Augmented Reality Technology in Early Schools: A Literature Review

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ARTICLE INFO	ABSTRACT
	In recent years, there has been a notable rise in the utilization of augmented reality within educational settings. However, there is still room for improvement in early childhood education. This study aims to investigate how current augmented reality works in early childhood education between 2017 and 2022 using library research methodology. The study's content was analyzed based on the case studies on integrating augmented reality in early school education between 2017 and 2022. 26 studies were found when the keyword "Augmented Reality in early school" was used to start the study (in primary school). With a sample size of fewer than 21 kids, early literacy discovered that Science (Animals, Newton) was the most frequently used subject. Regarding data collection techniques, testing has emerged as the dominant technique in research of "marker-based" augmented reality on mobile devices. These findings help to clarify the best ways to use this technology in early learning settings. Over the past five years, the number of schools using augmented reality in early childhood education has steadily increased.

1. Introduction

The transformation of the education system due to technological advancement significantly impacts the growth of the nation's economy. One of the transformations involved is developing innovative technology to assist teaching and learning [1-4]. This innovation enables the creation of an authentic, engaging, and entertaining learning environment [5]. Realizing the significance and advantages of technology in education, an increasing number of academics and teachers emphasize incorporating technology development into PDPC activities, particularly Augmented Reality [6-9]. Consequently, this survey aims to examine the trends in the application of augmented reality technology in early school education between 2010 and 2022.

On the brink of the technology revolution, information and communication technology (ICT) is indispensable in people's daily lives. They rely heavily on smartphones, computers, and the Internet to retrieve and transmit the latest information [10,13,14]. Moreover, ICT has also been widely applied in education sector to enhance, improve and support the teaching and learning process. In Malaysia

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Education Blueprint 2015-2025, the Malaysian government asserted to leverage ICT to elevate the standard of education throughout the nation [5,17].

Figure 1 shows the selection of study topics involving Augmented Reality technology in early childhood and its integration. The study was focused in terms of the most used subject topics, the type of augmented reality used, the selection of devices, the selection and number of research samples and the collection of data from the studies.
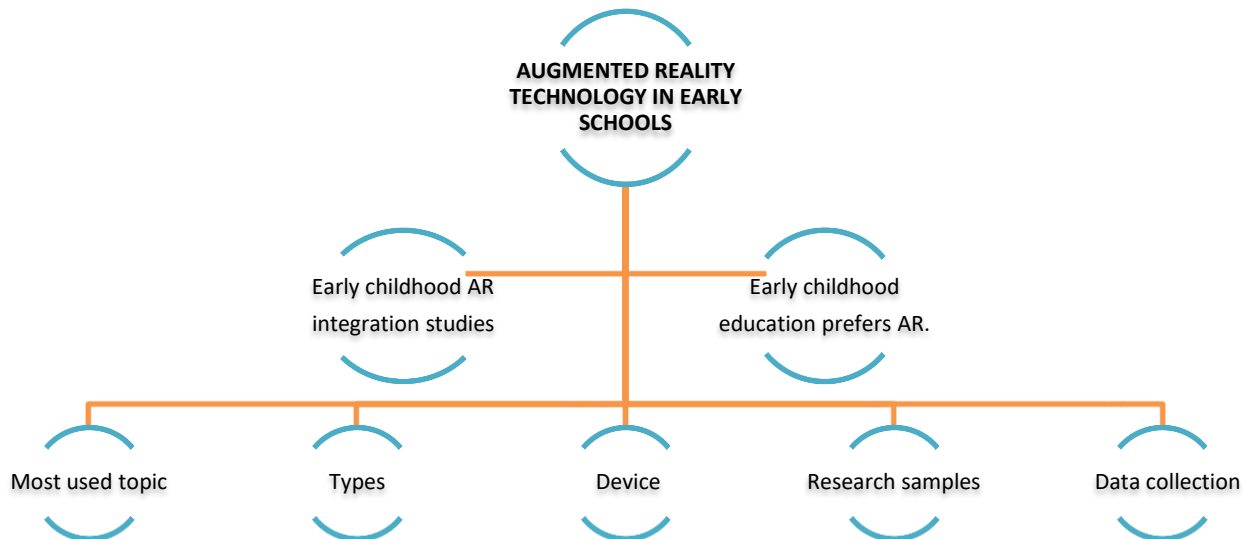

Fig. 1. The topic of studies involving augmented reality technology in early childhood and its integration

2. Purpose of The Study

This study aims to identify the existing augmented reality applications in early childhood education. Augmented reality has tremendous potential and should be utilized at all educational levels. This study examines the potential void and the inclination toward utilizing augmented reality in early school education. Moreover, this research will comprehensively investigate the most studied topics, types of augmented reality, devices used with augmented reality applications, study samples, and data collection methods involved in conducting an augmented reality assessment in early childhood education.

The research objectives for this study can be referred to as follows:

  i.   To identify existing integration of augmented reality in early school education.
 ii.   To investigate the preference for using augmented reality in early school education.
iii.   To identify the most used topic, types of augmented reality, devices used with augmented reality applications, research samples, and the data collection method used for augmented reality in early childhood education.

3. Methodology

This study followed the four processes as follows (library research methodology). As shown in Figure 2, the process of paper selection is listed. Through the four processes of this library research methodology, it begins with the development of research objectives. Followed by identifying appropriate research articles. After that, implement the selection of articles with inclusion or exclusion criteria. Finally, summarising and reporting the research findings of 26 articles.
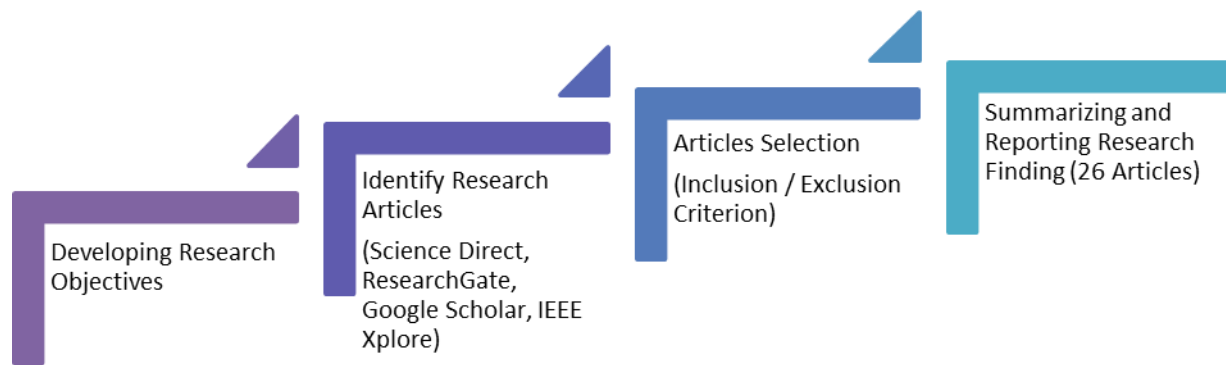
Fig. 2. The process of paper selection

3.1 Step 1: Developing Research Objectives

This study aimed to identify the current augmented reality trends in early childhood education between 2017-2022. The research objectives can be found in Section 2: Purpose of the study.

3.2 Step 2: Identify Research Articles

In this study, various databases like ScienceDirect, ResearchGate, Google Scholar, and IEEE Xplore have been used to search articles regarding young children's learning with augmented reality technology, published from 2017 to 2022. The keywords like "Augmented Reality and early school education", "Augmented Reality and primary school" and "Augmented Reality and kindergarten" were used.

3.3 Step 3: Articles Selection

The selected articles were examined using a set of inclusion and exclusion criteria, and the selection was determined by their relevance to the study. By referring to Table 1, the first inclusion criterion is that the selected papers were published between 2017-2022, while any articles published before 2017 were excluded.

Secondly, the selected articles focused on young children aged 5-8 years, and all papers involving young children with different abilities (special needs, autism, etc.) will be excluded. However, to find an article that accurately focuses on the exact age (5-8 years) as aforementioned was hardly found. Therefore, any paper that involves children within the mentioned age range was included in this review.

Table 1
Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Published papers between 2017-2012	Published paper before 2016
Young children aged 5-8 years old without special needs and requirement	Young children aged 5-8 years old with special needs and requirement
English and Malay language	Other languages
Studies that describe the application and framework of augmented reality in early school education	Systematic Review; Editorial; Concept articles; The article which used virtual reality and other irrelevant keywords, although augmented reality was mentioned in the study. Only terms appear in the references section.
For educational purposes	For other purposes

Thirdly, articles that used languages other than English and Malay were excluded. Fourthly Ives, all articles that work on ideas, concepts, or review papers without any evaluation were excluded to fill this research's objectives. Finally, only articles intended for educational purposes were included in this review.

3.4 Step 4: Collecting, Summarizing and Reporting Research Findings

After careful examination, 26 articles were found to be highly relevant to the purpose of this study. Examined articles were first coded into Microsoft Excel software. Frequencies and percentages of related data were presented in bar charts and tables.

4. Result and Discussion

This section describes and discusses the results of conducting the review based on the selected 26 articles.

4.1 Results for the Existing Works of Augmented Reality in Early Childhood Education

The number of published studies in early childhood education has slowly increased over the years, especially in the first five years, according to an analysis of the years of augmented reality publications. Although only very few studies were found between 2017 and 2022, the year with the most published articles was 2018. These findings suggested that early childhood researchers were interested in further exploring augmented reality's benefits in early childhood education. The scarcity of publications is ascribable to the fact that the survey is still in the initial phase, although some preliminary studies were reported in these five years. Due to the potential of technology in facilitating early childhood education, previous studies advised that more research be done on augmented reality (AR) mobile applications in early childhood education [27].

The number of publications between 2017 and 2022 is shown in Table 2. According to the statistics, there were 2 published studies in early childhood education in 2017, 7 published studies in 2018, 6 published studies in 2019, 3 published studies in 2020, and 2 published studies in 2021. 6 will thereafter be released in 2022.

Table 2
Numbers of publications between 2017 and 2022

Years	2017	2018	2019	2020	2021	2022
No of Publication	2	7	6	3	2	6

Figure 3 shows the Result of Integration of Augmented Reality in Early Childhood Education. Many studies have been published discussing the incorporation of augmented reality in education. Nonetheless, the educational benefits of its implementation in early childhood education have not been adequately studied.
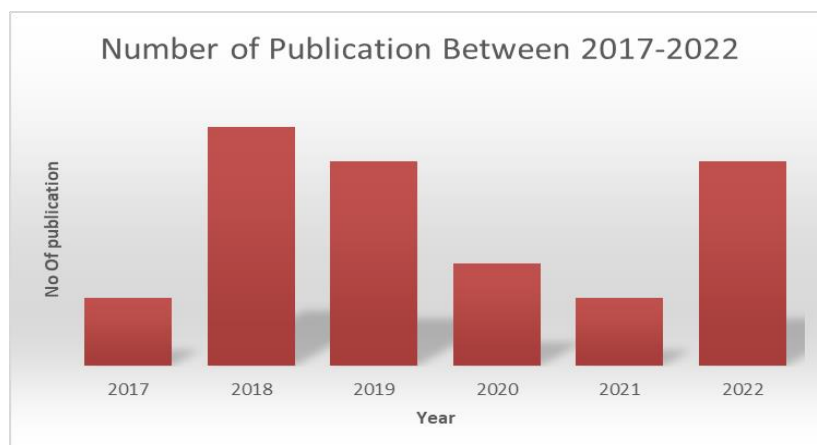
Fig. 3. Numbers of publications since 2017-2022

4.2 Result of Integration of Augmented Reality in Early Childhood Education

Table 3 summarizes the area of studies which involve the integration of augmented reality. There have been thirteen reports of augmented reality integrations, including (1) Science (Animals, Newton), (2) Early Literacy (Alphabet, writing, numbers, early childhood activities), (3) Art education, (4) English, (5) Religious education, (6) Storytelling, (7) Games, (8) Vocabulary, (9) Mathematics, (10) mother tongue (original alphabet), (11) Learning the hues, (12) Awareness of Dental Health, and (13) Other. As studies can cover various aspects, each study can be classified into multiple categories.

According to the study's findings, the topic "Science (Animals, Newton)" accounts for 26.92 percent of all integrated reports. It has been reported that augmented reality facilitates mathematical problem-solving, increasing children's interest and satisfaction [24-30]. Additionally, it suggested that augmented reality "improves achievement / performance / comprehension" (15.38%). On the other hand, some studies reported poorly-implemented augmented reality integration in early childhood education, specifically the integration of AR interactive book development; only two studies identified this integration [20-23].

Table 3
Augmented reality integration topic studies in early childhood education

Topics	Authors
Science (Animals, Newton)	Aydogdu [16], Duzyol *et al.,* [23], Fuchsova and Korenova [25], Kmurawak and Setyaningsih [28], Nasution *et al.,* [31], Ozdamli and Karagozlu [32], Shan [36]
Early Literacy (Alphabets, writing, numbers, early childhood activity)	Koca *et al.,* [21], Jamiat and Othman [27], Piatykop [33], Ya *et al.,* [37]
Art education	Rauf and Tan [12]
English language	Takkac Tulgar *et al.,* [11], Chen *et al.,* [19], Che Hashim *et al.,* [40]
Religion education	Pradibta [34]
Storytelling	Aydogdu [16], Nasution *et al.,* [31]
Games	Zhu *et al.,* [39]
Vocabulary	Chen and Chan [18], Chen *et al.,* [19], Cieza and Lujan [20], Che Hashim *et al.,* [40]
Mathematics	Demitriadou *et al.,* [22], Fernandez-Enriquez and Delgado-Martin [24], Idris *et al.,* [26], Najwa and Khalid [30]
Native language (native alphabet)	Aydogdu [16]
Color Learning	Rauf and Tan [12], Koca *et al.,* [21], So'ad and Ismail [29]
Dental Health Awareness	Salim *et al.,* [35]
Others (Text Book, AR Book)	Alhumaidan *et al.,* [15]

4.3 Results for Augmented Reality Applications in Early Childhood Education

Four distinct types of augmented reality exist: (1) marker-based augmented reality, (2) markerless augmented reality, (3) location-based augmented reality and (4) projection-based augmented reality. Marker-based augmented reality requires markers to identify the position of 3D objects on a real-world image [38], whereas location-based augmented reality follows the same procedure. However, instead of identifying markers, it provides digital information to a set of grid coordinates [39].

Figure 4 shows the types of augmented reality used in early school education settings. Most studies (96.15%) employ marker-based augmented reality, as suggested by the review. In comparison to other categories, marker-based augmented reality is easier to use and develop. Existing software such as Unity, Vuforia, and Aurasma facilitate the creation of marker-based augmented reality. Meanwhile, the least popular types of augmented reality are "augmented reality without markers" and "augmented reality based on location" (both with 0% usage).
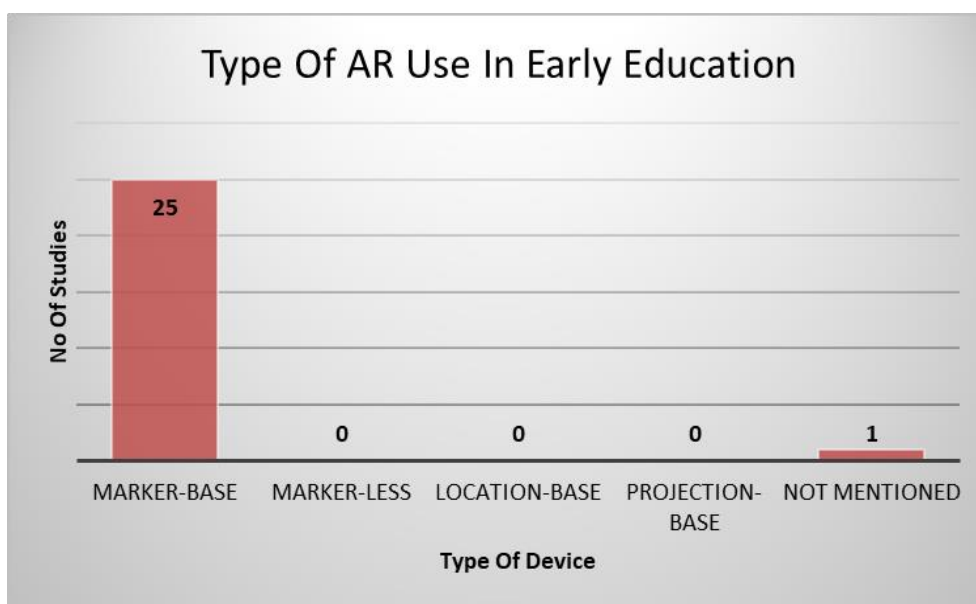

Fig. 4. Types of augmented reality used in early school education settings

4.4 Results for Augmented Reality-Enabled Devices

Based on the Figure 5, 'mobile devices' such as smartphones and tablets are the most popular devices used in early school education studies involving augmented reality, followed by 'cameras' (30.77%) [24]. The dominance of mobile device usage in early school education is due to its low cost, significantly lighter weight, and superior convenience compared to other tools such as Head Mounted Display (HMD) [33].
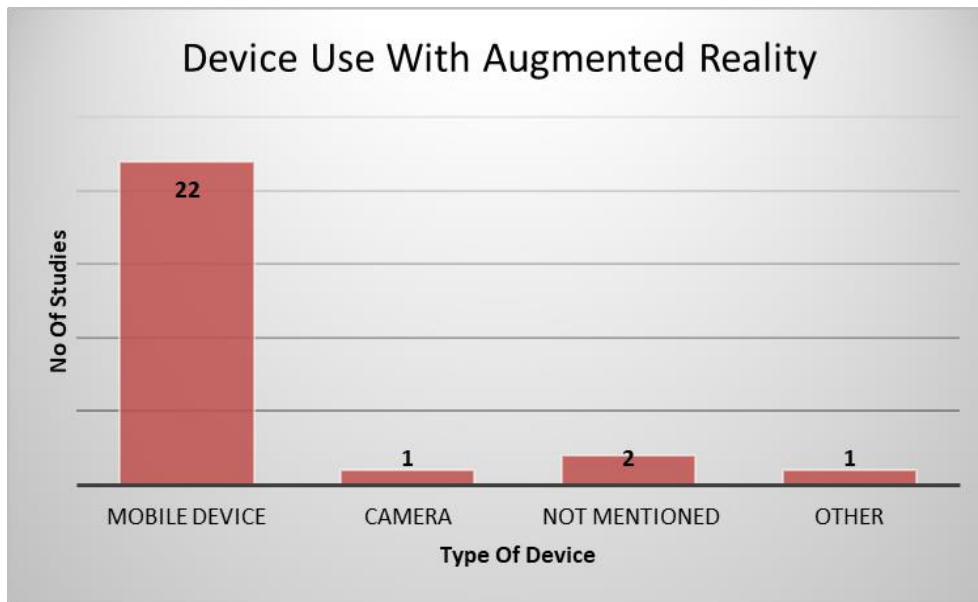
Fig. 5. Device used with augmented reality

4.5 Results for Augmented Reality Data Collection Methods in Early school education

As shown in Figure 6, the sample size used in augmented reality for early education that is often used is at the rate of 10 samples and less, which is from 18 studies, as many as 21 to 200 in 4 studies, and only 1 and 2 studies that exceed 200 and are not specified.
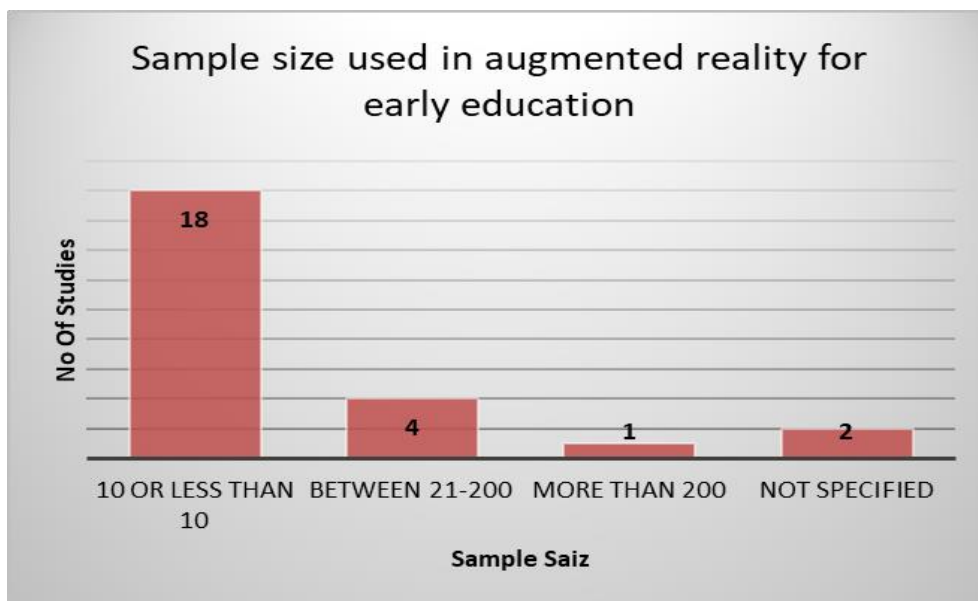

Fig. 6. Research sample reviewed

Figure 7 depicts the various augmented reality data collection tools used in early childhood education. The review found that "testing" was the most commonly used method in data collection (61.53%), followed by "observation" (15.38%). In addition, some studies use "Other" tools (3.84%), including drawing interventions, reports, and digital logs [24,34,36]. Perhaps, considering that a study can utilize multiple data collection methods, it falls into more than one category.
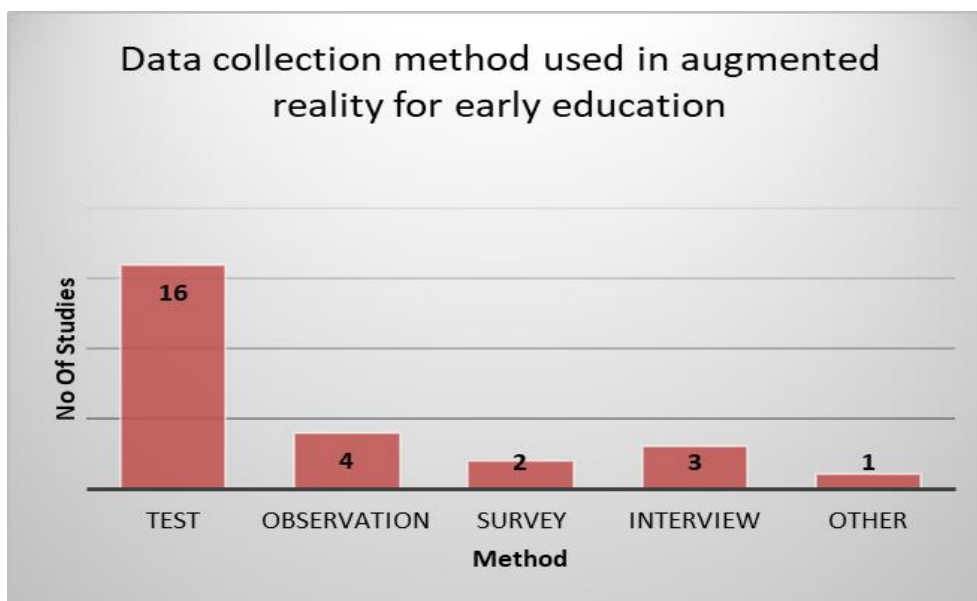
Fig. 7. Data collection method

5. Recommendations

Upon a systematized overview of the application of AR technology in early education, the following recommendations are made for potential future research.

i. Exploration of other disciplines. This survey revealed that early literacy had been extensively studied. Less research has been conducted on the efficacy of augmented reality technology in other fields, such as art and moral education, musical arts, and communication skills and questions. Therefore, it is suggested that educators and researchers need to conduct additional research on this subject.

ii. Creation of scientific materials. Developing scientific materials through this AR Interactive Book can pique children's interest in subjects that require a high degree of logical thinking by introducing them to more jovial yet ongoing learning activities. Children's participation in design is not a new and recent practice [15].

iii. The impact of mobile devices on young children's health and educational development. As the generation of digital natives, children communicate and interact with various technologies daily.

Nonetheless, several studies raised concerns about the widespread usage of mobile devices in the classroom. According to Chen *et al.,* [19], mobile phone overuse can distract children from learning activities. Ahmad *et al.,* [41] also reported this negative perspective, while teachers and parents are concerned about the possible adverse effects of using mobile devices with augmented reality technology. Therefore, there is scope for further research to delve into this matter and explore the effects of mobile phones on children's attention in class and their health.

6. Conclusions

This study has successfully investigated existing augmented reality applications in early childhood education. There was a total of 26 studies retrieved from databases, including ScienceDirect, ResearchGate, Google Scholar, and IEEE Xplore. Even though the literature review indicates that the number of research reported on augmented reality in early childhood education has increased over the past few years, the number of existing publications remains insufficient. Most researchers

focused on enhancing motivation, with early literacy being the most prevalent topic of investigation. Augmented reality and marker-based mobile devices have been widely adopted in early childhood education. The majority of studies included fewer than twenty-one children in their sample size. Examinations have become the most widely used instrument for assessing the outcome of augmented reality in early childhood education. In conclusion, this survey study can serve as a guide or reference for other researchers conducting research in augmented reality, emphasizing early childhood education as the end user.

Acknowledgment

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