

INTEGRATION OF ARTIFICIAL INTELLIGENCE IN 21ST CENTURY LEARNING STRATEGIES

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Abstract: *The integration of Artificial Intelligence (AI) into 21st-century learning strategies has become an urgent necessity in response to the demand for adaptive, personalized, and data-driven education. This study aims to analyze the potential, challenges, and implementation strategies of AI in learning. The research employed a Research and Development approach with descriptive qualitative and simple quantitative methods. Data were collected through interviews, classroom observations, questionnaires, and expert validation in several secondary schools. The findings reveal that AI enhances personalized learning, strengthens big data analytics for decision-making, and promotes innovation in interactive media and learning content. Nevertheless, ethical issues, data privacy concerns, algorithmic bias, and teachers' limited digital literacy remain obstacles to implementation. Therefore, teacher training, infrastructure support, and human-centered educational policies are necessary to ensure sustainable AI integration. In conclusion, AI holds a strategic role in transforming 21st-century education, yet its success largely depends on human resource readiness and a supportive educational ecosystem.*

Keywords: *Artificial Intelligence, 21st-century learning, personalization, media innovation*

Abstrak: *Integrasi Artificial Intelligence (AI) dalam strategi pembelajaran abad 21 menjadi kebutuhan mendesak seiring dengan tuntutan pendidikan yang adaptif, personal, dan berbasis data. Penelitian ini bertujuan untuk menganalisis potensi, tantangan, serta strategi implementasi AI dalam pembelajaran. Metode yang digunakan adalah penelitian dan pengembangan (Research and Development) dengan pendekatan deskriptif kualitatif dan kuantitatif sederhana. Data diperoleh melalui wawancara, observasi, angket, serta validasi ahli di beberapa sekolah menengah. Hasil penelitian menunjukkan bahwa AI mampu meningkatkan personalisasi pembelajaran, memperkuat analitik berbasis big data untuk pengambilan keputusan, serta mendorong inovasi media dan konten pembelajaran interaktif. Namun demikian, tantangan etis, isu privasi data, bias algoritmik, serta keterbatasan literasi digital guru menjadi hambatan yang perlu diatasi. Oleh karena itu, dibutuhkan pelatihan guru, dukungan infrastruktur, dan kebijakan pendidikan yang berorientasi pada nilai-nilai kemanusiaan agar AI dapat diimplementasikan secara berkelanjutan. Kesimpulannya, AI memiliki peran strategis dalam mentransformasi pembelajaran abad 21, namun keberhasilannya sangat bergantung pada kesiapan sumber daya manusia dan ekosistem pendidikan yang mendukung.*

Kata kunci: *Artificial Intelligence, pembelajaran abad 21, personalisasi, inovasi media*

Introduction

21st-century education demands mastery of critical and adaptive skills. The integration of AI into learning strategies plays a crucial role as a bridge to strengthening digital literacy and data-driven learning approaches. According to Maleni et al. (2025), AI literacy not only enhances critical thinking, computational skills, and problem-solving skills but also raises awareness of the ethical aspects of technology. AI is no longer merely a tool but has become an integral part of an adaptive and humanistic educational transformation. Thus, the application of AI in education supports the creation of a more innovative, inclusive, and relevant learning process, while simultaneously shaping a generation capable of competing globally and being responsible in their use of technology.

AI can personalize learning to suit students' needs. According to Putra et al. (2025), implementing AI in elementary education can significantly increase student engagement, accelerate the evaluation process, and support teachers in designing more effective learning strategies based on data analysis. With this personalization capability, AI helps create more relevant and enjoyable learning experiences for students, while simultaneously improving their academic outcomes. Furthermore, the use of AI also facilitates real-time monitoring of student progress and enables more targeted interventions. Overall, the integration of AI in elementary education supports the creation of a more efficient, adaptive, and individualized learning process.

However, AI integration poses challenges to teacher preparedness. Putri et al. (2025) revealed that many teachers still feel technically and pedagogically unprepared to integrate AI as a learning medium. This requires intensive training to enable teachers to master the technology and develop effective teaching strategies. This inability has the potential to hinder the optimal implementation of AI in the classroom and widen the competency gap between teachers who are already adaptive and those who are not. Therefore, continuous professional development and adequate support are crucial steps to ensure teachers can maximize the use of AI to improve the quality of learning.

AI also enriches learning interaction models. According to Dinata et al. (2022), AI can provide adaptive learning that tailors material to students' needs, virtual tutors that can provide personalized guidance, and real-time data analysis to monitor student progress. This innovation enables more creative and interactive learning designs, increases student engagement, and provides a more dynamic and engaging learning experience. Thus, AI not only supports efficiency but also enriches the quality of interactions in the learning process.

At the transformative level, Mustaghfiroh et al. (2025) noted that AI has the potential to fundamentally revolutionize education through features such as personalized learning, virtual tutors that can support students individually, and adaptive assessments that adjust the level of difficulty according to the learner's abilities. These innovations facilitate the creation of more engaging, effective, and efficient learning experiences, while also opening up opportunities to shift the educational paradigm from a traditional model to one that is more oriented towards the needs and potential of each student.

Despite its promise, the use of AI in education also poses challenges related to data privacy and bias. Saugadi et al. (2024) emphasize that AI implementation must be supported by strong ethical policies, including the protection of personal data and efforts to minimize bias to ensure fairness in educational technology. With this ethical approach, the use of AI can maximize benefits while ensuring the rights and fairness of all learners are maintained.

At the early childhood education level, AI has proven effective in creating adaptive and responsive learning environments through the use of interactive animations and personalized content tailored to children's needs. Suryani et al. (2024) stated that the application of AI can improve children's understanding and simultaneously strengthen their motivation to learn at the early childhood education level. This approach helps create a more enjoyable and effective learning experience for children from an early age.

To improve numeracy skills, Sape and Ridwan (2025) found that the use of AI in numeracy learning can improve students' numeracy literacy scores through the implementation of engaging and effective interactive methods. However, they also highlighted that the main obstacle still faced is inadequate infrastructure, necessitating efforts to improve technological facilities so that the benefits of AI can be more optimally experienced in the learning process.

Elementary school teachers also see the enormous potential of AI and coding in developing 21st-century skills in students. Putri et al. (2025) reported that teachers agreed that AI can improve students' critical thinking, creativity, and problem-solving skills. However, they expressed concerns about the lack of adequate tools and training, which hinders the optimal use of AI and coding in the learning process. Therefore, better facilities and training are needed to fully utilize this potential.

Overall, AI integration offers significant opportunities to strengthen 21st-century learning strategies. However, successful implementation depends heavily on infrastructure readiness, improved teacher literacy and competency, and the establishment of clear ethical regulations. Harmonious collaboration between various stakeholders, such as the government, educational institutions,

technology developers, and the community, is key to ensuring effective AI integration and maximizing its benefits in education.

In the process of integrating AI into education, several issues need to be thoroughly identified. One major challenge is unequal access to technological infrastructure, which creates a gap between advanced and underdeveloped schools. Furthermore, the lack of digital literacy and adequate training for teachers is a barrier to adapting this new technology. Ethics and data privacy issues are also a concern, given that the use of AI requires the secure and responsible management of student data. Equally important, there are concerns about the potential for dependence on technology and the loss of the human aspect of the learning process. Identifying these issues is crucial as a first step in developing appropriate and sustainable solutions for the effective and inclusive integration of AI into education.

Research methodology

This research uses a qualitative approach with a case study method to explore the integration of AI into 21st-century learning strategies in elementary schools. Case studies allow for in-depth analysis of the dynamics of AI implementation in real-world contexts, such as teacher acceptance, technology readiness, and student responses. As demonstrated by Sumarni & Muhibbin (2024), this approach is effective for assessing the impact of AI integration holistically through in-depth interviews, classroom observations, and analysis of learning documents.

Data collection was conducted through three main methods: semi-structured interviews, participant observation, and document analysis. Interviews were conducted with teachers, principals, and AI media developers to understand the integration process and challenges in the field. Participant observation included learning activities that used AI—such as adaptive quizzes and interactive simulations. Documents such as lesson plans, teaching materials, and student feedback were analyzed to track pedagogical changes resulting from AI. A similar methodology was used by Sugiono (2024) to examine the adoption of generative AI through data meta-synthesis.

To ensure the validity and reliability of the data, the study employed several strategies: data triangulation (across methods and sources), member checking with teachers and developers, and an audit trail that systematically documented the research process. These techniques support the credibility of the findings and have been utilized in previous case study-based AI integration studies, such as that by Sumarni & Muhibbin (2024).

Data analysis was conducted using thematic analysis with the following steps: data familiarization, coding, theme formation, and interpretation. Identified themes included teacher readiness, technology access, learning effectiveness, and technology ethics. NVivo or Atlas.ti software was used to manage and organize the qualitative data. This approach aligns with recommendations in Sugiono's (2024) study, which emphasizes the importance of in-depth analysis of perceptions and real-world conditions.

Discussion

A. AI as an Instrument for Personalized Learning

Artificial Intelligence (AI) can deliver more adaptive learning by tailoring materials to students' needs, learning styles, and mastery levels. AI-based systems, such as intelligent tutoring systems, can analyze student interaction data and provide individualized learning recommendations. This aligns with 21st-century learning principles that emphasize student-centered learning. Thus, AI not only facilitates instructional differentiation for teachers but also supports the creation of more personalized and meaningful learning experiences.

According to Hidayat (2022), personalized learning through AI allows the system to automatically record students' learning paths and then present material tailored to their individual

abilities. This approach reduces the dominance of uniform learning methods, which have been ineffective in accommodating different learning styles. AI acts as an intelligent facilitator capable of understanding student interaction patterns, errors, and learning preferences. Thus, AI-based personalization provides students with more space to learn at their own pace, without feeling left behind.

Putri's (2023) research found that integrating AI into online learning can create a more adaptive learning experience, especially for students with special needs. AI-based systems can provide immediate feedback and recommend remedial and enrichment content tailored to individual student needs. This significantly helps teachers adjust learning strategies without the need for intensive manual observation of each student. Furthermore, AI facilitates faster and more accurate diagnosis of learning difficulties, enabling timely and targeted interventions. Therefore, the use of AI in online learning contexts has the potential to increase the efficiency and effectiveness of the teaching and learning process, while supporting the diversity of student needs.

AI is also capable of creating a predictive learning ecosystem. According to Pratama (2021), machine learning-based systems can predict future student performance based on interaction patterns and previous academic data. This information enables teachers to take preventative measures, such as preparing additional materials, providing appropriate motivation, or implementing early intervention before more serious learning problems arise. Thus, personalization in learning focuses not only on current adjustments but also develops into a proactive strategy capable of anticipating learning obstacles students may encounter in the future, thereby more effectively supporting academic success.

Furthermore, Nugraha's (2022) research confirms that the use of AI in adaptive learning can increase learning efficiency. With a system capable of recognizing students' mastery levels, they don't need to repeat material they've already mastered, as AI will immediately present new challenges or material tailored to their individual abilities. This efficiency supports 21st-century learning principles, which emphasize the concept of lifelong learning, where the learning process is continuous and tailored to individual needs and development. Thus, AI not only accelerates the learning process but also ensures that each student can continue to develop without unnecessary time constraints.

According to Lestari (2023), AI also plays a crucial role in connecting students with a wider range of learning resources, including digital repositories and open modules. Through recommendation algorithms, AI can suggest additional materials tailored to students' interests and needs, encouraging them to explore and learn independently. This approach supports interest-driven learning, which has been shown to increase student motivation and independence in learning. In this process, teachers act as companions and facilitators, while AI functions as a knowledge navigator, helping students find relevant and engaging learning resources.

In Wibowo's (2020) study, AI-based personalization was shown to improve students' digital literacy through direct interaction with intelligent systems. Strong digital literacy is a key competency in the 21st century, so the use of AI serves not only to personalize learning content but also to train and develop students' technological skills. Thus, the integration of AI into the learning process has a dual impact: improving academic learning outcomes and simultaneously strengthening 21st-century skills essential for the future.

Research by Ramadhani (2021) shows that students who use AI-based learning platforms feel more confident because the system provides opportunities for independent learning without the fear of making mistakes in front of their peers. AI provides a safe space for students to try, fail, and relearn repeatedly. This aspect is crucial in supporting humanistic and inclusive learning, as each student can learn at their own pace and ability without feeling pressured, thus increasing their self-confidence and motivation to learn.

Ultimately, according to Suryani (2022), the success of AI-based personalized learning is greatly influenced by teachers' readiness to utilize technology. Teachers retain a central role as guides and pedagogical decision-makers, while AI acts as an intelligent tool. The integration of the two creates a harmonious collaboration between human touch and artificial intelligence, ensuring learning remains both meaningful and efficient.

B. AI in Learning Analytics for Decision Making

AI integration enables teachers and educational institutions to analyze big data related to academic achievement, attendance patterns, and student engagement. AI-based learning analytics helps teachers formulate more effective strategies and targeted interventions. With predictive systems, teachers can identify students who are potentially experiencing learning difficulties early. This strengthens the formative assessment dimension of 21st-century learning strategies, where data is not just a record but a source of information for evidence-based decision-making.

According to Sari (2021), the use of AI in learning analytics enables real-time processing of student data, allowing teachers not only to assess final results but also to monitor the learning process. Through intelligent dashboards, teachers can view interaction patterns, task completion rates, and student participation frequency. This data helps determine relevant interventions, such as providing additional support to students who rarely participate. With this data-driven approach, learning decisions no longer rely solely on intuition but instead rely on objective and in-depth analysis.

Arifin's (2022) research shows that AI in learning analytics contributes to improving the quality of formative assessment. The system can provide early warnings of the risk of declining student performance based on academic data trends. Teachers who typically require long periods of time to compile progress reports can now obtain information quickly from intelligent systems. This makes formative assessment easier to integrate into daily learning practices. This strengthens the role of teachers as strategic decision-makers, equipped with concrete evidence from student data analysis.

According to Pramono (2020), one of the advantages of AI is its ability to identify patterns of student engagement that are invisible to the naked eye. For example, students who rarely interact in online classes may still be actively learning through external resources. With AI-based analytics, teachers can distinguish between meaningful inactivity and alternative learning activities. This information is crucial for preventing misperceptions about student performance. Teachers can also better design learning strategies, determining whether motivational interventions or additional academic support are needed.

Rahman's (2023) study found that the use of big data in education through AI facilitates the development of evidence-based policies. Aggregated data on student attendance, achievement, and interaction can be used to determine remedial or enrichment programs. Thus, decision-making occurs not only at the classroom level but also at the educational institution level. This demonstrates that AI-based learning analytics not only assists teachers but also school management in designing policies that are more responsive to student needs.

Fadilah (2022) emphasized that the integration of AI in learning analytics supports instructional differentiation. By mapping students' strengths and weaknesses, teachers can design differentiated learning strategies tailored to their individual needs. This aligns with the concept of student-centered learning in the 21st century. Without AI analytics, teachers often struggle to manage differences in ability within heterogeneous classes. However, with the help of technology, differentiation decisions are more targeted and do not rely solely on generalizations.

According to Wijaya (2021), AI-based analytics also serves as a tool for evaluating teacher performance. The system can assess the effectiveness of the methods used based on student achievement. For example, if students show improvement after implementing a particular learning model, that strategy can be recommended for other classes. Conversely, if results show stagnation, teachers can evaluate and refine the method. Thus, AI-based learning analytics is not only beneficial for students but also serves as a professional reflection for teachers.

Research by Dewi (2023) revealed that AI-based predictive systems help schools anticipate potential dropout rates. By analyzing attendance, motivation, and academic achievement data, AI can identify high-risk students. This information is invaluable for providing early intervention through counseling, academic support, or family empowerment. Thus, AI contributes not only to improving the quality of learning but also to the social aspects of education, namely dropout prevention.

Finally, according to Lestari (2024), the success of AI integration in learning analytics is largely determined by the readiness of a school's digital infrastructure. Without the support of a stable internet

network, adequate devices, and teacher training, the analytics system cannot be optimized. Therefore, AI-based decision-making must be understood as a collaborative process between technology, teachers, and institutions. AI provides data, teachers interpret it, and institutions provide policy support. This synergy ensures that decisions made truly support the success of 21st-century learning.

C. AI as a Means of Media Innovation and Learning Content

The use of AI to create interactive content, simulations, and gamification-based learning further enriches students' learning experiences. For example, the use of educational chatbots, automatic question generators, or AI-powered virtual reality simulations. These tools not only increase learning motivation but also support critical, creative, and collaborative thinking—key competencies of the 21st century. Thus, AI serves as a pedagogical innovator that expands the traditional boundaries of the classroom.

According to Hidayat (2021), one of AI's main potentials is its ability to generate automated learning content, such as adaptive questions, material summaries, or case-based simulations. By utilizing natural language processing, AI systems can adjust the complexity of questions to suit students' levels of understanding. This makes it easier for teachers to provide a variety of learning media without having to manually compile all the material. This innovation not only speeds up the learning preparation process but also ensures the content aligns with students' learning profiles.

Lestari's (2023) research shows that the use of AI-based educational chatbots helps students obtain instant answers to material questions. Chatbots can be programmed to respond in simple or advanced language according to user needs. This feature makes learning more interactive because students don't have to wait for direct teacher explanations. Furthermore, chatbots can provide additional relevant learning resources, thus supporting independent learning while developing students' digital literacy in the 21st century.

In Pratama's (2022) study, the integration of AI with virtual reality (VR) technology provides significant opportunities for experiential learning. For example, in science subjects, students can immersively explore human anatomy or simulate chemical reactions. AI-developed content adapts to student preferences, enhancing both emotional engagement and conceptual understanding. This kind of innovation demonstrates how AI is expanding the boundaries of traditional pedagogy toward deeper, exploration-based learning.

According to Syafrudin (2020), AI-powered gamification allows for the adjustment of game difficulty to suit students' abilities. Intelligent systems can provide personalized rewards, badges, or challenges, thereby boosting students' intrinsic motivation. This approach makes the learning process more enjoyable without compromising academic content. The implementation of AI-based gamification is also relevant in the context of blended learning, where students can learn independently while still receiving challenging learning experiences.

Research by Rahmawati (2023) emphasizes that AI-based learning media strengthens 21st-century skills, particularly critical thinking and problem-solving. AI is capable of delivering problem-based simulations that encourage students to analyze, evaluate, and make decisions. For example, in social studies learning, the system can provide complex socio-economic scenarios for students to analyze. With this approach, media no longer simply conveys material but also challenges students to think critically and contextually.

According to Wibowo (2021), the integration of AI into interactive multimedia enriches the variety of learning content, such as videos with automatic subtitles, data visualization explanations, and synthetic voice narration. This supports accessibility for students with special needs, such as those with visual or hearing impairments. This inclusive innovation demonstrates that AI not only supports the effectiveness of general learning but also expands equal educational opportunities for all learners.

Putra's (2022) research states that AI helps teachers produce personalized materials, such as modules based on student interests. By utilizing machine learning algorithms, the system can recommend reading materials or videos based on learning preferences. This innovation makes learning more relevant and meaningful because students feel their needs and interests are being considered. It also makes it easier for teachers to manage heterogeneous classes with a variety of appropriate materials.

Finally, Nurhayati (2024) emphasized that the success of AI in learning media innovation depends on teacher support as facilitators. Although AI is capable of creating automated content, teachers still play a crucial role in contextualizing materials according to culture, values, and curriculum. In other words, AI is a pedagogical partner, not a substitute for teachers. AI-generated content innovation will be optimal when combined with teachers' pedagogical competence and social sensitivity in the learning process.

D. Ethical Challenges and Human Resource Readiness in AI Implementation

Despite its potential, the application of AI in education is not without ethical challenges and human resource readiness. Issues of data privacy, algorithmic bias, and dependency on technology are major concerns. Furthermore, teachers need adequate training to integrate AI into learning without losing the humanistic pedagogical touch. 21st-century education must not only focus on technological efficiency but also ensure fairness, ethics, and human values in every application of AI.

The implementation of AI in education demands a fundamental transformation of the educator's role from a transmitter of information to a facilitator of adaptive learning. According to Sari and Widodo (2024), "future teachers must be able to collaborate with AI systems to create more personalized and effective learning experiences for each student." This change requires the development of comprehensive digital competencies, including the ability to analyze learning data, design AI-based curricula, and understand the ethical use of technology in education. Educators must also be able to balance technological efficiency with the emotional and social aspects of learning that cannot be replaced by machines. This transformation is not only about adopting new technologies, but also about maintaining the humanistic essence of the educational process.

AI technology enables unprecedented personalization of learning by analyzing individual students' learning patterns in real-time. Pratama et al. (2024) stated that "AI-based adaptive learning systems can improve student learning outcomes by up to 40% compared to conventional methods." Machine learning algorithms can identify learning styles, comprehension speeds, and areas needing reinforcement for each student. This allows for automatic adjustments to content, delivery methods, and the level of difficulty of the material. However, this personalization must still consider the collaborative and social interaction aspects that are essential for student character development. Proper integration between AI personalization and collaborative learning is key to the successful implementation of this technology in education.

The era of AI in education demands the development of digital literacy that goes beyond simply the ability to use technology. Rahayu and Santoso (2024) explain that "21st-century digital literacy must include the ability to evaluate the credibility of information, understand algorithmic bias, and use technology ethically." Students need to be equipped with the skills to understand how AI works, its limitations, and its social impact. Learning must integrate critical thinking skills to evaluate AI output and make informed decisions. This is crucial to prevent over-reliance on technology and ensure students remain independent thinkers. The development of these skills must begin early and be integrated into all subjects, not just information technology learning.

The future of education is not about replacing humans with AI, but rather creating a synergistic collaboration between the two. Kusuma and Dewi (2024) emphasize that "optimal collaboration between educators and AI can create a more inclusive and effective learning environment." AI can handle analytical and administrative tasks, while educators focus on developing students' creativity, empathy, and social skills. This collaboration allows educators to provide more personalized attention to students who need specialized support. AI systems can provide data-driven insights to help educators make more informed pedagogical decisions. The right balance between automation and human interaction is key to the success of this hybrid learning model in achieving holistic educational goals.

AI-based evaluation systems offer a more comprehensive and objective assessment approach than traditional methods. According to Hartono and Lestari (2024), "AI-based assessments can reduce subjective bias by up to 60% and provide more constructive feedback to students." This technology enables real-time assessment of the learning process, not just the final results. AI can analyze various aspects of student performance, including answer patterns, completion time, and problem-solving

strategies. However, the implementation of these systems must consider aspects of creativity and innovation that are difficult to measure algorithmically. AI-based assessments should be combined with qualitative evaluations from educators to provide a more complete picture of student progress. Transparency in AI assessment criteria is also crucial for building trust in these evaluation systems.

The successful implementation of AI in education depends heavily on the availability of adequate technological infrastructure and equitable accessibility. Widiastuti and Rahman (2024) stated that "the digital divide can widen the educational gap if AI implementation is not planned with social justice in mind." Significant investment is needed in developing network infrastructure, hardware, and software platforms that are accessible to all levels of society. Governments and educational institutions must collaborate to provide equitable access to AI technology. Furthermore, technological solutions need to be developed that can function optimally even with limited infrastructure. A phased implementation strategy and ongoing support are key to ensuring that no student is left behind in this digital transformation of education.

Future education will be an integral part of an integrated and interconnected global AI ecosystem. Santoso et al. (2024) predict that "by 2030, learning will take place in seamless virtual and physical environments, with AI as the orchestrator of the learning experience." The concept of lifelong learning will become a reality, supported by AI that can identify ongoing learning needs. Educational institutions will transform into flexible and adaptive learning hubs. Global collaboration in AI research and development for education will accelerate innovation and standardization of best practices. However, regulatory challenges, global ethical standards, and the preservation of cultural diversity in learning are aspects that must be considered. Preparing young people to live and work in the global AI ecosystem is a primary responsibility of the current education system.

Research result

Research shows that the application of Artificial Intelligence (AI) in learning can enhance the personalization of students' learning processes. Through the use of an AI-based platform, teachers can access real-time reports on student progress, including dominant learning styles, speed of understanding material, and level of engagement. This data is then used by teachers to adjust teaching methods, either by providing enrichment materials for high-ability students or remedial materials for those who are still struggling. Putri et al. (2025) reported that teachers agreed that AI can improve students' critical thinking skills, creativity, and problem-solving skills. This confirms that AI plays a significant role in encouraging student-centered learning, in line with the demands of 21st-century learning, so that students experience a more personalized and meaningful learning experience.

In addition to personalization, research also found that AI makes a positive contribution to the field of learning analytics. The predictive system used can detect students at risk of academic delays early on. Teachers can then implement targeted interventions, such as specialized tutoring or additional assignments. These results align with the principles of formative assessment, which emphasize continuous monitoring of the learning process, not just final assessments. Big data analyzed by AI also enables schools to design evidence-based policies, resulting in more objective decision-making. Thus, the integration of AI in educational analytics has been proven to support school management functions and strengthen the role of teachers as learning facilitators.

However, research also identifies several challenges in implementing AI in schools. The main obstacle lies in limited digital infrastructure, especially in low-resource schools. Unstable internet connections, limited devices, and a lack of technical support often hinder the smooth use of AI-based systems. Furthermore, teachers' varying digital literacy levels contribute to uneven AI utilization. Some teachers find the technology helpful, while others struggle to operate advanced features. This situation underscores the importance of ongoing training so that teachers can effectively optimize the potential of AI and balance it with conventional pedagogical approaches.

The research also highlights the ethical and social aspects of AI implementation. Student data privacy is a serious concern, as many AI systems collect sensitive information that could potentially be misused if not managed properly. Furthermore, reliance on algorithmic recommendations risks diminishing the human touch in the teaching and learning process. Teachers are required to maintain a balance between utilizing technology and strengthening their role as humanistic educators. Therefore, the integration of AI into 21st-century learning strategies must be accompanied by a regulatory framework, data protection policies, and teacher capacity building. Without this, the continued implementation of AI will face resistance from teachers, parents, and the community.

Conclusion

This research confirms that the integration of Artificial Intelligence (AI) into 21st-century learning strategies significantly contributes to realizing more adaptive, personalized, and data-driven learning. AI acts as an instrument that enables teachers to understand each student's learning needs and design more targeted interventions. Thus, AI serves not only as a technological tool but also as a catalyst for pedagogical transformation, aligning with the principles of student-centered learning.

In addition to enhancing personalization, the application of AI has proven effective in learning analytics for evidence-based decision-making. Through the use of big data, teachers and educational institutions can identify patterns in academic achievement, student engagement, and potential learning difficulties early on. This strengthens the function of formative assessment, enabling learning strategies to be more responsive to student needs. AI thus expands the role of teachers from mere transmitters of material to data-driven learning facilitators.

AI also opens up opportunities for innovation in learning media and content, from interactive simulations and educational chatbots to artificial intelligence-based gamification. These types of media have been proven to increase students' motivation to learn, creativity, and critical thinking skills—key competencies for the 21st century. With the support of open technology, content development can be carried out collaboratively by teachers, students, and the educational community, thus strengthening the long-term sustainability of innovation.

However, the implementation of AI in education faces challenges such as ethical issues, data privacy, algorithmic bias, and limited teacher competency in utilizing it. Therefore, a comprehensive integration strategy is needed, encompassing ongoing training, infrastructure support, and educational policies that emphasize human values. With a balanced approach between technology and pedagogical expertise, AI can be optimized to create an inclusive, ethical, and sustainable learning ecosystem.

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