was conducted using four complementary approaches. Thematic analysis was used to identify major recurring themes in the literature, including personalized learning, administrative efficiency, ethical and privacy challenges, and digital inclusion. Article Classification grouped the included articles based on research design type (qualitative, quantitative, or mixed methods), educational level (primary, secondary, or higher education), the type of AI application studied, and geographic context, thereby facilitating comparisons across studies. The Research Trends Analysis examines the distribution of publication years and shifts in research focus over the 2022–2026 period to identify the direction of AI research in education and research gaps that still need to be explored. Finally, the Research Synthesis integrates findings from all included articles through a narrative synthesis to produce a comprehensive, coherent, and evidence-based report on the role, benefits, challenges, and prospects of Artificial Intelligence in education, going beyond merely summarizing individual findings to generate a deeper and more comprehensive understanding.

The selection technique was repeated with all papers included in order to increase the rigour of the thematic analysis. The constant comparison, refining and grouping of identified themes from each article in relation to AI application in education, adaptive learning, personalized learning, advantages, disadvantages and inclusive learning was done. This would allow us to identify emerging trends and recurring patterns among the selected studies. The adequacy of the final sample was determined by the topic coverage and the frequency of significant findings in the included articles. Thematic saturation was considered achieved when the analysis of additional eligible studies did not yield substantially new themes, categories, or research patterns relevant to the review objectives. The 25 papers chosen for this study also covered the entire period of the research (2022–2026) and reflected the most important ideas and developments in AI-assisted learning. Therefore, the final sample was considered adequate to provide a comprehensive synthesis of developments, challenges, emerging trends, and future research directions in AI-supported education.

RESULTS AND DISCUSSION

The Research Trends in AI-Based Education (2022–2026)

The systematic literature review of 25 articles published between 2022 - 2026 reveals a significant upward trend in research on the use of artificial intelligence (AI) in education. The ublications increased consistently from two articles in 2022, peaked at seven in 2023, and continued with six in 2024, six in 2025, and three in 2026. The publication peak observed in 2023 appears to be closely associated with the public release of ChatGPT in November 2022, which significantly increased the accessibility and visibility of generative AI technologies in educational settings. While studies published in 2022 mainly focused on conceptual discussions regarding the opportunities and challenges of AI in education (Humble & Mozelius, 2022; Celik et al., 2022), the literature published in 2023

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shifted toward practical concerns, including AI implementation, learning personalization, educational efficiency, assessment, academic ethics, and institutional transformation.

This pattern suggests that ChatGPT functioned as a catalyst that accelerated scholarly attention toward AI-enabled teaching and learning by providing educators and students with direct access to advanced conversational AI tools. The sustained publication output in 2024 and 2025 further indicates that this surge was not merely a short-term reaction to a technological novelty but rather the beginning of a broader and continuing research agenda on generative AI in education. Moreover, the trend resembles a technology-triggered research surge, in which a disruptive innovation stimulates rapid scholarly attention before entering a phase of consolidation and deeper empirical investigation.

This growth is a sign of growing academic interest and practical urgency to explore the potential and challenges of AI in the education sector, particularly in light of the emergence of large language models such as ChatGPT in late 2022. The annual distribution and cumulative trend are presented in Figure 1.

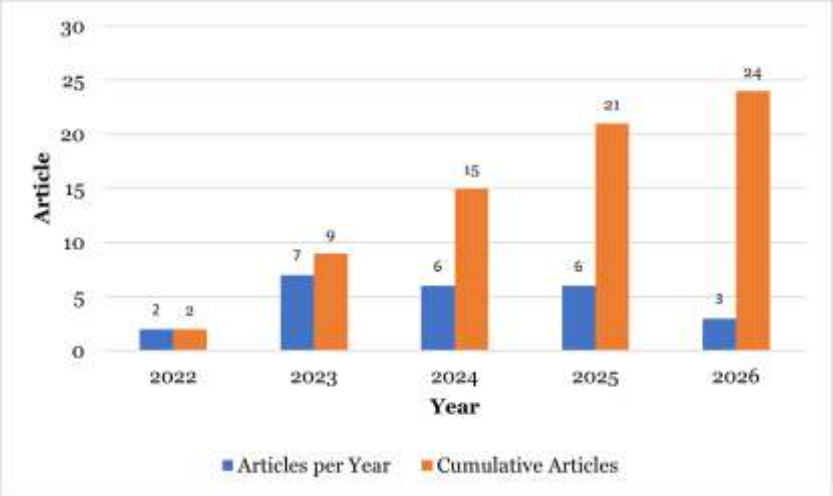

Figure 1. Research Publication Trend on AI in Education (2022–2026)

Regarding the geographical distribution of research, a substantial portion of the studies originates from emerging economies, specifically Indonesia and several African nations like Nigeria and Ghana. Additionally, contributions come from advanced economies such as the United States, China, the United Kingdom, and various European countries. This distribution may also reflect a gradual democratization of AI-related educational research. While studies on educational technology have historically been dominated by institutions in developed countries, the growing contribution from emerging economies suggests that AI has become a globally relevant educational issue. The increasing participation of researchers from diverse economic and educational contexts enriches the literature by providing broader perspectives on AI implementation, challenges, and opportunities across different learning environments.

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The research conducted in Indonesia focuses on localized applications, including the deployment of artificial intelligence within the Merdeka Curriculum (Supriyono et al., 2024), the incorporation of AI in science education (Harianti et al., 2025), and efforts to improve digital competency among elementary school educators (Mbuik et al., 2026). This observation concurrently underscores a recognized deficiency in scholarly literature specifically, the scarcity of empirical, field-based research originating from developing countries, including Indonesia (Hu, 2024; Dong et al., 2025; Harianti et al., 2025).

In the realm of AI in education research, a significant concentration has been observed within higher education settings. This level of education served as the primary setting for 14 out of the 25 articles that underwent review. A more limited scope of research addressed primary and secondary education. For instance, Mbuik et al. (2026) explored professional development related to AI integration for educators at the primary school level. Concurrently, Lindner et al. (2026) examined the perspectives of teachers at the secondary level concerning AI. Additionally, Turan Kaçar and Avşaroglu (2025) performed an analysis that spanned multiple educational tiers, including preschool, primary, foreign language instruction, and special education. A conspicuous deficiency in empirical studies conducted at the primary and secondary educational levels within developing nations warrants further academic investigation. A comprehensive breakdown of the distribution across all reviewed articles can be found in Table 2.

Table 2. Distribution of Articles by Year, Research Method, and Main Focus

Year	Author(s)	Research Method	Main Focus
2022	Humble & Mozelius (2022); Celik et al. (2022)	Conceptual review; Systematic review	AI opportunities & challenges; AI role for teachers
2023	Zahara et al.; Afrita; Sariyasa & Monika; Maola et al.; Sri Rahayu; Lampou; Cleopas	Qualitative; Literature study; Case study; Library research; Literature review; Qualitative analysis; Literature review	Personalization; Efficiency; Academic ethics; AI implementation; Assessment; Transformation; Prospects
2024	Supriyono et al.; Joseph & Uzondu; Ayeni et al.; Eden et al.; Batista et al.; Hu	SLR PRISMA; Literature review; SLR; Article review; SLR; Meta-analysis	ChatGPT; STEM; Personalization; Ethics; Generative AI; Personalized learning

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2025	Luo et al.; Zhu et al.; Turan Kaçar & Avşaroglu; Merino-Campos; Harianti et al.; Dong et al.	SLR PRISMA; SLR + Grounded theory; Document analysis; SLR PRISMA; Semi-systematic review; Meta-analysis	AI tools; Ethical risks; AI applications; Personalized learning (HE); AI in science education; Academic achievement
2026	Mbuik et al.; Lindner et al.; Kestin et al.	Community service (practice-based); Descriptive & correlational; RCT	Teachers' digital literacy; Teacher perceptions; AI tutor vs. active learning

The prominent artificial intelligence applications featured in academic discourse encompass Intelligent Tutoring Systems (ITS), AI-powered conversational agents (notably ChatGPT), dynamic educational platforms, educational data analytics, personalized suggestion engines, and automated evaluation instruments. A notable investigation by Kestin et al. (2025), employing a Randomized Controlled Trial (RCT) methodology, presents a significant outcome; it indicated that AI tutors designed with pedagogical principles resulted in superior learning achievements compared to traditional interactive classroom settings. Comprehensive reviews conducted by Dong et al. (2025) and Hu (2024) corroborate the beneficial impact of AI on educational attainment, reporting moderate to substantial effect magnitudes.

In terms of research methodology, the vast majority of studies (at least eight) are Systematic Literature Reviews (SLR) carried out following the PRISMA framework. Dong et al. (2025) and Hu (2024) conducted a meta-analysis, while Kestin et al. (2025) only used experimental design (RCT). What is recurrently missing in the literature is the frequent absence of experimental or quasi-experimental research and the high prevalence of review-based studies, pointing to the need for more field-based studies that directly measure the impact of AI on real learning processes and outcomes.

AI for Personalized Learning

Personalized learning is a pedagogical approach that puts the individual at the center of the entire educational process. It focuses on the needs, abilities, interests and learning styles of each student. Unlike conventional instruction, which delivers identical content to all students, personalized learning recognizes that every learner possesses unique cognitive, affective, and psychomotor characteristics, thereby necessitating individualized adaptation of the learning process (Ayeni et al., 2024; Merino-Campos, 2025).

The growing variety among students underscores the significance of tailoring educational experiences to individual needs. Artificial intelligence offers a practical method for achieving this personalization at scale, a feat that was previously beyond the capacity of a single educator working

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without technological assistance. A comprehensive review by Hu (2024), which consolidated data from 31 research investigations, indicated that employing AI to facilitate individualized instruction yielded substantial improvements in student academic performance, demonstrating effect sizes that were generally moderate to considerable.

AI Implementation in Personalized Learning

AI implementation in personalized learning is realized through a range of complementary technologies and mechanisms. Based on the reviewed literature, at least four main pillars can be identified. The first is the AI Recommendation System, which operates by analyzing students' learning histories, preferences, and performance to proactively suggest the most relevant content, learning resources, or educational pathways. Zahara et al. (2023) identify that AI can construct dynamic student profiles that are continuously updated in line with competency development. Afrita (2023) also points out that AI recommendation systems have been proven to improve learning efficiency by ensuring that every student gets the right material at the right time. Higher education showed considerable gains in educational outcomes through AI-based platforms with adaptive recommendation capabilities that tailored content and feedback to the specific needs of learners (Merino-Campos, 2025).

The second pillar is learning analytics, which is the use of data and sophisticated analytical tools to understand, optimise and predict student learning processes and outcomes. Afrita (2023) states that the analysis of student engagement is one of the AI applications most clearly shown to improve the efficiency of learning. Sri Rahayu (2023) points out that AI has the analytical capacity to identify learning patterns and predict student progress, such as the early detection of risks of failure, so that timely interventions can be made. Celik et al. (2022) describe that AI-enabled learning analytics help teachers to make more data-driven pedagogical decisions to improve overall instructional quality.

Artificial intelligence-powered chatbots, notably exemplified by ChatGPT, represent the third foundational element, fundamentally altering student engagement with educational materials and their methods of obtaining support. Research by Bilad et al. (2023) indicates that ChatGPT contributes to increased motivation and improved language proficiency in university students. Similarly, Supriyono et al. (2024) observed that integrating ChatGPT within the Merdeka Curriculum resulted in enhanced student motivation, critical thinking abilities, and self-directed learning. However, the study also recognised potential pitfalls, such as over-reliance on technology and academic dishonesty, that require careful teacher supervision and the continued advocacy of ethical scholarship. Batista et al. (2024) also emphasise the mixed evidence of chatbots' impact on educational outcomes. Some studies suggest positive effects on student engagement and academic performance, whereas others point to limitations and variable effectiveness across disciplines.

The fourth and most mature pillar is Intelligent Tutoring Systems (ITS), which replicate one-on-one human tutoring by delivering personalized adaptive feedback, adjusting task difficulty, and guiding students through optimized learning pathways. Bilad et al. (2023) report that cognitive tutors significantly improve learning efficiency. The strongest evidence comes from Kestin et al. (2025), whose

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RCT demonstrated that students using pedagogically designed AI tutors achieved significantly higher learning gains in less time than those in conventional active classrooms, while also reporting greater engagement and motivation. Luo et al. (2025) found that AI tools functioning as intelligent tutors generally improve students' cognitive knowledge and affective outcomes, though their impact on higher-order thinking skills remains variable.

The Impacts of Personalized Learning

AI implementation for personalized learning produces wide-ranging and multidimensional impacts on the learning process and student outcomes. Based on a synthesis of the 25 reviewed articles, at least four major impacts can be identified. First, one of the most consistently reported impacts is an increase in student learning motivation. Supriyono et al. (2024) found that ChatGPT use within the Merdeka Curriculum enhanced student motivation as its primary positive outcome.

Sariyasa and Monika (2023) found that 89,44% of students rated AI as practical and efficient, while 94,17% found it beneficial in their individual learning processes strong indicators of increased intrinsic motivation. Among the various benefits identified in this review, enhanced student motivation appears to be one of the most prominent and consistently reported positive outcomes of AI-supported learning. These findings suggest that enhanced student motivation may be one of the most significant benefits of AI-supported learning.

Besides improving access to information and learning efficiency, AI appears to improve students' willingness to actively participate in learning activities and sustain their participation throughout the entire learning process. This finding is especially significant as student motivation has been recognized as a critical factor affecting engagement, persistence, and academic success in AI-enhanced learning environments (Zhu et al., 2025; Dong et al., 2025). Thus, the positive motivational effect reported by the students adds to the evidence of how AI can contribute to not only cognitive outcomes but also to affective dimensions of learning. Kestin et al. (2025) confirmed through an RCT that students using AI tutors reported higher levels of engagement and motivation than control-group students in conventional active classrooms.

Moreover, Artificial Intelligence (AI) has been proven to be a lot more effective in the process of learning in many ways. Ayeni et al. (2024) showed that the use of AI-based personalized learning with adaptive content, real-time feedback, and smart tutoring systems significantly boosts students' interest, motivation, and success at school. Supriyono et al. (2024) found that ChatGPT helps with two important skills for the 21st century: critical thinking and autonomous learning. AI also improves learning for students with a range of learning needs and styles (Ayeni et al., 2024;Eden et al., 2024).

Third, AI is transforming the assessment and evaluation process through automation that saves time while simultaneously improving feedback quality. Sri Rahayu (2023) identifies several key advantages of AI in educational assessment: objectivity (reducing human bias), efficiency (saving time and cost), consistency (standardizing evaluation results), analytical capacity (identifying patterns and predicting student progress), and flexibility (enabling assessment anytime and anywhere. The

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assessment and evaluation was identified by Luo et al. (2025) as one of the three main functions of AI tools in higher education, allowing teachers to concentrate on the human side of student development instead of tedious administrative marking.

Fourth, there is strong empirical evidence that AI positively impacts overall student learning outcomes. A large meta-analysis by Dong et al. (2025) found that AI generally improves academic achievement, with the strongest and most consistent results for Intelligent Tutoring Systems and adaptive AI tools. In a meta-analysis of 31 empirical studies, Hu (2024) confirmed that AI-assisted personalized learning has significant positive effects on learning outcomes with medium-to-large effect sizes. Kestin et al. (2025) provide the strongest experimental evidence through an RCT, showing that students using pedagogically principled AI tutors achieved significantly higher learning gains than those in conventional active classrooms. Taken together, the evidence demonstrates that when implemented effectively and supported by sound pedagogical design, AI holds transformative potential for improving student learning outcomes across all educational levels.

The Challenges in Personalized Learning

Although the benefits of AI in personalized learning are promising, the implementation of it is faced by a variety of serious challenges that need to be addressed systematically. The SLR findings identify at least four major challenges that consistently emerge across the literature. The first and most frequently mentioned barrier is student data privacy and security. AI systems for personalized learning are most effective when they can gather and analyse vast amounts of student data. Afrita (2023) notes that AI in education requires careful planning to address data privacy, security and ethical concerns. Zhu et al. (2025), in their systematic review of ethical risks, identify privacy invasion and data leakage as two of five technological risks, emphasizing that these can cascade into broader educational and social harms. Protecting student data requires a robust regulatory framework, reliable encryption mechanisms, and transparent data governance policies from both educational institutions and technology developers.

The second challenge is technology dependence. Supriyono et al. (2024) explicitly identify technological dependence, intellectual passivity, and plagiarism as negative outcomes of ChatGPT use within the Merdeka Curriculum. Humble and Mozelius (2022) warn of overdependence on technology as one of the genuine threats posed by AI in education. The another major limitation identified in the studies on Generative AI in higher education is the over-reliance on AI, as found by Batista et al. (2024). This challenge requires a holistic AI literacy approach that teaches not only how to use AI, but also when not to rely on it and how to maintain independent critical thinking.

The third challenge is about teachers readiness to integrate AI into instructional practice. Bilad et al. (2023) highlight the significance of proper teacher training, as demonstrated by the low readiness of teachers to implement AI tools, which is a major barrier. Celik et al. (2022) found that a lack of AI literacy, ethical concerns, and fears of being replaced by machines constitute significant barriers. Lindner et al. (2026) identified a “pedagogical adoption gap” between early-career teachers who

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demonstrated higher AI awareness and experienced teachers who exhibited lower AI competency, highlighting the need for differentiated programs for professional growth. Mbuik et al. (2026) demonstrated that practice-based training and co-design pedagogy are effective in transforming teachers from passive users into active learning designers.

The fourth challenge is limited digital infrastructure, particularly in developing countries. Joseph and Uzondu (2024) highlight the digital disparity, characterized by uneven access to digital tools, as a principal obstacle to incorporating AI into STEM pedagogy. Eden et al. (2024) concur that disparities in accessibility have the potential to intensify existing educational inequities. Within the Nigerian setting, Cleopas (2023) pinpoints the substantial expense of AI infrastructure, a general lack of digital competence, and insufficient governmental policy backing as critical hindrances. Research by Harianti et al. (2025) indicates that Indonesia continues to trail other nations in AI research and infrastructure development. This observation emphasizes the necessity for deliberate policy frameworks and continuous professional development for educators to ensure that the advantages of AI in customized learning are available to all societal groups on a fair basis.

AI for Adaptive Learning

Adaptive learning is an educational method that employs artificial intelligence (AI) technology to tailor the learning process to the needs, abilities, and characteristics of each individual learner. This enables a more personalized learning experience where the material, feedback and learning paths can be adapted to suit the progress of each individual learner. According to research, AI has been found to be very important in developing learner profiles based on their abilities and learning styles that make the learning process more effective and targeted. Furthermore, the use of AI in education helps in creating personalized learning which can improve student engagement, motivation, and learning outcomes.

Adaptive learning is a flexible learning system that allows students to learn at their own pace and according to their individual needs. AI technology can offer real-time feedback, change the delivery of content, and assist in adaptive learning strategies that enhance student engagement in the learning process. In modern education, adaptive learning platforms and intelligent tutoring systems have shown a huge potential for the development of more interactive, efficient and learner-centred learning experiences.

The one of important feature of adaptive learning is that it automatically adjusts the difficulty level to the performance of the learners. AI systems, for example, can analyse data on learning outcomes and identify students' strengths and weaknesses, and then recommend materials or activities to students based on their level of mastery. By this method, learners who have mastered a topic can go on to a higher level while those still having difficulty will be given more appropriate material and exercises to help them. Studies have shown that the use of AI-powered personalized learning and adaptive learning tools can have a positive impact on learning outcomes and students' academic achievement.

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AI Technologies in Adaptive Learning

The implementation of adaptive learning is inseparable from the support of various artificial intelligence (AI) technologies that make the learning process more personalized, responsive, and effective. Intelligent Tutoring Systems (ITS) are among the most common technologies. They are intelligent tutoring systems that can provide guidance similar to a teacher by adapting the material, learning strategies and support to the individual needs of learners. Studies have shown that intelligent tutoring systems improve learning outcomes, offer a more personalized learning experience and support adaptive learning through continuous analysis of the learning data.

To enable automatic difficulty adjustment based on student mastery, Intelligent Tutoring Systems (ITS) commonly employ machine learning algorithms that model student knowledge and predict future learning performance. One of the most widely used approaches is Bayesian Knowledge Tracing (BKT), which estimates the probability that a learner has mastered a specific concept based on previous responses (Šarić-Grgić et al., 2024). More recent systems have adopted Deep Knowledge Tracing (DKT), a deep learning approach that analyzes sequential learning behaviors to predict future performance with greater accuracy (Xu & Hu, 2024). These algorithms allow ITS to continuously monitor learner progress, identify knowledge gaps, and dynamically adjust instructional content, feedback, and task difficulty according to individual mastery levels, thereby supporting more effective adaptive learning experiences.

Furthermore, AI also supports the implementation of adaptive assessment, a system that can adjust the difficulty level of questions based on learners' abilities. This technology enables more accurate evaluation as each student receives questions appropriate to their level of mastery of the subject matter. AI can analyse answer patterns, identify learning progress, and predict future learning needs. Through these analytical capabilities, the assessment process becomes more objective, efficient, and capable of providing a more comprehensive picture of a learner's abilities.

Another key technology is automated feedback, which provides automatic and real-time feedback to students. AI systems can offer corrections, suggestions for improvement, and recommendations for further study without the need to wait for a teacher's assessment. This swift and personalized feedback helps students understand their mistakes immediately, thereby making the learning process more effective. Several studies indicate that AI-generated personalized feedback can enhance learning motivation, student engagement, and overall academic achievement.

All of these technologies use machine learning algorithms that are designed to process and analyse large amounts of learning data. Machine learning algorithms enable AI systems to recognise learners' study patterns, predict academic performance, and automatically adapt learning materials and strategies. With the ability to learn from an ever-growing body of data, adaptive learning systems can provide a learning experience that is increasingly accurate and relevant to each individual.

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Consequently, machine learning forms the cornerstone of adaptive learning system development, enhancing the effectiveness, efficiency, and personalisation of learning in the digital age.

The Effectiveness of Adaptive Learning

The effectiveness of adaptive learning has become the main focus of various studies due to its ability to improve the quality of the learning process and outcomes. Adaptive learning systems use AI technology to tailor the content, methods, and difficulty levels of learning to the individual needs of each learner. Several studies have demonstrated the positive effect of this approach on students' academic performance, as the learning process is more focused and consistent with individual capabilities. Meta-analysis results show that the use of AI in education has, in general, a positive effect on academic achievement and that the use of intelligent tutoring systems and adaptive learning tools have a specific positive influence on learning outcomes.

Apart from improving learning outcomes, it was also found that adaptive learning increases student engagement in the learning process. In the learning system, personalized content, real-time feedback, and learning recommendations are customized to meet the needs of individuals, making learners more active and motivated to study. Research indicates that AI-based personalized learning and intelligent tutor systems have the potential to improve learners' motivation, participation, and learning experience. Indeed, experimental research suggests that learners who use AI tutors exhibit increased engagement and motivation relative to traditional active learning in the classroom.

In the context of digital learning, adaptive learning has also proven to be very effective in increasing the efficiency and quality of the learning experience. The AI technology allows for flexible materials, automatic feedback and continuous monitoring of learning progress. These capabilities make the digital learning process more responsive to the needs of learners than conventional digital learning models. Several studies have shown that the application of AI in digital learning can improve the quality of learning, speed of learning, and interaction with the learning system. Thus, adaptive learning can be seen as one of the key innovations in the transformation of digital education, focused on individual needs of learners.

The Challenges in Adaptive Learning

Despite the many advantages of adaptive learning in improving the quality of learning, there are still several challenges to its implementation. One of the major challenges is its relatively high cost to implement. Building and using AI-based systems requires investment in hardware, software, network infrastructure, and ongoing maintenance of the systems. Moreover, the training cost for the teachers and educational staff is also a factor that needs to be taken into consideration. Some studies have found that the high cost of technology and the infrastructure requirements are hurdles for the wide adoption of AI in educational settings.The next challenge relates to teachers' digital literacy and educators' readiness to utilise AI technology. The success of adaptive learning depends heavily on teachers' ability

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to integrate technology into the learning process. However, various studies indicate that many educators still lack sufficient knowledge and skills in using AI, necessitating ongoing professional development and training programmes. A lack of AI competence among teachers can hinder the optimal use of technology and reduce the effectiveness of adaptive learning implementation in the classroom.

In addition, the absence of technology in schools is also a major obstacle, particularly in regions where digital devices and internet access are not readily available. “There is a gap in the technology infrastructure, which can create a disparity in the extent to which adaptive learning is implemented. Not every learner will benefit equally.” Several studies highlight the existence of a digital divide that remains a major challenge in the implementation of AI in education, especially in resource-constrained schools.

In technical aspects, there are also many barriers to the use of AI in the area of ethical issues, data privacy, information security and algorithmic bias. When large amounts of student data are collected and not handled correctly, there is a risk of data misuse. In addition, badly designed AI algorithms may produce biased decisions and increase inequality in education. Hence, the implementation of AI-based adaptive learning necessitates clear regulations, strong data protection, and adequate oversight to ensure that the technology is used responsibly and in the best interest of the learners.

Adaptive learning systems have the capacity to personalize content, pace, and instructional support according to the individual learner’s needs, and this is much more than just improving academic performance. AI based adaptive learning enables learners to learn at their own pace which can take into account differences in prior knowledge, learning preferences and learning speeds. This flexibility removes the barriers to participation and levels the learning field for diverse groups of learners. Therefore, the principles that underlie adaptive learning are well suited to form a basis for inclusive education, in which all learners, irrespective of their abilities, backgrounds or learning needs, have access to meaningful and personalized learning experiences. Recent research also points to the relationship between personalization and inclusivity, with AI-based adaptive systems promoting a broader educational participation when developed in response to the diversity and accessibility needs of learners (Ayeni et al., 2024; Merino-Campos, 2025).

AI for Inclusive Learning

Inclusive learning is a way of teaching that offers equal opportunities of learning to all students irrespective of their physical condition, cognitive ability or background. It is not just about placing students with special needs into regular classrooms; it is about creating a learning environment that is responsive to the varied needs of each individual. AI can be used to develop learning systems that can be customised to the needs of each learner, including those with specific learning barriers (Eden et al., 2024). Equitable access is a basic principle of inclusive education, ensuring that all individuals have the same right to quality education. AI has huge potential for promoting educational equity through personalized content and timely feedback (Ayeni et al., 2024).

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This is in line with the SDG 4 agenda promoted by UNESCO to democratize knowledge and expand the accessibility of education globally (Lampu, 2023). The development of AI has resulted in various innovations that support inclusion, including speech recognition systems, text-to-speech devices, adaptive interfaces, and learning platforms that tailor content to individual needs. Personalized learning is made possible thru the construction of learner profiles tailored to individual abilities and learning styles, including thru platforms like Rumah Belajar in Indonesia as a concrete example of technology enabling broader access to education (Zahara et al., 2023).

AI for Students with Special Needs

Artificial intelligence (AI)-based speech recognition technology enables the automatic conversion of spoken language into text. This innovation opens up new opportunities for students with motor impairments or dyslexia to participate actively in the learning process. One relevant application of AI in education during the Fourth Industrial Revolution is the virtual assistant, which serves as an inclusive interface for learners facing barriers to textual interaction (Maola et al., 2024). Furthermore, AI-based text-to-speech (TTS) technology converts textual content into natural-sounding audio output. This technology is particularly beneficial for students with visual impairments or reading difficulties. Modern TTS systems can adjust speed and intonation according to user preferences, enabling students with special needs to access learning materials more independently without relying on human assistants (Afrita, 2023).

More broadly, AI has produced a range of accessibility tools such as computer vision-based sign language recognition, intelligent screen readers, and real-time translators specifically designed to meet various types of special learning needs. Human-centred, multimodal, transparent, and inclusive AI design forms a crucial foundation for the development of effective learning tools accessible to all categories of learners (Luo et al., 2025). Equally important, through intelligent tutoring systems, AI is capable of providing personalized guidance, adaptive feedback, and real-time content adjustments based on each student's learning progress. Pedagogically designed AI tutors have been empirically proven to yield higher learning outcomes compared to conventional active learning, whilst also reporting higher levels of student engagement and motivation (Kestin et al., 2025).

The Positive Impacts of Inclusive AI Learning

Artificial Intelligence enables the automatic adaptation of instructional content, the design of user interface, and the modes of delivery to match the nature and severity of the student's disability. AI has great potential to be applied in immersive virtual reality (VR) and augmented reality (AR) learning environments in order to enhance the educational experience of students who have a wide range of disabilities (Eden et al., 2024). In addition, AI also greatly supports educators, learners and administrative staff in making educational processes more efficient and student-centered (Kaçara & Avşaroğlu, 2025). AI-powered digital platforms enable learning that is possible anywhere, anytime, and break down the geographical and institutional barriers that often obstruct access.

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The adaptability of AI-driven assessments, unconstrained by temporal or spatial limitations, represents a crucial benefit for broadening educational opportunities (Rahayu, 2023). Artificial intelligence presents opportunities to make information more widely available and to expand access to education, a point highlighted by UNESCO (Lampou, 2023). AI systems capable of delivering immediate feedback and tailored content serve as valuable instruments for fostering independent learning, especially for individuals who need more adaptability in their educational journey. Notably, a substantial majority of students, precisely 94.67%, indicated that AI contributed positively to their personal learning experiences (Sariyasa & Monika, 2023).

Besides, a comprehensive review of 31 research studies shows a substantial positive impact of AI on student academic achievements, with an average effect size falling within the moderate to substantial range (Hu, 2024). AI can detect patterns of learning difficulty and proactively change instructional approaches before barriers escalate into more serious problems. Personalized feedback that improves learning efficiency has been provided by AI-supported Cognitive Tutors (Bilad et al., 2023). The most consistent positive impacts on students' academic achievement across different educational contexts are seen with intelligent tutoring systems and adaptive AI tools (Dong et al., 2025).

The Ethical Issues and Challenges

Algorithmic bias occurs when AI systems produce decisions that unfairly disadvantage certain groups, which in education can exacerbate existing inequalities. Algorithmic bias is among the five major technological risks of AI in education, alongside privacy invasion, data leakage, black-box algorithms, and algorithmic errors (Zhu et al., 2025). Addressing these risks requires cross-disciplinary collaboration among educators, technology developers, and policymakers (Joseph & Uzondu, 2024). The digital divide risks worsening educational inequality if AI implementation is not accompanied by equitable access to technology, digital literacy, and adequate institutional capacity. The exacerbation of the digital divide is one of the major social risks of AI in education that can deepen existing disparities between those who have access and those who do not (Zhu et al., 2025).

Indonesia still lags behind other countries in AI research and infrastructure, underscoring the urgency of structured equity policies (Harianti et al., 2024). Imprudent use of AI risks fostering excessive dependence, weakening critical thinking capacities, and threatening the integrity of academic assessment processes. The use of ChatGPT requires teacher supervision and enforcement of academic ethics to maintain learning integrity, with negative impacts including technological dependence and plagiarism that must be proactively addressed (Supriyono et al., 2024). Integrity, honesty, paraphrasing, and citation must be consistently applied to preserve the quality and credibility of academic output (Sariyasa & Monika, 2023).

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Table 3. Comparison of Previous Research on AI-Based Adaptive Learning

Authors	Research Focus	Key Findings	Similarities with Other Studies	Distinctive Findings
Zahara, Azkia, & Chusni (2023)	AI implementation in education	AI supports personalized learning through student profiling and adaptive instruction.	Consistent with studies emphasizing personalized learning and adaptive education.	Focuses on AI applications in Indonesian educational platforms such as Rumah Belajar.
Bilad, Yaqin, & Zubaidah (2023)	AI tools in education	Cognitive tutors, chatbots, and personalized learning platforms improve learning outcomes and efficiency.	Similar to studies highlighting Intelligent Tutoring Systems (ITS).	Emphasizes challenges related to educator readiness and ethical implementation.
Joseph & Uzondu (2024)	AI and ML in STEM education	AI enhances adaptive teaching, real-time feedback, and student engagement.	Supports findings on adaptive learning effectiveness.	Focuses specifically on STEM education and machine learning integration.
Ayeni et al. (2024)	Personalized learning and educational technology	AI-driven adaptive learning improves engagement, motivation, and academic performance.	Consistent with studies reporting positive effects on learning outcomes.	Highlights AI's role in promoting educational equity and inclusion.
Eden, Chisom, & Adeniyi (2024)	AI integration in education	Adaptive systems tailor instruction according to learners' individual needs.	Supports personalized learning and student-centered education.	Strong emphasis on ethical and accessibility concerns.
Kestin et al. (2025)	AI tutoring effectiveness	AI tutors significantly outperform conventional active learning in improving student achievement and engagement.	Supports evidence of AI effectiveness in adaptive learning.	Provides empirical evidence through a Randomized Controlled Trial (RCT).
Merino-Campos (2025)	AI and personalized learning in higher education	AI optimizes learning outcomes through adaptive content and individualized feedback.	Similar to studies on adaptive learning and personalized instruction.	Focuses specifically on higher education contexts.

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Luo et al. (2025)	AI-based learning tools	AI improves cognitive and affective outcomes but shows mixed results on higher-order thinking skills.	Supports positive impacts of AI on learning.	Identifies limitations regarding critical thinking and complex skill development.
Dong, Tang, & Wang (2025)	AI and academic achievement	AI has a positive overall effect on student achievement, particularly through adaptive tools and tutoring systems.	Consistent with most empirical studies.	Provides quantitative evidence through meta-analysis.
Hu (2024)	AI-assisted personalized learning	Personalized learning significantly improves student learning outcomes.	Supports adaptive learning effectiveness findings.	Highlights disciplinary differences affecting AI effectiveness.

The review of different studies on the use of Artificial Intelligence (AI) in education demonstrates several similarities that show consistency in researchers' finding. Most of the studies conclude that AI has a promising potential to support personalized learning via adaptive learning, intelligent tutoring systems, and automated feedback. Different researchers (Zahara et al., 2023; Ayeni et al., 2024; Merino-Campos, 2025) have demonstrated that AI can personalize learning materials based on the characteristics and needs of each learner, thus improving the effectiveness of the learning process. Also, various studies suggest that AI can assist educators with administrative tasks, learning assessment, and monitoring student progress.

But the research results of the effectiveness of AI implementation in learning are different. Kestin et al. (2025) conducted an experimental study and found that AI tutors resulted in higher levels of engagement and learning outcomes as compared to traditional active learning. Likewise, the meta-analysis by Dong et al. (2025) and Hu (2024) reported that AI positively impacted students' academic performance. However, results from Luo et al. (2025) show that although AI is effective in promoting cognitive and affective knowledge, the effects of AI are mixed in the development of higher-order thinking skills and complex skills.

There are many reasons for differences in research results. First, the effectiveness of AI implementation is affected by different educational contexts, including educational level, subject area, and learner characteristics. Secondly, the results obtained are also dependent on the technology of AI used. Studies on adaptive learning platforms and intelligent tutoring systems are more likely to report positive effects than administrative uses of AI. Thirdly, the success of AI implementation in learning also depends on the readiness of technological infrastructure, the digital competencies of teachers and the support of institutional policies.

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The analysis of previous studies shows that the majority of studies are still focused on the potential benefits and opportunities of applying AI in education. There are still relatively few studies of the long-term effects. Moreover, most of the research relies on literature reviews or conceptual approaches, which highlights the need to enhance the empirical evidence from direct implementation in school settings. In addition, several studies point out that ethical issues, data privacy, algorithmic bias, and the digital divide are challenges to be addressed towards the effective and sustainable implementation of AI-based adaptive learning. Therefore, future research needs to be done with better experimental designs and longer research periods to test the effectiveness of AI, while also considering the context of developing countries such as Indonesia that have limitations in infrastructure and digital literacy.

The Future Opportunities of AI in Education

Generative artificial intelligence (GenAI) creates new opportunities for automating the generation of instructional materials, formative assessment and curriculum personalisation at a scale not possible before. GenAI has enormous potential to transform higher education but its pedagogical impact needs to be further substantiated through more rigorous and longitudinal research (Batista et al., 2024). This technology is still valid for optimising learning outcomes by adapting content and providing feedback to the needs of individual learners (Merino-Campos, 2025).

The emergence of ChatGPT and other AI assistants has fundamentally transformed how students and educators interact with knowledge, enabling a personal tutor function available at all times. Its implementation within the Merdeka Curriculum demonstrates positive impacts, including increased motivation, critical thinking, and independent learning, although the risks of technological dependency and the erosion of academic integrity must be anticipated (Supriyono et al., 2024). ChatGPT has also been shown to enhance motivation and language skills as an effective learning tool (Bilad et al., 2023).

Smart classrooms that are powered by AI integrate sensors, IoT devices, and AI systems to collect and analyse learning data in real-time, thereby enabling the development of evidence-based instructional decisions. In the era of technology-based education, smart classrooms are fundamentally comprised of dual teacher classrooms and smart content (Maola et al., 2024). Teacher readiness is a critical prerequisite for successful and sustainable implementation, as practice-based training serves to connect abstract AI concepts with real-world classroom applications (Mbuik et al., 2026). In order to facilitate evidence-based instructional decisions, AI-powered smart classrooms integrate sensors, IoT devices, and AI systems to collect and analyse learning data in real time.

AI-based curricula position artificial intelligence as a structural component in the dynamic design, delivery, and evaluation of curricula based on current empirical evidence. The design-evaluation framework advocates for human-centred, inclusive, and ethical AI design as the foundation for the development of effective and responsible curricula (Luo et al., 2025). Indonesia requires an AI-

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integrated curriculum, pedagogical transformation, and continuous teacher training programmes to enhance competencies and compete at a global level (Harianti et al., 2024).

The future AI-supported digital learning ecosystem will consist of a network of adaptive platforms, intelligent assessment systems, VR/AR environments, and global learning communities that enable personalized and lifelong learning. AI is revolutionising education by enabling new methods of teaching and learning, with outcomes that are highly context-dependent and vary across different implementation settings (Dong et al., 2025). Multi-stakeholder collaboration among governments, schools, developers, teachers, and students, accompanied by clear accountability mechanisms, is a prerequisite for realising this ecosystem equitably for all (Zhu et al., 2025).

CONCLUSIONS

The study found that Artificial Intelligence (AI) is an important enabler of personalized, adaptive and inclusive learning through intelligent tutoring systems, learning analytics, adaptive learning environments, and AI-powered chatbots. The research results show that the AI helps to improve academic achievement, student engagement, educational accessibility, and learning effectiveness. But there are major barriers to be overcome in terms of ethics, educator preparedness, data protection and the need for digital infrastructure. One of the important findings from this review is that the combination of adaptive, personalized and inclusive learning gives a holistic framework to optimize the implementation of AI in modern education. Future research should aim to develop more longitudinal and empirical studies to assess the long-term impact of AI on learning outcomes in different educational settings and levels. Educational institutions and policymakers are encouraged to improve the digital infrastructure, improve educators' skills within the scope of AI, and develop ethical guidelines and data protection policies to enable the responsible, fair and effective use of AI in education.

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A. A. Z.: Data Curation; Writing – Review & Editing.
D. D. A.: Resources; Writing – Review & Editing.
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