Augmented Reality Technology in Early Childhood Education: Trends and Future Practices

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ABSTRACT
Augmented reality (AR) has emerged as a promising area of research for early childhood education (ECE) enhancement. Science learning to use AR technology has been explored in previous studies. This review aims to examine ten articles published between 2020 and 2022 that investigate the potential of AR in preschool science learning. The study conducted a literature search on databases such as Web of Science, SCOPUS, Google Scholar, IEEE, ERIC, Wiley, Emerald Publishing, and Taylor & Francis. The review revealed that the digital storytelling, literacy learning, language learning, and early mathematics were the main topics in AR technology. However, only three of the ten studies addressed AR science learning, highlighting the need for further research on the use of AR in science education in ECE. The research results imply that AR has the potential to revolutionize how young children learn and interact with the world around them. This study emphasizes the importance of incorporating AR technology in future ECE practices.

Keywords: Augmented Reality; Early Childhood; Literature Review; Children

INTRODUCTION

Augmented Reality (AR) is a relatively new technology that has recently become increasingly prevalent in the education field of study (Aydoğdu, 2022; Fidan, 2021). AR has been used for various purposes, including science education, to enhance learning experiences and to engage students in new and exciting ways. Furthermore, AR has been gaining a broadening focus in the educational domain as a tool to support learning and education, including early childhood education (ECE) (Dobrovská & Vaněček, 2021). Equally important, AR allows users to visualize

and interact with 3D virtual objects superimposed on the real world, which can provide a more immersive and engaging learning experience (Utami et al., 2021). AR-based application technology enables preschool teachers and children to transform their learning and engagement with classroom information (Saez-Lopez & Cozar-Gutierrez, 2020). AR has been used in early educational settings to help children visualize abstract concepts such as the solar system by overlaying digital content onto the real world (Timur et al., 2020; Duzyol et al., 2022). Subsequently, AR was implemented in gamification learning by adding a fun and interactive layer to educational content (Hassan et al., 2022). AR learning helped children stay engaged and motivated as they worked through the course materials (Farooq et al., 2022).

Augmented reality applications in early childhood education provide children with a highly immersive and interactive learning environment that can enhance their understanding and retention of scientific concepts. Digital overlays of AR technology that superimpose 3D elements and information onto the real world can make abstract or complex scientific ideas more tangible and accessible to learners (Kalemkuş & Kalemkuş, 2022). In addition, AR can provide children with opportunities to explore scientific concepts in a virtual setting without constraints of time, space, or physical resources. For example, children can use AR apps to explore scientific phenomena and visit remote or inaccessible locations, such as outer spaces or the deep sea. Moreover, incorporating augmented reality into early science education can foster several skills in children. By engaging in an interactive learning activities, children can develop collaboration, critical and creative thinking, and inquiry-based learning skills that are essential to the 21st century (Saadon et al., 2020; Alizkan et al., 2021; Kuleto et al., 2021).

Although research studies on the use of AR in education are abundant, there is a lack of research that specifically examines trends in AR use in the context of preschool education (Kayaduman & Sağlam, 2023). While there are certain general review studies that investigate the use of AR in preschool education (Aydogdu & Kelpsiene, 2021), a comprehensive review that specifically identify trends and future practices in this area is relatively uncommon. Hence, conducting a review of trends and practices is essential to guide future research on the use of AR in early science learning. Nonetheless, the previous analysis was limited to a few studies focusing on children's AR early science topics. However, there may be gaps in our understanding of how users can use AR most effectively in early science education, which is where this study comes in. Accordingly, this study aims to address this gap in the literature by searching for and analyzing augmented reality in early childhood education and identifying trends and best practices that can guide future educational initiatives. Moreover, this study can potentially contribute to educational technology. This could lead to new insights and innovations regarding the reality in early science education. While there is a growing interest in using AR in preschools, it is essential to approach its implementation with a scientific attitude. Any proposed use of the AR technology should be tested and evaluated rigorously to ensure that it is effective and appropriate for young children. This could have necessary implications for educators and learners alike, as it could help optimize the use of AR in various ECE educational contexts.

In brief, the overall outline of this study can help identify gaps in the existing literature and areas where further research is needed. By highlighting these gaps, researchers can direct future studies and contribute to developing a more robust body of research on AR use in early science learning. Despite these alarming challenges, it is important to continue researching the use of AR

in integrating the instructional and pedagogical strategies of inquiry-based learning with AR technology in early science education. More rigorous studies are needed to determine the effectiveness of AR in improving children's learning outcomes and to identify the best practices for integrating pedagogical strategies with AR into early science learning. The principal theoretical implications of this study can provide valuable insights into previous research, guide future studies, and provide a more comprehensive understanding of the capabilities of using AR in early childhood education.

THE RESEARCH PURPOSE

This study on Augmented Reality (AR) technology in Early Childhood Education (ECE) aims to explore current trends and future practices of using this technology in education, specifically at the early childhood education level. Early childhood educators must remain informed about trends and future approaches in augmented reality. AR-based applications are expected to become more prevalent in classrooms as technology advances. It is essential to ensure that these applications are developmentally appropriate, engaging, and effective in facilitating early childhood learning. Educators and developers can create more effective and developmentally appropriate AR-based learning experiences for young children by researching trends and best practices. Despite the potential benefits of using AR in early childhood education, more research on science learning is needed. While some past studies have shown that AR can enhance children's learning in science, previous studies have focused only on small-scale settings with limited generalizability.

The gap in knowledge from previous studies highlights the need for further research on educational technology to elucidate ECE-targeted groups. Thus, this research study will identify and investigate the primary goal of AR implementation in ECE and the main topic used among children in AR application technology learning.

The research questions of this study are summarized as follows.
1. What are the goals of augmented reality research trends in early childhood education from 2020 to 2022?
2. What are the main topics of augmented reality research trends in early childhood education from 2020 to 2022?
3. What are the benefits of augmented reality research trends in early childhood education from 2020 to 2022?

METHODOLOGY

The four main steps of this study are as follows.

Step one: developing research purposes
This study aimed to identify and investigate current research trends in early childhood education between 2020 and 2022. The research objectives are presented in previous section.

Step two: searching for relevant articles
This study applied different databases from Web of Science (WoS), SCOPUS, Google Scholar, IEEE, ERIC, Wiley, Emerald Publishing, and Taylor and Francis to search for relevant articles concerning augmented reality technology in early childhood education published between 2020 and 2022.

The keywords search terms to identify the relevant articles were "Augmented Reality technology and early childhood education", "Augmented Reality and children", "Augmented Reality and preschoolers", and "Augmented Reality and kindergarten".

Step three: selecting the articles
Inclusion and exclusion criteria (Table 1) were used to evaluate the suitability of the selection (Arksey & O'Malley, 2005). The five criteria chosen were the type of literature, language, the timeline of the published paper, research settings, and research performance technology.

Indexed journals were selected as the first inclusion criterion. Meanwhile, the non-indexed journal, systematic review journals, and chapters in the book were rejected in the exclusion criteria. Second, English was chosen as the search parameter for this study. Third, the timeline of the published paper was used between 2020 and 2022, with the exception of publication years less than 2020. Second, the research settings included only early childhood education targets. Finally, performance technology employs augmented reality application technology in early childhood education. Meanwhile, virtual reality application technology was eliminated. The selection of articles in this study was based on adherence to the inclusion criteria (see Table 1).

The recent publications in this study indicate the newness of the research topic or the emergence of new trends in the field. In the case of augmented reality (AR) in early childhood education, the inclusion of recent publications suggests that this area is still evolving and that there is ongoing research on the application of AR in this context. Table 1 depicts the inclusion and exclusion criteria of the methodology for this study in the educational field.

Table 1
Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Type of literature	Indexed journal	Non-indexed journal, systematic review journals, chapter in book
Languages	English	Non-English
Timeline of published paper	2020-2022	Less than 2020
Research settings	For early childhood education targets	For other targets
Research performance technology	The studies related to augmented reality application technology in early childhood education	The studies related to virtual reality and mixed reality application technology in early childhood education

Step four: identifying, outlining, and reporting the findings of the research
After thoroughly investigating the inclusion and exclusion criteria, ten articles were examined from various databases aligned with the research purposes. Specifically, Web of Science (WoS), SCOPUS, Google Scholar, IEEE, ERIC, Wiley, Emerald Publishing, and Taylor & Francis.

High-impact databases of scientific areas, such as SCOPUS and Web of Science (WoS), are considered the most accurate and powerful search and analysis tools for accessing the most accurate and useful information for retrieval goals. This finding supports that of Aksnes et al. (2019). As shown in Figure 1, the outline of the description describes the process steps for articles selection.
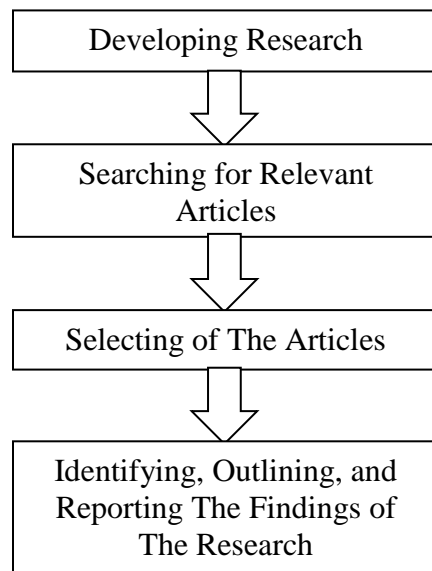

Figure 1: A description of the process for selecting papers

FINDINGS

This section describes and discusses the findings of the reviewed articles based on ten reports from previous studies. This study supplemented the reviewed literature with the results of the two research questions and research trends designed to answer the study's research questions.

What are the goals of augmented reality research trends in early childhood education from 2020 to 2022?
The first research question sought to determine and identify the leading purpose of augmented reality research trends in early childhood education from 2020 to 2022. The findings of the ten past studies are illustrated in Table 2.

Table 2
The research goal of augmented reality research trends in early childhood education
from 2020 to 2022

No	Title and author	Year of publication	Research goal
1	Introduction to Sea Animals With Augmented Reality-Based Flashcard for Early Childhood (Utami et al., 2020).	2020	To provide an overview of the use of AR-based flashcard media in the introduction of sea animals in early childhood.
2	The Limited Effect of Graphic Elements in Video and Augmented Reality on Children's Listening Comprehension (Del Rio Guerra et al., 2020).	2020	This study compares the effectiveness of AR and video for listening comprehension tasks.
3	Introducing augmented reality in early childhood literacy learning (Pan et al., 2021)	2021	To measure the impact of AR on early childhood learning and motivation in the literacy domain.
4	Implementation of Augmented Reality in Introducing Islamic Pillars Appication for Young Children (Cahyana et al., 2021)	2021	The development of a mobile AR-based application to introduce children to the five pillars of Islam.
5	Development of Food Pyramid Application Using Augmented Reality (AR) Technology (Waidi et al., 2021).	2021	To develop a food pyramid application by using AR technology to be one of the effective branches of education for children to better understand the definition of the food pyramid and how to take balanced nutrition according to category level in the pyramid.
6	Destroy Covid-19: 3D E-book in Augmented Reality & Games Application (Sarudin & Aziz, 2021).	2021	To evaluate the effectiveness of the new interactive learning method based on 3D AR, which consists of 3D and AR learning system game applications. To develop learning systems and game applications using 3D Augmented Reality (AR).

7	Mobile Augmented Reality applied as a learning strategy for early childhood education students (Petrlik et al., 2022).	2022	To determine the effect of the use of mobile augmented reality applied as a learning strategy for early childhood education students.
8	Developing a Financial Literacy Storybook for Early Childhood in an Augmented Reality Context (Sari et al., 2022).	2022	To develop and test the effectiveness of an AR-based financial literacy storybook for early childhood.
9	Early Mathematics Module for Stem Learning with Flipped Classroom Concept Using Augmented Reality (Idris et al., 2022)	2022	To increase students' understanding of pattern topics in the subject of Early Mathematics by integrating the concept of Flipped classrooms with an Augmented Reality application known as the EM-Flip module.
10	Designing an Augmented Reality-Based Eduplay Learning Media to Improve Early Childhood Reading Skills (Rahmawati et al., 2022).	2022	To develop an eduplay learning media designed to improve early childhood reading skills.

What are the main topics of augmented reality research trends in early childhood education from 2020 to 2022?
Despite that**,** the second research question attempts to investigate the main topics of the research trends on augmented reality in early childhood education. The results are demonstrated in Table 3 below.

Table 3
The main topic of augmented reality research trends in early childhood education from 2020 to 2022

No	Title and author	Year of publication	Main topic
1	Introduction to Sea Animals With Augmented Reality-Based Flashcard for Early Childhood (Utami et al., 2020).	2020	AR-based flashcard for early childhood.

2	The Limited Effect of Graphic Elements in Video and Augmented Reality on Children's Listening Comprehension (Del Rio Guerra et al., 2020).	2020	AR on children's listening comprehension.
3	Introducing augmented reality in early childhood literacy learning (Pan et al., 2021)	2021	AR in early childhood literacy learning.
4	Implementation of Augmented Reality in Introducing Islamic Pillars Application for Young Children (Cahyana et al., 2021)	2021	AR in Islamic learning for young children.
5	Development of Food Pyramid Application Using Augmented Reality (AR) Technology (Waidi et al., 2021).	2021	AR apps technology of education for children.
6	Destroy Covid-19: 3D E-book in Augmented Reality & Games Application (Sarudin & Aziz, 2021).	2021	AR 3D E-book and games app.
7	Mobile Augmented Reality applied as a learning strategy for early childhood education students (Petrlik et al., 2022).	2022	Mobile augmented reality applications as a learning strategy for children.
8	Developing a Financial Literacy Storybook for Early Childhood in an Augmented Reality Context (Sari et al., 2022).	2022	AR Storybook for early childhood in financial literacy learning.
9	Early Mathematics Module for Stem Learning with Flipped Classroom Concept Using Augmented Reality (Idris et al., 2022)	2022	AR module in early mathematics with flipped classroom concept.

| 10 | Designing an Augmented Reality-Based Eduplay Learning Media to Improve Early Childhood Reading Skills (Rahmawati et al., 2022). | 2022 | AR-based learning media in early childhood reading skills. |

What are the benefits of augmented reality research trends in early childhood education from 2020 to 2022?

Nevertheless, the third research question aims to examine the benefits of the research trends on augmented reality in early childhood education. The results are indicated in Table 4 below.

Table 4
The benefits of augmented reality research trends in early childhood education from 2020 to 2022

No	Title and author	Year of publication	Benefits
1	Introduction to Sea Animals With Augmented Reality-Based Flashcard for Early Childhood (Utami et al., 2020).	2020	• It can make it easier for teachers and parents to provide an understanding of sea animal introduction material. • With augmented reality technology that can be displayed on flashcard media, children can see sea animal objects in real terms. • This makes it easier for children to recognize these sea animals. • In addition, augmented reality-based flashcard media can also attract children's attention to the material taught by teachers or parents.
2	The Limited Effect of Graphic Elements in Video and Augmented Reality on Children's Listening Comprehension (Del Rio Guerra et al., 2020).	2020	• The study found that there were no significant differences between the two formats in terms of test performance, but there were differences in performance based on the participants' reading comprehension level.
3	Introducing augmented reality in early childhood literacy learning (Pan et al., 2021)	2021	• The use of innovative learning media, such as augmented reality, can increase students' understanding of the concepts given

			by educators and provide higher learning completeness.
4	Implementation of Augmented Reality in Introducing Islamic Pillars Application for Young Children (Cahyana et al., 2021)	2021	● Providing an interactive and engaging learning experience for children. ● Enhancing children's understanding of the five pillars of Islam. ● Encouraging children to learn about their religion in a fun and innovative way. ● Utilizing emerging technology to improve Islamic education for young children.
5	Development of Food Pyramid Application Using Augmented Reality (AR) Technology (Waidi et al., 2021).	2021	● Augmented Reality (AR) technology allows users to view and interact with virtual objects in a real environment. ● In the context of the food pyramid application developed in this study, AR technology was used to create a visual representation of the food pyramid that children could interact with and learn from.
6	Destroy Covid-19: 3D E-book in Augmented Reality & Games Application (Sarudin & Aziz, 2021).	2021	● AR is considered the most current and motivating technology that can attract many users. ● It can increase learning capabilities and deliver knowledge more effectively, straightforward and exciting. ● The principles of Ebook visualization have been used, and the application for games makes the information browsing process much more fun and accessible. ● The AR-based learning system game applications can provide an interactive and engaging learning experience for users.
7	Mobile Augmented Reality applied as a learning strategy for early childhood education students (Petrlik et al., 2022).	2022	● The use of mobile learning as a strategy in teaching and learning through the impact provided by ICT's allows early childhood education to make education more inclusive, accessible and equality.

8	Developing a Financial Literacy Storybook for Early Childhood in an Augmented Reality Context (Sari et al., 2022).	2022	● The use of AR technology in financial education can make learning more engaging and interactive, which can lead to better retention of information. ● It can also provide a more immersive learning experience, allowing students to visualize and interact with financial concepts in a more meaningful way.
9	Early Mathematics Module for Stem Learning with Flipped Classroom Concept Using Augmented Reality (Idris et al., 2022)	2022	● The EM-Flip module, which integrates the concept of Flipped Classroom with an AR application, was found to increase students' understanding of pattern topics in Early Mathematics. ● The combination of technology and active learning in the classroom was found to be effective in engaging students and improving their interest in the subject.
10	Designing an Augmented Reality-Based Eduplay Learning Media to Improve Early Childhood Reading Skills (Rahmawati et al., 2022).	2022	● The use of innovative learning media, such as augmented reality, can increase students' understanding of the concepts given by educators and provide higher learning completeness.

DATA ANALYSIS

The analysis pertains to the trends and future practices in the utilization of Augmented Reality Technology in Early Childhood Education. The analysis was conducted from 2020 to 2022 using Litmaps, a tool that analyzes research, identifies key themes, and establishes associations between articles and studies. This tool can help visualize a literature review and can identify gaps in knowledge, potential research areas, and emerging trends. The researchers most likely used Litmaps to search for articles related to Augmented Reality Technology and Early Childhood Education that were published between 2020 and 2022. The tool would have analyzed the articles, identified the authors and years, and visually mapped the relationships between the studies.

This data analysis approach likely resulted in a comprehensive understanding of the current trends and future practices related to the use of augmented reality technology in early childhood education. The findings of this analysis could be used to guide future research and inform the development of educational programming and policies related to the use of technology in early

childhood education. The illustrations presented in Figures 2 and 3 depict the procedure used to discover the articles.
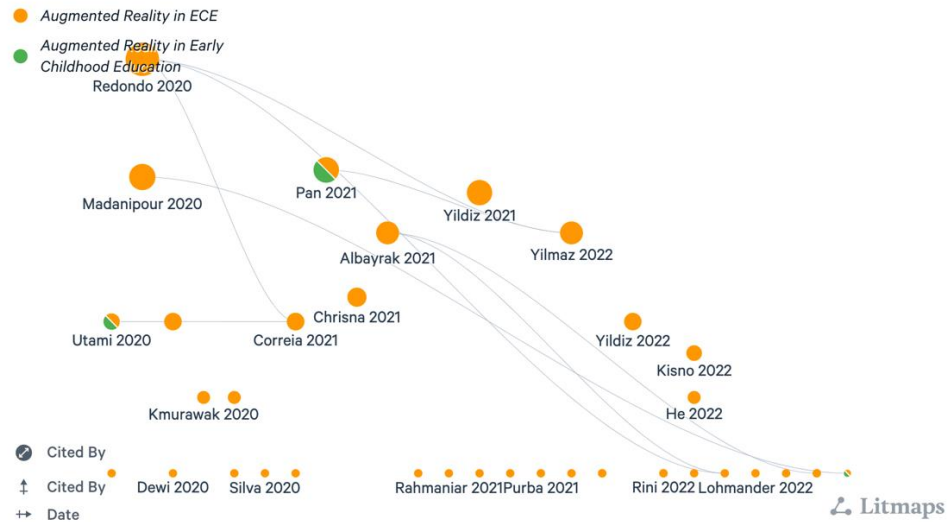

Figure 2: The visualization of the journals of Augmented Reality (AR) in early childhood education for the inclusion criteria process
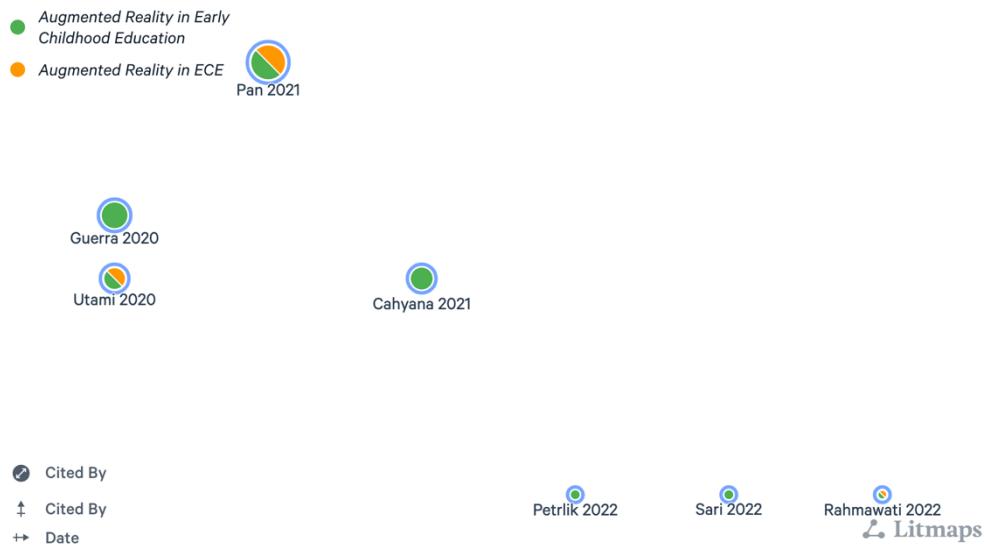

Figure 3: The exclusion criteria process with some of the AR in early childhood education journals selected

DISCUSSION

Augmented Reality (AR) is an innovative tool that can enhance the learning experiences of early childhood education (ECE) students (Hanid et al., 2020; Avila-Garzon, 2021; Liono et al., 2021; Sharma et al., 2021; De Lima & Owen, 2022; Turhan et al., 2022). AR integrates digital content with the real world to create an interactive and immersive learning environment. In recent years, AR has gained significant popularity in ECE, and many educators have begun to incorporate AR technology into their teaching practices. The purpose of this study is to explore and review ten articles on the current research on AR technology for ECE learning from 2020 to 2022.

The findings are discussed in further detail in the following sections.

RQ1:What are the research goals of augmented reality research trends in early childhood education from 2020 to 2022?
Interestingly, it has emerged as a promising technology for enhancing young children's learning experiences (Utami et al., 2020; Cahyana et al., 2021). Research trends in early childhood education from 2020 to 2022 indicate that many researchers are exploring the potential benefits of AR in improving children's cognitive, affective, and psychomotor development. Moreover, the impact of AR on children's engagement, motivation, and interest in learning has been studied (Pan et al., 2021; Waidi et al., 2021). These studies produced results that corroborate the findings of a great deal of previous work in this field (Cai et al., 2021), which revealed that AR positively improved motivation, attitudes, and skills.

One of the most common research objectives is to understand the effects of AR on early childhood learning outcomes, indicating that there is growing interest in exploring the potential of AR to enhance children's academic performance (Del Rio Guerra et al., 2020; Pan et al., 2021; Rahmawati et al., 2022). Other research goals include exploring the challenges and barriers to the implementation of AR tools in ECE settings and developing AR-based learning environments that cater to the diverse learning needs of young children (Idris et al., 2022; Sarudin & Aziz, 2021; Petrlik et al., 2022). These research goals indicate the growing interest in and importance of integrating AR technology into early childhood education to promote an interactive and engaging learning experience.

RQ2:What are the main topics of augmented reality research trends in early childhood education from 2020 to 2022?
Augmented reality (AR) technology has shown promising results in enhancing literacy, language learning, listening comprehension, and reading skills in early childhood education. Several studies from 2020 to 2022 have focused on these areas and demonstrated the potential of AR technology to support young children's language and literacy development. Del Rio Guerra et al. (2020) investigated the use of AR technology to enhance literacy skills among preschool children. This study found that AR-based learning activities were effective in improving listening comprehension. By incorporating augmented reality tools and apps into language and literacy instruction, children can engage with interactive stories, visual elements, and virtual environments that can help bring learning experiences into life. Studies have shown that using augmented reality in language learning can enhance children's motivation, engagement, and interest.

In the bargain, Utami et al. (2020) presented an intervention that used AR-based flashcards to introduce young children to sea animals. The intervention aimed to enhance the children's understanding and knowledge of sea animals. This study demonstrated the potential of AR technology to provide a hands-on and interactive learning experience for young children. Pan et al. (2021) used AR technology to support listening comprehension among kindergarten children in the United States. The results showed that AR-based learning activities positively affected children's listening comprehension and engagement in learning. Further, Cahyana et al. (2021) demonstrated the potential of AR technology to introduce young children to religious teaching. Specifically, the study used a mobile AR-based application to teach kindergarten students in Indonesia the five pillars of Islam. The results show that AR technology can be an effective tool for teaching religious concepts to young children. Similarly, Waidi et al. (2021) used the AR app technology for children to learn the food pyramid in a science topic.

In addition, Sari et al. (2022) explored the use of the AR Storybook to enhance financial literacy in early childhood in Indonesia. The purpose of this study is to evaluate the effectiveness of an AR-based storybook in improving financial literacy among young adults. The inclusion of reading skills in augmented reality research trends in early childhood education reflects the importance of reading in children's academic success and overall well-being. Augmented reality technology can be used to create interactive and engaging reading materials, such as pop-up books, which can help children develop reading skills, including sound-letter recognition and phonological awareness (Rahmawati et al., 2022).

RQ3:What are the benefits of augmented reality research trends in early childhood education from 2020 to 2022?

Augmented reality (AR) technology has the potential to transform early childhood education, and recent research trends from 2020 to 2022 have demonstrated a wide range of benefits offered by AR. Recent studies have indicated that AR provides children with interactive and immersive learning experiences that appeal to their curiosity and imagination. Consequently, children become more engaged and motivated in the learning process. For instance, Utami et al. (2020) discovered that using AR technology, children can view sea animal objects in real time, making it easier for teachers and parents to provide a comprehensive introduction to sea animals. Del Rio Guerra et al. (2020) found varying differences in performance based on the participants' reading comprehension level, implying that AR technology can improve education to fit individual learning levels. Pan et al. (2021) found that using innovative learning media, such as AR, could increase students' understanding of the material and improve overall learning completeness.

Cahyana et al. (2021) investigated the use of AR technology to introduce Islamic pillars to young children. This study found that AR provides an interactive and engaging learning experience for children, improving their understanding of Islam's five pillars. The learning approach also encouraged children to learn about their religion in a fun and creative manner and utilized emerging technology to enhance Islamic education for young children. Waidi et al. (2021) explored the development of food pyramid applications using the AR technology. This technology allows users to view and interact with virtual objects in real environments. AR technology creates a visual representation of the food pyramid from which children can interact and learn. Furthermore, Sarudin and Aziz (2021) discussed the AR in the eBook application for games, and

the outcome is that it makes the information browsing process much more fun and accessible. AR-based learning system game applications can provide users with interactive and engaging learning experience.

Based on past studies by Petrlik et al. (2022), the use of mobile learning as a strategy in teaching and learning makes education more inclusive, accessible, and equal. Sari et al., 2022 reviewed that using AR technology in financial education can make learning more engaging and interactive, leading to better retention of information. It can also provide a more immersive learning experience, allowing students to visualize and interact with financial concepts more meaningfully. Subsequently, the EM-Flip module, which integrates the concept of a Flipped Classroom with an AR application, increased students' understanding of pattern topics in Early Mathematics. The combination of technology and active learning in the classroom has been found to be effective in engaging students and improving their interest in the subject (Idris et al. 2022).

Thereafter, innovative learning media, such as augmented reality, can increase students' understanding of the concepts provided by educators and provide higher learning completeness (Rahmawati et al., 2022). In conclusion, AR technology has promising benefits in early childhood education that could enhance children's learning experiences, and further research is necessary to reveal new discoveries. Overall, research trends in AR in early childhood education from 2020 to 2022 have shown numerous benefits, including increased engagement and motivation, improved spatial and cognitive skills, multi-sensory learning experiences, and personalized learning. These benefits make AR a promising tool for enhancing early childhood education.

The use of augmented reality (AR) technology in early childhood education has the potential to improve learning outcomes and increase engagement and motivation in young children. Recent research has shown the effectiveness of AR technology in supporting literacy, language learning, listening comprehension, reading skills, early science, and mathematics education. However, despite growing support for the use of AR technology in teaching early science topics, the pedagogical strategies employed in its integration are still limited. Further investigation and development are required to effectively implement AR technology in teaching and learning.Therefore, it is vital to study effective pedagogical strategies for integrating AR technology into early science education to enhance children's scientific knowledge and skills. AR technology has the potential to promote inquiry-based learning in early science education, and its integration into the curriculum can have significant benefits for young children's academic achievement and overall development.

This article provides a comprehensive overview of current trends and future practices in utilizing AR technology in early childhood education, highlighting its potential to revolutionize traditional pedagogical practices and provide innovative, engaging, and effective educational opportunities for young learners. Educators and policymakers interested in improving early childhood education through technology are encouraged to study these findings. Although further investigation and development are needed, the adoption of AR technology in early childhood education holds immense potential to transform traditional practices and provide young learners with the skills they need to succeed in school and beyond. It is noteworthy that AR technology has been widely studied in early childhood education and can provide valuable insights into enhancing young children's learning experiences.

CONCLUSION AND RECOMMENDATION

In summary, this study provides an in-depth analysis of the research trends for utilizing augmented reality technology in early childhood education from 2020 to 2022. The findings indicate that most studies focus on the use of AR in literacy and language learning, comprehension learning, and mathematical learning, with less attention given to science learning. This highlights the need for more research and development in AR applications in science and other subject areas to ensure a well-rounded education for young children.

In general, the article makes an important contribution to the field of early childhood education by highlighting the potential of AR technology to enhance the learning experiences of young children. The authors provide recommendations for educators and policymakers to integrate AR into early childhood education effectively. This includes designing AR technology that aligns with young children's developmental abilities, providing adequate teacher training and support, ensuring accessibility and equity for all children, and evaluating the effectiveness of AR technology in promoting learning outcomes.

In terms of future research, there is a need for more empirical studies that investigate the effects of AR technology on children's learning outcomes and the optimal methods for integrating AR into early childhood education. Further research is also needed to develop and test AR applications and tools for different subject areas, including early science. Hence, this article provides valuable insights into the current trends and future practices of AR technology in early childhood education. It is recommended for educators, policymakers, and researchers interested in exploring the potential of AR technology to enhance the learning experiences of young children.

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Conflict of Interest
The authors have no conflict of interest to declare.

Authors' Contributions
All authors were involved in the conceptualization and writing of the article.

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