

THE CURRENT TRENDS OF AUGMENTED REALITY IN EARLY CHILDHOOD EDUCATION

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ABSTRACT

Augmented Reality has been widely used in various level of education such as higher-level education, secondary education (lower/upper secondary level), primary education, and in informal learning. However, the implementation in early childhood education is still limited. By using library research methodology, the objective of this paper is to investigate the existing work of augmented reality in early childhood education between 2009-2018. Based on the results, it shows that the publication of augmented reality in early childhood education increased slowly within these past ten years. It has been found that the main advantage of augmented reality is to enhance motivation. Early literacy has been found to be the most used topic with sampling less than 30 children. Finally, 'Marker-based' augmented reality has been widely used with mobile devices and in term of data collection methods, 'Test' has been used the most in this field of research.

KEYWORDS

Augmented Reality, Child Computer Interaction, Early Childhood Education, Preschool

1. INTRODUCTION

Augmented reality is a variation of virtual environments or virtual reality as it is more commonly called [1]. It can be defined as a system that allows real and virtual objects to coexist in the same space and be interact in real time [2]. This technology has been widely used especially in medical, training, military, advertising, and entertainment. In these recent few years, augmented reality gains a lot of attention among researchers in educational field due to its great features and advantages in enhancing teaching and learning. The features of the technology which according to Wu *et al.* [3], enables students to: (1) learn content in 3D perspectives, (2) ubiquitous, collaborative and situated learning, (3) learners' senses of presence, immediacy and immersion, (4) visualizing the invisible and (5) bridging formal and informal learning. By having these features, augmented reality has create a new way of learning, and making learning experience become more fun and engaging.

As aforementioned, the great features of this technology has made it widely use in the field of education. Due to its features, numerous educators and researchers have reported the advantages of augmented reality technology. For example, augmented reality can enhance learning, providing interaction, improving communication, triggering creativity and enhancing problem-solving skills. However, the biggest advantage of this technology can be seen from motivation perspective; especially in terms of: (1) fun, interest and enjoyment [4-6], (2) engagement [7-9], (3) satisfaction [10-11], (4) willingness to learn, (5) provide positive attitude [12], (6) attention [11], and (7) level of confidence [10].

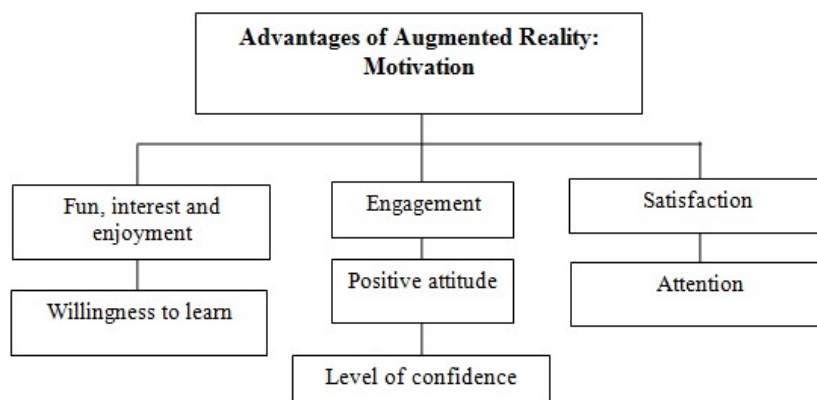


Figure 1. Advantages of augmented reality from motivation perspectives

According to Bacca *et al.*[13], augmented reality research has been conducted in various educational level such as higher level education (Bachelor), secondary education (lower and upper secondary level), primary education, and in informal learning. However, far too little attention has been paid for the implementation of augmented reality in early childhood education level [4], [14-17]. This statement is supported by Chen *et al.*[12] who reported the same results. Their review showed the same trends whereas augmented reality technology has been mostly applied in higher education settings and other compulsory education levels like primary and junior school and the least research has been done is with early childhood education.

As a user group that often being forgotten, therefore, it is very crucial for this research to be conducted in order to ensure that young users also can gain more benefits from AR technology as per claim by other researchers. Therefore, this paper reviewed several past studies related to early childhood education through the implementation of augmented reality technology.

2. PURPOSE OF THE STUDY

The purpose of this study is to search for the existing works of augmented reality in early childhood educational level. It is important to know what research has been so far, not only to fill in the gap in the educational field of research but also to ensure that this user group is not left behind. The great potential of augmented reality shall not been wasted and should be shared among all users in all level of education.

Secondly, as mentioned by many scholars, augmented reality has many positive benefits in learning. Therefore, this study will investigate whether this learning benefit can be found from the early childhood educational perspective. Finally, this research will investigate the most used topic that has been researched, types of augmented reality, devices used with augmented reality application, research sample and the data collection method involved when conducting augmented reality evaluation with young children.

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

- 1: To identify the existing works of augmented reality in early childhood education.
- 2: To investigate the advantages of augmented reality in early childhood education.
- 3: To identify the most used topic, types of augmented reality, device used with augmented reality application, research samples and the data collection method used for augmented reality in early childhood education.

3. METHODOLOGY

This study followed the four process as follows:

3.1 STEP 1: DEVELOPING RESEARCH OBJECTIVES

This study aimed to identify the current trends of augmented reality in early childhood education between years 2009-2018. The research objectives can be found in Section 2: Purpose of the study.

3.2 STEP 2: IDENTIFY RELEVANT ARTICLES

In this study, various databases like ACM, Science Direct, IEEE Xplore, ERIC and from Google Scholar have been used to search articles regarding young children’s learning with augmented reality technology published from 2009 to 2018. The search terms like “Augmented Reality and preschoolers”, “Augmented Reality and young children” and “Augmented Reality and kindergarten” were used.

3.3. STEP 3: ARTICLES SELECTION

The selected articles were examined by using a set of inclusion and exclusion criteria and determined whether they were related to the purpose of this study. By referring to Table 1, the first inclusion criteria is any paper published between 2009-2018 were selected and any articles that has been published before year 2009 were excluded.

Secondly, the selected articles focused on young children age 5-6 years and all papers involved young children with different abilities (special needs, autism, etc.) will be excluded. However, to find an article that really focusing on the exact age (5-6 years) as aforementioned was quiet impossible. Therefore, any paper that involving the children within the mentioned age range were included in this review.

Table 1. Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Published paper between 2009-2018	Published paper before 2009
Young children aged 5-6 years old without special needs and requirement	Young children aged 5-6 years old with special needs and requirement
English language	Other language
Studies that describes application and framework of augmented reality in early childhood education	Systematic Review, Editorial, Concept articles. Article that used virtual reality etc. although augmented reality mentioned in the study. Only terms appear in references section.
For educational purposes	For other purposes

Thirdly, articles that using other language than English were excluded. Fourthly, in order to fulfill the objectives of this research, therefore all articles that works on ideas, concept or review paper without any evaluation were excluded. Finally, only articles for educational purposes were included in this review.

3.3 Step 4: Collecting, Summarizing and Reporting Research Findings

After examination, 24 articles were found to be highly relevant to the purpose of this study. Examined articles were first coded into Microsoft Excel software. Frequencies and percentage of related data were presented in bar charts and tables.

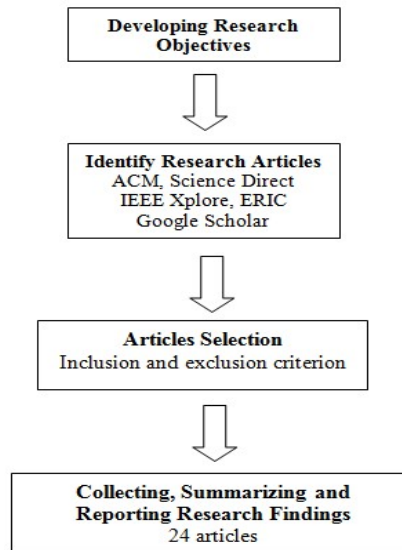


Figure 2. The process of paper selection

4. RESULTS AND DISCUSSIONS

In this section, the results of conducting the review based on 24 articles are described and discussed.

4.1.1 RESULTS FOR THE EXISTING WORKS OF AUGMENTED REALITY IN EARLY CHILDHOOD EDUCATION

By analyzing the year of publication of augmented reality in early childhood education studies, it has been found that the number of published studies has increased slowly especially during the first five years. While no study was found in 2009-2010, the highest number of published articles can be seen in year 2018. These results show that early childhood researchers are interested in exploring the augmented reality features and its advantages in early childhood education settings. Despite that, although a few additional researches have been found within these past ten years, however, the number of publication is not ample. A possible explanation of this result is that the technology could not be ready for being used by children since many aspects of interaction, such as the tracking and use of markers need to be solved [13].

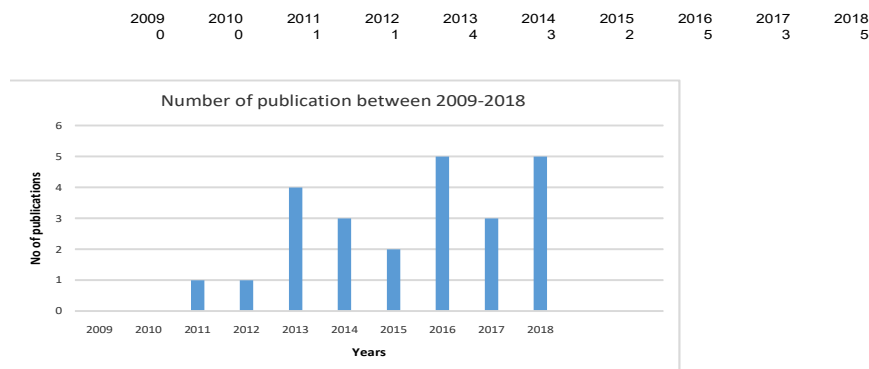


Figure 3. Numbers of publication since 2009-2018

4.2 RESULTS FOR THE ADVANTAGES OF AUGMENTED REALITY IN EARLY CHILDHOOD EDUCATION

There is a large volume of published studies that reported the advantages of augmented reality in education. However, it is important to get an overview of the real learning benefits of its implementation in early childhood educational settings. Table 2 shows the results of the reported advantages identified in the studies analyzed.

There are six advantages of augmented reality has been reported such as:(1) increase achievement/performance/understanding, (2) enhance motivation, (3) develop positive attitudes and behaviour, (4) enhance social skills, (5) fun learning and (6) others. Since one study can report more than one advantages, therefore, each study can meet more than one category.

From the results, it can be seen that the major advantages reported in the studies is “enhance motivation” (28.57%). Augmented reality has been reported can grab children attention [18-19], increase children interest and satisfaction [20]. Other than that, augmented reality has been claimed can “increase achievement / performance /understanding” (26.53%). On the other hand, a few studies reported on advantages of augmented reality in early childhood education such as positive attitude, behavior development, cognitive load and empathy [20-23].

4.3 Results for the Most Used Topic in Augmented Reality in Early Childhood Education

According to Table 3, augmented reality has been used in various learning topics. When analysed the implementation of augmented reality by field of education, ‘Early Literacy’ has been found the most explored topic in augmented reality in early childhood education. This is contrast with other level of education (primary, secondary and high level education) which focused more on ‘Science’ subjects [13], [15-16]. The possible explanation can be seen due to the importance of teaching young children about early literacy such as alphabets, numbers and writing. Meanwhile, other studies have focused on topic like ‘Storytelling’, ‘Art education’, ‘Religion education’, and ‘Native language’. On the other hand, in ‘Others’ category the research conducted is related to emotion, thinking, social behaviour and interaction.

Table 2. Advantages of augmented reality in early childhood education environment

Advantages of augmented reality	Number of studies
Enhance motivation (attention, relevance, confidence, satisfaction, engagement)	14
Increases achievement/ performance/understanding	13
Enhance social skills (self-esteem, collaboration, communication)	9
Fun learning (fun, excitement, happiness, enjoyment etc.)	5
Develop positive attitudes behaviour	4
Others (reasoning, cognitive and empathy)	4

Topics	Authors
Science (Animals, Newton)	[7],[24-26]
Storytelling	[20-21]
Art education	[27]
English language	[14],[23],[28-29]
Native language (native alphabet)	[30-32]
Religion education	[19],[33]
Early Literacy (Alphabets, writing, numbers, early childhood activity)	[4],[6],[18],[34-37]
Others (emotion, thinking, social behaviour, interaction)	[22]

Table 3. The use of augmented reality in different field of education

4.4 RESULTS FOR TYPES OF AUGMENTED REALITY USED IN EARLY CHILDHOOD EDUCATION

There are three types of augmented reality: (1) marker-based augmented reality, (2) marker-less augmented reality and (3) location based augmented reality. Marker-based augmented reality need to use a marker to fix the position of 3D objects onto real-worlds images [38] while location based augmented reality follows much the same process but rather than identifying a marker, it assigns digital information to a set of grid coordinates [39].

Based on the review, it has been found that most of the research used marker-based augmented reality (95.8%). The possible explanation for this finding is that marker-based augmented reality is easy to use and develop compared to other categories. The existing of software like Vuforia and Aurasma simplify the process of creating marker-based augmented reality. Meanwhile, the least type of augmented reality has been used is ‘Marker-less augmented reality’ and ‘Location based augmented reality’ (0%). According to Sirakaya & Sirakaya [16], this type of augmented reality was used less due to the lack of technical skills on the part of researchers in developing these applications.

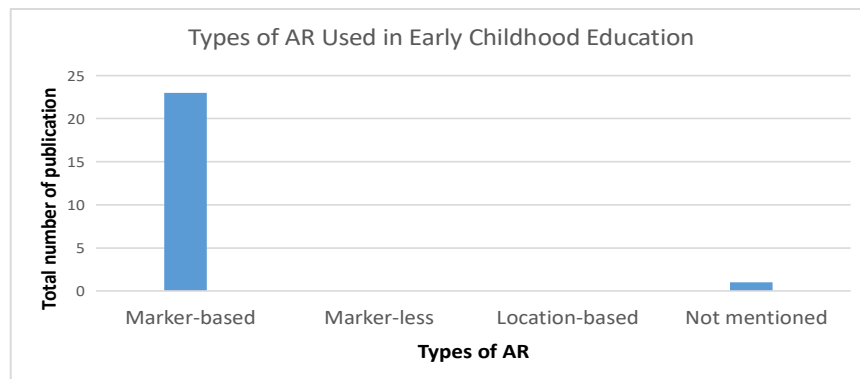


Figure 4. Types of augmented reality used in early childhood settings

4.5 RESULTS FOR DEVICE USED WITH AUGMENTED REALITY TECHNOLOGY

Based on the review, ‘mobile devices’ (42.31%) like smart phones and tablet have been used the most in augmented reality in early childhood education study and followed by ‘webcam’ (30.77%). Similar results have been found in [16] and [40]. The reason for this finding is that mobile devices are economically [33], much more lighter and easy to use compared to other technology like Head Mounted Display (HMD).

According to Roberto *et al.* [34], the long duration using HMD would not be comfortable for children. Gil *et al.* [21] have supported this statement, where during their experiment with augmented reality group, they need to hold the HMD because the glasses were too bulky for the children. There were also few studies used different devices with AR technology like projector and interactive whiteboard.

4.6 RESULTS FOR RESEARCH SAMPLES USED IN EARLY CHILDHOOD EDUCATION

In this review, we considered four categories for the research samples, which are: (1) 30 or less than 30, (2) between 31 to 200, (3) more than 200, and (4) not specified. The result shows that, most research with young children involved 30 or less than 30 children in the studies and no research involved more than 200 participants. As mentioned by Bacca *et al.* [10], the possible explanation of these results is that greater number in research samples would increase the cost in term of providing device like smart phone and tablets to each of participant involved in the study. Other than that, one of the studies reported two different experiments and has been included in two different categories. Meanwhile, five studies did not specified the number of participant involved in their research and only aged of the children have been provided.

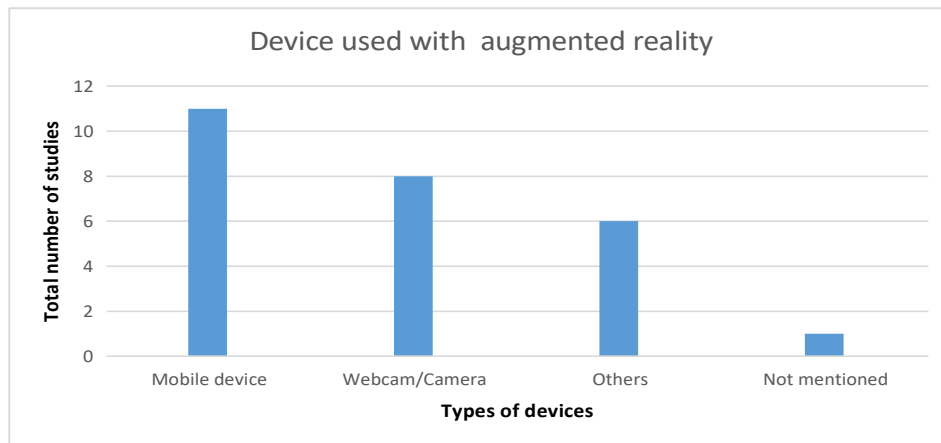


Figure 5. Device used with augmented reality

4.7 RESULTS FOR DATA COLLECTION METHOD USED IN AUGMENTED REALITY IN EARLY CHILDHOOD EDUCATION

Figure 7 shows different tools used for data collection in augmented reality in early childhood education. The review found that most frequently used data collection method is ‘Test’ (33.33%) and followed by ‘Observation’ (24.44%). Meanwhile, there are also few studies that used ‘Others’ (11.11%) tools like drawing intervention [34], report [36] and digital logs [24]. Since one study can use more than one data collection method, this study counts more than one category.

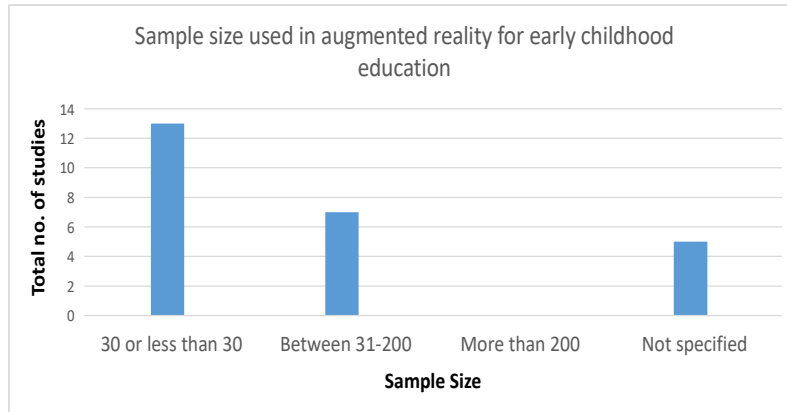


Figure 6. Research sample reviewed

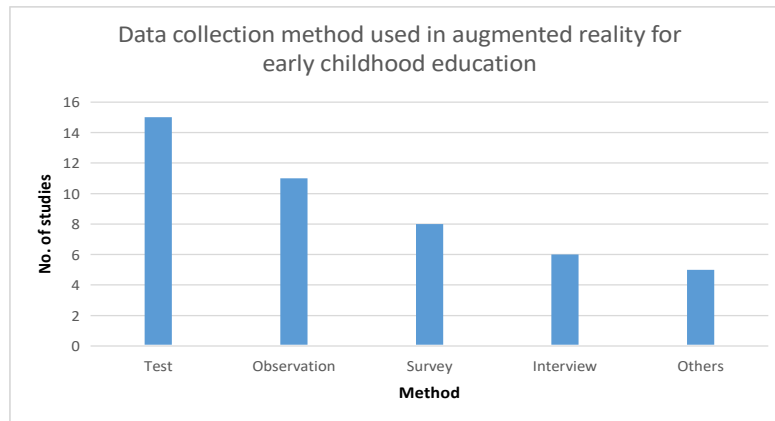


Figure 7. Data collection method

5. FUTURE WORKS

Young children is a special user group that has a unique characteristic. They can easily be motivated and they can easily be distracted and lost their attention during learning. This can be seen from the work of Rambli *et al.* [4], where as they revealed that after using augmented reality application for a while, children started to fell bored as they can predict what will happen next.

This statement shows that although augmented reality has been found to be a great tool in teaching and learning, however with ineffective design it is hard for researcher to sustain children attention and motivation. Based on their experience, Rambli *et al.*[4] suggested to embed element of surprise in the application so that children can become more engaging with technology and having more fun in learning. However, depending on element of surprise is not enough to maintain children motivation. Researchers need to have a deeper understanding about young children because as a digital natives, this user group have different preferences and needs. As mentioned by Markopolous *et al.* [41], children will use technology if they want to and if they dislike the technology, they will walk away.

Furthermore, based on the review, 14 out of 24 studies reported that children are engaged, satisfied, and paid more attention to their learning while using the augmented reality technology.

However, these studies did not mention which augmented reality element or features contribute the most to the children's motivation in learning.

Therefore, in our future works, we will investigate on an element that can enhance children's motivation and this is what we refer to as motivational design of augmented reality technology for young children. Designing a motivational technology is very important as it can improve children's motivation to learn. We will implement Keller's Motivational Design Model by focusing on four main motivation elements, which are: (1) attention, (2) relevance (3) confidence and (4) satisfaction.

6. RECOMMENDATION

We also would like to make the following recommendations:

1) Exploration in other subject

From this review, it has been found that early literacy has been well researched. However, the effectiveness of augmented reality technology in other fields like moral education, native language, art and social skills and development are less explored.

Therefore, educators and researchers are suggested to investigate further on these subjects and topics.

2) Design with children for children

It has been found that most of the research in augmented reality used adults as the main designer. It is worth to highlight here that children's participation is needed when designing augmented reality applications for their use as children have their own likes, dislikes and curiosities and their needs are totally different compared to adult users.

Involving children in design is not a new practice. According to Read & Markopolus [42], participation of children as designers is still understudied and explored. Therefore, we would suggest to other researchers to involve young children in augmented reality research, not only as a tester or user but also as a designer in their research work.

3) The effects of mobile devices in young children learning and health condition

Children as a digital native communicate and interact with various technology every day.

However, few researches highlighted their concern on the usage of mobile devices in the classroom. As mentioned by He *et al.* [28], the use of mobile phone may distract children's attention. This negative view was also reported in Huang *et al.* [27], whereas teachers and parents were concerned the side effects of using mobile devices with augmented reality technology in young children's learning.

Therefore, further investigation can be done regarding on this issue and the influence of mobile phone on children's attention and health condition.

4) Exploration in different types of augmented reality

There are three types of augmented reality: (1) Marker-based, (2) Marker-less and (3) Location based augmented reality. Marker-based has been well used in augmented reality research not only in early childhood education level but in all educational level.

Therefore, we would like to suggest other researchers to conduct a further research by using marker-less and location based must be done.

7. CONCLUSION

This study has successfully investigates existing work of augmented reality in early childhood education. In total, 24 studies have been found from various databases like ACM, Science Direct, IEEE Xplore, ERIC and from Google Scholar. Based on the review, although it shows that

research in augmented reality in early childhood education has increased since the past few years, however the number of publication exists is still not ample.

Most of the researchers focus on motivation enhancement and the most used topic is early literacy. Marker-based AR and mobiles device has been choose widely in augmented reality in early childhood education. In terms of research sample, small participant has been used in the most study, which is less than 30 children. Test has been the most popular tools for data collection purposes in augmented reality in early childhood education.

As a conclusion, this review study can be utilized as a direction or references by other researchers in conducting studies especially in the augmented reality field by focusing early childhood education as the target users.

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