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The Changing Role of Mathematics Teachers in the Age of Artificial Intelligence: A Systematic Review

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Abstract. This systematic review examines research on the transformation of the role of mathematics teachers in AI-driven early childhood education from 2015 to 2025. Based on a literature search of major academic databases, it analyzes the development trends of teaching tools, methods, and professional responsibilities. The results show that AI technology has brought numerous positive impacts, including facilitating personalized learning and data-driven instruction. Many studies indicate that the use of AI in teaching is transforming the teacher's role from a mere practitioner to a data facilitator, AI instructional designer, data interpreter, technology integrator, ethics guardian, and liaison between home and school. However, this process also presents many problems and challenges. For teachers, AI brings increased workload, role ambiguity, a lack of systematic teacher training, and a disconnect between theory and practice. For children, it may lead to excessive screen time, an inability to deeply understand content, and a lack of exploration in authentic environments. Meanwhile, parents may have concerns about teachers using AI in teaching, including concerns about quality and privacy. Therefore, AI presents unprecedented opportunities and challenges for the early childhood education system, making it imperative to promote a transformation in teachers' roles that benefits children, parents, and teachers a pressing issue. This article will analyze research from the past decade to identify existing problems and their impact on teacher education, curriculum design, and other aspects, and analyze and discuss how to solve these problems.

Keywords: Artificial Intelligence, Mathematics teaching, Early Childhood Education

1. Introduction

Artificial Intelligence (AI) is gradually infiltrating education systems across different levels, and it changes how to teach, promotes students' ways of studying improved and also curriculum construction. Mathematics education is extended in its method due to the use of AI that personalizes learning for students, increases engagement in classroom activities, and gives feedback based on data for educators [1].

There has been some increase in the amount of research looking at AI applications within primary and secondary schools, but not so much for studying the effects when it comes to Early Childhood Education (ECE) [2]. In the early learning stage, mathematics is mainly about basic concepts such as numbers sense, spatial concepts and patterns, and learning is significantly affected by play-based

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teaching and developmentally appropriate practices [3]. Therefore, as a bridge connecting technology and children, teachers will be the ones most directly facing the digital feedback of smart interactive teaching aids, and then designing rich learning activities based on this information, and using such tools to promote the all-round development of young children.

Therefore, the application of AI technology in the mathematics classroom for young children has raised some questions about whether teachers' roles have changed. Although some of the existing studies have delved into the potential benefits of AI-assisted teaching, problems like role confusion, ethical quandaries and insufficient professional development for preschool teachers have also emerged [4]. Research on the change of roles for mathematics teachers in AI supported Early childhood Education between 2015-2025 is systematically summarized in this paper. Based on empirical and conceptual studies, to some extent, the characteristics of the new type of teacher-student relationship have been explored, as well as its evolution path in different institutional environments; At the same time, problems such as the construction of teacher professional ethics and the practice strategies of classroom interaction have also gained the attention of scholars at home and abroad.

2. Method

2.1. Search strategy

Based on the PRISMA guidelines for this Systematic review. Four Academic Databases were used to search for related literature in order to broaden the range of this review: Web of Science, Scopus, ERIC and Springer Link. This choice of databases aims to cover more research in Educational Technology, early childhood education and mathematics education.

March to May 2025 the search was performed and peer-reviewed journal articles from 2015 to 2025 were included. Search terms were developed based on the initial scanning results, including the combination of "artificial intelligence", "AI", "early childhood education", "preschool", "mathematics education", "early mathematics", and "teacher role", and Boolean logic (AND/OR) was used to optimize the search strategy to enhance the accuracy of retrieval.

2.2. Inclusion and exclusion criteria

Studies included had to meet the following criteria: focused on early childhood education setting (aged 3 - 6); looked at the use of AI technology in mathematics teaching / learning; considered teachers' role(s), teacher's method(s) of teaching or teachers' own development issue(s); were empirical studies or systematic reviews; and were published in an English peer reviewed Journal.

The studies were excluded if they focused primarily on: (a) primary, secondary or higher education; (b) non-math subjects; (c) general educational technology without an AI element; (d) opinion/perspective pieces, editorials or conference abstracts; and/or (e) insufficient methodology.

2.3. Study selection process

Searching database gives this result, and all duplicate record have been deleted by using reference management software. Screen titles & abstracts for relevance 1st. Full-text articles were then checked according to the set inclusion and exclusion standards.

To increase reliability, double the screening procedures were added. For every single doubt, we'll read them both and we discuss the article to agree on it. Selection process of the studies is

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summarized as a PRISMA flow diagram (Figure 1).

2.4. Data extraction and analysis

A structured data extraction form was designed to record the main characteristics of the studies, such as the year of publication, research Design, participants, AI tools, teaching context, and the results reported by teachers.

Thematic analysis synthesizes qualitative and quantitively findings. Initial coding was done to find the repeated thoughts on teaching behavior, professional responsibility, difficulty and need for training. After several iterations of improvement, the codes were divided into many categories at a higher level. These themes were then compared in different studies to find out the main directions and research deficiencies.

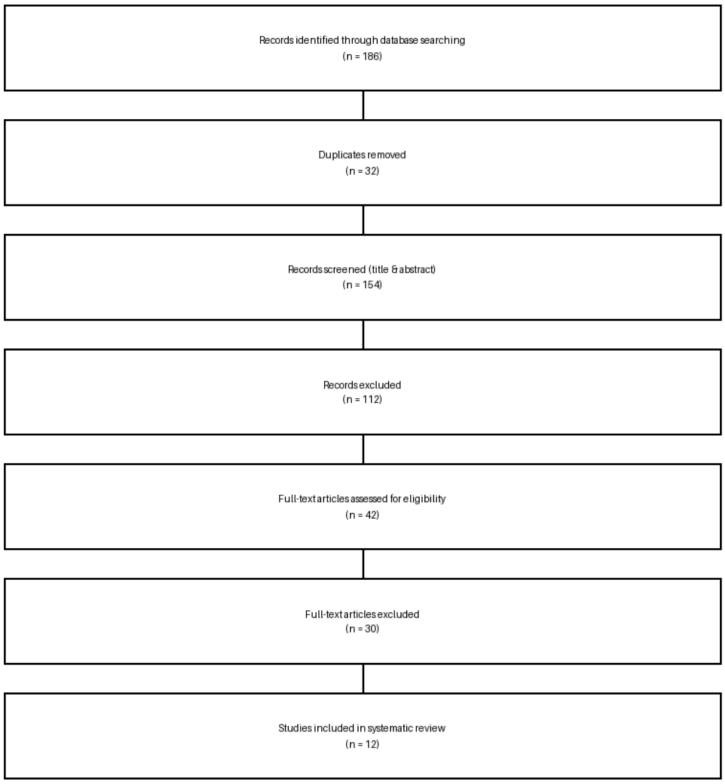

Figure 1. PRISMA flow diagram of the study selection process

3. Results: trends in AI-supported early childhood mathematics education

Among the 12 included studies, there were many different research designs, including systematic reviews, concept analyses, qualitative case studies and empirical studies. They explored together with AI integration applications in early childhood education and other fields from the perspectives of technology, pedagogy and profession [1, 2, 5, 6].

Based on the above-mentioned referred literature, there are three major categories as follows: (1) Application Forms of AI-related teaching tools; (2) Change of Teachers' Educational Role; (3) The link between AI and developmentally Suitable Learning Environment Construction.

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3.1. Instructional technologies and learning tools

Some scholars have explored the application of artificial intelligence supported learning system such as adaptive learning platforms, intelligent tutoring system and interactive application for promoting early math learning [1, 5, 7]. Back then, they were being used in order to personalize the learning experience through dynamically changing exercise difficulty levels and promptly giving learners answers.

Scoping and systematic reviews show that such systems are often used to help children learn basic mathematical knowledge, such as number recognition, counting skills, pattern recognition, space concept, etc. [2, 5]. Although most of them were based on the general educational context, they were often quoted in early childhood education research for reference in applying technology.

In terms of early childhood related literature, Yang [6] suggested using interactive and exploratory digital tools to introduce basic AI concepts and mathematical thinking through play-based activities. Alsaeed & Aladil [8] also found that digital platforms are usually accompanied by physical manipulative to enhance mathematical exploration in pre-school classrooms.

Based on several studies, the main one from the technological effects was if teachers could intervene effectively. Without any interventions, people's usages of digital tools tend to be merely some applications rather than a deep-dive exploration [6, 9]. This result was in line with the emphasis of research in learning sciences on meaningful interaction over passive technology application [10].

3.2. Teachers' expanding professional roles

A common finding in the reviewed studies is that teachers' professional duties have expanded in AI-supported learning environments. Teachers are no longer the single role of knowledge transmission but have taken on multiple new roles such as guides for learning Design and mediators of digital resources [4, 6].

Qualitative evidence from early childhood education teachers shows that it is the teachers who have to pick out appropriate AI instruments, align digital exercises with teaching aims, and facilitate kids' engagement with tech [4, 8]. There were both teaching goals and technical problems for teachers to solve at the same time.

Several studies have also pointed out that teachers are increasingly engaged in interpreting the AI-generated learning data. Learning Analytics, Performance Dashboards became more common for making instructional modifications as well as individual support [5, 11]. However, teachers also reported a lack of confidence in data analysis and could not systematically analyze the absence of training on how to use students' learning behavior data [4].

In addition teachers were also supposed to take up the roles of an ethicist and a communicator like being aware of screen time and children's privacy as well as including families in discussions regarding technology [2, 12]. This expanded Expectation has added to the workload and professional pressure in many cases.

3.3. Pedagogical integration and learning environments

Most of the research is about effective AI application in early childhood math education need to be compatible with the developmentally appropriate educational ideas. Review and theoretical analysis found that digital tools can be introduced into the play-based learning environment, inquiry-oriented learning environment, and social interaction learning environment [6, 9, 10].

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Empirical evidence showed that during the preschool years, a hybrid learning model consisting of digital activities and hands-on materials and collaborative tasks was often used [8]. These models were design to have the chance for physical exploration, peer interaction and teachers guiding discussion.

And Su [2] also said that many of these studies were mainly concerned about the technology part and ignored the connection with education. In similar ways, general concerns about educational technology also drew attention to its potential to overlook the development needs of children [1, 10].

A few other authors have also alerted us that there would be less time for a child's imagination and interaction with others when there is an overuse of screens [6, 9]. Thus, many studies have suggested a balanced teaching design that uses digital tools as support rather than the main resource.

3.4. Learning outcomes and assessment practices

In terms of learning results, most of the reviewed studies focused on enhancing children's foundational mathematics abilities in the short term, such as improving their count and perception of patterns and space [2, 5, 7]. The above effects were mainly evaluated according to in-app performance data, teachers' observation and evaluation as well as standardized tests.

Artificial intelligence-generated learning analytics is more and more used for helping formative assessment and early discovering of learning problem [5, 11]. Teachers found by means of the real-time data visualizations that they were able to see how students performed and arrange their teaching accordingly [4].

However, several reviews noted that only a few studies had explored long-term learning trajectories or development transfer beyond the digital environment [2]. Longitudinal evidence for sustained gains in math and socio-emotional outcomes were still missing. Likewise, there are not many reports in the literature on the comparison of culture-crossing [1, 5] which then limits the scope for generalization of the current findings.

4. Discussion: research gaps and implications

This assessment includes both the possible advantages and existing problems of AI in early childhood mathematics education. As was seen in the earlier reviews, there is evidence that AI can help students with personalized learning paths and also assist with formative assessment when used within lessons [1, 2, 5]. It's also highly dependent on the professional skills and pedagogical choices of teachers [4, 6], the results are at the same time. Based on the above analysis, we can draw the conclusion that technological innovation by itself is not beneficial for improving students' learning outcomes; therefore, at this time, it is necessary to combine pedagogy and institutions to support.

A major shortcoming of the current research referred to in this paper is that there are few methods. Most of the literature that has been reviewed use small samples, are short-term in execution or are context-specific which limits how universal the results can be [2, 5]. Longitudinal studies on the continuous improvement of students' mathematics learning over many years are scarce. In addition, there is no cross-cultural comparison, as AI-assisted education has gone around the world [1]. So, the present evidence can at best give us an incomplete image of the effects of artificial intelligence technology on the early learning of Mathematics under various socio-cultural and institutional circumstances.

There's another problem which is technology innovation for early childhood education being out of sync. Several studies have indicated that research and practice tend to focus more on technical efficiency and system function than on play-based learning, social interaction and developmentally

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appropriate practices [2, 6]. Although many people have promoted the frequent use of digital tools for their adaptability and analysis, fewer studies have explored how these tools can be combined with other elements in an all-around learning environment that helps promote children's cognitive development, social interaction and emotional regulation. The theoretical and pedagogical analysis suggests that the use of digital technology in mathematics teaching should be combined with exploration, experience and concept formation in the course system [3, 9]. Empirical evidence showing that such an alignment has been achieved in daily class teaching is still lacking.

In other words, the front-line role of teachers in AI assisted learning environment need to be adapted because of this situation. Teachers are no longer just knowledge imparters, but more so as an organizer, Instruction Designers and the mediator of the digital learning experience [4, 6]. Teachers should also be able to explain learning analytics and operate the technical infrastructure for big data in education, as well as respond based on data analysis [5, 11]. Although the increase of such responsibility indicates development of digital teaching, but also bring up a new kind form of professional stress and role confusion. Qualitative evidence suggests that many teachers have felt at a loss about how to combine teaching goals and technical requirements due to the lack of systematic institutional support [4, 12].

Professional learning and capacity building are also important deficiencies in the research. Though much emphasis has been laid on teachers' capability in AI application, little is known about how these capabilities are cultivated in pre-service and in-service teacher training programs [2, 5]. Reviewing and studying have shown that the professional development resources available to teachers of picture books are scattered, and the technical and pedagogical support provided by kindergartens is uneven [4, 11]. If there is no systematic training system involving AI literacy and mathematics education, it will be difficult for teachers to convert the technical advantages into actual educational gains. This deficiency may explain the discrepancy between the theoretical models of artificial intelligence (AI) - enhanced learning and its practice in classrooms.

Ethics and Development are commonly seen issues in the research mentioned. Issues such as students' privacy protection, digital security and algorithmic transparency have occurred frequently, and problems in the research of teachers' perception and application in the classroom environment were also reflected [2, 4, 12]. There are more concerns in early childhood education because young children have less ability to understand and cope with digital risks. Some other writers also have pointed out that if children spend too much time on screens, then this would lessen the chance of their involvement in physical exploration, interaction with peers and imagination & creation [6, 9]. The above all show the demand for child-centered, ethical responsibility in the use of educational technology.

Based on the above content, there are some implications for education in practice and policy. Firstly, teachers' education programs need to incorporate systematic training in AI-assisted mathematics teaching, data literacy and ethics so as to support the development of their professional abilities [2, 4, 5]. The focus should be on the integration of technological, pedagogical and development knowledge rather than a single technical ability for such training. Second, Curriculum Developers have the motivation to design instructional models that integrate digital tools with hands-on learning, collaboration, and inquiry [6, 8, 9]. For hybrid learning environment maybe the answer for keeping developmentally appropriate practice and taking advantage of ai technology.

At the policy level, there is a need for clear regulations and institutions to promote responsible AI applications in early childhood education. Those regulations should cover problem such as data management, platform selection, teachers' workload, make sure on the quality of teachings [1, 12]. If

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there is no such a framework, then the implementation practices will be different; some of the teachers may take action unplanned.

Finally, future studies will focus on the classroom application of a long-term and cross-cultural nature to strengthen the empirical evidence of AI-assisted early childhood mathematics education. Mixed-methods designs together learning analytics and qualitative classroom observations may help us have a deeper understanding of how artificial intelligence technology impacts the teaching behavior and learning experience of young children over time [2, 11]. Such ways are necessary to develop sustainable, pedagogically based, and ethically accountable models of AI application.

5. Conclusion

Systematic review of research on the change in role of mathematics teachers in AI supported Early Childhood Education during 2015 – 2025. Based on synthesis of the result from the three studies: it can be concluded that AI technology gives good condition for personalization learning, formation assessment and teaching support. At this moment， the realization of its effective integration is also highly rely on teacher's professional competence，pedagogical judgement and institutional support.

In addition, from the review of the research gaps at home and abroad, it can also be found that domestic research lacks long-term planning, the professional development system is imperfect, there is no good integration of technological innovation and educational philosophy in early childhood education, and practical application needs to be further explored. Ethical problems regarding data protection, digital safety and the growth of kids should also be discussed by researchers and policies constantly.

In order to realize the all-round development of AIED, we must bring together those who educate, develop curricula and make policies. Improve the Design of training courses closely linked to teaching practices and carry out in-class research for a long time, which may help to address the problem of uneven implementation. This review generally lays the groundwork for subsequent studies and supports the development of child-centered, ethically sound and educationally purposeful applications of AI within early childhood math education.

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