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Artificial intelligence applications for improving educational quality in elementary schools: A systematic literature review

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ABSTRACT

Elementary school education plays a fundamental role in developing students' basic skills and competencies, yet it continues to face increasing challenges related to diverse learner needs, instructional quality, and the growing demands of digital transformation. In this context, the rapid advancement of artificial intelligence (AI) offers promising opportunities to enhance learning quality through personalized instruction, adaptive learning systems, and improved instructional efficiency. This study aims to examine the use of artificial intelligence in improving the quality of education at the elementary school level and to analyze its implications for both teachers and students. This study employed a systematic literature review (SLR) approach by analyzing relevant studies published between 2020 and 2025 and retrieved from Google Scholar. A structured screening and selection process was conducted based on predefined inclusion and exclusion criteria, resulting in ten studies selected for in-depth analysis. The selected articles were analyzed using qualitative content analysis to identify patterns related to AI implementation, pedagogical impacts, and challenges in elementary education contexts. The findings indicate that AI in elementary education is predominantly utilized as a pedagogical support tool rather than as a substitute for teachers. The integration of AI contributes to improvements in students' cognitive understanding, learning motivation, engagement, and instructional differentiation. Additionally, AI supports teachers by providing rapid feedback, enhancing instructional efficiency, and assisting in the delivery of complex learning materials. However, the impacts reported in the reviewed studies tend to be incremental and short-term, with limited empirical evidence demonstrating long-term or transformational effects on learning outcomes. Furthermore, the successful implementation of AI is strongly influenced by teacher readiness, pedagogical competence, and institutional support. Issues related to AI literacy, ethical considerations, and human–AI interaction at the elementary school level remain insufficiently explored. This study concludes that while AI holds significant potential to improve the quality of elementary education, its sustainable and meaningful integration requires strengthened teacher capacity, supportive institutional frameworks, and further research employing longitudinal and experimental designs.

INTRODUCTION

Elementary school education is a very important foundation for students in the education system. At this stage, students learn various skills such as reading, writing, speaking, and arithmetic. Teachers play a vital role in guiding, directing, and supporting students throughout their development in elementary school. However, there are numerous challenges that must be

addressed during the learning process, such as improving human resources, varying teaching quality, and individual differences among students. Technological developments are accelerating, especially in the field of education. This has led to demands in the era of globalization that emphasize education that adapts to technology to improve the quality of learning. Teachers and students are now faced with an urgent need to master digital competencies (Wiziack & dos Santos, 2021). The use of technology in education can help teachers broaden students' horizons, improve the effectiveness and efficiency of learning, motivate students to learn, and increase student participation and critical thinking skills. One solution offered to address the challenges faced is the use of artificial intelligence (AI). In recent years, the development of AI technology and comprehensive improvements in education have progressed rapidly (Li & Su, 2020) According to Sarker, (2022), AI is a branch of computer science that involves the development of systems capable of performing tasks typically done by humans, such as vision, speech recognition, and problem-solving. AI enables computers to process large amounts of information and provide computer-based conclusions in a relatively short time (Ahmad et al., 2019). AI can help personalize learning, provide quick feedback, and offer varied learning resources t ailored to students' needs (Kaswan et al., 2024).

The application of AI in education has great potential to transform teaching and learning activities (Rasool et al., 2025). With the help of AI, teachers can manage learning effectively and provide positive support to students. This personalization ensures that each student receives the support and challenges needed to maximize their potential, enabling them to learn at their own pace while stimulating interest and motivation (Selvakumar et al., 2025). In addition to maximizing students' potential, AI-based learning also prepares the next generation to face the challenges posed by the digitalization era, where technological skills have become a top priority across various fields, particularly in education, which requires the use of technology-based learning media.

With the development of age-appropriate learning tools, AI concepts can be simplified through visual representations, such as block-based programming, Scratch, Zhorai, Learning ML, and Machine Learning for Kids (Yim & Su, 2024). The application of Artificial Intelligence (AI) can involve various technologies such as machine learning, Chatbots, Augmented Reality (AR), Virtual Reality (VR), and other technologies (Lampropoulos, 2025). AI has become an important part of the world of education, supporting learning through chatbots such as ChatGPT and Socratic by Google, as well as gamification technology to increase student motivation (Kassenkhan et al., 2025). There are various types of AI intelligence that can be used to support learning, such as Duolingo, Quizizz, Microsoft Teams, Gamma App, Edmodo, Cognii, SMART Learning Suite, ChatGPT, Perpelexity, and so on (Rani, 2024).

Although there have been many positive studies indicating that the use of artificial intelligence (AI) in education, particularly in elementary schools, greatly assists teachers and students in developing technological skills, it is important to conduct more extensive and in-depth research to understand its application in improving the quality of education in elementary schools. This study aims to analyze the use of artificial intelligence (AI) in learning at the elementary school level,

contributing meaningfully to preparing the younger generation to face the challenges of the digitalization 4.0 era. With a deeper understanding of the use of artificial intelligence (AI) to support education at the elementary school level. Furthermore, the results of this research can provide insights into how AI can solve problems faced by teachers and students and meet the demands of globalization at the elementary school level.

Based on the background described above, this study focuses on systematically exploring the use of Artificial Intelligence (AI) in elementary school education through a systematic literature review. Specifically, this study seeks to address the following research questions: (1) How is Artificial Intelligence (AI) implemented in learning processes at the elementary school level? (2) What pedagogical and learning impacts does the use of AI have on improving the quality of education in elementary schools, particularly in terms of cognitive development, motivation, engagement, and learning differentiation? (3) What challenges, readiness factors, and future directions are identified in the literature regarding the sustainable integration of AI in elementary school education? These research questions guide the analysis and discussion of findings presented in the results and discussion sections of this study.

METHOD

This study employed a systematic literature review (SLR) to examine the use of Artificial Intelligence (AI) in improving the quality of education at the elementary school level. A systematic literature review is a structured research method used to identify, evaluate, and synthesize findings from previous studies related to a specific research topic (Ramadhani & Usiono, 2023). This approach was selected to provide a comprehensive understanding of research trends, forms of implementation, and pedagogical impacts of AI in elementary education. The literature search was conducted in May 2025 using Google Scholar as the primary database due to its broad coverage of peer-reviewed educational research. The search process employed keywords related to the research topic, including "artificial intelligence (AI)," "elementary school," and "quality of education." Articles were selected based on predefined inclusion and exclusion criteria to ensure relevance and methodological clarity. The inclusion and exclusion criteria applied in this study are presented in Table 1.

Table 1. Inclusion and Exclusion Criteria

Aspect	Inclusion Criteria	Exclusion Criteria
Publication Year	Articles published between 2020 and 2025	Articles published before 2020
Education Level	Studies focusing on elementary or primary school education	Studies focusing on secondary, high school, or higher education
Research Focus	Studies examining the use of Artificial Intelligence (AI) to support or improve learning quality	Studies not related to AI use in educational contexts
Research Context	Educational settings related to classroom learning or teacher instructional practices	Studies conducted outside formal educational contexts

Aspect	Inclusion Criteria	Exclusion Criteria
Type of Publication	Peer-reviewed journal articles	Conference papers, theses, dissertations, book chapters, and non-peer-reviewed publications
Language	Articles written in clear and understandable academic language (English or Indonesian)	Articles written in unclear language or lacking academic structure
Methodological Clarity	Studies with clearly described research objectives and research methods	Studies with insufficient or unclear methodological descriptions

The process of identifying, screening, and selecting articles was conducted systematically following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The PRISMA flow diagram illustrates each stage of the literature selection process, including identification, screening, eligibility assessment, and inclusion of studies in the final review. Figure 1 presents the PRISMA flow diagram used in this study.

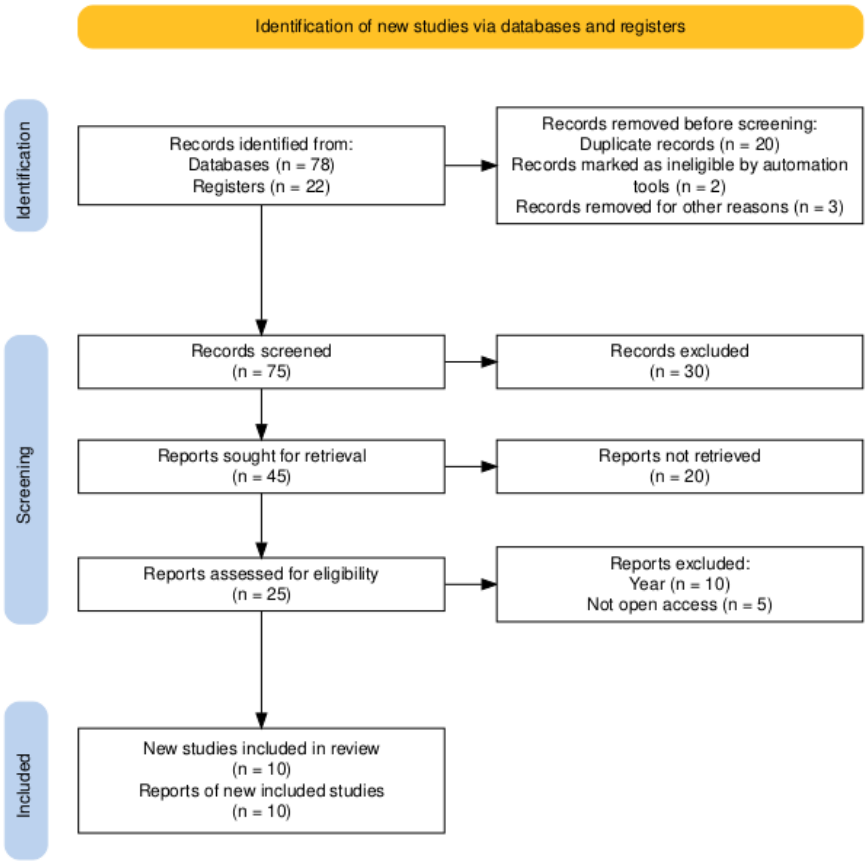

Figure 1. PRISMA Flow Diagram of the Study Selection Process

The initial literature search identified a total of 100 records, consisting of 78 records obtained from databases and 22 records from registers, published between 2020 and 2025. Prior to screening, 25 records were removed, including duplicate records, records marked as ineligible

by automation tools, and records removed for other reasons. As a result, 75 records remained for the screening stage**.**

During the screening process, titles and abstracts were reviewed, leading to the exclusion of 30 records that did not meet the research focus. Subsequently, 45 reports were sought for full-text retrieval, of which 20 reports could not be retrieved. The remaining 25 full-text articles were assessed for eligibility, resulting in the exclusion of 15 articles due to publication year mismatch and limited access. Following this multi-stage selection process, ten articles were deemed eligible and included for in-depth review and analysis, as illustrated in the PRISMA flow diagram. Data analysis was conducted using a qualitative content analysis approach. Each included study was systematically examined and categorized based on research objectives, research methods, forms of AI implementation, pedagogical and learning impacts, and identified challenges. The synthesis of findings was guided by the research questions of this study to ensure coherence between the methodology, results, and discussion sections.

RESULTS

This section presents the results of the systematic literature review (SLR) on the use of Artificial Intelligence (AI) in improving the quality of education at the elementary school level. The findings are derived from a rigorous selection and analysis of relevant studies published between 2020 and 2025, which were identified through a structured search process using predefined inclusion criteria. The selected articles represent diverse research designs, including literature reviews, qualitative studies, experimental and quasi-experimental research, as well as research and development (R&D) approaches, providing a comprehensive overview of current trends and empirical evidence related to AI implementation in elementary education.

The results are synthesized to capture key patterns, forms of implementation, pedagogical impacts, and challenges associated with the integration of AI in elementary school learning. To facilitate a systematic comparison and synthesis of the reviewed studies, the main characteristics of each selected article, including authors, research objectives, research methods, and key findings, are summarized in Table 2. This table serves as the foundation for the subsequent thematic analysis, which is organized according to the research questions addressed in this study.

Table 2. Articles on the Use of Artificial Intelligence in Improving the Quality of Education in Elementary Schools

No	Author's Name	Tittle	Research Objectives	Research Methods	Research Results
1.	Arda Purnama Putra, Sa'dun Akbar, Punaji Setyosari, and	Analisis Pemanfaatan *Artifical Intelligence* (AI) dalam Pendidikan terhadap Kualitas	To review the literature related to the use of AI in supporting learning, such as personalizing materials, automatic	a systematic literature review (SLR)	The use of AI has the potential to increase student engagement, provide rapid feedback, and support teachers in developing effective

No	Author's Name	Tittle	Research Objectives	Research Methods	Research Results
	Henry Praherdhion	Pembelajaran di Sekolah Dasar	analysis, and developing 21st-century skills in students		learning strategies (Putra et al., 2024)
2.	Imroatul Maufidhoh and Ismil Maghfirah	Implementasi Pembelajaran Berbasis *Artifical Intelligence* Melalui *Media Puzzle Maker* Pada Siswa Sekolah Dasar	To determine how artificial intelligence-based learning is implemented through puzzle maker media in elementary school students and how the implementation of learning affects cognitive development	Qualitative method using literature review and observation	The implementation of artificial intelligence-based learning is one of the innovations in the field of education and has a positive impact on students' cognitive development (Maufidhoh & Maghfirah, 2023)
3.	Siti Nur Khomsah, Romyati, and Eko Darmanto	Pembelajaran Berbasis Artifical Intelligence pada Siswa Sekolah Dasar	To determine how artificial intelligence-based learning is implemented among elementary school students and the impact of the implementation of learning on students' cognitive development	Qualitative method using literature review and observation	The implementation of artificial intelligence-based learning has a positive impact on students' cognitive development, such as making students more enthusiastic about learning and easier to understand the material taught (Khomsah & Darmanto, 2024)
4.	Dhiya Ulfah Fathin, Teguh Prasetyo, and Salma Yuliani	Pengaruh Penggunaan Teknologi AI dalam Meningkatkan Kualitas Pembelajaran di Sekolah Dasar	To analyze the impact of AI use on student achievement through a personalized approach tailored to students' needs, pace, and learning styles	A systematic literature review (SLR)	The application of AI technology can create an adaptive, enjoyable learning environment focused on students' needs, while addressing challenges faced by teachers in optimizing learning (Fathin et al., 2024)
5.	Abdillah Mahdi Aziz, Prayuningtyas Angger Wardani, and Herlina Usman	Pengembangan Media Pembelajaran Komik Digital Berbasis *Artifical Intelligence* di Sekolah Dasar	To evaluate the need for the development of digital comic learning media using AI as its basis	Research and development (RnD)	The development of AI-based digital comic learning media is needed to improve student understanding, strengthen learning interest, and develop critical thinking skills at the elementary school level (Abdillah Mahdi Aziz, Prayuningtyas Angger Wardani, 2024)

No	Author's Name	Tittle	Research Objectives	Research Methods	Research Results
6.	Yosdin Gagaramusu, Sarintan Kaharu, Khairunnisa, Ryan Pratama, Ammar, Shalehuddin, and Danti Indriastuti Purnamasari	Pemanfaatan Artifical Intelligence (AI) dalam Menyusun Modul Ajar Interaktif bagi Guru Sekolah Dasar	To provide training to elementary school teachers in Tanantovea	Learning by doing	Teachers are able to develop more interactive teaching modules tailored to the needs of students (Gagaramusu et al., 2025)
7.	Nurul Nujum and Muhamad Sofian Hadi	Pengaruh Pembelajaran Berbasis Masalah Berbantuan Media AI terhadap Peningkatan Keterampilan Berpikir Kritis Siswa di Sekolah Dasar	To determine the effect of AI-assisted problem-based learning (PBL) on the critical thinking skills of elementary school students	Quasi-experimental method	The use of AI media contributes to improving the quality of learning in elementary schools (Nujum et al., 2025)
8.	Rizki Adri Yohanes, Fredy, and Hafsemi Rapsajani	Penggunaan Kecerdasan Buatan dalam Konteks Pembelajaran di Sekolah Dasar	To address challenges in the learning process at the elementary level, explore and analyze the use of artificial intelligence (AI) in elementary school learning	Literature review method	With the right approach, AI can be an effective tool in supporting the learning process and preparing students to face challenges in the 4.0 Industrial Revolution era (Yohanes & Rapsanjani, 2024)
9.	Annisa Nidaur Rohmah	The Utilization of Artifical Intelligence (AI) Based Media In Enhancing The Learning Process The Elementary School Level	To present a literature review on the use of artificial intelligence (AI) media in improving the learning process at the elementary school level	Literature review method	The use of AI-based media in elementary education has the potential to provide learning experiences tailored to students' needs (Rohmah, 2024)
10.	Iin Almeina Loebis and Sofia Lim	The Effect of Artifical Intelligence in Adaptive Learning on Improving Student Understanding in Elementary School	To determine the effect of applying artificial intelligence in adaptive learning systems on students' understanding at the elementary school level	Experimental method	The application of AI in adaptive learning has great potential to improve students' understanding and effectively address the challenges of differentiated learning at the elementary level (Iin Almeina Loebis, 2025)

Based on the synthesis of the ten selected articles presented in Table 1, the results of this systematic literature review are organized according to the three research questions formulated in this study, namely: the implementation of Artificial Intelligence (AI) in elementary school learning, its pedagogical and learning impacts, and the challenges and readiness factors influencing its use.

1. Implementation of Artificial Intelligence (AI) in Elementary School Learning

The reviewed studies indicate that Artificial Intelligence (AI) has been implemented in elementary school learning primarily as a supportive instructional tool rather than as an autonomous learning system. AI applications are commonly integrated through digital learning media, adaptive learning systems, interactive modules, and AI-assisted instructional strategies. Several studies highlight the use of AI-based media such as puzzle makers, digital comics, adaptive learning platforms, and interactive teaching modules to support classroom instruction (Maufidhoh & Maghfirah, 2023; Abdillah Mahdi Aziz et al., 2024; Gagaramusu et al., 2025). In addition, AI implementation is often aligned with personalized learning approaches, where learning content, pace, and feedback are adjusted to students' individual needs and learning styles (Putra et al., 2024; Fathin et al., 2024; Loebis & Lim, 2025). AI is also utilized to assist teachers in instructional planning, material development, and learning evaluation, enabling teachers to design more interactive and student-centered learning experiences. Overall, the findings suggest that AI implementation at the elementary level emphasizes pedagogical support, instructional efficiency, and learning personalization within existing curricular frameworks.

2. Pedagogical and Learning Impacts of AI on the Quality of Elementary Education

The analysis of the selected studies demonstrates that the use of AI in elementary school education has a generally positive impact on learning quality, particularly in cognitive, motivational, and engagement-related aspects. Several studies report improvements in students' cognitive development, understanding of learning materials, and critical thinking skills as a result of AI-supported learning environments (Maufidhoh & Maghfirah, 2023; Khomsah & Darmanto, 2024; Nujum & Hadi, 2025). Furthermore, AI-based learning is shown to enhance student motivation and engagement by providing interactive, adaptive, and enjoyable learning experiences tailored to students' needs (Putra et al., 2024; Rohmah, 2024). Personalized feedback and adaptive content delivery enable students to learn at their own pace, thereby supporting differentiated instruction and inclusive learning practices. From the teachers' perspective, AI contributes to improving instructional effectiveness by facilitating rapid feedback, supporting material development, and assisting in the management of classroom learning activities (Fathin et al., 2024; Gagaramusu et al., 2025). However, the majority of the reviewed studies emphasize short-term improvements in learning processes rather than long-term or transformative changes in learning outcomes.

3. Challenges, Readiness, and Future Directions of AI Use in Elementary Schools

Despite the positive impacts identified, the findings also reveal several challenges and readiness issues related to the use of AI in elementary school education. A recurring theme across the reviewed literature is that the successful integration of AI is strongly influenced by teacher readiness, digital competence, and pedagogical understanding, rather than by technological availability alone (Yohanes & Rapsanjani, 2024; Putra et al., 2024). Some studies indicate that AI use in elementary schools remains limited to individual initiatives or experimental applications and has not yet been systematically integrated into school policies or curricula. Additionally, the literature points to a lack of comprehensive training and professional development programs for teachers to effectively implement AI-based learning strategies. Ethical considerations, AI literacy for young learners, and the sustainability of AI-supported learning practices are also identified as underexplored areas within the current body of research. These findings suggest that future efforts should focus on strengthening teacher capacity, institutional support, and pedagogical frameworks to ensure the sustainable and meaningful integration of AI in elementary school education.

DISCUSSION

The findings of this study indicate that the implementation of Artificial Intelligence (AI) in elementary school learning tends to be positioned as a pedagogical support tool that functions to personalize learning, improve teacher work efficiency, and increase student engagement, rather than as a replacement for the role of teachers or the educational process itself. AI implementation that directly involves teachers in the co-design of learning materials has been shown to be capable of producing lesson plans that are appropriate to students' age and curricular context (Kosmas et al., 2025). Factors influencing the adoption of AI in elementary classrooms, such as teachers' attitudes and readiness as well as their ability to integrate technology into their pedagogy, indicate that AI implementation does not depend solely on the technology itself, but also on internal readiness and the school context (Li, 2025). Adaptive learning technologies, as part of AI utilization in elementary schools, enable the adjustment of content according to individual student learning profiles, which represents one of the most widely discussed forms of AI implementation in current international literature (Hariyanto et al., 2025). In addition, studies that empirically examine elementary school teachers' perspectives show that although teachers have a strong intention to use AI, they often face limitations in knowledge and experience in applying it effectively in the classroom (Mazı & Yıldırım, 2025). Teachers' perspectives on adaptive technologies also highlight the importance of professional support and appropriate training in implementing AI for instruction that is responsive to students' needs (Simon & Zeng, 2024). Nevertheless, there is also evidence that AI implementation approaches must consider broader pedagogical aspects, including AI literacy and human–technology interaction, so that AI integration can truly empower students' learning processes in elementary schools (Yim & Su, 2025).

The findings of this study show that the impact of using Artificial Intelligence (AI) in elementary school learning is most prominent in improving the quality of the learning process, particularly in cognitive aspects, motivation, and learning differentiation, while structural changes in learning paradigms have not yet been observed significantly. Similar to the review conducted by S. J. Lee & Kwon, (2024) it was found that the use of AI contributes to improved conceptual understanding and student engagement through adaptive content presentation and faster feedback, which supports learning processes aligned with students' individual needs and abilities. This pattern of pedagogical impact is consistent with international findings indicating that AI in elementary education tends to strengthen existing learning quality, especially in terms of classroom engagement and the effectiveness of learning processes (Mazı & Yıldırım, 2025). From a motivational perspective, the use of AI in interactive learning environments has been proven to increase students' learning interest and participation, particularly when AI is used as a learning companion that supports problem solving and learning differentiation, rather than as an independent learning system (Kuo et al., 2026; H. Lee et al., 2025). Namun demikian, temuan penelitian ini juga mengindikasikan bahwa dampak AI terhadap hasil Nevertheless, the findings of this study also indicate that the impact of AI on long-term learning outcomes remains limited, as most of the analyzed studies emphasize short-term improvements in learning processes and provide limited longitudinal evidence demonstrating sustained changes in academic achievement. This is reinforced by international studies emphasizing that increases in motivation and learning process quality through AI do not automatically correspond to long-term transformation of learning outcomes (Gao, 2025). Thus, AI in the elementary school context can be understood as an effective pedagogical tool for incrementally improving learning quality, particularly in cognitive and motivational aspects, but it has not yet functioned as a transformational force that fundamentally alters the structure or paradigm of learning.

The findings of this study indicate that the main limitations in the use of Artificial Intelligence (AI) in elementary schools do not lie in technological aspects, but rather in teacher readiness and institutional contexts that do not yet fully support the systemic integration of AI. This pattern is consistent with Russell et al., (2025) who emphasize that the successful use of AI in education systems depends heavily on the alignment between technology, educators' capacities, and organizational support, rather than merely on the availability of AI-based tools. This relationship is further reinforced by Sanusi et al., (2024), who show that differences in perceptions, needs, and levels of readiness among teachers, students, and policymakers constitute major barriers to AI integration in school environments. In the elementary school context, these conditions help explain why AI use remains partial, relies on individual initiatives, and has not yet been formally integrated into educational policies or curricula.

Beyond teacher and institutional readiness, the results of this systematic literature review also reveal limited attention to issues of AI literacy, ethics, and human–AI relationships in the use of AI in elementary schools. Yue Yim, (2024) emphasizes that the absence of a holistic AI literacy framework for young learners may create gaps in understanding how AI works, how data are used, and what ethical implications are involved, leading AI use to remain largely instrumental and

technical. From a pedagogical perspective, Joo & Park, (2024) show that many AI programs are still designed for short durations and do not sufficiently consider the cognitive developmental characteristics of elementary school students, which limits the sustainability of AI-based learning. Meanwhile, Xu, (2025) highlights that strengthening the role of AI in education requires institutional support through teacher learning communities and structured professional collaboration, so that AI use does not remain at the experimental stage. Overall, the findings of this study affirm that the main challenges of AI use in elementary schools are systemic and human-centered rather than technological. While the potential of AI to improve the quality of elementary education is substantial, its sustainability is largely determined by teacher readiness, institutional support, strengthened AI literacy, and integration aligned with educational policies and curricula. Therefore, future directions for AI development in elementary schools should focus on building educator capacity, strengthening pedagogical and ethical frameworks, and developing policies that support holistic and sustainable AI integration.

CONCLUSION

This systematic literature review examined the use of artificial intelligence (AI) in elementary school learning and its contribution to improving educational quality in the context of the digitalization era 4.0. The findings indicate that AI is predominantly positioned as a pedagogical support tool that enhances existing learning processes rather than transforming learning paradigms. Across the reviewed studies, AI was found to improve students' cognitive understanding, motivation, engagement, and learning differentiation, while also assisting teachers in delivering complex material, providing rapid feedback, and increasing instructional efficiency. However, the impact of AI remains largely incremental, with most evidence pointing to short-term improvements in learning quality rather than sustained or transformative changes in long-term learning outcomes. The review also reveals that the effectiveness of AI implementation in elementary schools is strongly influenced by teacher readiness, institutional support, and pedagogical capacity, rather than technological availability alone. Limited attention to AI literacy, ethical considerations, and human AI interaction further constrains the optimal use of AI in this context. This study is limited by the small number of reviewed articles and the dominance of non-experimental, short-term research designs, which restricts broader generalization and causal inference. Future research should therefore prioritize longitudinal and experimental studies, focus on strengthening teacher professional development and institutional frameworks, and integrate ethical and pedagogical considerations to ensure the sustainable and meaningful use of AI in elementary education.

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