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Uses of Augmented Reality in Preschool Education

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SUMMARY

It is a proven fact that augmented reality applications have been widely used in the field of education in recent years and have a significant effect on the learning process. It is noticeable that augmented reality (hereinafter-AR) applications were first used with university students and later on children who were educated at lower levels. It is important to mention that only a few years ago, it was stated that the usage of AR in preschool education was also used and some limitations were noticed. However, with the rapid development of technology and the widespread use of apps, multimedia, smart devices, laptops, etc. it has also made an important progress in preschool education in recent years. Nowadays, it has been a matter of curiosity in which areas the augmented reality is used in preschool education applications and what are the research trends. Determining these trends is considered important in terms of designing and developing augmented reality applications in preschool education. In this direction, the usage areas of augmented reality in preschool education were examined in the perspective of the researches. As a result of the research, it was observed that activities were carried out for early literacy, foreign language teaching, spatial skills, artistic skills and musical skills. The results provide suggestions for increasing the applications for art and music activities for future research, designing applications for different subjects on the preschool level, and using different objects and entities in applications.

Keywords: Augmented reality, preschool education, applications, skills, technology

INTRODUCTION

Augmented Reality (AR) is a technology that enriches the real physical world with computer-generated 3D virtual objects, where users can interact on the screen of devices such as camera, smartphones or tablets (Lee et al., 2017). Also, augmented reality is a technology that combines two-dimensional or three-dimensional virtual objects in a three-dimensional real environment and then reflects these virtual objects in real time (Dhiyatmika, Putra & Mandenni, 2015). Augmented reality allows a person to see or otherwise perceive the computer-generated virtual world integrated with the real world (Meisner, Donnelly & Roosen, 2007). Augmented reality (Hassan, Rahim & Shin, 2021), which enables interaction between computer-generated objects and the real world, is an application concept that unites the physical world (real objects) with the digital world (Saurina, 2016). Augmented reality (AR) is one of the new technologies with excellent reflection, which has recently developed critically, especially due to its competence in the field of education (Cabero-Almenara & Roig-Vila, 2019; Jaiswal et al., 2021). Kirner, Reis, & Kirner (2012), augmented reality is becoming an increasingly popular technology that can be used on a variety of platforms: desktops, laptops, portable devices, and smartphones. Applications developed using augmented reality technology allow 3D objects, texts, images, videos, and animations to be used together simultaneously (Wang et al., 2013). As a result, augmented reality users can naturally interact with events, information, and surrounding objects. With the emergence of AR recently, technology has begun to attract the attention of researchers and educators as a beneficial alternative and interactive way to create teaching and learning tools (Rambli, Matcha & Sulaiman, 2013). Augmented reality is suitable to use in educational field, and many applications are successfully implemented to enrich learning process (Dobrovská & Vaněček, 2021). These days augmented reality is widely used to improve the learning process in different educational fields (Hossain & Ahmed, 2021). Augmented reality has a wide range of applications in teaching and learning environments (Yuen, Yaoyuneyong & Johnson 2011). AR provides blended, interactive, self-direct, active, discovery-based and error-free learning (Su, Tang & Winoto, 2018). AR has succeeded in encouraging students to make meaningful and enriching experiences that facilitate their learning skills (Chen et al., 2017a). It helps students to understand complex spatial relationships and abstract concepts, allowing the coexistence of virtual objects and real environment elements (Arvanitis et al., 2009). Augmented reality allows for an educational application that enables a range of interactions in the classroom (Saez-Lopez & Cozar-Gutierrez, 2020). However, according to Shelton (2002), the integration and purposeful use of augmented reality technology in the educational environment faces challenges due to financial opportunities and lack of awareness of the environmental needs of the educational community.

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Despite that researchers are interested in ways how to apply augmented reality technology to schools, as well as to preschool education, still there is a lack of scientific attitude to AR tools implementation in early childhood education. The least research has been done on early childhood education (Masmuzidin & Aziz, 2018). Despite this, practices for the education of children of this age have been increasing in recent years. Augmented reality applications attract the attention and focus of children in this period (Hassan, Rahim & Shin, 2021), create a sense of reality, embody the content, develop peer relationships, make information colourful-visual and provide a fun learning environment (Kuzgun, 2019). Augmented reality applications include children's various senses through the appropriate combination of sound, image and touch as a powerful and motivating tool (Cascales et al., 2012). With these features, the use of AR technology in education stimulates the senses of young children, arouses their curiosity, draws their attention, and leads them to explore (Chen et al., 2017b). When augmented reality is used as a learning tool, it positively affects preschool children's levels of motivation, concentration of attention, knowledge, literacy, creativity and satisfaction (Cascales, Pérez-López & Contero, 2013). The augmented reality technology used in the preschool period can help children to recognize the learning content and understand the material provided more quickly (Hsieh & Lee, 2008). Augmented reality-based applications enable preschool children to acquire the skills of knowing the environment, attention concentration, memory training, vocabulary enrichment, learning to read, creativity, learning sounds, and using software (Kelpšienė, 2020).

Various researches (Rasalingam, Muniandy & Rass, 2014; Sidi, Yee & Chai, 2017) and thesis studies (Gecü-Parmaksız, 2017; Huda Wahida, 2013; Yıldırım, 2019) were conducted to support the development of preschool children's skills by using augmented reality tools. It appears to provide significant effects. Hence, the idea of AR at the moment is not limited to an innovation. It should be re-examined and conceptualized from a comprehensive perspective (Utami, Andika & Sumarni, 2021). Although AR-based applications have been implemented in early childhood since 2002 (Huang, Li & Fong 2016), it has been observed that there are limited studies determining the conceptual structure and tendency of augmented reality applications in preschool period. Regarding the subject, Masmuzidin and Aziz (2018) examined the studies on augmented reality in early childhood education between 2009 and 2018 and found that the main advantage of augmented reality in preschool education is to increase motivation. Aydoğdu and Turan (2020) revealed in their research that AR applications are realized within the scope of science, language, literacy, mathematics and art activities. Research trends on augmented reality (AR) have shown that limited work has been done on early education. It is stated that there are limited solutions and studies regarding AR applications for preschool children (Barreira et al., 2012). Since technology helps children to learn interactively at an early age (Turan and Aydoğdu, 2020), more studies are recommended on the usage of augmented reality applications in preschool education (Jamiat & Othman, 2019). Augmented reality, which provides new possibilities for different education areas, has not yet been fully explored in educational settings (Dobrovská & Vaněček, 2021).

In the research, "What are the usage areas of augmented reality applications in preschool?" the answer to that th question was sought. Based on this requirement, the trends of augmented reality applications in preschool education were examined and subject areas were reported under the following headings.

Early literacy

With the presence of children developing differently around us, problems tend to arise as the teaching and learning process continues. Kids tend to have different learning curves. Sometimes they refuse to learn completely. There is convincing evidence that today our children struggle with reading and text comprehension. One potential way to improve reading performance and understanding is to make children more interested in reading. AR technology enriches the perception of the user, without abstracting the user from the reality they are in, with experiences such as touching, feeling and moving objects that are not in reality through the contents of mobile AR technology applications (Özarslan, 2013). AR offers a fun and attractive experience for kids, creating a magical feeling and providing engaging learning experiences. AR can transform 2D images into 3D virtual objects and animations, offering an interactive way to learn (Yilmaz, Kucuk & Goktas, 2017). In this context, it is stated that augmented reality can be a way to encourage children's reading skills (Bhadra et al., 2016). To improve children's reading skills, applications that allow the use of modern mobile technologies, especially augmented reality technology, to study the alphabet, and to learn how words are made, are necessary (Ablyaev, Abliakimova & Seidametova, 2019).

It is stated that AR technologies can increase children's attention by improving sensory stimulation and thus increase efficiency in word recognition learning (Su, Tang, & Winoto, 2018). Augmented reality is a new technology that allows many objects, elements and events that cannot be reached or concretized in real life to take place in the real world with its richness (Doğan, 2016). This view supports the claim that AR-supported applications can facilitate the cognitive development of children, provide high-level cognitive access to complex visualizations and reinforce educational effects (Huang, Li & Fong, 2016). Visual markers used in AR applications allow users to "animate" information associated with pointers. Applications using pointers allow the user to read information about a particular object or location using mobile devices. The learning process becomes much more interactive when every letter and every word is accompanied by three-dimensional visualization and animation.

This contributes to the rapid memorization of new knowledge, children's attention retention, visibility, dynamism and sensitivity (Ablyaev, Abliakimova & Seidametova, 2019).

It is also important to mention that the traditional book used to support reading skills consists of text and pictures printed on a surface include emotional aspect in reading skills development. It is a controversial subject due to the thoughts that digital books will never replace an emotionally printed book and the difficulty of reading an e-book on the screen (Oğuz, 2013). In the current context of an AR storybook, the view of the physical book (or the real world) is enhanced using virtual objects (3D models, animations, text, and sounds) viewed through a computer display device (Rohaya et al., 2012). In other words, the images of the book are displayed on the camera of mobile devices. Thus, the real image falling on the screen instantly is presented by enriching it with virtual objects. Reality is enriched with content codes included in the visuals on the pages of the book, which is a part of the real world (Ablyaev, Abliakimova, & Seidametova, 2019). Presenting information with 3D visuals in AR-supported books and integrating it with technology enables the details to be displayed and the details to be permanent in memory (Doğan, 2016).

Rambli, Matcha, & Sulaiman (2013) tested the effectiveness of an augmented reality-based AR alphabet book designed to teach preschool children the alphabet on aged 5-6. The app includes features such as viewing each alphabet on the presentation of the corresponding pattern marker, seeing 3D models of objects starting with each alphabet character, pattern markers for children to view animation of how each letter was drawn, and a puzzle game for each letter to test children's understanding. The results showed that the AR alphabet book had the potential to create an enjoyable learning environment for preschool children.

Yilmaz, Kucuk & Goktas (2017) developed 10 picture books with AR technology. The main purpose of these books was to improve the story understanding performance, taste and positive attitude of preschool children. All the stories had an educational theme and animated pages. Each child could pick up a book, read it, and interact with it using AR technology. When they looked at the computer screen, they could see 3D animations of the stories. As a result of the application, it was determined that children mostly remember the outcome, time and place of their stories, but they had difficulty to remember the main theme. However, it was found out that the augmented reality applications in the books entertained the children, made their learning process joyful and let them feel happy.

Foreign language teaching

Second language learning has long been an active area of research. With the development of technology, language learning methods have undergone a great transformation. Increasing children's motivation to learn a new language is an important factor in acquiring language skills (Li, Chen & Vorvoreanu, 2015). It is stated that attracting children's attention by using animation and multimedia tools is effective in providing motivation (Gilakjani, 2012). Since early language learning plays a vital role in language development and can affect the success of many other basic skills (Fan, Antle & Warren, 2020), there is a need for learning environments that can attract the attention of children in the preschool period, which is the critical phase of language learning. Augmented reality-based learning resources, which are characterized by dynamic interactions and visualization, can interact in ways that facilitate children's understanding (Chen et al., 2017).

In traditional classrooms, educators and children try to enrich language by interacting with each other only through body language and talking to each other. However, this type of practice lacks learning fun. Different learning experiences are needed that can support children's language learning. Augmented reality is an effective application which is suitable to fulfill these functions. Learning words is the most basic stage in language acquisition. Those who start learning a new language learn the language from the alphabet and words (Beck, McKeown & Kucan, 2002; Hsieh & Lee, 2008). Based on the fact that no language acquisition and application can take place without vocabulary (Liu et al., 2010), AR-based applications have been made by using words to help preschool children acquire language skills. Fan, Antle & Warren (2020), on the other hand, found that word spelling games, vocabulary activities and location-based vocabulary activities were used for language learning in their research, where they analyzed AR-supported applications for early language learning.

Dalim et al. (2016) applied through TeachAR, an Augmented Reality (AR) tool, to teach non-native English speakers of 4-6 years old basic English words (colors, shapes and prepositions). In this application, two applications with and without AR support were used together. As a result of the research, it was determined that AR-supported application increased children's participation in learning. As a matter of fact, Vernadakis et al. (2005) increased the phonological awareness of preschool children, word recognition, and writing skills with animated and interactive multimedia content using the computer-aided teaching method, allowing them to learn in the most appropriate way following their learning pace.

Çevik et al. (2017) included children aged 5-6 in their research to reveal the difference between English vocabulary learning with AR applications and learning with traditional methods. In practice, while the control group was being taught traditionally, the children in the experimental group were allowed to access animated images in which the English equivalents of the animal names were voiced by keeping the mobile device in QR. The visuals under the

QR codes are made up of images captured by sniping from videos. As a result, it was determined that augmented reality-supported teaching is more effective in terms of English vocabulary learning success than teaching using pictures and toys. In addition, it was determined that the children involved in the AR-supported application were eagerly waiting to look at the square frame with the device, which attracted their attention and actively participated in the activities.

Spatial skills

AR provides a natural environment where children can both interact with virtual manipulatives and relate them to the real physical world. This natural link has the potential to support skills such as attention and spatial cognition. AR can also provide environments for children to explore different views of three-dimensional spaces, which helps children learn spatial content (Bujak et al., 2013). Although not designed to improve spatial skills, AR-aided applications provide significant contributions to the development of spatial skills. The observation of 3D interaction and virtual structures from different angles enables spatial abilities and concepts to be reinforced (Fleck, Simon & Bastien, 2014; Hsiao & Rashvand, 2011; Yen, Tsai & Wu, 2013).

The term spatial abilities includes spatial perception, spatial visualization, mental rotation, spatial relationships and spatial orientation (Kaufmann, 2003). 3D modeling activities supported by augmented reality within the framework of these components are effective in the development of spatial skills as they perform manipulative operations such as rotating objects, moving objects, and changing dimensions by using different perspectives (Similar, 2018). Although it is physically two-dimensional to support preschool spatial skills, geometric shapes are mostly used due to their characteristics such as three-dimensional projection on the screen, the possibility of different sizes or positioning, and the abundance of objects resembling geometric shapes.

Zhu et al. (2017) presents an AR-enabled educational game designed for preschool children aged 4-7. The main purpose of this game is to enable children to learn various abstract concepts such as color mixing, math, and 2D-3D geometric shape recognition. They made an AR-enabled construction toy in the design. Children can learn different concepts by playing with blocks or cards. They create buildings using numbers, colors and geometric shapes. This practice enabled children to join and rotate blocks, provided a better understanding of abstract concepts and contributed to a better learning experience.

Gecü-Parmaksız & Delialioğlu (2020) tested the effect of augmented reality application on children's spatial skills. There was a special marker on the shape cards (tracing cards) used in the experimental group. When the app scans these viewers, the interactive 3D geometric shape model automatically opens on the tablet screen. Children in the control group worked with physical manipulatives of wooden blocks and shape cards. As a result of the application, significant differences were determined in favor of the spatial skills of the children in the experimental group.

Artistic skills

Since AR helps young children to examine 3D objects from different angles and improve their understanding of different concepts, AR supported visual art applications can bring children to their environment from different perspectives. Thanks to this application, which is operated with mobile technology, it is stated that they can interact with physical arts in new ways and share their artistic experience with other users (Ihamäki & Heljakka, 2020). Augmented reality is one of the newest technological developments that can be used as an educational tool that encourages creativity, it is an application that allows users to see and experience the real world by mixing it with various virtual objects without losing the sense of reality (Persefoni & Tsinakos, 2015).

Painting with pencils and paper is a natural activity and an important experience for children to practice and express their creative skills. Attracting the attention and interest of children engaged in these creative activities is the main challenge teachers and parents face. Augmented reality applications designed for children can be used to solve this problem (Mokhtar et al., 2018).

Ucelli et al. (2005) developed an AR system (ARGarden) to teach children color theory. The 3D virtual chameleon showed children how to obtain secondary colors from a combination of primary colors and vice versa. The study showed the positive effects of engaging children in AR learning and demonstrated educational value to nurture children's creativity and imagination.

Huang, Li & Fong (2016) designed and implemented a series of art education activities using AR for children aged 4-5. This design-based research aims to explore the feasibility of using Augmented Reality (AR) technology in early art education by focusing on the gains and downsides of this innovation. The results showed that all children can design, control and interact with animated objects created by the AR application.

Musical skills

Music education is accepted as a tool in the development of cognitive, language, motor, emotional and social skills in children today. The importance of early music education points to the importance of children's musical experiences. Learning music in early childhood is linked to experimentation, creativity, and cognitive development. The basis for listening to music, singing, playing, and improvising is often included in educational

programs and curricula to provide versatile quality education (Paule-Ruiz et al., 2017). Teachers are directed to initiate activities that include rhythm, melody, songs, verbal music games, combined music dynamics, spontaneous creation or self-expression (Preka & Rangoussi, 2019). (Gomes et al., 2014) In this context, activities have been designed to gain such features in applications for augmented reality-based music education.

Gomes et al. (2014) created an augmented reality software Music-AR program to teach sound features such as pitch, loudness, and volume. This application allows children to manipulate virtual objects associated with sound and learn the bass and treble of the sound. Results of usability testing are presented. Taking into account that usability of Music-AR program was evaluated with six children it is possible to report that they (children or teachers) are motivated to use the software because they are introduced to a new technology.

Preka & Rangoussi (2019) designed, developed and implemented an educational intervention in the preschool classroom. The subject chosen as learning content is music (rhythm, pitch, structure of songs, meaning of words, body synchronization with music, introduction to musical instruments). They created a 'treasure hunt' game to teach these skills. It has shown that the application has significant effects on the cognitive, social and emotional development of children.

Research by Rusiñol, Chazalon & Diaz-Chito (2018) presents the design and resolution of the technical challenges associated with the development of the Augmented Reality (AR) mobile app that aims to teach young children the relationship between music notation, music, lyrics and animations, and popular songs. Application of musical note gives an opportunity listen to the sound played by some instruments and the keys pressed on the virtual keyboard. This application also includes lyrics, music played and animations about the story of the song. The application was tested in real environments with a few parents and their children and positive reactions were received.

DISCUSSION AND CONCLUSION

AR offers the possibilities of a real world environment by providing additional and contextual information to support learning, blending children's learning environment with real environments. While doing this, it enables concrete visualization of abstract objects, understanding of complex concepts, and a better learning experience by using spatial images, videos and sounds. It is clear that AR applications that offer interesting and fun learning opportunities that stimulate different senses include an important learning environment, especially for preschool children. Studies showing that augmented reality improves the interest and participation (Antonia & Evgenia, 2018; Utami, Andika & Sumarni, 2021), motivation (Rasalingam, Muniandy & Rass, 2014), skills and competencies of preschool children were emphasized in related studies.

In this study, the effectiveness of augmented reality technology as used with preschool children on the development of their skills such as early literacy, language, spatial and artistic abilities have been revealed. It should be noted that there are more studies on the development of the skills listed above than those stated in this article. The development of early literacy (Chen & Chan, 2019; Jeffri et al., 2017; Redondo et al., 2020) and foreign language teaching (Lee et al., 2017; Pu & Zhong, 2018; Redondo et al., 2020; Taskiran, 2019; Topsakal & Topsakal, 2019) skills was broadly analysed by foreign researches. There are a lot of evidences that many studies exist on how to enhance early literacy in preschool augmented reality applications (Masmuzidin & Aziz, 2018) and foreign language teaching (Fan, Antle & Warren, 2020). Such grouping has not been done in previous studies. In this study, by making this grouping, it was determined on which subjects and skills the applications related to augmented reality preschool activities concentrate on and which subjects need more research. The results showed that important work has been done to support early literacy, language and spatial skills, while studies on artistic and musical subjects are limited. The literature review analysis showed that integrating information and communication technologies into early art activities is difficult for most kindergarten teachers (Huang, Li & Fong, 2016). On the other hand, the necessity was stressed on music activities and the inclusion of different features such as movement and sound. The programming process of such AR applications requires more efforts and therefore can be considered as the reason for the scarcity of music activities.

The analysis of these articles presents a common situation on how AR is used in the early childhood educational process. In spite of the fact that recently children use computer-mediated learning material in their home environment, still there is not much experience in using AR technology for educational purposes in early childhood education. Also, the analysis of the articles presented a few important aspects about the impact of AR technology on children's learning through playing process. However, these articles do not provide more specific knowledge about the effects that AR technology have on the development of the child's abilities, on the changes in the roles of the educator and the child, and on the need for appropriate modifications in the curriculum. The analysis of the articles revealed that both educators and children found it attractive and beneficial to use AR applications for educational purposes. Therefore, there is hope that the gap between the existing supply of applications with augmented reality and their use in preschool education process will be bridged up.

RECOMMENDATIONS

The results obtained that there is a need for further study on these topics for future research orientations, by using images other than the objects found in the immediate environment, such as animals, geometric shapes, numbers and letters. Also, this study reveals the necessity of including activities such as drama and movement more in preschool. It can be suggested to teach how to apply augmented reality tools in preschool teaching process, also to train teachable education, to produce teachable AR books, to produce teaching-based AR books.

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