

# The current state of AI applications in early childhood education and the challenges it faces

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**Abstract:** The rapid advancement of artificial intelligence (AI) technology is profoundly impacting various industries, with the field of education being no exception. In early childhood education, the application of AI extends beyond mere computation and data processing; it encompasses an ongoing cognitive process aimed at enhancing teaching effectiveness, optimizing learning experiences, and promoting educational equity. However, despite the promising prospects of AI in early childhood education, numerous challenges remain. This paper explores the current state of AI applications in early childhood education and the challenges it faces and then offers sustainable insights and recommendations for the future development of AI in this domain.

**Key words:** artificial intelligence; early childhood education; current state; challenges; future development

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## 1 Introduction

In 1956, artificial intelligence (AI) was defined as "the science and engineering of creating intelligent machines" [1]. AI refers to the creation of intelligent machines capable of solving various problems using technologies such as natural language processing, neural networks, and machine learning. Today, AI is transforming numerous fields at an unprecedented pace, including medicine, psychology, science, and public policy [2]. In the realm of education, AI has the potential to assist teachers in predicting students' learning states and performance, recommending appropriate learning resources, and enhancing instructional effectiveness through intelligent agent systems, chatbots, and recommendation systems.

In early childhood education, the goal of AI is to provide children with an engaging and enjoyable learning experience. Through carefully designed AI products and curricula, even preschoolers can begin to develop a basic understanding of AI [3]. By interacting with AI-driven products and courses, young children gradually learn about and explore AI-related concepts. While they may not yet fully grasp the underlying technical principles, these children can interact with and experience AI technologies in their daily lives, thereby enhancing their digital literacy.

Although most AI research focuses on secondary or higher education, relatively little research has been done on its application to early childhood education. In fact, AI holds significant potential in fostering various aspects of child development, particularly in cultivating creativity, enhancing emotional expression, and improving cognitive skills. Therefore, this study aims to explore the current state of AI applications in early childhood education and the challenges it faces. Additionally, it offers recommendations for future researchers and educators to advance the study of AI literacy and

learning methods in early childhood education.

## **2 Artificial intelligence (AI)**

Artificial intelligence (AI), a branch of computer science, focuses on mimicking and enhancing human intelligence, enabling machines to perform tasks that typically require human cognitive abilities. With the continuous improvement in computing power and the exponential growth of data, AI technology has developed rapidly, expanding its applications across various fields, including autonomous driving, intelligent healthcare, financial analysis, and language translation. In recent years, an increasing number of researchers have begun to explore how AI can be taught and learned from K-12 to higher education. These AI applications can support computer-assisted collaborative learning, automate teaching and assessment processes, recognize learners' emotions, and recommend appropriate learning resources for students.

### **3 Current applications of artificial intelligence in early childhood education**

#### **3.1 Artificial intelligence robots and STEAM educational tools**

The rapid development of artificial intelligence and digital information technology is profoundly impacting education, driving significant changes not only in primary, secondary, and higher education but also in early childhood education. Against this backdrop, STEAM curricula have been introduced at the early childhood education stage. STEAM education is an integrated educational model that combines the disciplines of science, technology, engineering, mathematics, and the arts. Educational robots, as an effective tool, can help children grasp STEAM concepts, which are essential components of STEAM education.

Research has explored the impact of STEAM education, facilitated by educational robots, on young children's learning outcomes. A study of preschoolers in Singapore implemented a 7-week STEAM robotics program. The results indicated significant improvements in the children's understanding of basic programming concepts, as well as in their communication, collaboration, and creative behaviors [4]. This study demonstrates that educational robots, as a teaching tool, can effectively promote young children's acquisition of foundational engineering and programming skills, laying the groundwork for more advanced STEAM education in the future.

#### **3.2 Applications of artificial intelligence products**

In early childhood education, AI products can serve not only as toys but also as educational companions, enhancing children's cognitive and language abilities through playful learning. These products also promote social interaction, encouraging the development of cooperative behaviors among young children. With the continuous advancement of AI technology, the market has seen the emergence of various AI products designed specifically for children, such as Pleo, iPal, and Kibot-2. These products typically feature bionic simulation, interpersonal interaction, speech recognition, environmental perception, behavior decision-making, and motion control. They are capable of autonomous navigation, obstacle avoidance, and predicting moving objects, and have speech-based dialogue, facial recognition, and emotional response capabilities.

Research indicates that AI products have a significant impact on enhancing educational outcomes. Compared to virtual AI systems, physical AI products more effectively foster human-machine interaction, improving children's performance in physical activities [5]. Additionally, studies have found that interacting with AI products possessing nonverbal immediacy features helps children focus on and learn nonverbal cues, such as gaze and gestures, thereby enhancing their social interaction skills and cognitive development [6].

These AI products, while satisfying children's desire for play, are equipped with carefully designed educational content that guides them in developing cognitive, language, and social collaboration skills, thus contributing to effective early childhood education.

## **4 Challenges in the application of artificial intelligence in early childhood education**

### **4.1 Educators lack awareness of artificial intelligence products**

In recent years, numerous researchers have conducted in-depth studies on the application value of AI products, yielding significant results. These studies suggest that AI products hold tremendous potential in the educational field, such as enhancing children's cognitive abilities, promoting personalized learning, and improving classroom interaction [7][8]. However, despite the many positive findings, the educational value of AI products has yet to gain widespread recognition and acceptance. Many educators remain skeptical about their actual effectiveness, expressing concerns that AI products may lead children to become overly engrossed in technology and thus neglect the importance of academic learning.

This skepticism stems from the fear that AI products could result in children becoming "distracted by play", meaning that these technologies might divert their attention away from effective cognitive development. Consequently, many kindergartens and families are cautious about introducing AI products, hesitating to fully integrate them into daily education and family life. Nevertheless, with ongoing technological advancements and deeper exploration of educational applications, the true potential and value of AI products are likely to be further validated and gradually accepted by the educational community.

### **4.2 Integration of technology and early childhood education**

Despite the rapid advancements of artificial intelligence (AI) technology, effectively integrating these technologies into early childhood education systems remains fraught with challenges. Currently, many AI applications are still in the experimental phase, lacking extensive real-world application experience and successful case studies. For instance, while intelligent tutoring systems can provide personalized learning recommendations based on individual student progress, ensuring the stability and reliability of these systems in actual educational settings is a pressing issue that needs to be addressed.

The application of AI in early childhood education requires not only technological innovation but also adaptation to specific educational needs and contexts. Critical challenges include designing intelligent interactive systems that are appropriate for the developmental stages of young children, effectively integrating AI with traditional educational methods, and ensuring that these systems genuinely and effectively support educational objectives. Therefore, while AI holds enormous potential in the field of education, realizing its full and effective application will require continuous exploration and refinement of the relevant technologies and strategies.

### **4.3 Adaptation and training of early childhood educators**

The introduction of artificial intelligence (AI) technology presents new challenges to early childhood educators. Teachers are now required not only to master new technologies and teaching methods but also to develop a certain level of technological literacy to effectively utilize AI tools in their instruction. However, many early childhood educators currently lack sufficient training and necessary support in this area, making it difficult for them to adapt to these emerging teaching models. For instance, when using intelligent tutoring systems, some teachers may encounter technical difficulties or operational challenges, which could negatively impact the effectiveness of their teaching.

Therefore, it is crucial to provide systematic training and ongoing professional development support to enhance teachers' technical skills and pedagogical capabilities. This support will ensure that educators can fully leverage the advantages of AI tools, ultimately improving the quality of education delivered in early childhood settings.

## **5 Conclusion**

This paper explores the current state and challenges of integrating artificial intelligence (AI) in early childhood education, aiming to provide valuable insights for researchers and early childhood educators. The challenges related to AI

literacy in early childhood education include educators' lack of knowledge and skills in AI, the absence of well-designed curricula, and a shortage of teaching guidelines. However, the paper also highlights opportunities to enhance AI literacy among young children, such as the application of AI products in educational practices.

To address these challenges, the paper offers several recommendations. For instance, future educators could design engaging AI activities that help children learn relevant concepts through interaction with AI products. Our discussion lays the groundwork for further research into the effectiveness of early AI literacy and provides valuable guidance for stakeholders in developing stimulating and engaging AI products and curricula in the educational field.

### **Conflicts of interest**

The author declares no conflicts of interest regarding the publication of this paper.

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