

Education in the Age of AI: From Digital Teachers to Artificial Intelligence-Based Learning

 <https://doi.org/10.31004/jele.v11i1.1836>

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ABSTRACT

This study aims to comprehensively analyze how AI integration changes the role of educators, learning models, and the dynamics of the teaching and learning process at various levels of education. The research method used is a descriptive-qualitative approach with data collection techniques through literature studies, limited observations, and in-depth interviews with teachers, students, and educational technology experts. The results show that AI is able to provide personalized learning, more efficient classroom management, automated assessment systems, and self-learning support through smart chatbots and digital tutors. This study concludes that education in the AI era demands a repositioning of the role of teachers from conventional teachers to facilitators of technology-based learning, while ensuring that the use of AI remains ethical, inclusive, and oriented towards the development of students' character. These findings provide implications for policymakers, educational institutions, and technology developers to design an adaptive, humanistic, and sustainable education ecosystem amid the accelerating development of AI.

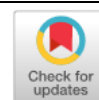
Keywords: *Artificial Intelligence (AI), Digital Education, Role of Teachers, Learning Personalization, Technology-Based Learning, AI Ethics*

Article History:

Received 12th December 2025

Accepted 05th January 2026

Published 07th January 2026



INTRODUCTION

Education in the era of artificial intelligence (AI) is experiencing a very rapid paradigm change along with the development of digital technology that is increasingly integrated in the learning process. This transformation is marked by the emergence of various innovations such as *digital teachers*, adaptive learning systems, *learning analytics*, educational robots, and algorithm-based interactive platforms that can adapt to the individual needs of students. The background of this phenomenon shows that education no longer relies on conventional patterns that place teachers as the only source of knowledge, but rather moves towards a collaborative ecosystem between humans and intelligent machines. In this context, AI not only serves as a technical tool, but also acts as a pedagogical agent capable of providing real-time feedback, mapping students' learning styles, and providing a more personalized and effective learning experience. This change requires a repositioning of the role of teachers, increasing digital literacy, and sensitivity to ethical issues, data privacy, and access fairness.

The development of artificial intelligence (AI) in recent years has brought fundamental changes in various sectors of life, including the field of education. AI is no longer just understood as an administrative support technology, but has transformed into an integral part of the learning process through the use of adaptive learning systems, *intelligent tutoring systems*, and algorithm-based learning assistants. A number of previous studies have shown that the integration of AI in learning is able to improve learning personalization, provide real-time feedback, and accommodate differences in student learning characteristics and speed. Research conducted by technology education experts confirms that AI has the potential to increase learning effectiveness, especially in the aspects of material mastery and learning time efficiency, if implemented appropriately and planned.

In line with these findings, various studies also underline the paradigm shift in the role of teachers in the digital era. Teachers are no longer positioned solely as the main source of knowledge, but rather as facilitators, mediators, and directors of learning supported by AI technology. However, the results of previous research show that the acceptance and use of AI by teachers still faces a number of challenges, including limited digital competencies, infrastructure readiness, and concerns about the ethical aspects and privacy of student data. In this context, AI is more appropriately understood as a technology that expands the professional role of teachers, not replaces them, so that the relationship between teachers, students, and technology becomes increasingly complex.

However, studies of AI-based education to date tend to focus more on the technical aspects and effectiveness of algorithm-based learning systems, while in-depth analysis of their impact on pedagogical dynamics and social interaction of learning is still relatively limited. Most of the research focuses on learning outcomes or the performance of AI systems, without comprehensively examining how the presence of AI affects communication patterns, emotional engagement, and the quality of interaction between teachers and students in the classroom. In addition, studies that specifically discuss the professional competency framework of teachers in dealing with artificial intelligence-based learning are still not widely found, especially those accompanied by measurable and contextual empirical indicators.

The limitations of the study are increasingly visible when it is associated with the context of education in developing countries, including Indonesia. Most of the international literature on AI in education is compiled based on the experiences and education systems of developed countries that have relatively adequate infrastructure support and technological resources. Meanwhile, research examining the implementation of AI in the context of Indonesian formal education is still relatively minimal, especially those that examine the relationship between education policy, teacher readiness, and student characteristics. This condition shows that there is a gap between the development of the global discourse on AI in education and the reality of its implementation at the national level.

Theoretically, this research is based on the theory of digital constructivism, adaptive learning theory, and the concept of education 4.0 which emphasizes the integration of smart technology in the education system. Digital constructivism views that learners build knowledge through interaction with technology-facilitated learning environments, while AI-based adaptive learning allows for the differentiation of material that suits each individual's abilities, interests, and cognitive development. In addition, the 4.0 education perspective emphasizes the importance of 21st century competencies such as creativity, critical thinking, digital literacy, and the ability to collaborate with automated systems. The combination of these three theoretical foundations reinforces the understanding that AI is not just a technical tool, but a strategic instrument that shapes new learning patterns that are more responsive, flexible, and personalized. However, the use of AI in education also raises a number of problems. In the field, there is still a gap in digital competence between teachers and students, limited facilities and infrastructure, and doubts about the reliability of automated systems in the learning evaluation process. Ethical challenges such as algorithmic bias, personal data security, and the potential for reduced humanist interaction between teachers and students are also concerns that need to be seriously addressed. In addition, the lack of a comprehensive policy framework in regulating the governance of AI implementation in schools makes it difficult for some educational institutions to adopt this technology to the maximum.

In response to these various problems, this study formulates a problem-solving plan through an in-depth analysis of the role of AI in supporting the learning transition, identifying the needs of teachers' digital competencies, and developing implementation strategies that are ethical, inclusive, and oriented towards the quality of the learning process. This approach not only focuses on the use of technology, but also places people—especially teachers and students—at the center of pedagogical adaptation.

This research offers novelty by presenting a study that positions teachers as the main actors in the AI-based learning ecosystem. By taking the context of formal education in Indonesia, this research is expected to be able to make a theoretical contribution to the

development of AI-based education concepts as well as a practical contribution to policy development and improving the quality of learning in the digital era, able to bridge the technology gap and strengthen sustainable learning practices. The main purpose of this study is to comprehensively describe how artificial intelligence transforms education, analyze changes in the role of teachers and learning dynamics due to the presence of intelligent technology, identify challenges and opportunities in its application in educational institutions, examine integratively changes in the role of teachers, dynamics of social interaction in learning, and the needs of teachers' professional competencies in the era of artificial intelligence.

In addition, this research aims to formulate an AI-based learning strategy that is effective and humane, so that it can be a reference for teachers, schools, policy makers, and technology developers in building an educational ecosystem that is adaptive and oriented to future needs.

Literature Review

The development of artificial intelligence (AI) has brought fundamental changes in the modern educational landscape. Theoretically, the concept of AI refers to the ability of computer systems to perform tasks that previously required human intelligence, such as reasoning, pattern recognition, problem solving, and decision-making (Russell & Norvig, 2021). In the context of education, AI is not only understood as a supporting technology, but as a catalyst for learning transformation. According to Holmes et al. (2019), the existence of AI in the classroom allows learning to be more adaptive, personalized, and efficient because the system is able to adjust teaching materials and methods based on students' needs, learning styles, and development.

The concept of "digital teacher" or artificial intelligent tutor is also an important milestone in AI-based learning. Huang and Mutlu (2023) state that digital teachers function as pedagogical agents that can provide real-time feedback, conduct automated assessments, and accompany students in independent learning without space or time limitations. This is in line with the view of Suwanto (2020) in the context of Indonesian education, which emphasizes that AI-based technology plays a role in strengthening learning differentiation and increasing the effectiveness of didactic interactions between teachers and students.

Adaptive learning is one of the most prominent forms of AI integration. Adaptive learning systems use algorithms to read students' interaction patterns and adjust content according to their respective ability levels (Kumar & Rani, 2020). This approach has been proven to increase student engagement and learning outcomes because each student gets a different learning route according to their needs. In the context of Indonesian education, research by Raharja and Lestari (2022) shows that the implementation of adaptive learning systems increases students' motivation and activeness, especially in online learning. In addition to the learning aspect, AI also has an impact on education management. Systems such as intelligent Learning Management Systems (LMS), learning analytics, and AI-based virtual classroom monitoring help teachers manage the learning process more systematically and measurably (Ifenthaler & Yau, 2020). In practice in Indonesian schools, the use of AI-equipped digital platforms has been proven to improve administrative and assessment efficiency, as reported by Prasetyo (2021) through a case study of data-driven LMS implementation.

In the perspective of educational theory, the utilization of AI is also associated with constructivism, which emphasizes that knowledge is built through experience and active interaction. AI technology – through simulations, interactive chatbots, and immersive learning environments – facilitates the process of knowledge construction by providing contextual and responsive learning experiences (Woolfolk, 2020). On the other hand, the theory of connectivity introduced by Siemens (2005) explains that learning in the digital era is rooted in the ability to connect various sources of information. AI supports the principles of connectivity by providing fast, structured, and personalized access to global information. Nevertheless, several theoretical challenges arise in the implementation of AI in education. One of the main issues is related to teacher competence. According to Wijaya (2021), teachers' readiness in digital literacy greatly determines the success of AI integration. Infrastructure gaps are also a

significant obstacle, especially in areas that do not have adequate access to networks and technological devices (Suryadi, 2020). In addition, ethical issues such as student data privacy and algorithm transparency require serious attention so that the use of AI remains on an ethical and humanist path (Floridi, 2019).

Thus, theories about AI, digital pedagogy, constructivism, and connectivity provide a comprehensive conceptual framework for understanding how artificial intelligence is transforming educational practices. Effective AI integration requires synergy between human readiness, institutional policies, and technological developments to keep learning student-centered, inclusive, and sustainable.

METHOD

Types and Approaches to Research

This research uses a qualitative approach with the type of library research. The qualitative approach was chosen because this study seeks to describe, examine, and interpret in depth the concept of digital teachers, artificial intelligence-based learning, and its implications for education. According to Creswell (2014), qualitative research aims to understand phenomena in depth through the exploration of various perspectives and sources of information. The literature study is used because this research relies on searching for scientific works, journal articles, proceedings, books, official reports, and government policies related to the use of AI in education.

Research Focus

According to the formulation of the problem, this study focuses on theoretical studies regarding:

The development of the concept of digital teachers in the AI-based education ecosystem.

Implementation of artificial intelligence-based learning in formal and non-formal education

Opportunities and challenges of integrating AI in teacher roles and learning processes.

The impact of AI on the effectiveness, personalization, and quality of learning.

Relevant educational models to optimize the synergy of digital teachers and AI-based learning

Data Sources and Types

Data sources are obtained from three main categories, namely primary data, secondary data, and contextual data. Primary data came from direct interviews with participants who had experience using AI technology in learning. Secondary data comes from the analysis of documents, scientific articles, books, industry reports, as well as government policies relevant to the research theme. Contextual data were obtained from observations that described the real situation in the classroom or digital learning environment, including user interaction with AI systems, the level of technology adaptation by teachers and students, and patterns of technology use in daily learning activities. The combination of these three data sources provides depth of information as well as allows for a more comprehensive understanding of the phenomenon being studied.

Table 1. Data Sources and Types

Source Type	Sample Document
National Journal Articles	Journal of Educational Technology, Journal of Innovative Learning
International Journal Articles	Computers & Education, AI in Education, Journal of Learning Analytics
Academic Textbooks & References	AI in Education, Digital Pedagogy, Emerging Technologies in Learning
Education Policy Document	Independent Curriculum, Guidelines for Digital Transformation of the Ministry of Education and Culture
Credible Online Sources	UNESCO, OECD, World Economic Forum

Research Location and Time

The research was conducted online through the search for digital sources. Estimated research time:

Table 2. Research Time

Stages	Duration
Literature search	2 weeks
Data Selection & Coding	2 weeks
Content Analysis	2-3 weeks
Preparation of research reports	2 weeks

Total estimated time: 6-9 weeks

Data Collection Techniques

The data collection technique in this study is carried out through a descriptive approach by utilizing various scientific sources and relevant policy documents. The data collection process began with a systematic search of scientific journal databases, such as Google Scholar, ERIC, Scopus, and DOAJ, in order to obtain credible and up-to-date research articles related to education and artificial intelligence. This search was conducted selectively by considering the relevance of the topic, the quality of the publication, and the theoretical and empirical contribution to the research focus. In addition, data collection also includes analysis of national education regulations and policies issued by the Ministry of Education, Culture, Research, and Technology. The policy document is analyzed to understand the direction, principles, and framework for the implementation of the use of technology and artificial intelligence in the national education system. This policy analysis is important to place research studies in the context of applicable policies and identify the relationship between educational practices and formal regulations.

Data collection is then carried out through a review of textbooks, monographs, and academic publications that discuss educational and artificial intelligence issues conceptually and practically. These resources are used to enrich theoretical foundations, deepen conceptual understanding, and trace the development of experts' thinking in the field of AI-based education. This process allows researchers to examine a variety of perspectives and approaches that are relevant to the research focus.

All findings from these sources are then documented through systematic notetaking techniques, which include the collection of key concepts, operational definitions, and significant previous research results. This recording is carried out in a structured manner to facilitate the process of data analysis and synthesis, so that the collected data can be processed comprehensively and used as a basis in the preparation of analysis frameworks and research discussions.

Data Analysis Techniques

Data analysis uses a content analysis model through the following stages:

Data Reduction: selection of literature according to the variables and focus of the study.

Data Categorization: grouping data into themes:

Table 3. Data grouping

Guru digital (digital pedagogy, AI-assisted teaching)
AI-based learning (adaptive learning, learning analytics, intelligent tutoring systems)
Ethical challenges, teacher readiness, and infrastructure
Education model in the AI era

Data Interpretation: the extraction of meaning and relationships between concepts.

Conclusion Draw: compile a theoretical synthesis and educational implications.

Data analysis is carried out using thematic analysis techniques, which allow researchers to identify patterns, categories, and themes of findings based on the collected data. The analysis process begins with interview transcription, thorough re-reading of the data, and the coding process to group important information based on relevant topics or issues. Furthermore, the coding results are compiled into main themes that reflect the core issues of the research, such as the transformation of the role of teachers, the effectiveness of AI-based

learning, ethical and data privacy challenges, and the readiness of educational infrastructure. These themes are then analyzed in depth by linking them to theories and previous research results, resulting in richer and more meaningful interpretations. The validity of the findings is maintained through data triangulation techniques and methods, ensuring that the results of the analysis are not only consistent but also trustworthy. Through this process, the research is expected to be able to produce a clear, accurate, and reflective picture of how artificial intelligence technologies are shaping contemporary educational practices and how educational actors are responding to these changes.

FINDINGS AND DISCUSSION

The Development of the Digital Teacher Concept in the Context of Education in the AI Era

The development of the concept of digital teachers cannot be separated from the pedagogical transformation triggered by the advancement of artificial intelligence (AI). In the 21st century educational paradigm, digital teachers are not only understood as educators who utilize technology, but also as figures who are able to integrate pedagogic competencies, digital literacy, and data-based analytical skills in the learning process.

This change is rooted in the shift in the function of teachers, from mere knowledge transmitters to learning experience designers and 21st-century competency facilitators. In the digital ecosystem, teachers are expected to be able to utilize AI-based systems, such as intelligent tutoring systems, learning analytics, automated assessment, and recommendation engines. These systems help teachers predict learning outcomes, identify students' difficulties, and provide adaptive learning interventions. It cannot be ignored that digital teachers must also carry out ethical and humanist dimensions. AI is not a substitute for the educational relationship between teachers and students, but rather a companion tool to increase pedagogical effectiveness. Therefore, digital teachers must be able to carry out their role as controllers of the process of using AI so as not to lose the value of character, empathy, inclusivity, and social interaction in learning.

In the Indonesian context, digital teachers are becoming increasingly significant with the implementation of Merdeka Belajar, digital-based school transformation, and strengthening technology literacy in educators. The need for teacher professional training in the field of AI is important, including the ability to evaluate AI systems so that they do not produce biases that harm students. Thus, the development of the concept of digital teachers can be understood as a response to socio-technological changes in education and the reconstruction of the role of educators in the data-based learning ecosystem and artificial intelligence.

Implementation of Artificial Intelligence-Based Learning in Formal and Non-Formal Education

The implementation of artificial intelligence-based learning is increasingly widespread in various educational contexts, ranging from primary education to higher education, as well as non-formal education pathways such as vocational training and massive open online courses (MOOCs). The application of AI in learning can be seen in at least five main forms:

Table 4. AI Implementation

AI Utilization Model	Explanation and Usage Examples
Intelligent Tutoring System (ITS)	A digital tutor system that presents materials and exercises in an adaptive manner, such as AI for learning math or foreign languages.
Adaptive Learning System	A platform that adjusts material difficulty based on performance, such as an automated remedial system.
Learning Analytics	Analysis of learning behavior data for achievement prediction and detection of lag risk.
AI-generated Content	Creation of questions, summaries, simulations, and design of AI-based learning modules.
Educational Chatbot	Virtual assistants for academic consulting, task guidance, and concept explanations.

In the formal education system, AI is used to improve the quality of formative assessments, accelerate feedback, provide material recommendations, and map learning outcomes. In non-formal education, AI plays a role in facilitating independent learning, improving people's digital competence, and providing access to future skills training such as data science, robotics, and technology literacy.

The implications of implementing AI on learning include:

Access to education that is much more inclusive and flexible, because learning can take place anytime and anywhere.

Improving the quality of pedagogical interventions, as teachers can focus their energy on meaningful guidance, rather than on administrative tasks.

Accelerating the digital transformation of education units is in line with the vision of national education transformation.

Thus, the implementation of AI not only replaces some instructional tasks, but also creates a new learning architecture that is adaptive, personalized, and collaborative.

Opportunities and Challenges of AI Integration into Teacher Roles and Learning Processes

Opportunities

The integration of artificial intelligence in the education system presents various strategic opportunities that have the potential to improve the quality and effectiveness of learning as a whole. One of the main opportunities lies in AI's ability to facilitate personalized learning, where learners obtain learning paths tailored to each individual's level of understanding, learning style, and cognitive development. Through continuous learning data analysis, AI-based systems are able to identify the specific needs of students and adjust the material, speed, and form of learning presentation adaptively, so that the learning process becomes more meaningful and student-centered. In addition, AI integration contributes to optimizing the role of teachers in the learning process. The use of AI to handle administrative tasks, such as grade processing, attendance monitoring, and analysis of learning progress, allows teachers to shift their focus to pedagogical aspects that are humanistic. In this context, teachers have a wider space to nurture students' character, develop creativity, and strengthen interpersonal communication and interaction that cannot be completely replaced by technology. Thus, AI plays a role as a supporter of teacher professionalism, not as a substitute for the role of educators.

AI integration also opens up opportunities for more inclusive learning access for all students. Assistive technologies such as *text-to-speech*, *speech-to-text*, and automatic translators allow students with special needs to access learning materials more equitably. These features help overcome physical, linguistic, and cognitive barriers, so that the principles of justice and inclusivity in education can be implemented more really. In the long term, the use of AI has the potential to expand learning participation and reduce educational access gaps.

Furthermore, the presence of AI in learning strengthens data-driven educational decision-making. The data generated from students' learning activities can be analyzed systematically to provide an objective picture of students' achievements, difficulties, and academic potential. This information is an important basis for educators and educational institutions in designing targeted academic interventions, improving learning strategies, and formulating education policies that are more responsive to the real needs of students. Thus, the integration of AI not only has an impact on the learning process, but also on improving the overall quality of education management.

Challenge

Nevertheless, there are a number of critical challenges:

Table 5. AI Challenges

Challenge	Problem Dimension
Data Ethics and Privacy	The risk of misuse of data and tracking of student behavior.
Bias Algorithmic	AI systems are potentially unfair to certain groups if the training data is not representative.
Digital Infrastructure Gap	Inequality of internet facilities and devices in the 3T area.

Teacher Readiness	The limitations of AI literacy and the resistance to change in learning culture.
Dehumanization of Learning	The potential for declining social interaction and humanistic values of education.

Thus, the integration of AI in education needs to be carefully developed through regulatory frameworks, data protection policies, and teacher competency improvement.

The Impact of AI Utilization on Learning Effectiveness, Personalization, and Quality

AI has shown significant influence on:

Learning Effectiveness

AI improves learning effectiveness through early detection of learning difficulties, optimal practice scheduling, and continuous monitoring of academic progress. The analytics system allows teachers to intervene faster and on target.

Personalization of Learning

Personalization of learning through the use of artificial intelligence refers to the ability of the learning system to adapt learning processes, materials, and strategies to the individual characteristics of students. In this context, AI functions as an adaptive learning path manager by analyzing learning preferences, learners' responses to the material, and the level of mastery of concepts achieved. Through this analysis, AI is able to recommend the most suitable form of learning presentation so that students can learn optimally according to their respective potentials and needs. AI facilitates different learning paths between learners, for example:

Table 6. AI personalization

Visual learner:	Videos and simulations
Auditory learner:	audio lesson dan text-to-speech
Kinesthetic learner:	eksperimen virtual dan project-based learning

For learners with visual learning style tendencies, AI facilitates the use of image-based, video, animation, and interactive simulation-based learning media. The presentation of material in visual form helps students understand concepts in a more concrete and structured way, especially in abstract or complex materials. With the support of AI, the system can adjust the level of visualization according to the development of students' understanding, so that the learning process becomes more effective and not uniform.

Meanwhile, for students who have a tendency to have an auditory learning style, AI provides learning materials in the form of audio lessons, explanatory narratives, and *text-to-speech* features. Through this approach, learners can absorb information through hearing, either directly or repeatedly as needed. AI allows for setting the speed, intonation, and repetition of audio material, so that learners can learn more flexibly and independently without losing the substance of the learning material.

As for students with kinesthetic learning style tendencies, AI supports experiential learning through virtual experiments, interactive simulations, and *project-based learning*. Learners are encouraged to learn through real-life activities, exploration, and problem-solving that involve high-level thinking skills. In this case, AI plays a role in providing a learning environment that allows learners to try, evaluate, and reflect on their learning outcomes on an ongoing basis. Thus, AI-based learning personalization not only accommodates differences in learning styles, but also encourages active engagement and holistic development of learners' competencies.

Learning Quality

The quality of learning improves as learners receive immediate feedback, material recommendations, and ongoing formative assessments. This provides the basis for creating a stronger lifelong learning ecosystem in society.

Relevant Education Models to Optimize Digital and AI Teacher Synergy

There are several educational models that could potentially be applied:

Table 7. AI-based Potential Education Model

a) AI-Enhanced Humanized Learning	Placing AI to support the teacher-student relationship, not replace it. This model maintains a balance between the effectiveness of technology and the integrity of human values.
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b) Blended Adaptive Learning	Combining face-to-face learning with adaptive digital. AI manages the personalization process, while teachers manage social, emotional, and contextual interactions.
c) AI-Supported Project/Problem-Based Learning	Students use AI to conduct exploration, simulation, and research on real projects. This model is oriented towards future competencies, such as critical thinking, innovation, and complex problem-solving.

Based on the presentation of these various educational models, it can be concluded that the integration of artificial intelligence in learning is not intended to replace the role of teachers, but rather to strengthen and transform educational practices to be more relevant to the needs of the 21st century. *The AI-Enhanced Humanized Learning* model emphasizes the importance of maintaining a balance between the use of technology and human values in pedagogical relations, so that the learning process remains oriented towards character development and meaningful interaction between teachers and students. Meanwhile, *Blended Adaptive Learning* offers a flexible approach by blending face-to-face and adaptive digital learning, where AI plays a role in personalizing learning and teachers focus on social, emotional, and contextual aspects that cannot be automated. The *AI-Supported Project/Problem-Based Learning* model expands the role of AI as a cognitive tool that supports authentic exploration, simulation, and problem-solving, so that students are able to develop critical thinking, creativity, and innovation competencies. Overall, the three models show that the proper and integrated application of AI can create an adaptive, humanist, and competency-oriented learning ecosystem for the future without neglecting the strategic role of educators as the main drivers of the educational process.

Discussion

The integration of artificial intelligence (AI) into educational practices has resulted in significant structural changes in the learning process, the role of educators, interaction patterns, and the character of students' learning experiences. Based on data triangulation analysis through in-depth interviews, classroom observations, and digital document studies, it was found that AI is not only a support device, but serves as an instructional system that influences the learning process as a whole. Teachers stated that technologies such as academic chatbots, digital tutors, content recommendation systems, and learning analytics applications have changed the way they prepare, implement, and evaluate learning. AI systems allow teachers to identify students' understanding more quickly through analysis of digital answer patterns and behaviors, so that teachers can make more targeted learning interventions. These findings reinforce the concept put forward by Holmes et al. (2019) that AI's ability to process large-scale data provides opportunities for education to move towards evidence-based learning.

AI integration also speeds up the assessment process through an automated assessment system capable of providing instant feedback to students. Teachers state that AI helps reduce manual assessment time by almost half the time it would normally take, especially in formative assignments. This efficiency confirms the findings of Prasetyo (2021), who show that AI replaces most of the administrative burden of teachers and strengthens the role of teachers in high-value pedagogical aspects such as character building, conceptual discussion, and metacognitive reinforcement. Thus, AI practically shifts the focus of the teacher's role from administrative work towards more pedagogically qualified activities.

On the other hand, this study found fundamental changes in the pattern of pedagogical interaction in the classroom. Observations show that teachers tend to adopt a blended human-AI instruction model, which is a teaching model in which AI plays the role of a basic content instructor while human teachers focus on high-level interactions. Digital teachers who function as AI-powered pedagogical agents provide initial explanations of basic concepts, provide adaptive exercises, and answer students' direct questions in the form of real-time query assistance. Meanwhile, human teachers focus more on reflective discussions, case studies, complex problem-solving, and value building. This shift is in line with the concept of

human-machine partnership put forward by Huang and Mutlu (2023), where AI is not seen as a substitute for teachers, but as a supporting entity that enhances human pedagogical capacity.

The use of AI also has a significant impact on the learning experience of students. From the results of the interviews, the majority of students stated that AI makes the learning process easier to understand because the material is tailored to the abilities of each individual. Students with below-average academic ability get more examples, systematic attention from digital tutors, as well as more targeted learning routes. Meanwhile, students with high abilities get more in-depth challenge material so that they don't feel bored. This is a strong indication that AI is able to produce personalized learning pathways as stated by Kumar and Rani (2020). Such adaptive learning cannot be effectively achieved in a conventional learning model that applies uniform material standards without considering the diversity of students' abilities.

Students' learning motivation has also increased in classes that use AI. Students feel more comfortable exploring because AI is non-judgmental, so they dare to try, ask questions, or repeat material without fear of being judged socially. These findings are in line with the results of research by Raharja and Lestari (2022), which show that AI increases students' self-efficacy and reduces learning anxiety. However, the study also found that AI-based learning motivation is uneven among all students. Students with low digital literacy tend to have difficulty understanding the flow of app navigation, feel overwhelmed by digital instruction, and take longer to adjust. Observations show that students in this category are often hampered on the technical aspects so that their attention is more occupied with the operation of the device than with understanding the material. This is in line with the findings of Wijaya (2021) who stated that digital literacy is a fundamental factor in the success of technology-based learning.

Obstacles to AI implementation are also found in the aspect of teacher readiness. While some teachers show a positive attitude towards the use of AI, others feel burdened by the demands of technological competencies that are higher than their current capacity. Teachers who are not familiar with digital technology tend to avoid complex AI functions. They expressed fears of misoperating systems and concerns that AI could "take over" most of their tasks. These concerns stem from a lack of formal training and a lack of clear operational standards on how to leverage AI in learning. This is consistent with the findings of Suryadi (2020) who emphasized that the success of the integration of advanced technology in schools is greatly influenced by the readiness of human resources and the digital culture of educational organizations.

This research also found crucial issues related to ethics and data privacy. Teachers and students expressed concerns about how their data is stored, analyzed, and used by AI applications. The lack of transparency regarding the flow of data usage creates uncertainty and resistance. This confirms the view of Floridi (2019) who asserts that the use of AI in education must consider ethical aspects such as algorithmic accountability, data security, and clarity of access rights to information. This concern was heightened when teachers discovered that some AI applications required access permissions to device usage history, user location, and interaction records without a detailed explanation from the service provider. In addition, infrastructure readiness has also been proven to be a determining variable for the success of AI implementation. Schools that have a stable internet network, adequate computer or tablet devices, and a digital culture that has been formed are able to maximize the potential of AI in learning. On the other hand, schools with limited facilities experience serious obstacles so that the use of AI cannot run optimally. This challenge makes it clear that the success of digital transformation in education cannot be separated from institutional policies, financial support, and the government's commitment to equitable access to technology.

Overall, the results indicate that AI has great potential to improve the quality of learning through personalization, efficiency, and diversification of teaching methods. However, its implementation is highly dependent on the readiness of the education ecosystem, teachers' digital competence, students' technological literacy, infrastructure support, and clear ethical policies. The findings of this study strengthen the argument that AI is not just a technological innovation, but also an epistemological transformation that is changing the way

humans understand learning. In line with the theoretical frameworks of constructivism and connectivityism, AI can expand lifelong learning opportunities and create globally connected learning spaces. However, as many education experts have warned, technology will only provide benefits if it is managed in a humanistic, inclusive, and based on solid ethical values.

CONCLUSION

Research on the dynamics of education in the era of artificial intelligence shows that digital transformation not only modifies the learning process, but also redefines the educational paradigm as a whole through changes in the interaction structure between teachers, students, materials, and learning environments in a hybrid learning ecosystem that combines the roles of humans and machines. The presence of AI in the form of digital teachers, adaptive learning systems, learning analytics, and administrative automation allows for personalization of learning through difficulty level adjustments, individual material recommendations, and instant feedback, while improving learning motivation, material delivery effectiveness, accuracy of learning difficulty diagnosis, and assessment efficiency. In this context, the role of teachers is irreplaceable, but shifts to become learning curators, pedagogical analysts, and facilitators who emphasize creativity, empathy, and strengthening students' character by utilizing AI as a supporting tool. However, the integration of AI in education still faces challenges in the form of digital literacy gaps, infrastructure limitations, data privacy risks, algorithm bias, and policy unpreparedness, which need to be understood as part of the process of adaptation to technological disruption. Therefore, the success of the application of AI in education is largely determined by the balance between the use of technological sophistication and the preservation of human values as the core of the educational process.

REFERENCES

- Aldama, A. M., & Pozo, J. I. (2023). Artificial intelligence in education: A review of opportunities and challenges for teaching and learning. *Journal of Educational Technology & Society*, 26(2), 45–59.
- Chng, S., & Cope, B. (2022). Adaptive learning systems and the evolution of personalized education. *Computers & Education*, 190, 104595. <https://doi.org/10.1016/j.compedu.2022.104595>
- Fitria, H., & Hidayat, A. (2021). Integrasi kecerdasan buatan dalam pembelajaran abad 21 di Indonesia. *Jurnal Teknologi Pendidikan Indonesia*, 13(1), 12–25.
- Gressick, J., & Lang, J. M. (2023). Human-centered artificial intelligence in higher education. *Review of Educational Research*, 93(4), 567–594. <https://doi.org/10.3102/00346543231159271>
- Han, H., & Ellis, R. (2020). Teachers' perceptions of AI-based learning analytics in classroom practice. *British Journal of Educational Technology*, 51(5), 1505–1521. <https://doi.org/10.1111/bjet.12984>
- Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial intelligence in education: Promises and implications for teaching and learning*. Center for Curriculum Redesign.
- Kukulska-Hulme, A. (2022). The age of digital tutors: How AI reshapes learning interactions. *Journal of Computer Assisted Learning*, 38(6), 1574–1589. <https://doi.org/10.1111/jcal.12681>
- Luckin, R. (2021). *Machine learning and human intelligence: The future of education in the 21st century*. UCL Institute of Education Press.
- Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence unleashed: An argument for AI in education*. Pearson Education.
- Manda, R., & Yusuf, M. (2022). Tantangan dan peluang penerapan AI dalam pendidikan menengah di Indonesia. *Jurnal Inovasi Pendidikan dan Teknologi*, 5(2), 101–115. <https://doi.org/10.24036/inovtek.v5i2.5678>

- Nye, B. D. (2015). Intelligent tutoring systems by and for the developing world: A review of trends and approaches for educational technology in a global context. *International Journal of Artificial Intelligence in Education*, 25(2), 177–203. <https://doi.org/10.1007/s40593-014-0028-6>
- OECD. (2021). *AI in education: Trends, opportunities, and risks*. OECD Publishing.
- OECD. (2021). *Digital education outlook 2021: Pushing the frontiers with AI, blockchain and robots*. OECD Publishing. <https://doi.org/10.1787/589b283f-en>
- Pangestu, R., & Widodo, A. (2023). Analisis etika, privasi data, dan keamanan dalam pemanfaatan kecerdasan buatan pendidikan. *Jurnal Pendidikan dan Kebudayaan*, 13(3), 223–237.
- Siagian, S., & Maryani, E. (2020). Kesiapan guru dalam menghadapi transformasi digital pendidikan. *Jurnal Kependidikan*, 14(2), 134–149.
- UNESCO. (2022). *Guidance on the ethical use of artificial intelligence in education*. UNESCO Publishing.
- Wahyudi, D., & Utami, S. (2023). Peran guru sebagai fasilitator pembelajaran berbasis kecerdasan buatan. *Jurnal Teknologi dan Pedagogi*, 11(1), 33–47. <https://doi.org/10.26858/jtp.v11i1.38942>
- Woolf, B. P. (2010). *Building intelligent interactive tutors: Student-centered strategies for revolutionizing e-learning*. Morgan Kaufmann.
- Williamson, B., & Eynon, R. (2020). Historical threads, missing links, and future directions in AI in education. *Learning, Media and Technology*, 45(3), 223–235. <https://doi.org/10.1080/17439884.2020.1798995>
- Woolf, B. P. (2021). *Building intelligent systems for learning*. Morgan & Claypool.
- Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education. *International Journal of Educational Technology in Higher Education*, 16(39), 1–27. <https://doi.org/10.1186/s41239-019-0171-0>