



AI-Assisted Learning in Early Childhood Education: Opportunities and Challenges for Supporting Cognitive Development – A Literature Review

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ABSTRAK

This study aims to analyze the opportunities and challenges of AI-assisted learning in supporting cognitive development in early childhood education and to examine its implications for developmentally appropriate educational practices. This study employed a qualitative approach using a library research method through the analysis of various scholarly sources, including international journal articles, academic books, and relevant research reports. Data were collected through documentation techniques from scientific publications retrieved from reputable academic databases and analyzed using content analysis and thematic analysis to identify key themes, patterns, and relationships among concepts. The findings indicate that AI-assisted learning offers significant opportunities to support early childhood cognitive development through personalized learning experiences, increased learning engagement, and the enhancement of critical thinking, problem-solving, creativity, and cognitive flexibility. However, the implementation of AI also presents several

challenges, including excessive screen time, reduced social interaction, data privacy concerns, ethical issues, and limited teacher readiness to integrate AI technologies into educational practices. The study further reveals that the effectiveness of AI-assisted learning depends on its alignment with children's developmental characteristics, play-based learning principles, meaningful social interaction, and the active role of teachers as learning facilitators. This study contributes a comprehensive synthesis of the opportunities, challenges, and implications of AI-assisted learning in early childhood education, providing a foundation for the development of innovative, ethical, and child-centered educational practices.

INTRODUCTION

Artificial Intelligence (AI) has emerged as a transformative innovation in the field of education, influencing how teaching and learning processes are designed and implemented. In recent years, the integration of AI technologies into educational settings has expanded rapidly, including in early childhood education contexts. AI-assisted tools such as intelligent tutoring systems, adaptive learning platforms, and interactive applications have begun to support learning activities in various educational levels. Previous studies highlight that AI has the potential to enhance personalized learning experiences and improve educational outcomes (Ayeni et al., 2024). However, the application of AI in early childhood education remains a relatively new and underexplored area of research.

Early childhood is a critical period for cognitive development, during which children rapidly develop foundational thinking, reasoning, and problem-solving skills. During this stage, learning experiences play a crucial role in shaping brain architecture and cognitive functions. Research indicates that early experiences significantly influence children's long-term cognitive and socio-emotional development (Immordino-Yang et al., 2025). Developmental theories emphasize that children learn best through active engagement, exploration, and meaningful interactions. Therefore, any integration of AI technologies must align with these developmental characteristics to be effective.

Previous studies have increasingly explored the integration of artificial intelligence (AI) in educational settings and have reported its potential benefits for learning outcomes. Katiyar et al. (2024) found that AI technologies can enhance personalized learning by adapting instructional content to learners' needs and performance. Similarly, Chen and Perez (2023) highlighted the capacity of AI systems to provide intelligent feedback and support individualized learning pathways. In the context of early childhood education, (Kewalramani et al., 2021) demonstrated that AI-interfaced robotic tools can foster children's engagement and participation in learning activities. Furthermore, Demir et al. (2025) emphasized that AI-assisted learning environments can create interactive experiences that support children's curiosity and exploration, while Cai et al. (2025) argued that emerging AI technologies are reshaping pedagogical practices in early childhood education and care. However, despite the growing body of research on AI in education, limited studies have specifically examined its role in supporting early literacy development among young children. Moreover, empirical evidence regarding the implementation of AI-based learning tools in early childhood educational contexts remains insufficient, highlighting the need for further investigation.

Although these studies provide valuable insights, most of them primarily focus on the technological capabilities and educational benefits of AI rather than examining its implications from a child development perspective. Existing research tends to discuss AI implementation in general educational contexts, while studies specifically addressing early childhood cognitive development remain limited. Moreover, previous investigations often emphasize the opportunities offered by AI technologies without providing a balanced discussion of the associated challenges, such as excessive screen exposure, reduced social interaction, ethical concerns, and teacher

readiness. Consequently, there remains a lack of comprehensive understanding regarding how AI-assisted learning can simultaneously support cognitive development while remaining aligned with developmentally appropriate practices in early childhood education.

To address this gap, the present study provides a comprehensive literature review that synthesizes both the opportunities and challenges of AI-assisted learning in supporting cognitive development among young children. Unlike previous studies that focus predominantly on technological innovation, this study integrates perspectives from educational technology, cognitive development, and early childhood pedagogy. The novelty of this study lies in its holistic analysis of AI-assisted learning through the lens of developmentally appropriate practice, emphasizing not only the potential cognitive benefits of AI but also the pedagogical and ethical considerations necessary for its effective implementation in early childhood education.

From a theoretical perspective, the integration of AI in early childhood education can be understood through constructivist and sociocultural learning theories. Constructivist theory emphasizes that children actively construct knowledge through interaction with their environment (Bringuier & Piaget, 1980). Meanwhile, sociocultural theory highlights the importance of social interaction and guided learning in cognitive development. AI-assisted learning environments have the potential to support these theoretical frameworks by providing interactive and responsive learning experiences (Vygotsky, 2018). However, the extent to which AI can replicate or complement human interaction remains a topic of ongoing discussion.

Furthermore, AI-assisted learning should not be viewed as a replacement for teachers, but rather as a supportive tool that enhances teaching practices. Teachers play a central role in facilitating meaningful learning experiences, especially in early childhood education where emotional and social support are essential. AI can assist teachers by providing data-driven insights, personalized feedback, and adaptive learning materials. This collaboration between educators and AI systems is essential to ensure developmentally appropriate practices. Therefore, understanding the supportive role of AI is crucial in early childhood education contexts (Chen, 2025).

The rapid advancement of AI technologies has created new opportunities for enhancing learning experiences in early childhood education. AI systems can provide immediate feedback, adapt instructional materials, and create engaging interactive environments. These features have the potential to support higher-order cognitive skills such as critical thinking, problem-solving, and creativity (Alkhatib, 2019). However, these opportunities must be balanced with children's developmental needs. Without proper guidance, the use of AI may lead to passive learning rather than active engagement.

Despite its potential benefits, the implementation of AI in early childhood education also presents several challenges. Ethical concerns related to children's exposure to technology, such as screen time, data privacy, and digital dependency, must be carefully considered. Additionally, many educators lack sufficient knowledge and training to effectively integrate AI into their teaching practices. This lack of readiness can hinder the effective implementation of AI in early childhood classrooms. Therefore, addressing these challenges is essential for successful integration.

Another significant issue is the limited availability of research specifically focusing on AI in early childhood education. Most existing studies on AI in education tend to focus on higher education or secondary education contexts (Zawacki-Richter et al., 2019). As a result, there is a lack of empirical and theoretical understanding of how AI can be effectively applied in early childhood settings. This gap highlights the need for more research that specifically addresses early childhood contexts. Addressing this gap is important for developing evidence-based educational practices.

Moreover, the integration of AI must consider the importance of play-based learning, which is a fundamental principle in early childhood education. Play-based learning allows children to explore, experiment, and construct knowledge in meaningful ways (Edwards, 2017). Therefore, AI-assisted learning should support playful and interactive experiences rather than replace them. Aligning AI with play-based approaches ensures that technological integration remains developmentally appropriate. This alignment is essential for maintaining the core values of early childhood education.

In relation to cognitive development, AI-assisted learning has the potential to support various cognitive skills. These include critical thinking, problem-solving, creativity, and cognitive flexibility. AI can provide adaptive challenges that encourage children to explore multiple solutions and engage in deeper thinking processes. However, the effectiveness of AI in supporting these skills depends on how it is designed and implemented. Poorly designed AI systems may fail to achieve these outcomes and may even hinder learning processes.

Despite the growing interest in artificial intelligence in education, there is still a lack of studies that specifically examine its role in early childhood education, particularly in relation to cognitive development. Furthermore, existing studies tend to focus more on technological advancement rather than its alignment with child development principles. In addition, limited research provides a balanced analysis of both the opportunities and challenges of AI-assisted learning in early childhood contexts. These gaps highlight the need for a comprehensive review that integrates theoretical and practical perspectives. Addressing these gaps is essential for advancing knowledge in early childhood education.

Therefore, this study aims to synthesize existing literature on AI-assisted learning and its role in supporting cognitive development in early childhood education. This study focuses on analyzing both the opportunities and challenges associated with AI implementation. It also examines how AI can be aligned with developmentally appropriate practices. Through this approach, the study seeks to provide a balanced and comprehensive understanding of AI in early childhood education. This contribution is expected to support educators and researchers in making informed decisions.

Based on the discussion above, the research question of this study is: How does AI-assisted learning support cognitive development in early childhood education? In line with this question, the objective of this study is to analyze the opportunities and challenges of AI-assisted learning through a literature review approach. The findings of this study are expected to contribute to the development of innovative and evidence-based practices in early childhood education.

Additionally, this study aims to provide practical insights for educators and stakeholders. Ultimately, this research seeks to support the development of child-centered and technology-enhanced learning approaches.

RESEARCH METHOD

This study employed a qualitative approach using a library research design to examine the role of AI-assisted learning in supporting cognitive development in early childhood education. A literature review approach was selected because it enables the researcher to synthesize existing theoretical and empirical studies related to artificial intelligence and early childhood learning. The study focused on identifying opportunities and challenges associated with the implementation of AI-assisted learning in early childhood education settings.

The data sources consisted of scientific publications obtained from reputable academic databases, including Scopus, Google Scholar, SpringerLink, and ScienceDirect. The population of this study comprised scholarly publications discussing artificial intelligence, early childhood education, and cognitive development. The sample was selected purposively based on the following inclusion criteria: (1) publications focusing on AI-assisted learning and early childhood education; (2) studies discussing cognitive development outcomes; (3) articles published between 2015 and 2026; and (4) publications written in English. Studies that did not specifically address early childhood contexts were excluded from the review.

Data were collected through documentation techniques by identifying, screening, and selecting relevant journal articles, books, and research reports. The keywords used during the search process included “artificial intelligence in early childhood education,” “AI-assisted learning,” and “cognitive development in early childhood.” The researcher served as the primary research instrument, supported by a data extraction framework used to organize and categorize the collected literature.

The collected data were analyzed using content analysis and thematic analysis techniques. Content analysis was employed to identify key concepts and recurring patterns across the selected studies, while thematic analysis was used to categorize findings into major themes related to opportunities, challenges, and implications of AI-assisted learning for cognitive development. The results of the analysis were then synthesized to provide a comprehensive understanding of the role of AI-assisted learning in early childhood education.

RESULTS AND DISCUSSION

Opportunities of AI-Assisted Learning in Supporting Cognitive Development in Early Childhood Education

The findings of this study indicate that AI-assisted learning offers significant opportunities for supporting cognitive development in early childhood education. Based on the reviewed literature, artificial intelligence enables learning environments to become more adaptive, interactive, and responsive to children’s individual developmental needs. Unlike conventional

digital technologies, AI systems can analyze children's learning progress and adjust instructional content accordingly. This adaptive capability allows children to receive learning experiences that match their cognitive readiness and learning pace. Consequently, AI-assisted learning has the potential to create more personalized and meaningful learning experiences for young children.

One of the most prominent opportunities identified in the literature is the ability of AI to facilitate personalized learning. Strielkowski et al. (2025) argue that AI technologies can provide adaptive learning pathways that respond to learners' strengths, weaknesses, and progress. In early childhood education, personalized learning is particularly important because children develop cognitive abilities at different rates. AI-assisted systems can modify learning tasks, feedback, and instructional strategies according to individual needs. This finding suggests that AI can support more inclusive and developmentally responsive learning environments.

From a constructivist perspective, the adaptive nature of AI-assisted learning aligns closely with the theory proposed by Piaget, which emphasizes that children actively construct knowledge through interaction with their environment. Although Piaget's theory remains foundational, recent studies continue to support the importance of active exploration in cognitive development. According to Kewalramani et al. (2021), AI-supported learning environments can encourage children to explore concepts independently through interactive activities. These experiences provide opportunities for children to build understanding through experimentation and discovery. Therefore, AI can function as a tool that strengthens active learning processes rather than merely delivering information.

Another significant opportunity lies in the enhancement of children's engagement and learning motivation. The reviewed studies consistently indicate that AI-assisted applications create dynamic and interactive learning experiences that attract children's attention. Kundu and Bej (2025) found that AI-interfaced robotic tools increased children's participation and enthusiasm during learning activities. Interactive features such as immediate feedback, gamification, and adaptive challenges contribute to maintaining children's interest in learning tasks. As engagement is strongly associated with learning effectiveness, AI-assisted learning can play an important role in fostering sustained participation in educational activities.

The findings also reveal that AI-assisted learning can support the development of critical thinking skills. AI technologies often present children with opportunities to analyze situations, make predictions, and evaluate different responses. According to Yuan and Hu (2025), AI-supported learning environments encourage learners to engage in reflective and analytical thinking processes. This finding is consistent with contemporary educational approaches that emphasize higher-order thinking skills as essential competencies in the twenty-first century. Through adaptive questioning and problem-based activities, AI systems can encourage children to think beyond simple memorization and engage in deeper cognitive processes.

In addition to critical thinking, AI-assisted learning contributes to the development of problem-solving abilities. The literature indicates that AI technologies can create learning scenarios that require children to identify problems, test solutions, and evaluate outcomes. Such

experiences stimulate reasoning and logical thinking processes that are fundamental to cognitive development. Bierman and Torres (2016) emphasizes that problem-solving activities play a crucial role in strengthening executive functions during early childhood. By providing structured yet flexible challenges, AI-assisted learning environments can support the development of children's cognitive competencies in meaningful ways.

The analysis further demonstrates that AI-assisted learning can enhance creativity among young learners. Creativity is increasingly recognized as an important component of cognitive development because it supports innovation, imagination, and flexible thinking. Rigopouli et al. (2025) argues that technology-enhanced learning environments can foster creative thinking when designed to encourage exploration and experimentation. AI-powered applications often provide open-ended activities that allow children to generate ideas and express themselves in multiple ways. As a result, AI-assisted learning can create opportunities for children to engage in creative knowledge construction rather than passive content consumption.

Another important opportunity identified in this study is the promotion of cognitive flexibility. Cognitive flexibility refers to the ability to adapt thinking and behavior in response to changing situations or new information. According to Lee et al. (2024), cognitive flexibility is a core component of executive functioning that supports learning and adaptation. AI-assisted learning environments expose children to diverse challenges and learning pathways that require them to modify strategies and perspectives. This process encourages children to become more adaptable thinkers, which is essential for long-term cognitive growth and academic success.

The findings also suggest that AI-assisted learning can support immediate and personalized feedback mechanisms. Feedback is a critical component of effective learning because it helps children understand their progress and identify areas for improvement. Unlike traditional learning environments where feedback may be delayed, AI systems can provide real-time responses to children's actions. Song et al. (2024) emphasize that intelligent feedback systems can enhance learning efficiency and support individualized instruction. Therefore, AI-assisted learning has the potential to strengthen cognitive development by creating continuous cycles of learning, feedback, and improvement.

From a sociocultural perspective, AI-assisted learning may also support cognitive development when integrated appropriately with social interaction. Vygotsky's theory highlights that learning occurs through guided participation and interaction within the social environment. Recent studies suggest that AI technologies can function as supportive tools within collaborative learning settings rather than replacing human interaction entirely. Rojas and Chiappe (2024) argues that AI should be viewed as part of a broader pedagogical ecosystem that includes teachers, peers, and learning resources. Therefore, the educational value of AI depends on how effectively it is integrated into meaningful social learning experiences.

Overall, the findings demonstrate that AI-assisted learning provides multiple opportunities for supporting cognitive development in early childhood education. These opportunities include personalized learning, increased engagement, critical thinking development, problem-solving

enhancement, creativity stimulation, cognitive flexibility improvement, and immediate feedback mechanisms. The findings are supported by both contemporary educational research and established learning theories, indicating that AI has considerable potential as an educational tool. However, the effectiveness of AI-assisted learning depends on its alignment with developmentally appropriate practices and child-centered pedagogical principles. Consequently, AI should be implemented as a supportive educational resource that enhances children's cognitive growth while maintaining the essential values of early childhood education.

Challenges of AI-Assisted Learning in Supporting Cognitive Development in Early Childhood Education

Despite the considerable opportunities offered by AI-assisted learning, the findings of this study reveal several challenges that must be carefully addressed to ensure its effective implementation in early childhood education. The literature indicates that the integration of artificial intelligence is not free from developmental, pedagogical, and ethical concerns. While AI technologies can enhance personalized learning experiences, their use may also create unintended consequences that affect children's cognitive and socio-emotional development. These concerns become particularly significant because early childhood represents a critical period during which learning is strongly influenced by direct interaction, play, and environmental exploration. Therefore, understanding these challenges is essential for achieving a balanced and developmentally appropriate implementation of AI-assisted learning.

One of the most frequently discussed challenges in the literature is excessive screen time. AI-assisted learning often relies on digital devices such as tablets, computers, and interactive applications, which may increase children's exposure to screens. Clemente-Suárez et al. (2024) emphasizes that technology integration in early childhood education should be carefully monitored to prevent overreliance on digital media. Excessive screen time may reduce opportunities for physical activity, outdoor exploration, and hands-on learning experiences that are essential for young children's development. Consequently, educators and parents must ensure that AI-assisted learning complements rather than replaces active and experiential learning activities.

The findings further suggest that prolonged screen exposure may influence children's attention regulation and learning behaviors. Recent studies have reported that excessive engagement with digital technologies can contribute to difficulties in maintaining attention and self-regulation among young children. According to Reid Chassiakos et al. (2016), the rapid expansion of digital technologies in early childhood settings requires careful consideration of children's developmental needs and capacities. While AI systems can provide engaging learning experiences, excessive use may encourage passive consumption of information rather than active exploration. Therefore, the educational value of AI depends not only on the quality of the technology but also on the duration and context of its use.

Another significant challenge identified in the literature concerns the potential reduction of social interaction. Early childhood learning is fundamentally social in nature, and meaningful interactions with adults and peers play a critical role in cognitive development. From the

perspective of Vygotsky's sociocultural theory, cognitive growth occurs through collaborative activities and guided participation within the social environment. AI-assisted learning environments that rely heavily on individual interaction with digital systems may reduce opportunities for dialogue, cooperation, and shared problem-solving. As a result, excessive dependence on AI technologies may limit important social experiences that contribute to children's cognitive and language development.

This concern is supported by Selwyn (2019), which argues that technological innovations should supplement rather than replace human relationships in educational settings. Learning in early childhood involves not only acquiring knowledge but also developing communication skills, empathy, and social understanding. While AI systems can simulate certain forms of interaction, they cannot fully replicate the complexity of human communication and emotional responsiveness. Therefore, maintaining teacher-child and peer interactions remains essential in AI-supported learning environments. The findings suggest that AI should be integrated as a complementary educational tool rather than a substitute for social engagement.

The analysis also highlights data privacy as an increasingly important challenge in AI-assisted learning. Many AI systems collect, process, and store large amounts of user data to personalize learning experiences and improve system performance. However, young children represent a particularly vulnerable population with limited capacity to understand issues related to data collection and digital security. Nguyen et al. (2023) emphasize that educational AI systems must prioritize transparency, accountability, and the protection of learners' personal information. Without adequate safeguards, there is a risk that children's data may be misused, exposed, or accessed without appropriate consent. Consequently, data protection mechanisms must become a central consideration in the implementation of AI technologies in early childhood education.

Closely related to privacy concerns are broader ethical issues associated with the use of artificial intelligence in education. The literature suggests that AI systems may unintentionally reproduce biases embedded in algorithms or datasets, potentially affecting the fairness and inclusivity of learning experiences. According to Zawacki-Richter et al. (2019), ethical considerations have become a central topic in discussions surrounding educational AI because algorithmic decision-making can influence learning opportunities and outcomes. In early childhood education, where equity and inclusion are fundamental principles, any form of technological bias may have long-term implications for children's development. Therefore, ethical governance frameworks are necessary to ensure that AI technologies are used responsibly and equitably.

Another ethical concern involves the possibility of excessive dependence on technology. While AI systems can provide adaptive support and personalized feedback, overreliance on technology may reduce opportunities for children to develop independence, creativity, and social problem-solving skills through real-world experiences. Recent research by Daher (2025) argues that AI literacy should be accompanied by critical awareness regarding the appropriate use of technology in educational contexts. Children require diverse learning experiences that involve

physical exploration, imaginative play, and social interaction. Consequently, AI should be positioned as one component within a broader educational ecosystem rather than as the dominant mode of learning.

Teacher readiness also emerged as a major challenge in the reviewed literature. The successful implementation of AI-assisted learning depends significantly on educators' knowledge, skills, and confidence in using technology. Nawaz and Khan (2012) found that many educational institutions continue to face difficulties related to technological competence and professional preparation. In early childhood education, teachers must not only understand how AI technologies function but also evaluate whether these tools align with developmental principles and learning objectives. Without adequate training and support, educators may struggle to integrate AI effectively into classroom practice. Therefore, continuous professional development is essential for maximizing the educational benefits of AI-assisted learning.

Overall, the findings indicate that the implementation of AI-assisted learning in early childhood education involves a range of interconnected challenges, including excessive screen time, reduced social interaction, data privacy concerns, ethical issues, and limited teacher readiness. These challenges demonstrate that technological innovation alone cannot guarantee positive educational outcomes. Consistent with Vygotsky's sociocultural perspective and contemporary educational research, effective learning requires a balanced integration of technology, human interaction, and developmentally appropriate pedagogical practices. The findings suggest that AI should be implemented within a carefully designed educational framework that prioritizes children's well-being, rights, and developmental needs. Only through such a balanced approach can AI-assisted learning contribute positively to cognitive development while minimizing potential risks.

Implications of AI-Assisted Learning for Developmentally Appropriate Practices in Early Childhood Education

The findings of this study suggest that the successful implementation of AI-assisted learning in early childhood education depends largely on its alignment with developmentally appropriate practices (DAP). While artificial intelligence offers considerable opportunities for enhancing cognitive development, its educational value is determined by how well it supports children's developmental characteristics and learning needs. Early childhood education emphasizes holistic development, active exploration, and meaningful interaction, all of which must remain central in technology-supported learning environments. Therefore, AI should not be viewed merely as a technological innovation but as a pedagogical tool that supports child-centered learning. This perspective highlights the importance of integrating AI within established principles of early childhood education rather than allowing technology to dictate educational practices.

One important implication emerging from the findings is the need to maintain play-based learning as the foundation of educational experiences for young children. Research consistently demonstrates that play is a primary mechanism through which children construct knowledge, develop cognitive abilities, and engage in social learning. Hirsh-Pasek et al. (2020) argue that

playful learning promotes critical thinking, creativity, communication, and collaboration, all of which are essential competencies in contemporary education. Although AI technologies can provide interactive learning experiences, these technologies should complement rather than replace opportunities for play. Consequently, educational institutions must ensure that AI-assisted activities remain embedded within playful and exploratory learning contexts.

The findings also indicate that AI-assisted learning should be implemented in ways that promote active rather than passive engagement. Constructivist learning theory emphasizes that children develop understanding through direct interaction with their environment and through the active construction of knowledge. Recent studies on AI-enhanced learning environments support this perspective by demonstrating that adaptive technologies are most effective when learners are actively involved in problem-solving and exploration activities (Eti et al., 2026). Therefore, AI systems designed for early childhood education should encourage inquiry, experimentation, and decision-making rather than simple content consumption. Such an approach ensures that technology supports meaningful cognitive development.

Another implication concerns the role of teachers in AI-supported learning environments. The literature consistently highlights that AI cannot replace the pedagogical expertise, emotional support, and professional judgment provided by educators. According to Kolhatin (2025), AI functions most effectively when it augments rather than substitutes human teaching. In early childhood education, teachers play a particularly important role because learning involves social, emotional, and behavioral dimensions that extend beyond cognitive outcomes. Therefore, AI-assisted learning should be conceptualized as a collaborative model in which technology supports educators in facilitating individualized and engaging learning experiences. This perspective reinforces the continuing centrality of teachers in educational practice.

From a sociocultural perspective, the findings emphasize the necessity of preserving meaningful social interactions within AI-supported learning environments. Vygotsky's theory suggests that cognitive development occurs through interactions with more knowledgeable others and participation in socially mediated learning experiences. While AI systems can provide adaptive feedback and individualized support, they cannot fully replicate the richness of human communication and collaborative learning. Recent research by Palmquist et al. (2026) similarly argues that AI should be integrated into broader pedagogical ecosystems that prioritize relationships and social engagement. Consequently, educational practices should ensure that AI-assisted learning remains embedded within interactive social contexts that support children's overall development.

The findings further suggest that AI-assisted learning should be guided by ethical and child-centered principles. Young children require learning environments that prioritize safety, well-being, equity, and inclusion. Berson et al. (2025) emphasizes that technological innovation in education must be accompanied by ethical safeguards that protect children's rights and promote responsible use of digital technologies. This includes ensuring transparency in data collection, preventing algorithmic bias, and protecting children's privacy. As AI technologies become

increasingly integrated into educational settings, ethical considerations must become a fundamental component of implementation strategies. Such measures help ensure that technological advancement remains aligned with educational and developmental goals.

Another important implication relates to the design of AI learning applications. The literature suggests that technologies developed for early childhood education should reflect developmental characteristics rather than simply adapting products designed for older learners. Children in early childhood require concrete, engaging, and developmentally appropriate experiences that support exploration and discovery. According to Cimino et al. (2025), effective AI applications in early childhood contexts must consider children's cognitive, social, and emotional developmental needs. Therefore, collaboration among educators, developmental psychologists, and technology developers is necessary to create learning tools that genuinely support child development. Such interdisciplinary cooperation can enhance the quality and relevance of AI-assisted educational resources.

The findings also indicate the importance of strengthening teachers' digital competence and AI literacy. As educational technologies continue to evolve, teachers must possess the knowledge and skills necessary to evaluate, select, and implement AI tools effectively. Daher (2025) emphasize that AI literacy is becoming an increasingly important competency for educators across educational levels. In early childhood education, this competency extends beyond technical skills to include understanding developmental appropriateness and ethical implications. Professional development programs should therefore provide teachers with opportunities to develop both technological and pedagogical expertise. Such preparation can improve the quality and effectiveness of AI integration in educational practice.

Furthermore, the findings suggest that policymakers have an important role in supporting responsible AI implementation in early childhood education. Clear policies and regulatory frameworks are necessary to guide the use of AI technologies in ways that protect children's interests and promote educational quality. These policies should address issues related to privacy protection, screen time management, teacher training, and ethical standards. According to recent discussions in educational technology research, effective governance is essential for ensuring that AI innovations contribute positively to learning outcomes (Chan, 2023). Therefore, policy development should accompany technological adoption to ensure sustainable and responsible implementation.

Overall, the findings demonstrate that the educational value of AI-assisted learning depends not only on technological sophistication but also on its alignment with developmentally appropriate practices. The opportunities and challenges identified throughout this review suggest that AI should function as a supportive educational resource that enhances children's learning experiences while preserving the fundamental principles of early childhood education. The novelty of this study lies in its integrative perspective that combines technological, developmental, pedagogical, and ethical considerations within a single analytical framework. By synthesizing these dimensions, the study provides a more comprehensive understanding of how AI can be

implemented responsibly and effectively in early childhood education. Ultimately, the findings support a balanced approach in which AI serves as a tool for enriching cognitive development while maintaining the central importance of play, social interaction, and teacher guidance.

CONCLUSION

This study concludes that AI-assisted learning has considerable potential to support cognitive development in early childhood education when implemented in developmentally appropriate ways. The findings reveal that AI technologies can enhance personalized learning experiences, increase children's engagement and motivation, and foster important cognitive skills such as critical thinking, problem-solving, creativity, and cognitive flexibility. Through adaptive learning systems, AI can respond to individual learning needs and provide immediate feedback that supports meaningful learning processes. These opportunities demonstrate that AI can serve as an effective educational resource for promoting cognitive growth among young children. However, its educational value depends on how well technological innovation is aligned with the developmental characteristics and learning needs of early childhood learners. Despite these opportunities, the study also identifies several challenges that require careful consideration. Excessive screen time, reduced social interaction, data privacy concerns, ethical issues, and limited teacher readiness represent significant barriers to the effective implementation of AI-assisted learning. The findings highlight that cognitive development in early childhood is strongly influenced by social interaction, play-based experiences, and teacher guidance, elements that cannot be fully replaced by technology. Therefore, AI should function as a complementary tool that supports rather than substitutes human interaction in educational settings. Addressing these challenges requires collaborative efforts among educators, policymakers, researchers, and technology developers to ensure the responsible and ethical use of AI in early childhood education.

The novelty of this study lies in its integrative analysis of AI-assisted learning through technological, developmental, pedagogical, and ethical perspectives within the context of early childhood education. Unlike previous studies that primarily focus on the benefits of AI technologies, this literature review provides a balanced synthesis of both opportunities and challenges while emphasizing the importance of developmentally appropriate practices. The findings suggest that the successful integration of AI depends on maintaining child-centered learning principles, play-based approaches, meaningful social interaction, and active teacher involvement. Consequently, AI should be viewed as a supportive educational innovation that enriches children's learning experiences without compromising the fundamental values of early childhood education. Future research is recommended to conduct empirical investigations that examine the long-term impact of AI-assisted learning on various domains of child development in diverse educational contexts.

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