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The Application of 3D Technology as Teaching Tools in Preschool: A Systematic Review

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ABSTRACT

Most preschool teachers introduce shapes, letters, and pronunciation to children, however, they often ignore technical aspects such as the position of the tongue when pronouncing words. Preschool teachers place less emphasis on this aspect, which can affect children's pronunciation and reading/speaking skills. Children's mastery of learning is influenced by several factors, therefore, teacher's understanding is important to improve their teaching practices. Teachers should be skilled in teaching various disciplines because they are required to teach various subjects at the preschool level. In relation to that, more research needs to be done to compare the teaching methods or approaches used by preschool teachers. Therefore, this study aims to identify the effectiveness of the latest application of 3D technology in the preschool context to increase students' interest in learning as well as the approach that can be used by teachers during teaching and learning in preschool. The production of 3D applications for children can be interesting and enthusiastic in learning a subject in class. Children feel fun and not bored if they use 3D applications in class. The study used the Preferred Reporting Items Framework for Reviews and Meta-Analyses (PRISMA) to conduct a systematic literature review of the literature of 3D applications for learning published between 2019 and 2023 obtained from Scopus, DOAJ and Mendeley.

1. Introduction

At this phase, children grow up rapidly compared to the stages of adult age. The National Association for The Education of Young Children (NAEYC) defines early childhood education as an education program to provide treatment, care, and guidance. Studies have indicated that children with access to early childhood education have higher potential for success in the next education levels.

Early childhood years are considered the golden age for children early education [1], preschool education at age four to six provides children with an enriching experience which helps them to learn things quickly and agilely. Prior to schools, young children acquire their first language by listening to

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their parents speak at home from birth. At the same time, some families in Malaysia communicate bilingually at home by using their mother tongue and English interchangeably.

Past systematic reviews of the preschool education system have revealed areas for improvement, specifically the teaching methods or approaches used by preschool teachers. Therefore, this study aims to present a literature review focusing on the latest technology-mediated methods or techniques that can be used by preschool teachers to support learning.

1.1 Theoretical Study

Preschool education provides learning experiences to children aged four to six years before entering primary school. Preschool helps pupils to socialize and interact with their peers and adults. Preschool teachers use various approaches for teaching and learning, these approaches include storytelling, playing, role-playing, acting, art, group work, collaboration, and problem-solving.

Teachers and parents play a critical role in supporting and encouraging young learners' development. In this regard, the selection of preschool teachers is imperative in ensuring the effectiveness of early childhood education [2]. In Malaysia, the revised version of The National Preschool Standard Curriculum emphasizes the use of various teaching methods and approaches in the learning process, specifically through play and, inquiry-based learning. Teachers' selection and planning learning activities are important to ensure to allow productive, coherent, and creative learning, which indirectly improve children's learning performance. Scholars advocate play-based learning as an appropriate approach to support pupils' mastery of basic skills in preschool. It can also allow students to interact with their peers and teachers in the classroom environment.

Play-based learning is a concept grounded on learning through play. In this regard, it helps create a conducive learning environment that is safe and supportive of the pupils' need. This learning approach involves individual, group and class activities. It allows children explore and learning skills without the fear of failure. Other studies also found that play based learning helps children's physical, socio-emotional, linguistic and cognitive development [3]. There is a need for the play-based approach to be applied into a more structured form of activity at school or home. Parents should also create an exciting learning environment for their children at home [4].

The use of ICT and 3D technology has exponentially increased in the 21st century and this scenario has changed teaching and learning approaches; for instance, the introduction of 3D apps to support self-directed learning to preschool children in developed countries [5]. Other inventions include the Interactive Whiteboard Technology (IWB), which is a type of ICT tool that allows children to engage in activities that increase self-confidence, especially children who are still new to the school [6]. However, studies have revealed that some teachers lack the skills to use 3D apps and tools in teaching and learning [7]. This calls for teachers to improve their skills and teaching and learning approaches to facilitate a positive change so that our education system is on par with developed countries.

In this light, this study reviews articles on the latest learning approaches teachers use in the context of preschool education.

2. Methodology

Before commencing the review, a protocol was developed based on the review framework. In this light, the study used the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) framework. The researchers reviewed papers obtained from the database to find data to answer the research questions as below, and identify relevant articles for the review and synthesis to obtain findings.

- i. What are the educational benefits and learning outcomes associated with the use of 3D technology in preschool?
- ii. What are current 3D teaching tools or approaches that can be used by preschool teachers?
- iii. How does personalized learning through technology contribute to improved student outcomes and engagement?

2.1 Identification Relevant Studies

Papers containing articles for review were derived from three databases: Scopus, DOAJ and Mendeley, and the search was carried out in February 2023. The identification of keywords in the analysis was based on the article's title and abstract. Therefore, keyword recognition was conducted on the Scopus, DOAJ and Mendeley databases (see Table 1). At the initial phase the systematic review process, 727 articles with the relevant keywords (method teaching, preschool, early education, application, mobile app, 3D) were derived from the database.

Table 1

The search string

Scopus	TITLE-ABS-KEY (teach* AND app* AND mobile AND preschool) AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (PUBYEAR, 2023) OR LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018)) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SRCTYPE, "j"))
DOAJ	https://doaj.org/search/articles?ref=homepage-box&source=%7B%22query%22%3A%7B%22query_string%22%3A%7B%22query%22%3A%22teach*%20%20AND%20%20app*%20%20AND%20%20mobile%20%20AND%20%20preschool%22%2C%22default_operator%22%3A%22AND%22%7D%7D%2C%22track_total_hits%22%3Atrue%7D
Mendeley	https://www.mendeley.com/search/?page=1&query=teach%2A%20AND%20app%2A%20AND%20mobile%20AND%20%20preschool%20&sortBy=relevance

2.2 Articles Selection and Data Management Process

Papers and past works related to the keywords were selected based on the inclusion and exclusion criteria (see Table 2). Initially, 727 papers were retrieved from the databases (Scopus 187, Doaj 15 and Mendeley 528). Afterwards, two redundant papers were removed. This was followed by removing unrelated papers. Consequently, only 7 papers containing relevant articles were retained for the review process, as shown in Figure 1.

Table 2

The selection criterion is searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Time line	>2019	<2019
Literature Type	Journal (only research articles)	Journal (conference paper, book, note, editorial, letter, short survey)
Age Range	0-6 years	7-12 years

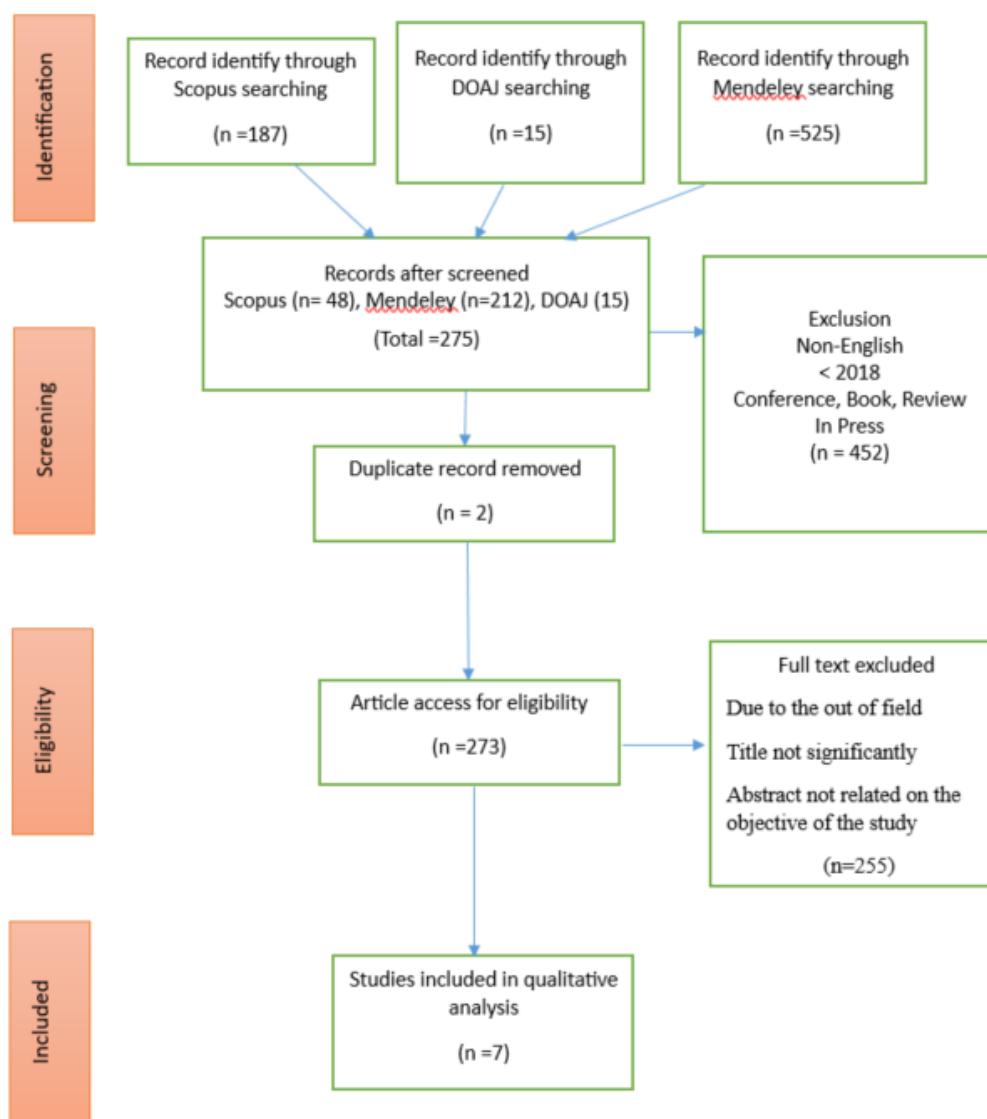


Fig. 1. PRISMA flow diagram of studies' screening and selection

2.3 Data Collection Process

The article search process is divided into several phases to ensure that accurate and appropriate articles are selected for review. Articles are searched based on selected keywords and they are obtained from databases (Scopus, Mendeley and Doaj). Papers obtained from the database will be classified in an Excel file. Then, these papers are filtered based on several criteria, year of publication, keywords, problems and solutions.

3. Findings

The articles in the database will be selected based on the research questions, namely teaching aids, technology involvement and the effectiveness of 3D applications. It is also used as a keyword for researchers in searching for the article. The initial phase found 727 articles on the related keywords published between 2019 and 2023. However, only seven articles were retained for the review because they meet the criteria set by the author. The articles are listed in Table 3.

Table 3

Literature that Meets Inclusion Criteria and Weight of Evidence

Reference	Purpose	Content Area	Age Group	Name of the application
[9]	Development of an application for learning preschool children, improving their learning, satisfaction and preference compared to traditional teaching.	- Learning Quechua - Augmented Reality (AR) - Preserve the mother tongue	3-5 Years	Augmented Reality Quechua
[10]	Designing a tool to overcome weaknesses in the traditional education system	- Augmented Reality (AR) - Knowledge to early childhood	NO	ABCD-AR
[11]	Development of a learning app for android devices to teach vocabulary to preschool children by providing the user with a straight forward interface.	- Learning English	3-6 Years	BenKids
[12]	Examining knowledge about real-world objects by categorizing them under some common properties or functions.	- Dynamic categorization	3-6 Years	CogSkills Application
[13]	Designed to teach multiplication to preschoolers.	- Mathematics education	4 Years	Triangular App (TriApp)
[14]	Design a mobile game-based learning application for preschool children on oral health education by using Malay culture elements.	- Dental health - Elements of Malay culture	No	Know the Teeth App
[15]	To identify the needs of parents and teachers on the usage of multimedia learning application in preschool learning	- Islamic education	5-6 Years	M-Kids Mobile Apps

3.1 Benefits of Technology-Based Learning

In today's world, users of all ages, from toddlers to senior citizens, have been accustomed to using technology, including 3D. As a result, most preschools nowadays incorporate technology as a teaching tool since it can entice children to learn. Even at the preschool level, technological advancement has indirectly provided better learning opportunities. Studies have found Technology-based learning tools, such as 3D application can be utilized to improve reading, literacy, numeracy, and other learning skills [8].

One of the primary feature of the ABCD-AR app is its capacity to display a three-dimensional visual depiction of audio and interactive AR information. In six degrees of freedom, children can interact with virtual objects by scanning it and listening to audio pronunciations. For instance, an audio clip of "A for Apple" will play when a marker, like an apple, is scanned and a three- dimensional image of

the object will appear on the mobile app. This interactive feature makes learning more engaging, which in turn help support and motivate pupils to learn.

The app incorporates several learning tasks such as reading, speaking, writing, coloring, and quizzes. Each category includes different levels. In this regard, the difficulty of the tasks will gradually increase and the players will go up to the next level as they learn more. At the same time, parents may request to unlock specific category levels, with teachers will have the access to grant such requests. This concept encourages parents' and teachers' active participation and collaboration, creating good communication about pupils' development.

In general, the ABCD-AR app offers pupils a fun and dynamic learning environment. It not only strengthens the idea of education but also makes it easier for parents and teachers to communicate. The app aims to create a fun and dynamic process through engaging activities and creative use of AR technology. This will support their growth and learning development.

There are four sections in the main page of the "BenKids" application, vocabulary, handwriting, games and songs. The vocabulary section also contains a subsection for alphabet. Each alphabet is supplemented by a picture and associated word to improve pupils' understanding of beginning sounds. The audio feature allows children to hear the pronunciation by pressing the audio button. They can also press repeat and navigate between each alphabet using the arrow given.

The numbers section provides a similar learning experience. The app presents the numbers along with pictures and audios demonstrating the pronunciation of the numbers in English. The pupils can repeat the audio or continue to the next number. Meanwhile, the animal section introduces the pupils with English words for animals through pictures, and audio pronunciation, helping children to improve their vocabulary.

Similar to other apps presented, "BenKids" application facilitates interactive learning and support the development of pupils' listening, speaking and literacy skills. It offers a user-friendly interface and engaging content to make language learning fun. The combination of visual elements, audio pronunciation and interactive features helps provide a comprehensive learning experience for young children.

The test module supports both single and multiple categorization tests. The single categorization test requires pupils to choose the objects from a list of probable items in a category. The domain ontology was used to generate these test instances online. Meanwhile, the multiple categorization requires the pupils to use the drag-and-drop interface to assess pupils' ability to put items into different categories based on their vocabulary knowledge.

The app generates example based on user profiles, explicit knowledge and randomly and individually selected categories and concepts Red boxes indicate incorrect responses, whereas green boxes indicate correct answers. The reward-based system used by CogSkills gives stars for right answers and deduct one star for wrong answer. CogSkills provides interactive learning opportunities and testing possibilities with the overall goal of facilitating the learning of categorization skills using mobile applications.

The application's user interface and code implementation is handled by activity files (Java classes) and layout files (XML format) handing Over 70 activity files and corresponding layout files programmed for TriApp. The application also incorporates the MediaPlayer class for sounds, the PersianReshape class for language conversion to Persian and the CoutDown Timer class for the number sequences.

Before using the application's features, users must sign up and log in and they will find five buttons as they open the programme; if they want to begin learning, they should select the Learning Multiplication (LM) portion. Here, pupils can select a particular multiplication table to learn and get started.

Pupils can advance to the testing and competition (TC) level after they passed the multiplication levels. In this section, the pupils will get a point if they answer the questions accurately. This app helps make learning and testing simple and enjoyable in hope of increasing their engagement in the learning process.

3.2 Tools and Technologies for Mobile Application Development

Mobile application development involves various tools such as Unity 3D, Vuforia SDK, Android SDK, Firebase and 3D models. Designers have integrated application architecture, including loading QR codes as images into the Vuforia database and the exported database into a Unity project to create an application interface using canvas. In regard to educational tools, researchers have developed news ways to incorporate downloaded 3D models and configure functions using target images to support learning.

Previous study [9] showed that using Quechua in preschool can strengthens cultural integration and combat racism and discrimination. The app features interactive games which are divided into different learning levels. There are three distinct varieties of Quechua, with southern Quechua being the most widely spoken and easily understood throughout Peru and its neighbours, including Bolivia. Qualitative and exploratory techniques were employed to create a useful application for teaching Quechua to pre-schoolers. The application is an example of using information and communication technology (ICT) in pre-school education to enhance the teaching of second language like Quechua. In this study, the researchers created a Firebase database to store Quechua words and audio pronunciations.

A previous study [10], presented the ABCD-AR application which was developed using Unity and Vuforia technology to help children learn through Augmented Reality (AR). The study's main focus is to develop an application that serves as a comprehensive learning tool to improve children's learning by relating alphabet and phonics to different topics like food, animals and non-living objects. It provides varied of interactive activities such as coloring, writing and reading.

"BenKids" application was developed by Aisha Nori Idres and Saria Eltalhi in 2019 as a language learning tool to support the ESL (English as a second language) learning for preschool children between three and five years old [11]. The app helps pupils learn the alphabet and numbers, as well as vocabulary on animals and objects. It features the 26 alphabets, numbers 1-10 and 19 words about objects and 12 words about animals

Another study [12], provided an example of dynamic generation categorization implementation through a mobile application called CogSkills. The app was developed using the JQuery mobile library on the Android platform and uses the CagOntology translated into a relational database using the SQLite database engine.

CogSkills include learning modules and tests to support the development of categorization skills among pupils. For instance, in learning vocabulary about parts of a bird, the module exposes the pupils to the important words in the target category, such as beak, wings and legs for the "bird". Just like the other app mentioned, the uses images to represent categories and their associated properties, allowing children to learn interactively by experiencing these properties together.

A study [13], developed developed a prototype for TriApp, a kid-friendly smartphone app for learning numeracy with an appealing and intuitive user interface. The Java programming language (SE 9) and Android SDK version 26.1.1 were used in the development of TriApp for Android platform. The researcher used the Genymotion software as an Android emulator for Windows testing, while the Eclipse IDE (Oxygen version) was utilized for development.

Previous Researcher [14], different from other apps which focused on literacy and learning skills, this study developed a Malay Language mobile game application for children's dental education that is based on "pantun", an of traditional Malay poetry and traditional Malay clothing [10]. The user interface features Malay characters wearing "Baju Melayu", the traditional clothing for men and boys, and "Baju Kurung", the traditional clothing for Malay girls and women. The female character also wears a scarf, which is characteristic of the Malay culture.

The graphical representation used in the app seeks to complement the project's conceptual design. The game has three levels, including "Know the Teeth" where the player arranges the teeth within the given time. Meanwhile, the app's main screen features a tutorial and the "rhyme" section as depicted in the storyboard. There are also a "play" button which allows the player to start the live game and a tutorial button.

The main characters, wearing traditional Malay clothing, a girl wearing a scarf and "Baju Kurung" and a boy wearing "Baju Melayu", "samping" (Malay short sarong) and "kopiah" (a skull cap) are featured on the landing page. In the tutorial page, a female dentist teaches players about the dental health through a Malay pantun. The doctor shows the player how to identify certain parts of the tooth before starting the game.

The use of "pantun", traditional Malay clothing and visual representations allows the application design to emphasize on the Malay culture. It aims to increase children's awareness and appreciation of Malay culture while providing an interesting and educational dental education experience for children.

Another Malaysian study [15], designed a prototype of a mobile learning application for preschool children aged five to six. The design was based on the results of a needs analysis and included verified concepts, theories, and professional deliberations. The study also sought to provide recommendations for creating mobile learning applications for preschoolers and to identify the most crucial elements in the design and development of multimedia learning applications for young learners.

Thematic analysis was used to analyses the data and identify patterns or themes within the qualitative data. This method has allowed flexibility in probing the various aspects of teaching and learning without being reliant to a specific theoretical framework. The researcher examined data from interviews with eleven experts from different fields, comprising teachers, early childhood experts, game designers and multimedia content developers. The analysis is aimed to identify themes and patterns emerging from the interviews.

The experts' feedback from the interview were analyzed to guide the design and development of the mobile learning application for young learners. The study's general objective is to develop a suitable mobile learning application prototype by incorporating verified principles, theories, and experts' judgment. The input obtained from the thematic analysis of expert interviews has offered insightful guidance for the subsequent stage of the research. The study warrants a broad view on designing and creating mobile learning applications for young learners guaranteed by choosing experts from different backgrounds and specialties.

Overall, studies have developed 3D-based mobile application for learning which offers a user-friendly interface, engaging learning experiences and convenient features to support children's learning and practice of literacy, numeracy, thinking skills and heath effectively.

4. Discussion

There are many advantages to introducing children to a second language at an early age [9]. Asserted that it strengthens neurons connections, which in turn, support learning. There is a general

consensus that young learners should start learning a second language between the ages of 3 and 12 as children at this age are at the development stage where they can acquire different languages naturally. In the case of Quechua, the study found that it provides positive stimulation to young children's linguistic ability, helping them acquire additional languages easily.

Technology, paired with skilled teachers are the backbone to educational transformation. Information and communication technology (ICT) resources, including AR, can be used to support didactic learning processes and collaboration in the educational context. This is exemplified by the use of AR and 3D technology to create new learning experiences. In this regard, such efforts have shown encouraging results in the primary and secondary education domains. The articles reviewed have found it accelerates learning through the use of videos, animations and didactic activities to simplify complex content, which have proven effective in both physical and virtual classrooms.

As shown, studies have developed apps that not only support learning, but also incorporate the preservation of indigenous languages, such as Quechua [9], and cultural heritage [14]. The former emphasized learning a second language at home to supplement the instruction at school while the later helps pupils to learn dental hygiene. In this light, these apps' effectiveness can be assessed by comparing students' satisfaction of the AR- based approach and conventional teaching methods.

Most articles reviewed feature studies that highlight game-based learning as an effective approach to engage young learners in learning [9-15]. This emphasizes the importance of game-based learning. In this regard, the studies incorporated various game features into a structured learning environment. Unlike traditional learning approaches, this strategy makes use of kids' innate desire for games to engage them in learning. These findings support the idea that pupils are more motivated to learn with the adoption of the game-based learning approach.

These studies showed the benefits of game-based learning in improving pupils' motivation, engagement, and interest toward learning. Gamification support the development of soft skills, improves the learning process, helps achieve the learning objectives. It encourages collaboration, communication and creative thinking through specific features like scoring, visual aesthetics, collaboration, problem-solving, and competition [9-15].

The studies on the use of augmented reality (AR) in early childhood education has addressed concerns about the defining characteristics, user experiences, and design principles of AR apps. This is especially significant for its use with younger learners specifically regarding screen size, engagement, consistency, and functionality of children's interaction with mobile-based AR applications. Previous researcher [10] discussed these concerns and proposed a usability guideline for in developing an app to increase performance, dependability, and satisfaction.

The review highlighted the benefits of mobile devices and digital education applications, specifically in supporting learning among preschoolers. These tools eliminate the need for bulky equipment, making digital learning more accessible for young learners. Children, as digital natives are attracted to the instructiveness of mobile devices, like touch-screen and automatic screen rotation and tend to be more engaged with educational content presented digitally. In this light, digital learning applications help children to express themselves and promote cognitive, language, and socio-emotional development.

Previous studies [9,11] demonstrated that preschool teachers have embraced the use of mobile devices and digital education applications as practical and efficient tools for learning. Mobile devices have become parts and parcels of living, and children has started to be exposed to mobile learning at an early age. In this regard, teachers should take advantage of the mobility, flexibility and ease of use of mobile devices by incorporating them into learning. This method allows pupils the freedom to use mobile devices in the classroom and at home through self-directed learning.

The articles reviewed highlighted the adoption of gamification and games-based learning theory into learning preschool, for instance, the M-Kids Mobile App [15]. The incorporation of simulations and gamification, help teachers plan learning activities that stimulate the pupils' cognitive, psychological, and social-emotional development. Games can help present learning content that are relevant to children's everyday lives and foster engagement, aspiration, and knowledge sharing. This is in line with the aim to support pupils' holistic growth through engaging and interactive learning experiences that mirror real-life situations.

Ultimately, the use of 3D technology aims to provide young children with suitable instruction, especially in facing challenges brought by the recent pandemic and ever changing norms. These studies have offered insights into how digital technology can enhance education by integrating theories and practices.

5. Limitation and Future Suggestions

The limitation of this study is that it only reviewed studies which highlighter the keywords. Therefore, it is more focused on the application of technology and 3D tools for teaching and learning to increase preschoolers' interest in learning. The studies reviewed highlighted the use of AR and 3D tools chosen to attract children's interest in learning. In this regard, future reviews can focus on other types or technologies and searched for articles in other databases like Scopus, DOAJ, and Mendeley to obtain more related articles.

6. Conclusion

This paper has reviewed 7 articles on 3D and AR application in the preschool setting to answer the research question on the current teaching methods or approaches used by preschool teachers. Three databases were searched for relevant articles published between 2018 and 2023. The review found that all articles presented the use of gamification and game-based learning approach in the preschool context. It has been found as for preschoolers as it fits young children's interest for games, hence, it can increase their engagement in learning. In this regard, with today's technology, more applications can be developed as teaching aids to help teachers facilitate learning in classrooms.

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