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Exploring The Future of Early Childhood Education : Research Trends and Implementation of Augmented Reality

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Abstract: This study aims to examine the research trends and implementation of Augmented Reality (AR) technology in improving various aspects of child development, the challenges of its implementation, and the direction of future research in the context of digital education for early childhood. This study uses the Systematic Literature Review (SLR) method, with a bibliometric mapping approach and content analysis. A total of 17 articles were selected from the Scopus and DOAJ database in the period 2019–2024 for further analysis. The research findings show that the use of AR significantly enhances the learning experience to be more interactive, contextual, and enjoyable for children. In addition, AR has proven effective in conveying abstract concepts visually and helping to reinforce practical values such as financial responsibility from an early age. However, challenges such as limited infrastructure, access to technology, uneven teacher training, and excessive dependence on technology are major obstacles to the widespread implementation of AR. The implications of this study highlight the importance of increasing technological support in educational institutions, developing AR applications that are aligned with the curriculum, and continuous teacher training. Thus, AR has great potential as an innovative medium in early childhood education, as long as it is balanced with the right implementation strategy.

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Introduction

Early childhood is a period of growth and development of all aspects of child development, one of the characteristics of early childhood is that they have a high curiosity and get bored easily so it is very necessary to use a variety of learning media according to their needs (Berk & Meyers, 2020). Early childhood is in a golden age that greatly determines their cognitive, social-emotional, language, and motor development in the future. Therefore, learning at this stage must be designed in such a way as to be able to stimulate all aspects of child development. One of the characteristics of early childhood is having a high curiosity, short attention span, and the need for fun and contextually meaningful learning activities (Berk & Meyers, 2020).

The rapid development of technology plays an important role in changing the way children learn. One of the technologies that is currently developing and is starting to be widely applied in early childhood education is Augmented Reality (AR). Through AR technology, interaction between the real and digital worlds is possible through electronic devices such as tablets or smartphones, thus creating a more immersive and interactive learning experience (Yuen et al., 2011). The application of AR in learning has been proven to be able to improve various aspects of early childhood development, from basic literacy, gross

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motor skills, to emotional involvement and learning motivation (Gómez-Galán et al., 2020; Mamani-Calapuja et al., 2023). In addition, AR also plays an important role in visualizing abstract concepts such as financial and environmental values, so that they are easier for children to understand (Sari et al., 2022). Despite its enormous potential, AR integration in early childhood learning also faces various challenges, such as limited infrastructure, lack of teacher training, and the incompatibility of AR materials with the national curriculum (Mena et al., 2023).

However, until now there have not been many studies that systematically map the development of AR research and implementation in early childhood education, both in terms of themes, methodological approaches, and areas of application. Most studies are still separate and contextual without providing a comprehensive picture of the direction and global trends of AR use in early childhood education. This creates a research gap in understanding how AR truly contributes to early childhood education in the long term.

The novelty of this study lies in the comprehensive approach used in analyzing global research trends on AR in early childhood education in the last five years, including the classification of research contributions, methods used, and gaps that still exist. Not only summarizing the existing findings, this study also presents recommendations for the direction of AR development that is more adaptive and contextual to the needs of early childhood education in the digital era. This study aims to present the results of a Systematic Literature Review (SLR) related to research trends and implementation of AR technology in early childhood education. By analyzing recent articles (2019–2024), this study identifies the contribution of AR to child development, the challenges of its implementation, and future research directions in the context of digital education for early childhood.

Research Method

The method used in this study is the Systematic Literature Review (SLR), with a bibliometric mapping and content analysis approach. SLR is a systematic, explicit, and replicable method for identifying, evaluating, and interpreting all relevant evidence related to a particular research question (Kitchenham & Charters, 2007). In the context of social and educational research, Sugiyono (2017) stated that systematic literature reviews help formulate theoretical constructs and emerging empirical trends. Meanwhile, Ghozali (2021) emphasized the importance of using this method in combining the results of previous studies to build a strong and valid framework for thinking.

A total of 17 articles selected from various Scopus and DOAJ indexed databases, related to the implementation of Augmented Reality (AR) in early childhood education, were analyzed. The article selection process was carried out by considering the quality of the journal, the relevance of the topic, and the methodology used. This study focuses on the main findings that identify trends in the use of AR in various aspects of education, including literacy (Pan et al., 2021; Sari et al., 2022), learning motivation (Gómez-Galán et al., 2020; Takkaç Tulgar et al., 2022), emotional and narrative development (Neira-Piñeiro et al., 2024), and gross motor skills (Faruk et al., 2025). The results of this analysis are expected to provide a comprehensive picture of the contribution of AR technology to the holistic development of early childhood.

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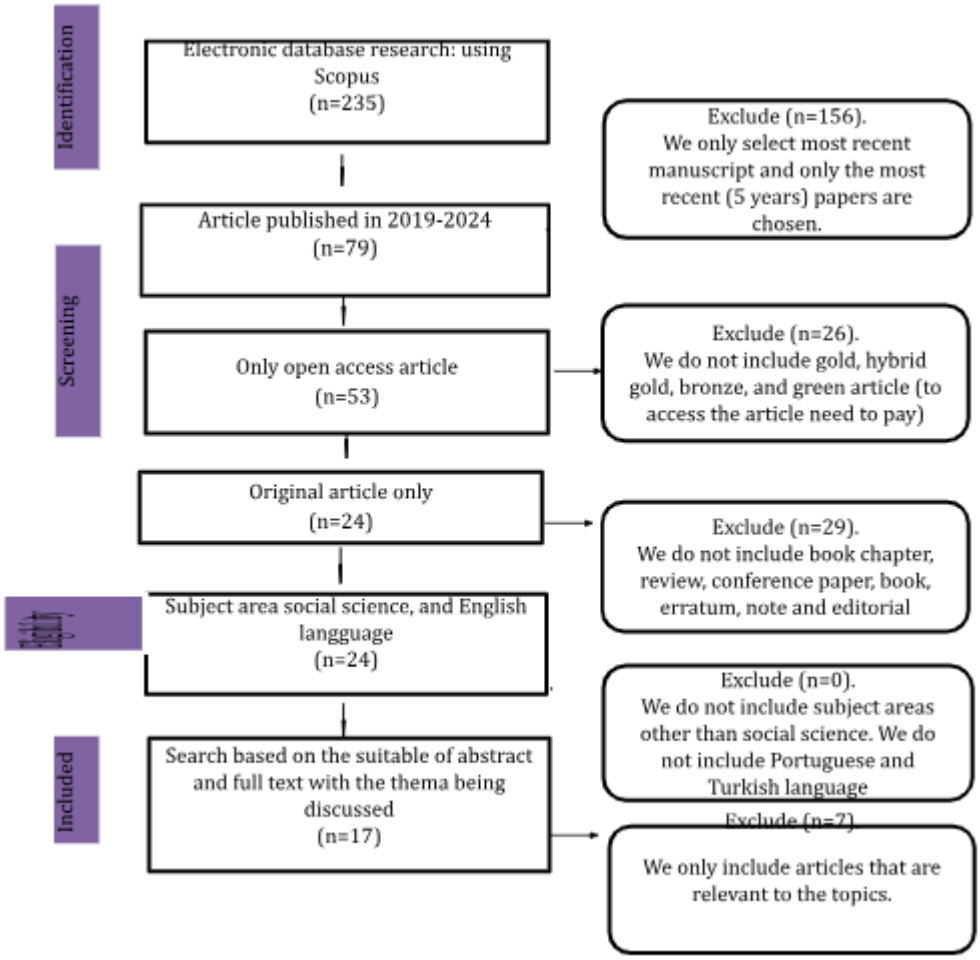

Figure 1. The Map of Research Locations

The Quality Review process for 17 articles was conducted based on five main criteria: topic suitability, methodology clarity, data completeness, result relevance, and contribution to the field of study. The QR results showed: 94% of articles (16 out of 17) met all criteria with a perfect score of 1.00.1 article (i.e. AR in Teacher Training: Literature Review) scored 0.90 because primary data was incomplete. Overall, the average QR score for all articles was 0.99, indicating that the articles analyzed had high methodological quality, strong relevance to the research topic, and significant contributions to the development of studies on the use of Augmented Reality in early childhood education. Thus, the literature base in this study was considered very worthy to be used as a basis for drawing SLR conclusions.

Tabel 1. Sample Distribution Across Districts

No	Article Title and Author Name	Topic Suitability	Clear Methodology	Data Completeness	Relevance of Results	Contribution of Field of Study	Final Score
1	Gómez-Galán et al. (2020) - Socio-Educational Impact of AR in Social Education	1	1	1	1	1	1.0
2	Diaz-Noguera et al. (2019) - Professional Action Competences	1	1	1	1	1	1.0

	through Experiences with AR						
3	Takkaç Tulgar et al. (2022) - Trends in Using AR in English Language Teaching	1	1	1	1	1	1.0
4	Mena et al. (2023) - AR in Teacher Training: A Literature Review	1	1	0.5	1	1	0.9
5	Mamani-Calapuja et al. (2023) - Wordtastic Kids App: AR for Early Childhood English Learning	1	1	1	1	1	1.0
6	Tadeu (2024) - Teaching Fractions to Children Using AR and AI Tools	1	1	1	1	1	1.0
7	Vatamaniuk et al. (2024) - Interactive Methods for Preparing Preschoolers for School	1	1	1	1	1	1.0
8	AlAli & Al-Barakat (2024) - AR for Enhancing Creative Reading Skills in Children	1	1	1	1	1	1.0
9	Del Moral-Pérez et al. (2024) - Transmedia Storytelling and AR for Teacher Education	1	1	1	1	1	1.0
10	Simşek (2024) - AR vs Coloring in Environmental Education	1	1	1	1	1	1.0
11	Guo et al. (2024) - Global Trends in Multimodal Teaching and AR	1	1	1	1	1	1.0
12	Mohammad Faruk et al. (2025) - AR for Gross Motor Skill Development	1	1	1	1	1	1.0
13	Takkaç Tulgar et al. (2022) - AR Research Trends in Foreign Language Teaching	1	1	1	1	1	1.0
14	Sari et al. (2022) - AR-Based Financial Literacy Storybook	1	1	1	1	1	1.0
15	Pan et al. (2021) - AR for Literacy and Motivation in Early Childhood	1	1	1	1	1	1.0
16	Neira-Piñeiro et al. (2024) - Children's Emotional Response to	1	1	1	1	1	1.0

17	AR Storybooks Mohammad Faruk et al. (2025) - Augmented Reality-Based Mobile Learning in Gross Motor Skills	1	1	1	1	1	1.0

This research uses the Systematic Literature Review (SLR) method which combines two main analysis techniques, namely:

1) Content Analysis

This technique was used to evaluate in depth the content of 17 selected articles. The focus of the content analysis was on:

a) The aims and research contributions of each article,
b) Dominant themes and topics such as the influence of AR on literacy, motor skills, motivation, and emotional development of early childhood,
c) The methodology used, including the research approach and type of data,
d) Key findings and their relevance to early childhood education.

Through this content analysis, manual and thematic categorization was carried out to identify research trends, research gaps, and implications of AR implementation in the context of early childhood education. This technique allows researchers to compile a thematic synthesis and build an integrative narrative from various studies.

2) Bibliometric Analysis

Although not explained in detail in the opening section, the use of the phrase "bibliometric mapping" indicates that the research also identified:

a) Distribution of publication years,
b) Geographical distribution/country context (shown from the "Map of Research Location"),
c) Dominant research topics,
d) Possible collaboration between researchers or institutions (if data supports).

The purpose of this bibliometric analysis is to map publication trends and directions of research developments on a macro scale in the last five years (2019–2024), as well as to identify literature that provides a strong foundation for developing the use of AR for early childhood.

3) Quality Review (QR)

As a complement, the Quality Review technique was used to assess the methodological quality of each article based on five criteria: topic suitability, methodological clarity, completeness of data, relevance of results, and contribution to the field of study. The QR score (average 0.99) indicates that the articles analyzed are worthy of being used as a basis for generalization and synthesis of results.

Results and Discussion

The following is a summary of the main findings found in the 17 articles analyzed:

The Use of AR in Early Childhood Literacy

Several studies have shown that AR improves literacy skills, such as letter naming and vocabulary development in children. The use of AR in language and literacy learning has shown significant improvements compared to traditional 2D materials Pan et al. (2021). AR facilitates more engaging and interactive learning, increasing children's motivation and engagement Takkaç Tulgar et al. (2022).

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AR to Improve Financial Literacy

AR is also applied to teach financial literacy concepts to young children. AR-based story books have proven effective in improving understanding of financial concepts, such as delaying gratification and the purpose of saving Sari et al. (2022). AR intervention helps children understand financial responsibility at an early age.

Children's Emotional Responses and Engagement

The use of AR in gamified narratives has a positive impact on children's emotional responses to the subject matter. Children show higher engagement in stories presented with AR technology compared to conventional learning methods Neira-Piñeiro et al. (2024). This shows that AR not only improves cognitive understanding, but also strengthens their emotional experience in learning.

Motor Skills Improvement

AR not only affects cognitive and emotional aspects, but also plays a role in the development of gross motor skills in children. Mobile-based learning with AR shows a significant increase in gross motor skills compared to conventional learning methods Mohammad Faruk et al. (2025).

Research Methodology and Trends in AR Usage

Most of the studies analyzed used quantitative designs, especially experimental designs. Random sampling and data collection using questionnaires or achievement tests were the most commonly used methods. This trend shows the growing use of experimental designs in AR research Takkaç Tulgar et al. (2022). Mixed methods were also used to explore the impact of AR on learning, which enriched the research findings (Pan et al. (2021) and Neira-Piñeiro et al. (2024).

Table2. Research results Article

No	Article Title and Author Name	Research purposes	Research methods	Key Findings	Subject/Sample
1	Gómez-Galán et al. (2020) - Socio-Educational Impact of AR in Social Education	Analyzing the socio-educational impact of AR in social education and professional training.	Quantitative	AR increases motivation and interactivity. Challenges include teacher training and accessibility.	344 students (2016–2019)
2	Diaz-Noguera et al. (2019) - Professional Action Competences through Experiences with AR	Analyzing students' professional competencies through experiences with AR.	Quantitative.	AR increases engagement, but effectiveness decreases post-use.	1920 students from various educational majors
3	Takkaç Tulgar et al. (2022) - Trends in Using AR in English Language Teaching	Analyzing AR bibliometric trends in English teaching.	mixed methods	AR is effective for motivation, academic achievement, and vocabulary learning.	Study on preschool children and students
4	Mena et al. (2023) - AR in Teacher Training: A Literature Review	Reviewing AR integration in teacher training.	Qualitative	The use of AR is still limited, continuous didactic training is needed.	72 documents (articles & proceedings)
5	Mamani-Calapuja et al. (2023) - Wordtastic Kids App: AR for Early Childhood English Learning	Testing the effectiveness of AR in PAUD English learning.	Quantitative	AR increases motivation and vocabulary acquisition in children aged 3–5 years.	42 children aged 3–5 years (Peru)
6	Tadeu (2024) -	Examining pedagogical	qualitative	AR and visual tools help	Not stated (K–10

	Teaching Fractions to Children Using AR and AI Tools	strategies in teaching fractions using digital aids and manipulatives.		address fraction misconceptions, suggesting a personalized approach.	children)
7	Vatamaniuk et al. (2024) - Interactive Methods for Preparing Preschoolers for School	Evaluating the effectiveness of digital-based interactive methods in preparing children for school.	mixed methods	96% of children in the experimental group were ready for school, higher than the control (89%).	170 children aged 5–6 years (Ukraine)
8	AlAli & Al-Barakat (2024) - AR for Enhancing Creative Reading Skills in Children	Testing the impact of AR on children's creative reading skills.	Quantitative.	AR enhances fluency, originality, and flexibility in creative reading.	254 elementary school students
9	Del Moral-Pérez et al. (2024) - Transmedia Storytelling and AR for Teacher Education	Comparing two groups of students in creating educational games based on children's films.	Quantitative	AR & AI boost students' motivation and transmedia skills.	77 students of the University of Oviedo
10	Simşek (2024) - AR vs Coloring in Environmental Education	Comparing children's understanding of the environment using AR and coloring.	Quantitative	Children's scores improved significantly with AR (mean from 4.3 to 13.6).	94 children aged 48–60 months
11	Guo et al. (2024) - Global Trends in Multimodal Teaching and AR	Analyzing bibliometrics and content of multimodal and AR teaching research.	mixed method.	689 articles analyzed, main themes: AR, cognitive load, learning technologies.	Articles from 36 countries (1995–2023)
12	Mohammad Faruk et al. (2025) - AR for Gross Motor Skill Development	Testing the effectiveness of AR mobile learning in physical education.	Quantitative	Gross motor skills increased significantly in the AR group.	60 elementary school students (intervention & control)
13	Takkaç Tulgar et al. (2022) - AR Research Trends in Foreign Language Teaching	Analyzing trends and effectiveness of AR in foreign language teaching.	Quantitative	AR is effective for early childhood engagement and vocabulary mastery.	64 articles (students & pupils)
14	Sari et al. (2022) - AR-Based Financial Literacy Storybook	Developing AR-based financial literacy media for early childhood.	Mixed Methods .	Increased understanding of saving, honesty and responsibility.	20 Kindergarten children in Yogyakarta
15	Pan et al. (2021) - AR for Literacy and Motivation in Early Childhood	Testing the impact of AR on early childhood literacy and motivation.	Mixed Methods	6.28% increase in rapid letter naming in AR class.	Preschool children (number not stated)
16	Neira-Piñeiro et al. (2024) - Children's Emotional Response to AR Storybooks	Analyzing children's emotional responses to AR gamified narratives.	Mixed method.	Children's drawings predominantly show emotional responses and narrative understanding.	113 kindergarten children in Spain
17	Mohammad Faruk et al. (2025) - Augmented Reality-Based Mobile Learning in Gross Motor Skills	The aim was to demonstrate the effectiveness of augmented reality in physical education Save to Notebook Augmented reality mobile learning significantly improves	Quantitative		

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	gross motor skills in students not found.

Advantages of Using Augmented Reality (AR) in Early Childhood Education

Increasing Student Engagement and Motivation

Many studies in this SLR show that AR can significantly increase student engagement and motivation. The use of interactive technology makes learning more interesting, so that children are more enthusiastic and active in participating in the learning process. As found in a study by Mamani-Calapuja et al. (2023), AR increases early childhood learning motivation in learning English, which in turn also accelerates the process of vocabulary mastery.

Increasing Student Engagement and Motivation

AR provides a more interactive and fun learning experience, which is perfect for children who need visual and kinesthetic stimulation. For example, in a study by Simsek (2024), the use of AR in gross motor learning was shown to improve children's physical skills more effectively than traditional learning methods.

Support for Cognitive and Emotional Skills Development

Several studies have shown that AR can help develop children's cognitive and emotional skills. For example, in a study by Gómez-Galán et al. (2020) that focused on financial literacy, AR helped children not only understand basic financial concepts but also foster values such as honesty and responsibility. Likewise, AR can provide emotional story experiences and help children develop social skills through interactions with virtual objects and characters (Mohammad Faruk et al., 2025).

Enhancing Visual and Contextual Learning Experiences

The use of AR allows children to see abstract concepts visually, which strengthens their understanding of the learning material. For example, in Pan et al. (2021), AR was used to teach various mathematics and language learning concepts in a more contextual and applicable way, increasing deeper understanding among students.

Weaknesses of Using Augmented Reality (AR) in Early Childhood Education

Challenges in Infrastructure and Accessibility

One of the main obstacles to the use of AR in early childhood education is the availability of adequate infrastructure. Not all schools have access to the hardware and software needed to run AR applications. As stated in several articles, such as Gómez-Galán et al. (2020), many schools in areas with limited budgets struggle to provide the technology needed for effective AR implementation.

Limitations in Teacher Training

Effective AR implementation requires adequate training for teachers so that they can properly integrate this technology into the learning process. Several studies, as noted in Mena et al. (2023), revealed that although AR has the potential to improve teachers' teaching skills, lack of training and in-depth understanding of this technology can limit its effectiveness. Without adequate training, AR can become a suboptimal tool.

Technology Addiction and Attention Deficit Disorders

AR, while very engaging and interactive, can also lead to excessive dependence on technology. This risks distracting children from direct or social learning, as found in Pan et al. (2021), where children may be more interested in the visual and interactive elements of AR than in the learning material itself. This dependence can reduce children's ability to focus on learning tasks without technological intervention.

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Limitations in Adaptation to the Curriculum

AR is still in its development and limited implementation in many education systems. Often, the available AR applications are not fully adapted to the needs of the existing curriculum. Several articles analyzing the use of AR in early childhood education (Simsek, 2024; Mena et al., 2023) show that integrating AR into existing curricula requires extra effort to ensure that this technology can support learning objectives holistically. The use of AR in early childhood education shows great potential to enhance learning experiences in various areas. From literacy to motor skills, AR has been shown to be effective in enriching the learning process. Research shows that Augmented Reality can facilitate more interactive, immersive, and fun learning, which is especially important at an early age. However, there are several challenges that need to be overcome, such as limited access to technology and the need to develop more structured and age-appropriate learning materials for children. These studies also highlight the importance of collaboration between parents, teachers, and researchers in designing and implementing AR technology in education. As technology advances, further research is needed to explore the long-term impact of AR use on children's social and emotional development. In addition, the application of AR in financial literacy shows that this technology can be used to teach practical values that are very relevant in everyday life.

Conclusion

The conclusion obtained from the findings of this study is that the use of AR significantly enhances the learning experience to be more interactive, contextual, and enjoyable for children. In addition, AR has proven effective in conveying abstract concepts visually and helping to strengthen practical values such as financial responsibility from an early age. However, challenges such as limited infrastructure, access to technology, uneven teacher training, and excessive dependence on technology are major obstacles to the widespread implementation of AR. The implications of this study highlight the importance of increasing technological support in educational institutions, developing AR applications that are aligned with the curriculum, and ongoing teacher training. Thus, AR has great potential as an innovative medium in early childhood education, as long as it is balanced with the right implementation strategy.

Recommendation

Infrastructure and Accessibility Improvements

To maximize the potential of AR, schools and educational institutions need to pay attention to adequate technological infrastructure, including the provision of compatible devices and appropriate AR applications. In addition, efforts to increase access to technology in less developed areas need to be encouraged, so that no child is left behind in this technology-based learning experience.

Ongoing Teacher Training

Teachers should be given ongoing training in the use of AR technology to ensure they can make the most of it. Training that involves not only the use of hardware, but also a deep pedagogical understanding of how to integrate AR into learning, is critical to the successful implementation of AR in education.

Increasing AR Research and Development Integrated with Curriculum

There is a need to develop more AR applications that are integrated with the national education curriculum, so that the use of AR can be maximized and relevant to educational

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goals. In addition, further research on the long-term impact of AR use on early childhood development needs to be conducted to assess its effectiveness in the longer term.

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