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How Real is Augmented Reality in Pre-school? An Examination of Young **Children's** AR Experiences*

Artırılmış Gerçeklik Okul Öncesinde Ne Kadar Gerçek? Çocukların AG Deneyimlerinin İncelenmesi

Hacer BÜLBÜL** **Fatih ÖZDİNÇ*****

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ABSTRACT: The research aims to examine augmented reality (AR) technology during the pre-school years. For this purpose, we created activities with AR cards and compared them to activities with other materials. We designed the study as a case study, a qualitative research model. We used the convenience sampling method to select the study group and the criterion sampling method from the selection methods. The study group consists of eighteen children, ten boys, and eight girls attending kindergarten. Children are between 54 and 77 months. We gathered data through semi-structured interviews, observation, and audio and video recordings. We used the content analysis method to analyze the data, creating codes and themes. Findings show that using AR technology in the pre-school period attracts children's attention, gives them a sense of reality, embodies the content, supports peer relationships positively, and allows children to participate in activities willingly and focus on the activity. Furthermore, we have seen that AR technology can be a distraction. When comparing AR technology to other materials, we discovered that children prefer materials that directly connect to real life. They prefer materials that contain AR to materials that do not. We presented recommendations for the use of AR in the pre-school period and future research.

Keywords: Pre-school, technology in pre-school, augmented reality, augmented reality in pre-school.

ÖZ: Bu çalışmanın amacı, artırılmış gerçeklik teknolojisinin okul öncesi dönemde kullanımını incelemektir. Bu amaçla artırılmış gerçeklik kartları kullanılarak etkinlikler geliştirdik ve bu etkinlikleri diğer materyal kullandığımız etkinliklerle kıyasladık. Çalışmayı, nitel bir araştırma modeli olan durum çalışması şeklinde desenledik. Çalışma grubunu uygun örnekleme yöntemiyle seçtik, seçim yöntemlerinden ise ölçüt örnekleme yöntemini kullandık. Çalışma grubunu anaokuluna devam eden onu erkek sekizi kız olmak üzere toplam18 çocuk oluşturmaktadır. Çocuklar 54-77 ay aralığındadır. Uygulama süreci dört hafta sürmüştür. Verileri, yarı yapılandırılmış görüşme, gözlem, ses ve video kayıtları yardımıyla topladık. Verileri, kod ve temalar oluşturularak içerik analizi yöntemi ile analiz ettik. Çalışmanın sonuçları, artırılmış gerçeklik teknolojisinin okul öncesi dönemde kullanılmasının çocukların ilgisini çektiği, çocuklara gerçeklik hissi yaşattığı, içeriği somutlaştırdığı, akran ilişkilerini olumlu yönde desteklediği, çocukların etkinliklere istekli katılmalarını ve etkinliğe odaklanmalarını sağladığını göstermektedir. Bunun yanında artırılmış gerçeklik teknolojisinin, bazen dikkat dağıtan bir araç olabildiğini gördük. Ayrıca, artırılmış gerçeklik teknolojisini diğer materyallerle kıyaslandığımızda, çocukların doğrudan gerçek yaşamla bağlantısı bulunan materyalleri tercih ettiğini, gerçek yaşamla doğrudan bağlantısı bulunmayan materyallerde ise artırılmış gerçeklik teknolojisi içeren materyalleri tercih ettiğini gördük. Çalışmanın sonunda artırılmış gerçeklik teknolojisinin okul öncesi dönemde kullanımına ve gelecek çalışmalara yönelik öneriler sunduk.

Anahtar kelimeler: Okul öncesi, okul öncesinde teknoloji, artırılmış gerçeklik, okul öncesi artırılmış gerçeklik.

* This study is based on Hacer (Kuzgun) Bülbül's master dissertation titled "*Utilization of augmented reality in early childhood: A case study*".

** M.Sc, University Ministry of Education, Ankara, Turkey, hacer.kuzgunn@gmail.com, https://orcid.org/0000-0002-5732-5952

*** *Corresponding Author*: Asst. Prof. Dr., Afyon Kocatepe University, Afyonkarahisar, Turkey, fatihozdinc@gmail.com, https://orcid.org/0000-0003-2150-5019

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Content-rich pre-school education necessitates a solid and systematic structuring process and supports children's developmental areas (Sayan, 2016). In this case, it is critical to use rich content materials that support children's developmental areas during the pre-school education period while being appropriate for their developmental levels. Technology that appeals to multiple senses is also content-rich material in learning (Kol, 2012). By giving more space to technological materials that are appropriate for pre-school education environments and can attract children's attention, a content-rich learning environment can be offered to children in every aspect. Because technology has become an integral part of our lives, it is necessary to provide learning environments that include situations and tools relevant to their interests, given that the interests of new generation children differ. In response to this need, we believe AR technology will help pre-school children learn in an environment tailored to their interests by providing various experiences.

Although AR is not a recent technology, it has been used in education since the 2000s. Its use in education has increased and become popular and is widely used in many other sectors. According to Parhizkar et al. (2011), children nowadays find traditional learning methods dull and boring due to the widespread use of digital media and communication technologies. When traditional materials alone are insufficient, it is unavoidable to use technological materials to make the lesson more effective. AR technology, which is used as one of the technological materials in education, benefits students in several ways and provides significant gains (Bacca et al., 2014; Özsevgeç & Eroğlu, 2017; Radu, 2014). AR technologies can be used in both the classroom and outdoor learning at all levels of education.

AR technologies, developed for educational environments, use multimedia materials such as 2D or 3D animation, 3D objects, pictures, sound, and video, depending on the educational goal (Wei et al., 2015). It is well known that such technologies aid in the concretization of content and the understanding of complex subjects by visualizing structures that are not present in the real world but must be visualized in 3D (Wu et al., 2013). The fact that the contents are embodied by AR technology is seen as a benefit. According to the literature, AR technologies are widely used in educational settings (Abdüsselam & Karal, 2012; Fonseca et al., 2014). Interaction is ensured when 3D content is materialized and viewed from various angles, and it increases students' interest and motivation while also improving their spatial abilities (Cheng & Tsai, 2012; Hsiao & Rashvand, 2011; Kerawalla et al., 2006). At the same time, AR technology provides instant feedback thanks to the real-time interaction it contains, allowing students to control their learning processes (Bujak et al., 2013; Yuen et al., 2011). With these aspects, AR technology used in education can make learning enjoyable by enabling students to learn the subjects desired to be learned more easily. Yuen et al. (2011) emphasized the importance of AR technology, stating that it could help gain different perspectives on subjects, enable collaborative work, and realize the student's own learning pace. The following factors must be considered in order for AR technology to be used in education most effectively and beneficially: it must be compatible with the curriculum, the process must be balanced, and appropriate interactions must be created (Hsiao et al., 2010).

The literature discusses the benefits of AR technology for children. As a result of this situation, numerous AR applications have been released. The majority of AR

products on the market suffer from either a lack of theoretical support or a lack of ability to depict entertaining learning interactions (Yang & Wang, 2017). Besides, the relationship between developmental changes and AR designs for young children is important (Radu & MacIntyre, 2012), and teachers' and parents' decisions over which augmented reality applications to use are crucial. As a result, it is critical to examine children's learning processes using AR technology and identify opportunities and threats.

This study aims to examine children's reactions to AR technology, how AR technology affects the efficiency of activities, the effect of AR technologies on peer relations, in short, the use of AR technology in the pre-school period. Simultaneously, we investigated children's material preferences in AR activities and the problems that may arise when using AR technology. For these purposes, we sought answers to the following research questions:

1. How do children react to AR technology?
2. How are the peer relationships of children in activities using AR technology?
3. What are the material preferences of the children in the activities?
4. What kinds of problems do children have when they use augmented reality technology?

Literature Review

According to studies on developing materials supported by AR technology and the achievements brought by AR technology, AR technologies provide high motivation and a collaborative learning environment among children, bringing interaction while also assisting children in learning simple concepts (Haughland, 2000; Parette et al., 2000). Campos et al. (2011) concluded that play with AR technology effectively maintains high motivation and cooperative learning among children, particularly when feedback is used. It can also help children teach simple concepts. According to Chen et al. (2007), the AR learning material demonstrated to kindergarten children a new way of assisting them with Chinese pronunciation and memorization while motivating and attracting their attention. Yılmaz (2016) found that children prefer educational magic toys that include puzzles and flashcards to teach fruit, vegetables, occupations, color, animal, vehicle, number, and shapes using AR in his study for pre-school children.

Gecu-Parmaksiz and Delialioğlu (2020) examined the effect of AR technology, which was developed to teach geometric shapes to improve the spatial skills of pre-school children. The study results revealed that there is a significant difference in favor of the experimental group in the spatial ability test scores of pre-school children. In another study, Çevik et al. (2017) stated that the use of AR technology increases the desire to learn and the level of success in their study, in which they examined the effect of AR technology applications on the success of pre-school children in learning English words. Cascales, Pérez-López, and Contero, (2013) found that AR-supported content provides motivation and encouragement for children and can be used as a valuable tool in the learning-teaching process for children aged 4-5. Simultaneously, it is claimed that AR technology activities become more enjoyable for both pre-school children and their teachers and positively impact both teachers and children. According to Safar et al. (2017), the use of AR in the pre-school period has a positive effect on students'

academic achievement and motivation. However, in the long-term use of AR technology, students become bored and feel uncomfortable with the technological tools' weight.

Related research indicates that AR technologies used in the pre-school period effectively maintain high motivation and collaborative learning processes, attract attention and active participation among children, and increase the desire to learn and the level of success when feedback is used. The number of studies on the use of AR technology in the pre-school period is quite limited (Çevik et al., 2017; Koç, 2021). This may be related to the belief that technology used in the pre-school period will harm children, as it can become a problem when planned and applied without considering children's developmental levels and needs. The study is significant because it combines the pre-school period and technology, and there are few studies in the pre-school period that use AR technology (Aydoğdu, 2022; Cascales, Laguna, Pérez-López, Perona, & Contero, 2013; Gecu-Parmaksiz & Delialioğlu, 2020; Yilmaz et al., 2017).

Method

Research Design

We designed the study as a case study to investigate the use of augmented reality technology during the pre-school period using a qualitative research model. A case study is an empirical research method used when (1) the current issue is studied in its real-life context, (2) the lines between fact and content are blurred, and (3) more than one source of evidence or data is available (Yin, 2009). We designed this study as a case study because augmented reality studies are new in the pre-school period and data were collected with observation interview techniques. We used the holistic multiple-case design in the study, one of case study designs. The research consists of three different cases in three weeks.

Participants

We combined the purposive sampling methods, convenience and criterion sampling methods, to identify the participants of this study. We determined a public kindergarten in Afyonkarahisar, a city in western Turkey in line with the criteria of the school to be implemented, the socio-economic status of the families being at a moderate level, having a separate class where the participants can practice outside their classrooms, and having internet access.

The study group consists of eighteen kindergarten students ranging in age from 59 to 72 months who attend an independent kindergarten. The distribution of the participants by gender and age is shown in Table 1.

Table 1

Distribution of Children by Month and Gender

Gender – Age (month)	59-65	66-72	*N*	%
Girls	2	6	8	44
Boys	3	7	10	56
Total	5	13	18	100

The participants consist of eight girls (44%) and ten boys (56%). Five of the children are between the ages of 59 and 65 months, and thirteen are between the ages of 66 and 72 months. In the study, children were coded as C1, C2 ... C18.

Instruments

Diversity in data collection methods is an important aspect used to ensure validity and reliability in qualitative studies (Patton, 1990). For this purpose, the researcher and co-observer audio-recorded and analyzed the children's opinions about AR technology. The implementation process was video recorded. The researcher and co-observer kept observation notes during the application. Two pre-school teachers were involved in the implementation process in terms of the validity and reliability of the data collection process. One of them acted as a co-observer and the other as an assistant teacher during the process.

We created the semi-structured interview form. The interview form consists of nine questions. Following the preparation of the interview questions, we asked for feedback of two pre-school education experts to determine the content's suitability and intelligibility by children. In accordance with the suggestions, we completed the interview form. The following are two of the interview questions:

> "Did you enjoy the activity with the photograph occupation cards or the activity with the animated occupation cards?"
>
> "Would you prefer to do this activity with animated cards or non-animated cards if we did it again?"

We recorded the interview and took notes from time to time during the interview. One of us was in the research environment, observed and took notes on the participants' behavior.

We gathered information about the children and the activity process during the preliminary interviews. With the recommendation of an expert in pre-school education, we conducted separate interviews with the children the day after the implementation, which was held every week. Children were interviewed one at a time to ensure that the responses of the children involved in the implementation process during the interview were not influenced by one another.

Throughout the implementation, we observed children's behaviors, reactions, and thoughts toward activities and AR technology and how AR technology influences their peer relationships. As participant-observers, we took part in the implementation process. Children's reactions to the materials used in the activities, their reactions to AR technology, peer relationships and the types of behaviors they exhibit, and so on. We and the co-observer each observed and recorded the situations separately. The children's reactions to the activities, the materials used in the activities, their reactions to AR technology, peer relationships, and the kinds of behaviors they exhibit were all observed. We spent much time with the participants in their daily lives to better understand their behaviors, values, and social relationships in the social context because we were involved in the implementation process for a long time.

Implementation Environment and Materials

Physical Environment

The physical environment and layout of the implementation were created so that the students could sit at the tables in groups and gather around the table according to the content of the activities. The physical environment in which the children participated in the activities by participating in the implementation is given in Figure 1.

Figure 1

The Physical Environment Used in the Implementation Process

When deciding where the implementation would be developed, we looked for an environment where children were constantly engaged in their activities. We conducted the implementation in the children's natural environment in order for the study's data to reflect reality more closely and for the children to feel more at ease in the environment where the application will be made without being affected by the physical environment.

The AR Cards

To begin, we have compiled a list of AR applications that can be used inside the research aim. In terms of answering the research questions and being integrated with the activities, the applications we listed were reviewed by a total of two experts, one in the field of pre-school and one in the field of technology.

As a result of the evaluation, the "3D Magic Educational Cards" application contains objects in three different categories in terms of content. Besides, the "Octaland 4D+" application was chosen to be used because it is different from digital learning environments and, at the same time, is related to daily life. Figure 2 shows a 3D Magic educational card displayed in 3D.

Figure 2

3D Magic Educational Card 3D View

We used this set in the animals and fruits activity of the training given with AR support. When the camera detects the card, animals or fruits can be displayed in 3D and the displayed objects move when the user touches the screen.

We used the Octaland AR card set in the occupations activity. Octaland 4D+ is made up of characters who represent various occupations. Twelve occupation cards were chosen based on the judgments of two experts to be used in the activity. Figure 3 shows the cards relating to the various occupations.

Figure 3

3D Representation of Octaland 4D+ Cards

When the camera detects the cards, the characters specific to the professions are displayed in 3D, and the characters move when the screen is touched. As seen in Figure 3, more than one card can be played at the same time.

Other Materials

Animal toys are another material we use in the implementation process. Two experts' opinions were used to determine the toys used in the implementation, which took into account the activity's content. At the same time, other materials used in animal-related activities are platforms that resemble animal living spaces. Forest, sea, glacial, and glacial sea are among these habitats.

We used twelve cards with real-life photographs of occupations for the occupation-related activity, which is the last step in the application process. We sized the photos to fit other cards with AR technology used in the event and pasted them on the background cardboard.

Role of the Researcher

As a participant observer, the researcher took part in the procedure. The researcher guided the children's AR activities while also observing them. Because the researcher was not a natural member of the group previously, the researcher's role is observer as participant (Ahola & Lucas, 1981).

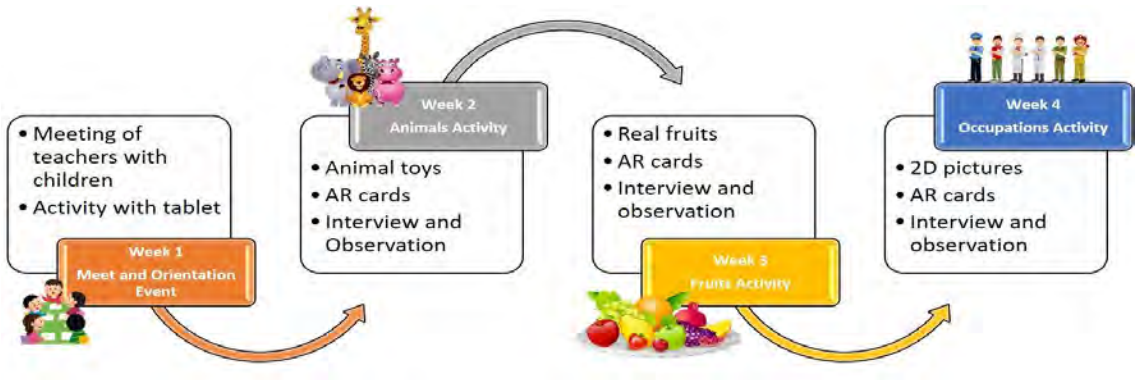
Teachers who participated as observers and the researcher both had appropriate expertise in technology use. They have previously used augmented reality (AR) and other technology-supported learning activities at the pre-school level. They also used the AR cards and tablets that had previously been used in this research.

Procedure

The procedure took four weeks. The contents of the activities in the implementation process according to the weeks are given in Figure 4.

Figure 4

Activity Contents by Week



The activities were first carried out without using AR cards, then animated using AR cards. Only during animated events are tablets distributed. Every week before the procedure, physical materials and digital learning environments were prepared in the kindergarten. Each week, the activity lasted for two hours. The children all took part in the first meeting. The second week's activities included fourteen children, the third week's activities included twelve children, and the fourth week's activities included eleven children.

First Week – First Meeting and Orientation

In the first week of the study, we held a meet and orientation activity to help the children get used to the researcher and teacher. They will perform the application to ensure reliability in the data collection process. Children were taken to the practice room in small groups and played with tablets in this activity.

Second Week - Animals Activity

This activity is aimed to examine whether 3D toys or visuals that become 3D in the virtual environment with the AR application attract more attention, which material the children prefer in such a situation, and whether the children are interested in the relevant AR material in the animal activity. We asked the students to place two different materials containing animal content in relevant habitats in the activity. Figure 5 depicts an animal-related activity performed without and using AR technology.

Figure 5

Animals Activity

Children with animal toys are seated around a table. Each child was asked to select two animals. Following the selection of the animals, the children are asked questions such as “Where do these animals live?” and “What do you know about these animals?” interacting with children through questioning.

After collecting the animals left in the living areas, the children were seated around the table again. We gave the children the AR cards with the backs visible and asked them to choose two cards from them. “How do the animals on the card you are holding sound?” inquire the children. We asked them to guess the animal sounds and make the corresponding sound. We asked the children to place their animal cards in appropriate animal habitats. Then, we animated the AR animal cards using the tablet and showed them to the kids. We gave each child a tablet and asked them to draw the animals they had placed in their space.

Third Week - Fruits Activity

We divided the children into small groups and had them sit around a table. The assistant teacher asked the children to guess the answers to the riddles by asking them fruit-related riddles and providing hints as needed. The children did positioning exercises with commands such as “under”, “above”, “between”, and fruits.

The visual of the activity related to the fruit, which was conducted with and without the use of AR cards, is given in Figure 6.

Figure 6

Fruits Activity

The children were asked to follow the instructions given with the AR cards in their hands by giving the same instructions in the activity content of real fruits. At each instructional stage, the teacher animated the AR fruit cards using a tablet and showed them to the students in the same manner. "Where is the fruit on the plate right now?" asks the process. By asking the question, she was able to discuss location concepts with the children.

Fourth Week – Occupations Activity

The teacher placed the occupation cards with real photos prepared for the activity on the table and discussed with the children which images on the cards represented occupations. She then instructed each child to select four occupation cards. She talked by asking questions like, "What do people with this occupation do?" "Where do they work?" "What tools do they use while doing their occupation?" and "Have you ever seen someone who does this profession in real life?"

The event was also conducted using AR cards. The teacher animated the profession cards created with AR technology and showed them to the children, and the children played the profession cards on the tablet in the same way. Children were allowed to interact with the visual, which became 3D, and working environments were allowed to be seen even in the virtual environment, and "Have you ever been to a place where anyone working in this profession?" Children were given the opportunity to connect with their daily lives by asking such questions. The visual of the activity related to the occupations performed with and without the use of AR cards is given in Figure 7.

Figure 7

Occupations Activity

The event was also conducted using AR cards. The teacher animated the profession cards created with AR technology and showed them to the children, and the children played the occupation cards on the tablet in the same way. We allowed children to interact with the visual, which became 3D, and to see their work environment even in a virtual environment. The teacher questioned the children about their portrayed occupations, asking, "Have you been to a place where anyone is working in this occupation?" and "Did you see someone doing this occupation?"

Data Analysis

We used the thematic and content analysis methods to analyze the data. We began by transcribing the audio-recorded data from the interviews. Then, we converted the data into code and themes. Another expert examined 10% of the themes and sub-themes we chose randomly. The expert and we discussed the points of contention about the themes and sub-themes and made the necessary arrangements.

We determined that there was 85% agreement using the reliability formula proposed by Miles and Huberman (1994) for calculating the reliability of the codings. The fact that the reliability calculations were greater than 70% indicated that the research was trustworthy. We compared the video recordings to the observation notes before analyzing and interpreting the data. We obtained the study's findings by organizing and interpreting the data, which was analyzed in accordance with the thematic framework.

Ethical Procedures

This study, in which we collected data from young children, was approved by an ethical committee. In its meeting dated 27.10.2017 and numbered 06, the Afyon Kocatepe University Science and Engineering Scientific Research Publication Ethics Committee found no ethical objections to the conduct of this study.

Results

Children's Reactions to AR Technology

Table 2 shows the themes and sub-themes that emerged from observations and interviews about how children react to AR technology used in pre-school.

Table 2

Children's Reactions to AR Technology

Theme	Sub-Themes
Reactions to AR technology	Surprised
	Sound effect
	Entertainment
	Willingness to possess
	Loss of effect of AR technology over time
	Animation effect
	Sense of reality
	Generalizing the animation

The data presented in Table 2, children's reactions to AR technology, "surprise," "sound effect," "interaction", "entertainment, desire to possess", "loss of effect of AR technology over time", "animation effect", "sense of reality", and "generalization of animation" shows that they are grouped under the sub-themes.

We observed that the children were surprised by the reanimated character and wanted more cards to portray them out of curiosity. To the animated characters, C1 said, "Oh, the nurse came out on this one." and C15 said, "Oh, the builder is out."

It is interesting to see how children react to the sounds in the applications. While some of the children felt the need for a sound, others did not like it, and some repeated it. In the event of the occupation, C11 made the sound of water by saying "puff" while portraying the firefighter, C3 made a scissors sound like "ktktktkt" on the hairdresser card, and C1 made a siren sound while portraying the police character.

When most children see the tablet later in the activity, they say, "Give it to me, give it to me, start with me first." Some of them refused to let go of the tablet, patiently waiting impatiently for it to come to them. Some of the kids wanted to take the AR cards home with them. This situation revealed a sub-theme of the desire to own AR-enabled materials.

We observed that the AR technology used in the activities initially drew children's attention and captivated their interest in AR technology. In the latter stages of some activities, we observed that some children exhibit behaviors such as putting the tablet aside from time to time, claiming boredom, and experiencing distraction. We noticed that AR technology could not maintain its effect at the start of the event over time and eventually lost its effect during the event.

C3 sat on the sidelines of the animals activity after leaving the tablet in his hand for a while. C3 refused the instructions by putting the tablet aside after a while in the fruit-related activity.

The children perceived the 3D images created on AR cards as accurate. "Let me catch you," he said, running his hand over the card as a seventeen participant in the Professions event. C3 participant expressed an opinion, saying, "It feels real." Similarly, while performing the animation process, participants C1, C3, C5, C6, and C10 in the activities took the tablet aside and looked at the AR cards to see if there was anything there. Throughout the AR activities, the children were continuously conversing and interacting.

When the three-week activity ended, it was clear that the children attempted to animate each object by generalizing the animation work. C8 held the tablet up to the light during the Fruits event and said, "I will make the light come alive." Similarly, after the C17, tablet, and cards were dealt, he turned the back of the AR-enabled cards and declared, "I will play the clown." He attempted to bring it back by placing the tablet on top of the clown.

Similarly, participant C17 turned the back of the AR-enabled cards and said, "I will portray the clown," before attempting to revive it by holding the tablet over the clown. All of the children participating in the occupations activity attempted to illustrate the 2D occupation cards used as physical material by holding the tablet.

Peer Relations in the Process of Using AR Technology

Table 3 shows the themes and sub-themes that emerged from observations and interviews about how peer relations.

Table 3

Children's Reactions to AR Technology

Theme	Sub-Themes
Peer relations	Helping each other
	Communication
	Wonder

Some children helped each other animate the characters during the AR technology activity. For example, while C19 was attempting to complete the animation, C18 attempted to help his friend by saying, "No, you will do it slowly." Similarly, C17 supported C5, who was struggling with animation, and assisted him in playing the character by guiding his friend by saying, "You will pull the tablet up a little bit, okay, okay."

It was observed that the children were conversing during the AR activities. Most of the children looked at each other's animated characters during the activities and attempted to animate them in AR activities. In the occupations activity, participant C17 animated her friend's card by saying, "I was inquisitive about food," C18 called her friends to her by saying, "Look guys, this is very nice." C11 asked his friends after reanimating his own character, "Mine is coming back. What is yours doing?"

Children's Material Preferences

Table 4 shows frequency and percentage values derived from the interviews about the children's material preferences.

Table 4

Children's Material Preferences

Activity	Preference	*f*	%
Animals Activity	AR cards	12	86
	AR cards and other material	2	14
Fruits Activity	Real fruits	9	75
	AR cards	2	17
	AR cards and real fruits	1	8
Occupation Activity	2D pictures	4	36
	AR cards	6	55
	AR cards and 2D pictures	1	9

Twelve (86%) of the fourteen children who participated in the animals activity said they preferred materials with AR technology, while two (C1, C11) said they preferred both. Regarding their material preferences, the children said the following:

C1: "Because the animated one was exciting, the toys were fun and they looked nice.",

C11: "Sometimes I want to do it with animation and sometimes without animation because you do it more comfortable when you are without animation, you act more easily when you are constantly animated, you get bored.",

C17: "Because it is very nice to animate".

Nine (75%) of the twelve children who participated in the activity of the fruits said they preferred real objects, two (C6, C17) preferred materials containing AR technology, and one (C9) preferred both. Regarding their material preferences in the fruit activity, the children stated:

C10: "Because I want to eat well.",

C11: "Man with and without animation gets bored. It is boring to just animate. I have come to eat the fruits."

C16: "I also like animation, but I like fruits more this time. Because the fruits are real.",

In the occupations activity, six out of eleven children (55%) said they preferred materials with AR technology, four (8, 11, 13, and 18) said they preferred 2D real painting materials, and one (15) said they preferred both. The children were questioned about why they preferred the relevant material. The following are the children's responses to the question:

C5: "Animation is more fun. I like the activities we animate more.",

C10: "Because I love it, animated cards are more fun.",

C11: "Both of them are fun because this is real and animated. But the real picture is more fun."

Problems Encountered While Using AR Technology

Table 5 shows the themes, sub-themes, and codes developed as a result of our observations and interviews about the problems encountered when using AR technologies in pre-school.

Table 5

AR Usage Problems

Theme	Sub-Themes
AR Usage Problems	Unable to move tablet
	App response time
	Hand-eye coordination
	Technical issues

Usage problems with AR technology are classified into sub-themes such as tablet weight, waiting time, hand-eye coordination, and technical difficulties.

During the activities, some of the children used the tablet by leaning against something for support, had difficulty grasping the tablet, and tended to leave the tablet on the table from time to time, even for a short period. In the interviews, the children expressed their feelings about these situations, saying, "I didn't like the animation because my hands were tired," and "Animation was not that easy because my hands

were tired." Due to a lack of hand-eye coordination, some of the children covered the camera with their hands. Similarly, the tablet's camera had difficulty detecting the card due to reflections of light in the environment on the card, and some of the children took their time performing the animation process. The children's reactions to this situation were as follows:

C9: "I said scan, scan, scan, scan, scan, scan,"

C14: "Why doesn't it come alive?"

C3: "This isn't playing, I'm bored," C11: "I don't like this tablet either."

In this situation, we observed that the teacher had problems with classroom and time management while using AR technology in the pre-school period. She had difficulty gathering all the children around a single tablet in groups where the tablet was insufficient.

Discussion and Conclusion

This study found that using AR technologies in the pre-school period allows children to participate in activities willingly and focus on the activity by attracting the child's attention, concretizing the content, presenting information colorfully and visually, and providing a fun environment. In line with the study's findings, Yusoff and Dahlan (2013) found that AR technologies capture children's attention. As a result, students are willing to use AR materials and participate in the lesson. In their study on kindergarten children, Chen et al. (2007) emphasized that AR technologies demonstrated a new way of motivating and attracting children's attention. Casscales et al. (2013) reported that using AR technology makes activities more enjoyable for both pre-school children and their teachers and has a positive effect on both teachers and students. According to Çevik et al. (2017), and Huang et al. (2016), AR technologies increase attention and active participation, the desire to learn, and the level of success.

We concluded in this study that children who are not interested in the content of the activity or do not want to participate in the activity participate in AR-enabled activities that attract their attention, calm them down, and focus on the activity by beginning to deal with the content of the activity. According to Özsevgeç and Eroğlu (2017), AR technology applications drew students' attention and interest because they were technology-based. It is well known that children engage in AR-related activities for a more extended period and more frequently (Bai et al., 2013). In this case, AR technologies used in the pre-school period arouse children's desire to participate in activities and provide an interactive and fun learning environment. Hsieh and Lee (2008) state that children learn by having fun and interacting more with their teachers when teaching with AR technology. Children have fun, their interest and attention are drawn, their success increases, they provide interactive and active participation, and they support cooperation with the media in activities involving AR technology, according to the literature (Cascales, Laguna, Pérez-López, Perona, & Contero, 2013; Çevik et al., 2017; Han et al., 2015). As a result, the results of this study are consistent with the result of other studies in the literature. Most of the children, when they saw the animated characters for the first time, gave various reactions such as liking, surprised, excited, happy, curious, and having fun by interacting with the content that became 3D at the end of the application process, all of the children stated that they had fun in activities containing AR technology. We think that children's reactions to AR

applications may be caused by the novelty effect and the appearance and movement of content not in the natural environment on the tablet screen. Indeed, Di Serio et al. (2013) states that AR technologies are new and can create a novelty effect when used in the learning process. Kuru (2015), on the other hand, stated that users are familiar with the product after they start using a product, and the user's perception of the product begins to change after the initial novelty effect wears off.

When AR technologies are used considering the developmental characteristics and needs of children in the pre-school period; we can say that it can reveal student-student interaction and support collaborative learning in activities involving AR technology by creating a desire to arouse curiosity, and engage in dialogue and help each other. AR technologies used in the learning process are viewed as adequate to support individual interaction and participation in the literature.

It is claimed that the use of AR technologies in education ensures individual interaction (Azuma, 2004; Bujak et al., 2013; Ivanova & Ivanov, 2011; Kamarainen et al., 2013; Kerawalla et al., 2006; Kesim & Özarslan, 2012; Wojciechowski & Cellary, 2013; Wu et al., 2013; Yılmaz, 2016). We think the interaction in the learning process will bring about collaborative learning. Ke and Hsu (2015) state that AR technologies can also be used in collaborative learning environments. In their study, Campos et al. (2011) concluded that they presented a game for kindergarten children that uses AR technology to support collaborative learning by providing motivation, fun, and curiosity, and that the game is effective in increasing their willingness to continue the high motivation and collaborative learning process with the feedback provided. In another study, Yuen et al. (2011) stated that AR technology could help gain different perspectives on subjects, enable collaborative work, and realize the student's own learning pace. Rasalingam et al. (2014) concluded in their studies that pre-school AR activities support cooperation and engage children in learning activities.

Except for the fruits activity, children preferred materials containing AR technology in all other activities within the scope of the study. According to McKenzie and Darnell (2003) and Wang et al. (2013), children have positive attitudes toward AR applications and find them more accessible and inspiring than traditional activities. Furthermore, research shows that students want to use AR applications again and are satisfied with AR learning materials (Gün, 2014). In the fruits activity, children preferred real fruits to AR and stated that they wanted to eat fruits. Coulthard and Sealy (2017), in their experimental research, concluded that sensory play activities (FV) with fruits and vegetables promote more FV tasting in pre-school children than non-food play or visual exposure. We think this preference is due to the children's desire to taste the fruits.

The children had some problems with the heavy tablet, the long waiting time, and their hand-eye coordination while using AR cards and the tablet. According to Munoz-Cristobal et al. (2015), students may have difficulty using AR technologies in their learning processes. During the activities, when the tablet uses the camera to capture the character on the card, the animation process is sometimes delayed due to the card reflecting ambient light. External factors such as image quality, light, and output can have a negative impact on applications and make it challenging to use AR in education (Yılmaz & Göktaş, 2018). In their study, Dunleavy et al. (2009) stated that technological, managerial, and cognitive difficulties arise during the application. In the

studies of Ibáñez et al. (2014), students who participated in the study during the application encountered issues due to the devices used. Chang et al. (2015) stated in their study that technical and ergonomic issues might arise when using AR technologies. Children whose characters' revival times were extended became bored over time, did not want to repeat the activity, tended to leave the environment, and their interest waned. The literature has documented that difficulties encountered during the learning process can negatively impact students' attitudes toward the process (Gündoğdu, 2014). We believe that this situation is related to pre-school children's short attention span. According to Radu and MacIntyre (2012), attention can be a problem in children's interaction with AR, and children should have fine motor, spatial, attention, logic, and memory abilities to interact with AR effectively.

Implications

The research found that animations and sounds in AR applications used in pre-school significantly impact children. As a result, it is essential to emphasize that AR applications for use in activities should be chosen to meet children's expectations in terms of animation, sound, and interaction.

When using AR technology, it is important to ensure the internet connection is strong and set up an order that is not affected by the environment's physical conditions (e.g., lighting, etc.). We recommend using tablet holder platforms in AR technology activities so that children do not have trouble using multiple materials.

AR is best used with pre-school children in small groups and additional materials. Students will not become bored with AR activities because they are not done sequentially and are spread out throughout the semester. We recommend in-service training on AR technologies for kindergarten teachers in the pre-school period.

Because they wanted to taste the fruits, the children preferred the activity with real fruits over the AR-supported activity. In future studies, we recommend that children's preferences for AR with real objects be thoroughly investigated using a variety of vegetables and objects.

Statement of Responsibility

Hacer Bülbül took responsibility in the processes of collecting data, planning the research, and creating the application materials. Hacer Bülbül ve Fatih Özdinç created measurement tools, conducted data analysis and reported the research.

Conflicts of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

Author Bios

Hacer Bülbül received a bachelor's degree from the Department of Computer Education and Instructional Technology Department at Suleyman Demirel University in 2016. She also has Master's degree from Computer Department, from Afyon Kocatepe University in 2019. He conducted studies on the usability of learning environments and the use of technology in pre-school. She continues to work as an Information

Technologies teacher in a school in Ankara. At the same time, she continues her studies on the use of technology by pre-school students.

Fatih Özdinç received a bachelor's degree from the Department of Computer Education and Instructional Technology Department at Selcuk University in 2007. He also has Master's and Doctorate degrees from Computer Education and Instructional Technology Department, from Hacettepe University in 2014. He took part as a researcher in 2 TUBITAK projects on STEM. He directed the projects called "Examination of teacher candidates' collaborative project development experiences", "Developing artificial intelligence-based smart toys for pre-school children" and "Examination of pre-service teachers' robotic coding experiences". He continues his academic studies on STEM applications in education and online collaborative learning. He is currently working as a faculty member at Afyon Kocatepe University. He teaches undergraduate and master level courses about instructional technology.

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