



Utilization of Artificial Intelligence (AI) in Adaptive Learning: A Conceptual Study in the Era of Education 5.0

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ABSTRACT. The development of digital technology is pushing the world of education into the era of Education 5.0, a phase where humans and technology work collaboratively to create more personalized, humanistic, and flexible learning. One of the most influential technologies in this transformation is artificial intelligence (AI). This conceptual article aims to in-depth examine the use of AI in adaptive learning through a literature review approach of various national and international journals in the last five years. The analysis shows that AI can facilitate personalized learning through material recommendation systems, machine learning-based automated assessments, and real-time monitoring of student learning progress. Furthermore, the presence of AI encourages teachers to shift from an instructional role to a facilitator who focuses on mentoring, character building, and metacognitive guidance. However, this study also identified several challenges such as unequal teacher digital literacy, the risk of algorithmic bias, student data protection, and gaps in technological infrastructure. This article emphasizes that the integration of AI in adaptive learning in the Education 5.0 era requires comprehensive education policies, improved teacher competency, and ethical, safe, and student-centered learning design. Thus, AI is not just an automation tool, but becomes a strategic partner in improving the quality of inclusive, responsive, and sustainable learning.

Keywords: Artificial Intelligence, Adaptive Learning, Education 5.0

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INTRODUCTION

Amidst this wave of change, artificial intelligence (AI) has become a key technology making a significant contribution to modern learning. AI is no longer merely a tool, but has evolved into an intelligent system capable of analyzing learning data, adapting materials, and even providing learning recommendations automatically. The presence of AI makes learning in the 5.0 era more experience-centric by providing an effective, efficient, and personalized learning environment for each student. (Destari & Rifai, 2025)

The concept of adaptive learning then emerged as a solution to address the diverse learning needs of each individual. By analyzing students' learning styles, level of mastery of the material, and activity patterns, AI enables the system to adjust the learning flow personally. This process makes learning more accurate and sustainable because each student receives material according to their individual development. (Zebua, 2024)

Numerous studies have shown that integrating AI into adaptive learning can improve learning outcomes, accelerate conceptual understanding, and encourage deeper learning

engagement. Machine learning-based systems are capable of providing rapid feedback and targeted material recommendations. Thus, learning is no longer one-way, but rather a dynamic process that continuously adapts to students' needs. (Inuwa et al., 2025)

However, implementing AI in adaptive learning is not without challenges. Infrastructure readiness, teachers' digital competency, and ethical issues such as data security and algorithmic bias are obstacles that require attention. Without thorough preparation, AI integration has the potential to widen educational disparities. Therefore, the use of AI needs to be supported by clear regulations, technological assistance, and increased capacity of educators. (Xaveria & Kristianingsih, 2025)

In the Indonesian context, the digitalization of education is occurring unevenly. Some schools have adequate technological facilities, while others still have limited access. This directly impacts the successful implementation of AI-based adaptive learning. Therefore, a national strategy is needed that can accommodate geographical, social, and infrastructure differences to ensure optimal use of AI. (Mustafa et al., 2024)

The changing role of teachers also presents a challenge. In AI-based adaptive learning, teachers are no longer simply transmitters of material, but rather facilitators, guiding students in critical thinking, reflection, and the development of metacognitive competencies. Teachers also play a role in ensuring that the use of AI remains ethical, inclusive, and appropriate to human needs. This aligns with the spirit of Education 5.0, which emphasizes harmony between technology and human values.

Given these potentials and challenges, conceptual studies through literature reviews are crucial for understanding how AI can be optimally utilized in adaptive learning in the Education 5.0 era. Such studies help identify research gaps, formulate innovative theoretical frameworks, and provide implementable recommendations for teachers, schools, and policymakers to ensure ethical and effective AI integration. (Irvan & Annur, 2024)

METHOD

This research uses a literature review approach to analyze the use of artificial intelligence in adaptive learning in the Education 5.0 era. This literature review model was chosen because it allows researchers the flexibility to review various relevant scientific articles, books, and research reports without the need for field data collection. The primary focus of this method is the process of identifying, categorizing, evaluating, and synthesizing findings from previous research, thereby building a strong conceptual framework. This approach also provides space to understand the latest developments related to AI integration in education, examine various adaptive learning models used, and identify the challenges and opportunities for their implementation in various educational contexts.

The research procedure was carried out through several stages, starting with the determination of keywords such as artificial intelligence, adaptive learning, education 5.0, and digital pedagogy. Next, sources were selected based on the criteria of relevant publication year, journal credibility, and relevance to the study topic. Subsequently, a content analysis was conducted to identify patterns, concepts, and key findings from each source. The final stage was the preparation of a conceptual synthesis that served as the basis for the discussion of this research. Content analysis techniques are used to compare various AI-based adaptive learning models and identify open research gaps. This approach is widely used in conceptual research because it can map the development of educational technology broadly and in-depth.

RESULT AND DISCUSSION

The Concept of Adaptive Learning in the Framework of Education 5.0

Adaptive learning is an approach that adapts materials, methods, and learning pace based on the unique needs of each student. In this approach, students are not treated as a homogeneous group, but rather as individuals with different learning characteristics, including learning styles, tempo, preferences, and levels of conceptual mastery. Adaptive learning not only provides variation in the presentation of material but also responds to student development in real time, allowing each student's learning path to be unique. In the modern era, this approach is increasingly relevant because it encourages education to move from a one-way instructional pattern to flexible, personalized learning that focuses on the development of individual potential. In other words, adaptive learning is a concrete manifestation of a paradigm that places students at the center of the learning process. (Ahmad et al., 2023)

The key characteristics of adaptive learning include the system's ability to diagnose student understanding, adjust material complexity, provide rapid feedback, and present a specific learning path for each individual. This process involves continuous evaluation that enables the system to detect whether students are experiencing difficulties, are ready for new challenges, or need reinforcement of specific material. Conceptually, adaptive learning emphasizes not only content customization but also learning strategies tailored to students' learning patterns. For example, students with visual tendencies will be more likely to receive content in the form of images or infographics, while students with analytical abilities can be given problem-solving-based exercises. With an adaptive system, the learning experience becomes more targeted, less monotonous, and able to accommodate diverse learning profiles within a single class.

In the context of Education 5.0, adaptive learning is highly strategic because it aligns with the idea of collaboration between humans and technology. This concept emphasizes that technology should not replace humans, but should work side by side to improve the quality of pedagogical interactions. Education 5.0 demands a harmonious integration of human intelligence with machine intelligence, not simply digitalization. Therefore, adaptive learning is a crucial pillar because technology can understand students' learning needs, while teachers retain their crucial role as guides, providers of emotional touch, and guardians of humanistic values. In this era, teachers act as learning partners who understand the dynamics of students through the aid of intelligent technology, making adaptability the philosophical foundation for more relevant and contextual learning.

Furthermore, the principle of human-technology collaboration in adaptive learning opens up opportunities for truly personalized and sustainable educational design. Technology helps prepare analytics, learning recommendations, and certain automation processes, while teachers ensure the learning process remains ethical, meaningful, and aligned with character-building goals. The two complement each other: technology optimizes data processing and personalization, while teachers strengthen values, social-emotional aspects, and interpersonal communication. The presence of Education 5.0 actually strengthens the role of teachers as central figures who facilitate adaptive data interpretation and translate it into a more humane teaching approach. Thus, adaptive learning is not just a technology-based solution, but an evolution of the educational paradigm that combines artificial intelligence with human wisdom to create equitable, relevant, and future-oriented learning.

The Role and Working Mechanism of AI in Adaptive Learning

Artificial intelligence (AI) plays a central role in adaptive learning systems due to its ability to quickly and accurately collect, process, and analyze student learning data. AI systems are able to read student activity patterns, such as assignment completion time, problem success rates, interactions with materials, and even frequent error tendencies. All of this data is then processed using machine learning algorithms to generate a picture of each individual's learning profile. With

this mechanism, AI is not merely a tool but also functions as an "intelligent observer" capable of providing an initial diagnosis of student understanding and helping teachers understand students' conditions without relying on manual observation.(Gligore et al., 2023)

Once student learning characteristics are mapped, AI can automatically adjust the material based on each individual's needs. This process is known as an adaptive pathway, a learning path dynamically designed to follow the student's abilities and progress. Students who struggle will receive additional explanations, reinforcement exercises, or simpler explanations. Conversely, students who grasp the material more quickly will be directed to more complex challenges. This adaptation makes learning more personalized and efficient because the material is tailored to each student's capacity, rather than being forced to follow a uniform class rhythm.

In addition to content adaptation, AI also utilizes various technologies such as Natural Language Processing (NLP), Intelligent Tutoring Systems (ITS), and learning analytics, all working in an integrated manner to create a more interactive and responsive learning experience. NLP enables AI to understand students' language, enabling it to provide automated feedback or answer questions in a human-like manner. ITS acts as a virtual tutor, providing personalized guidance, step-by-step instructions, and recommendations for relevant learning strategies. This technological integration demonstrates that AI can fill gaps not fully addressed by traditional learning methods.

Research shows that adaptive AI systems have a positive impact on learning outcomes at various levels of education. Platforms such as ALEKS, Knewton, and Carnegie Learning utilize predictive algorithms to assess students' likelihood of success in completing specific material and then provide appropriate follow-up or remedial recommendations. In addition to increasing learning effectiveness, AI-based adaptive systems can also reduce teachers' workload on formative assessments and provide analytical data that helps teachers design more targeted learning strategies. Thus, AI serves not only as an automation engine but also as a pedagogical partner, strengthening the effectiveness, personalization, and accuracy of the learning process.(Pinela-cárdenas et al., 2025)

Challenges and Opportunities of AI Implementation for Adaptive Learning

The implementation of AI in adaptive learning faces a number of structural and technical challenges that cannot be ignored. One major challenge is teacher competency readiness, as not all educators possess sufficient digital literacy to optimally operate AI-based systems. Many teachers still focus on traditional learning methods that utilize minimal technology, so when faced with adaptive platforms based on machine learning, they require in-depth training that is not instantaneous. Furthermore, educational infrastructure is also unevenly distributed. Schools in urban areas may have stable internet access and adequate devices, while schools in remote, underdeveloped (3T) regions often experience signal interference, limited devices, or even lack digital laboratory facilities. This challenge is exacerbated by the issue of the digital divide, which creates disparities in learning abilities between students with access to technology and those without. Furthermore, AI also faces the risk of algorithmic bias, where adaptive learning systems can provide inaccurate recommendations if the training data is not representative. Another crucial challenge is data privacy and security, as adaptive learning collects sensitive student data that must be managed with strict protection standards.(Yusuf, 2025)

Despite these challenges, AI actually offers tremendous opportunities to improve the quality of adaptive learning at various levels of education. AI can create truly personalized learning, where each student receives materials, exercises, and a learning pace tailored to their individual abilities. This allows students to learn without feeling left behind or pressured to follow the pace of their classmates, as the entire learning flow automatically adapts to their needs dynamically. AI also increases the efficiency of the learning process: from automated assessments and progress monitoring to real-time feedback, which teachers find difficult to achieve manually. With algorithms that continuously learn from student interaction patterns, AI can predict potential

challenges and provide learning recommendations before students experience greater difficulties. This predictive capability makes adaptive learning faster, more responsive, and more effective in preventing the learning loss that often occurs in conventional methods.(Sari et al., 2024)

Another significant opportunity is the shift in the teacher's role to a more strategic one. In AI-based adaptive learning, teachers are no longer preoccupied with administrative work, manual corrections, or time-consuming repetitive material preparation. Instead, teachers can focus on more humanistic and pedagogical roles, such as guiding thinking processes, providing emotional touch, and facilitating meaningful discussions. AI becomes a pedagogical partner, not a substitute for teachers, as it manages the technical aspects while teachers strengthen students' values, character, and self-development. By capitalizing on this opportunity, schools can build a collaborative learning ecosystem between humans and machines, where technology optimizes the learning process while teachers remain the moral and intellectual compass for students. Therefore, the success of AI implementation depends not only on technological sophistication but also on the ability of schools and governments to design regulations, improve competency, and implement data protection policies that ensure the use of AI remains safe, ethical, and supports the future of students.(Jameel & Imran, 2024)

CONCLUSION

Adaptive learning stands as a transformative approach in the era of Education 5.0, offering a learning model that positions students not as a uniform group but as unique individuals with diverse needs and capabilities. Through personalized pathways, continuous diagnosis, and dynamic adjustments, adaptive learning shifts the educational paradigm toward student-centered learning that is flexible, contextual, and future-oriented. Artificial intelligence becomes the core driver of this shift by enabling rapid data processing, real-time feedback, and precise adaptation of learning materials capabilities that traditional learning systems cannot match. With technologies such as machine learning, NLP, intelligent tutoring systems, and predictive analytics, AI strengthens the ability of educational institutions to deliver learning experiences that are accurate, engaging, and tailored to each learner's progress.

However, the adoption of AI-based adaptive learning is not without challenges. Issues such as uneven teacher digital literacy, disparities in technological infrastructure, algorithmic bias, and threats to data privacy represent significant obstacles that must be addressed. These challenges are particularly evident in developing contexts where access to digital resources remains unequal. Nevertheless, the opportunities that AI presents for improving learning outcomes, enhancing efficiency, and supporting truly personalized education far outweigh the risks provided that institutions and policymakers implement AI responsibly and ethically. AI's potential to reduce teacher workload while improving instructional precision highlights its role not as a replacement for educators but as a complementary partner.

Therefore, the successful implementation of AI-driven adaptive learning requires strategic planning, strong governance, and continuous professional development for teachers. Education stakeholders must ensure that systems remain human-centered, equitable, and aligned with the core values of Education 5.0. When supported by adequate infrastructure, ethical guidelines, and data protection policies, AI can serve as a powerful catalyst for transforming learning environments into inclusive, intelligent, and future-ready ecosystems. In this way, AI and human educators together can shape a new educational landscape one that empowers learners, enhances creativity, and prepares students for the increasingly complex demands of the digital era.

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