

Artificial Intelligence in Early Childhood Development and Practical Pathways: Cognition, Education, and Ethics

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Abstract. As artificial intelligence technology spreads in children's studies and daily life, all sorts of changes have occurred in their early cognitive abilities, language, and social skills, etc. In light of the above, artificial intelligence, developmental psychology, and early childhood education have been integrated to conduct this research. A literature review method will be used to gather the 14 relevant studies published at home and abroad. This paper will try to answer three problems: What is the basic nature of artificial intelligence in children's growth? In what ways does it have the potential to promote the development of early childhood education? At what stages will it be at risk of development? It has been determined in this study that artificial intelligence can be regarded as a "tool" to extend children's cognition and as "other feedback" in the process of building knowledge. It has shown good results in early-stage assessment accuracy, language study, creativity development, and related areas. However, it is also problematic because it entails uniformity of thought, the absence of subjectivity, and other obstacles to social development. Therefore, this paper argues that the main direction for future development should be to place children at the forefront of artificial intelligence technology and to build a cognitive development ecosystem that prioritizes both dynamic artificial monitoring and humanistic care. The above measures will help children grow normally and personally in all aspects during the age of intelligence and information.

Keywords: Artificial intelligence, early childhood development, cognitive development, subjectivity, human-machine collaboration

1. Introduction

As artificial intelligence (AI) can collect knowledge and reason logically to some extent, education needs to address the question of which talents should still be cultivated [1]. Therefore, this issue is particularly prominent in early childhood education. AI has been deeply integrated into children's daily lives, and now various forms of it are used for interactive learning and intelligent companions to alter how they view the world, think critically, and build their own identities [2].

At present, as attention has been drawn to children's development and AI, various research directions have begun to appear. Some studies focus on how technology can improve the accuracy and adaptability of early health assessment for children and explore the practical effects of AI devices in enriching game forms in preschool education and in the education of special needs

children [3, 4]. Another part of the study is criticism and reflection, which will investigate the general impact of AI on the development of young children or conduct an ethical analysis of using AI in early childhood education [5, 6]. Recently, there have been some good developments in education, and now robots are being used more and more often in early childhood education [7]. In terms of the specific design of products, researchers have started to focus on how intelligent drawing toys can be developed according to the characteristics of children's cognition [8]. They have also begun to explore the application and improvement of AI in the visual design of children's cognitive interactive picture books [9]. The above studies have provided an academic basis for learning and also offered some small ideas for teaching.

There is still a serious problem in the present study. When exploring the technical application and critical thinking philosophy of this study, they are often done independently without an analytical link. As a result, discussions on the empowerment and problems of AI tend to be at a level of listing functions or abstract worries, and it is difficult to answer the fundamental question of how exactly cognition and thinking are formed or affected in the continuous interaction between children and intelligent machines.

This paper aims to address the problem mentioned above. This paper takes a look at the related domestic and foreign literature in the past five years. A total of 14 multidimensional reviews and practical ways of intervention for generative AI in the early cognitive development of children were selected for a systematic review, and a framework for systematic analysis was established to include media examination, dual-effect analysis, educational reconfiguration, etc. The first is the theoretical nature of AI in the all-round development of young children; next, it will look at how it can help develop children's language and creativity, and later on, some problems that need to be solved will also be mentioned. Finally, based on the empowerment of the development of children's early cognitive thinking with AI, this paper puts forward an educational practice path and provides a good reference for constructing a child-friendly human-machine collaboration environment.

2. Theoretical framework

2.1. Structure

To understand the effect of AI on children's all-round development, it is necessary to explain what AI is. In the study of educational changes in the era of AI, it has been concluded that technology will provide tools for people's learning and development [10]. Therefore, technology no longer needs to be used as an external tool but should be regarded as part of the inner world of cognition. In terms of evolutionary epistemology, AI is also one of the "Seven Liberal Arts" that have historically driven the development of knowledge, and it is a "new tool" for knowledge creation and learning that appears on the foundation of digital media [10]. In other words, AI is not an outside power but a new channel that children use to broaden their world of thought and learn about life all around.

However, as AI continues to develop, it will be able to create new content and offer suggestions; at that time, people's lives will be affected by it in many ways. Dai Xinwei and Zhao Ronghui have pointed out that in the process of children's concept formation, AI has begun to play a role as an additional agent, and the continuous feedback it provides will have significant changes on the foundation of children's beliefs, basic logic, and fundamental concepts [2].

"Technological devices" and "others" are the two theoretical supports for exploring the relationship between AI and the development of children. The former shows that AI has the material function of cognitive extension, and the latter is the idea of a "pseudo-subject" in talk and response. The two Positions are to alert us that AI will either serve as strong support for children to climb the

ladder of cognition or become a "voice of the other" that hinders their own development. Any discussion of the development of children under AI must be considered from both sides carefully.

2.2. The main laws of children's cognitive development

After clarifying the dual roles of AI, a more fundamental question emerges: In the interaction between technology and children, who is the true protagonist of development? The answer can only be the children themselves. There is a widespread misconception in current early childhood education practice: Ignoring the developmental characteristics and individual differences of children and blindly introducing technology, resulting in the empowerment being merely a formality [11]. She clearly stated that AI-enabled teaching must abandon the "adult-centric" perspective and truly "put children at the center," and, based on interdisciplinary research at the intersection of child development psychology and AI technology, construct a dual-adaptation model of "AI stage functional boundaries and individualized needs" [11].

This stance has been responded to in numerous specific research fields. When developing and exploring intelligent painting toys, the core premise is to investigate the cognitive characteristics of children as they develop their painting skills, to reduce their frustration and enhance their confidence in creation through AI assistance [8]. Children's cognitive interactive picture books emphasize the use of visual elements such as colors, graphics, and images, as well as the integration of AI into the interactive format. All these aspects need to be adjusted, utilized, and improved in accordance with the phased characteristics of children's cognitive development [9].

These studies collectively point to a core principle: the stages, sequential nature, and individual differences in children's cognitive development should define clear functional boundaries for AI's technological possibilities. The technical logic should be in service of the children's psychology and their development; it should not be the opposite. Even in the discussion of new applications such as robots, the original position must be maintained, and AI should be introduced into children's classes properly [7].

3. Empowerment and concerns

3.1. The enabling effect of AI

This section systematically examines the actual impact of AI on children's early cognitive development. In the context of empowerment, AI is currently used for initial evaluations and in health management. In the early days of children's health, traditional evaluation methods have been based on manual examination, and they are prone to several problems, such as strong dependence on people, lack of cultural adaptability, and failure to conduct dynamic monitoring [3]. With the help of AI, combined data from all kinds of situations and optimization algorithms can be employed to enhance the objectivity of evaluation for the purpose of autism screening and prediction of language disorders to some extent [3]. Therefore, a foundation has been laid for the construction of a "dynamic monitoring and intervention" personalized closed-loop system to quickly identify problems in children with special needs and address them [3].

In children's daily study and all sorts of cognitive growth, AI technology has also shown good results in individualized education. AI interactive learning tools in kindergartens, through gamified learning and personalized feedback mechanisms, have significant effects in promoting children's language skills, critical thinking, and social interaction abilities, and can effectively stimulate the learning interest of children with learning difficulties [12]. Interactive applications and educational

robots, among other AI technologies, have played a significant role in the development of preschool children's language comprehension, problem-solving abilities, and creative thinking [13].

Furthermore, the application of AI has significantly expanded the forms and possibilities of education. AI devices can enrich the forms of games, conduct big-data-based predictions of students' academic performance, and provide new paths for the education of special children [4]. The core insight of these applications is that, if used appropriately, AI can serve as a key to unlocking children's untapped potential, helping to cultivate "inquiring" children and enabling them to develop critical and creative thinking through exploration [1].

The research and practical cases above all demonstrate that AI has significantly expanded the delivery channels and formats of early childhood education. When used appropriately, it can deeply tap into children's potential and facilitate the cultivation of their higher-order thinking skills.

3.2. Concerns and risks

At the same time, there are also other problems due to the use of AI. The most serious problem is that children's internal construction of thought is subjective. AI is a continuous source of external feedback that can have profound effects on the development of children's thinking at all levels, such as fundamental ideas, logic and methods, as well as knowledge [2]. When AI can provide a relatively easy answer and a complete picture, children may lose the motivation to think independently and gradually stop experimenting and self-questioning. Over time, the original ideas that have been shaped by one's own experience will be replaced by passive acceptance and conformity to the standard outputs of AI. Therefore, there will be profound risks of thought homogenization and deviation from values [2]. Precisely because of this concern, in the AI era, cultivating "questioning" children must be placed at the core of education; only then will individuals who have a strong sense of self-awareness and critical thinking be able to maintain independent thinking amidst the tide of information in the information age [1].

In addition to the way people form ideas, its possible effects on all sorts of aspects of life in society will also be considered. Children are often exposed to the behavior of programmed, unemotional two-way communicators [14], and as a result, the complex interpersonal relationships they need to constantly coordinate, empathize with, and compromise for in real life may gradually disappear. It is precisely this area that advanced social emotions and social skills are developed. In the analysis of children's cognitive interactive picture books, if the visual paradigm generated by AI is the only object for children to imitate, it may restrict their imagination and become a limitation on the development of their own visual expression abilities [9]. In other words, too much use of AI may restrict the development of children's practical social skills and their ability to participate in personalized creation; it is a double constraint on the growth of children's socialization and innovation.

The above reasons together indicate that the application of AI in the early years of children's life is not just about technology, but rather a problem of cognitive development ecology that needs to be studied in light of educational wisdom and ethical boundaries. Continuous and critical evaluation of the application of AI in early childhood education should be undertaken by all members of the academic community [6].

4. Human-machine collaboration for children

Given the situation that both empowers and worries people, the issue is no longer whether to accept or refuse AI; rather, it is how to use the wisdom of education to restructure it and build a

development ecosystem that can make full use of the strengths of technology while mitigating potential risks. This paper presents some practical paths at the three levels of cognition, Design and Ecology.

4.1. Distance from AI

The most fundamental educational task in responding to the crisis of ideological construction in the AI era is to help children distinguish boundaries at the cognitive level. Guide children to distinguish between themselves and AI, clarify their own role in the process of concept generation, and allow them to take the initiative and show initiative [2]. It is not about isolating technology, but rather about helping children develop good metacognition, so when they receive a response from an AI, they can learn to question it carefully, think about it deeply, evaluate it reasonably, and decide whether or not to use it as a reference.

The focus of education should shift from obtaining correct answers to posing sincere questions and fostering children's habit of continuous inquiry about AI, books, adults, and themselves [1]. Under the guidance of separation and dialogue, children will be able to use powerful AI technology to extend their thinking independently, not be replaced by it. To preserve the subjectivity of metacognitive thinking, one should strive to prevent value drift and promote the realization of ideals in life [2].

4.2. Functional boundaries from children's natural tendencies

At the level of educational practice, the reconfiguration mainly takes the form of careful design of products and teaching application strategies. The two-level adaptation model of the boundaries of AI stage functions and personalized needs has provided some very useful basic ideas in this regard [10]. Therefore, all AI systems intended for children should have clear boundaries in their basic functions that are strictly based on the general cognitive traits of children at different age groups, and information that cannot be understood by them should be avoided. Based on the above, the data integration capabilities of AI need to be made good use of to meet children's different needs at various stages of development.

At the product level, based on the above principle, the Design of intelligent drawing toys should consider the perception and representation characteristics of children at that age very well so as not to be excessively intrusive in the creation of the AI as an assistant [8]. The AI module of cognitive interactive picture books also needs to be developed in line with the staged laws of children's visual cognition [9]. When AI devices are used in early childhood education comprehensively, it is even more necessary to adhere to the principle of protecting children at the bottom line, to design from the perspective of children, and to focus on the deep integration of applications and educational goals, rather than just on showmanship [4]. To promote the all-round health of children's cognition and social development and to balance the application of AI, both educators and developers of technology need to work together in the digital age [5]. Design Ethics also cover careful consideration of the application scenarios for more complex objects, such as robots, so that the technology can be used for the good development of children [7].

4.3. An ecological system for dynamic monitoring and human-centered care

The aim is to construct an all-round development pattern for children in their early years based on technology and humanistic care. It should be noted that this closed-loop system is not to replace the

observation and care provided by adults for children. On the contrary, its value is to free teachers from the pressure of standardized tests so they can spend more time interacting with students and providing creative teaching that cannot be done by machines and is filled with human warmth. The final goal of the whole system is not to train more efficient "information processors," but rather to cultivate and develop the individual advantages of each child [1]. Ultimately, how to promote the cognitive development of people in the era of digital media is a problem that every educator in every technological period needs to address constantly [10].

5. Conclusion

Based on the results of 14 research studies, this paper has built an all-round system covering the theoretical basis, impact analysis, and path reconstruction for the current problem of "AI and Early Cognitive Development in Children." The system found that AI has a dual nature; it is both a "technical tool" and "other." Although it brings new opportunities for children's metacognition and personalized development, it also has serious problems for the development of their sense of self, independence, and social skills.

This research has enriched the theoretical framework in the fields of AI and children's cognitive development and provided a feasible reference for the standardized application of AI technology and the innovation of educational practices in preschool settings. Fundamentally, the impact of AI technology depends on whether it protects and promotes children's subjective thinking as a reference point and provides careful, wise guidance and boundary setting.

Future practice needs to move beyond the binary debate of "using" or "not using" and focus on the educational reconstruction of "how to collaborate wisely." Taking the scientific laws of child development psychology as the unbreakable functional boundary for AI applications, cultivating an independent and inquisitive "self" is the fundamental goal of education. Ultimately, it is important to build a child-friendly development ecosystem that combines humanistic warmth with technological sharpness. In such an ecosystem, AI will become a mirror that helps children illuminate unknown paths, expand possibilities, and gain a deeper understanding of themselves, rather than casting a shadow that obscures their unique brilliance.

References

- [1] Tang Xiaoyong. (2025). Half-day Plan per Week: Developing Children's Potential. Primary and Secondary School Management, (3), 61.
- [2] Dai Xinwei, & Zhao Ronghui. (2025). What Does AI Mean for Children's Cognitive Development. Journal of Inner Mongolia Normal University (Educational Sciences Edition), 38(2), 37-44.
- [3] Xiang Jiabin, Chen Weijun, Sun Xiaoyan, & Yuan Zhenming. (2026). A Review of the Application of Artificial Intelligence Technology in the Assessment of Children's Early Health Development. Health Research, 46(1), 6-13.
- [4] Zhang Huchuan & Fang Lei. (2025). AI and Children: The Application of Artificial Intelligence Devices in Early Childhood Education. Journal of Qilu Normal University, 40(1), 49-56.
- [5] Karlis Kandars, Louis Stupple-Harris, Laurie Smith, & Jenny Louise Gibson. (2024). Perspectives on the impact of generative AI on early-childhood development and education. Infant and Child Development, 33(4), n/a-n/a.
- [6] Silvia Cimino, Angelo Giovanni Icro Maremmanni, & Luca Cerniglia. (2025). The Use of Artificial Intelligence (AI) in Early Childhood Education. Societies, 15(12).
- [7] Joohi Lee, Junoh Jo, Joo Ok Lee, & So Hyang Kim. (2025). Incorporating Humanoid Artificial Intelligence (AI) Robots into Early Childhood Education. Early Childhood Education Journal, 53(8), 2849-2857.
- [8] Wang Jun & Xiao Yutong. (2026). Research on the Design of Children's Intelligent Drawing Toys Based on Cognitive Development Theory. Packaging and Design, (2), 50-51.
- [9] Zang Tianjiao. (2025). Research on the Visual Presentation of Children's Cognitive Interactive Picture Books. Screen Printing, (22), 47-49.

- [10] Guo Wenming. (2023). Educational Transformation in the Era of Artificial Intelligence. Peking University Education Review, 21(1), 62-82.
- [11] Zhang Qian. (2025). Research on AI-Enabled Teaching Based on Children's Developmental Laws. Intellectual Era, (9), 147-149.
- [12] Zhang Yali. (2024). The Impact of AI Interactive Learning Tools in Kindergartens on Children's Cognitive Development. Wanxiang, (26), 190-192.
- [13] Miao Lichui & Cheng Qi. (2024). The Digital Age: The Impact of Artificial Intelligence on the Cognitive Development of Preschool Children. New Education Times Electronic Magazine (Student Edition), (25), 37-39.
- [14] Sun Min, Jia Shanshan, & He Shuangjiang. (2021). The Current Situation and Development Suggestions of Interactive Educational Products for Preschool Children (Early Education Devices). Exhibition Economy, (6), 37-39.