The Facilitators and Barriers of AI in Gamified Teaching Models for Early Childhood Education

Sitong Zhou *

Graduate School of Education, University of Pennsylvania, Philadelphia, Pennsylvania, USA

* Corresponding Author Email: sitongzh@upenn.edu

Abstract. Artificial intelligence (AI) and gamification are receiving more attention in early childhood education (ECE). Their integration is still not well studied. AI gives personalized feedback and adaptive learning. Gamification keeps children motivated with tasks and rewards. This paper reviews recent work on AI-supported gamified teaching in ECE. It looks at key technologies such as speech recognition, social robots, and virtual reality. It also examines models like role-play, simulation, and story-based learning. Findings show that these methods can improve engagement, thinking skills, and social interaction. They also give teachers real-time feedback and data analysis. There are still problems. These include complex system design, unequal access to resources, and possible bias in algorithms. Such issues raise concerns about fairness and long-term impact. Based on this review, it is suggested that future research should include longitudinal studies, attend to children's voices and agency, and examine diverse and under-resourced contexts. Such efforts are needed to ensure that AI-enhanced gamified teaching supports not only engagement but also fairness and inclusion in early childhood education.

Keywords: Artificial intelligence; gamification; early childhood education.

1. Introduction

In recent years, artificial intelligence (AI) and gamification have begun to play a growing role in early childhood education (ECE). AI technologies are being used to support personalized learning and offer real-time feedback, while game-based approaches are often adopted to keep young learners engaged and motivated [1,2]. These developments reflect an increasing interest in technology-enhanced, learner-centered approaches in early childhood education.

Although AI and gamification have both been studied in the context of education, their integration in early childhood settings remains underexplored. Most research focuses on either AI or gamification, but not on how they are used together in early childhood education. For example, there is still little analysis of how AI tools work in gamified learning for preschool children [3]. Many studies are short and only look at classrooms. As a result, the long-term effects of AI in different learning settings are still not clear.

This review looks at recent work on AI in gamified teaching in early childhood. It describes the models used, the AI technologies that support them, and how they are applied. It also compares their use in different regions and groups of learners. In addition, it discusses barriers such as access and teacher readiness and points to areas for future study.

2. Review of AI-Supported Gamified Teaching in Early Childhood

2.1. AI Technology that Supports Gamified Teaching

In recent years, AI has been used more often in early childhood education, not only for language but also for inquiry-based activities. Studies show that research on the preschool stage is still limited [1,3]. Early childhood education has also been studied for the use of key AI technologies [1]. Tools such as robots, data mining, and machine learning have been tried in practice. For example, social robots can act as game characters to support role play and other tasks. Research has also looked at broader technologies such as AI, robotics, virtual reality, and touchscreen devices [3].

The main value of these tools is that they provide interaction, feedback, and emotional support. These features fit well with gamified teaching. Interaction keeps play going, feedback balances challenge and reward, and emotional support helps children stay motivated. In classrooms, speech recognition turns storytelling into challenges that score oral performance. Image recognition gives feedback on drawing tasks. Recommendation systems change game levels and tasks based on records.

The uses of AI gamified teaching can be grouped into three types: engine-based (changing task difficulty), interaction-based (characters interact with students), and analytics-based (tracking and feedback) [4]. Examples show these in practice. For instance, in China, an AI speech recognition system was added to kindergarten English classrooms [5]. It recorded and analyzed children's speech. Teachers used it to find and correct errors quickly. This improved accuracy and gave children more confidence. Another case used chatbots to help children practice multiplication with text and images [6]. The system included badges and levels. It also changed the difficulty based on answers and gave feedback to keep children engaged.

2.2. AI Integration in Contextualized Gamified Models

In early childhood education, AI and gamification are often used together. A common approach is contextualized game-based learning. This means placing tasks in real or simulated settings so that children can explore and solve problems in meaningful ways [7]. The model links learning content with play. Interactive settings make learning more interesting and engaging. AI tools like speech recognition, image recognition, and virtual reality help create or improve these environments. As a result, story-based tasks, role-play, and simulations become more immersive and interactive.

In practice, three models are most common: role-play, simulation, and story-based tasks. Role play lets children practice communication and teamwork in social situations. It can reduce conflict, increase peer interaction, and help children stay focused. In such tasks, AI speech recognition gives real-time feedback and prompts, making the activity more responsive. In simulations, AI and VR systems adjust the settings based on children's actions and give personalized guidance. These models often use virtual environments that resemble real life [8]. Children can try different options for many times and get feedback after each attempt [8]. Story-based tasks embed learning in a narrative. This keeps children emotionally engaged while solving problems [9]. AI systems also adjust the difficulty of these tasks so that the challenges match children's abilities. During these activities, teachers provide various forms of scaffolding, such as guiding questions, material support, and timely feedback, to help children complete the tasks successfully [9]. When combined with AI, these models can use technologies like speech recognition, image analysis, and virtual reality to enhance immersion and interaction, thus improving children's engagement and learning transfer in contextualized tasks.

According to previous articles, designing contextual digital gamification learning tools can not only help young children master knowledge better but also stimulate their curiosity, creativity, and problem-solving skills. Although these cases show the potential of technology in teaching, economic conditions, network environment, and teachers' digital literacy still affect the popularization of these technologies. Children from different backgrounds have different opportunities and effects in using these technologies.

3. Cognitive aspects

Multiple studies have shown that artificial intelligence and related assistive technologies can provide strong support for children's cognitive, social-emotional, and behavioral development in preschool education.

3.1. For Children

AI-based gamified activities and adaptive learning systems can flexibly adjust task difficulty based on children's learning progress and performance [2]. They help children effectively complete tasks assigned by teachers or parents. When task difficulty matches children's ability, it supports

learning and builds interest [1]. For social skills, AI tools like chatbots, social robots, and AAC systems have been used with children who have autism. These tools help them express emotions, join interactions, and work with others. This improves communication and social skills [10]. For children with ADHD, studies show that virtual robots and multimodal platforms can extend attention, reduce distractions, and improve classroom engagement [11].

3.2. For Teachers

AI technology in gamified platforms gives teachers real-time feedback and analysis. It helps them see children's progress and adjust teaching methods. Data from games allows teachers to track participation and outcomes. This helps meet the needs of children with different backgrounds and abilities. Such data supports growth in language, thinking, and social skills. AI-supported platforms may also lower barriers for children with disabilities. They can provide more equal opportunities for disadvantaged groups. In general, AI and assistive tools show strong potential in early childhood education. They can support children's full development and promote fairness.

4. Challenges and Practical Mitigations in AI-Supported Gamified Teaching

4.1. Interface and Social Concerns

In early childhood education, AI in gamification has potential but also faces many challenges. Some systems have complex icons or too much text. This makes them hard to use. Young children may feel confused. They may lose interest and feel frustrated. Too much time in virtual worlds can also reduce real-life interaction. Children may miss chances to build skills like cooperation and empathy. Overuse of AI can also harm their physical and mental health [12]. To reduce these risks, systems should use simple icons, limited text, and no more than three choices per screen. Functions should be shown step by step. Timers can remind children to switch to offline play with the same goals.

4.2. Equity and Bias in AI-Supported Gamified Teaching

Fairness is another issue. Research shows that children from poor or rural areas may have less access to AI resources. This reduces their chance to benefit from quality education [13]. Such gaps can widen inequality. Problems also appear in the data used to train AI. If the data are not balanced, the system may give biased feedback or content [13]. In gamified learning, bias can show up in the way tasks, roles, or rewards are given. For example, some groups may receive the same types of tasks more often. Over time, this can reinforce stereotypes and lead to unfair results. These patterns may create new forms of injustice. Teachers may treat system recommendations as advisory rather than absolute and always retain the ability to adjust difficulty levels themselves. In addition, reward patterns such as badges or levels should be reviewed regularly across different learner groups, with tasks and roles rotated when necessary to prevent bias and ensure fairness.

4.3. Barriers to Effective Integration in Schools

In addition, limited teacher training, maintenance challenges, and funding shortages have further hindered the effective integration of AI in early childhood education [14]. These issues are interconnected. They not only reduce the impact of technology in the classroom but may also deepen existing inequalities in access to educational resources and learning opportunities. In gamified contexts, these barriers become even more evident. Such activities rely on stable internet, enough devices, and teachers who can read dashboards showing badges, levels, or progress. Without proper training, teachers may struggle to make sense of this feedback or to adjust task difficulty, which limits the value of the tools. A practical way forward is to begin with small pilot projects before expanding, so that problems can be identified early. Teachers also need short, focused training that covers not only how to use AI systems but also how to guide gamified tasks and interpret the results. Platforms

should include offline or low-bandwidth options to ensure children in resource-limited schools can continue learning and playing.

5. Conclusion

This review highlights the promise and challenges of AI-supported gamified teaching in early childhood education. Existing studies show that AI tools combined with game-based models can enhance engagement, provide adaptive feedback, and support the development of both cognitive and social skills. At the same time, concerns remain about excessive screen use, superficial reward-seeking, and the risk of interrupting deeper learning processes.

The effectiveness of these tools is also shaped by context. Teachers' technical skills, school infrastructure, and resource availability play a decisive role in determining outcomes. Children in well-resourced urban schools may benefit more than those in rural or underfunded settings, raising important questions of equity. These challenges suggest that gamified learning environments must be carefully designed and implemented to complement, rather than replace, existing educational practices.

Future research should go beyond short-term, classroom-based studies to examine the long-term developmental impact of AI-supported gamification. Greater attention is also needed to children's own perspectives, their agency in making choices, and the role of families and teachers in shaping learning experiences. Future research should include under-resourced contexts to show whether AI-supported gamification can promote not only engagement but also fairness.

References

[1] Yi H, Liu T, Lan G. The key artificial intelligence technologies in early childhood education: A review. Artificial Intelligence Review, 2024, 57(1): 1.

[2] Alotaibi M S. Game-based learning in early childhood education: A systematic review and meta-analysis. Frontiers in Psychology, 2024, 15: 1307881.

[3] Liu J, Chen M, He H, Liu H, Luo W, Li H. Forms and functions innovation: A scoping review of digital and intelligence technologies in Early Childhood Education Practice. AI, Brain and Child, 2025, 1(1).

[4] González-Castro N, Muñoz-Merino P J, Alario-Hoyos C, Delgado Kloos C. Adaptive learning module for a conversational agent to support MOOC learners. Australasian Journal of Educational Technology, 2021, 37(2): 24-44.

[5] You X, Sanmugam M. Literature analysis on the impact of gamified education on engagement, motivation, and learning outcomes among preschool children in rural communities in China. JENTIK: Jurnal Pendidikan Teknologi Informasi Dan Komunikasi, 2024, 3(2): 68-79.

[6] González-González C S, Muñoz-Cruz V, Toledo-Delgado P A, Nacimiento-García E. Personalized gamification for learning: A reactive chatbot architecture proposal. Sensors, 2023, 23(1): 545.

[7] Cornito C M. The effectiveness of contextualized digital game-based learning resources in improving kindergarten pupils' alphabet knowledge level. International Journal on Studies in Education, 2023, 5(2): 130-140.

[8] Weiszhaupt K, Bastedo K, Macy M. Play-based assessment through a simulation-based widget: Reflection to practice. Journal of Early Childhood Teacher Education, 2024, 45(2): 177-191.

[9] Zhou W, Yang W. Story-based stem design challenges in early childhood education: Child engagement and pedagogical strategies. Early Childhood Education Journal, 2024, 53(6): 2177-2192.

[10] Iannone A, Giansanti D. Breaking barriers—The intersection of AI and assistive technology in autism care: A narrative review. Journal of Personalized Medicine, 2024, 14(1): 41.

[11] Richter B, Petras I K, Vollmer A L, Luong A, Siniatchkin M, Wrede B. Vaco: a Multi-perspective Development of a Therapeutic and Motivational Virtual Robotic Agent for Concentration for children with ADHD. arXiv preprint arXiv:2405.03354, 2024.

[12] Kok Cha W, Daud P. Enhancing early education with Artificial Intelligence: A comparative study of AI-powered learning versus traditional methods. International Journal of Academic Research in Business and Social Sciences, 2025, 15(2).

[13] Fitas R. Inclusive Education with AI: Supporting Special Needs and Tackling Language Barriers. SSRN Electronic Journal, 2025.

[14] Plumb M, Kautz K. Innovation determinants and barriers: A tri-perspective analysis of its appropriation within an early childhood education and Care Organisation. Australasian Journal of Information Systems, 2015, 19.