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Augmented Reality in Early Childhood Education: The Effect of Quiver Application on Science Learning

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Abstract

This study aimed to investigate the effect of Quiver application on science learning in the preschool period. The study was designed as an experimental design from the nice research type. The sample of the study consisted of a total of 40 children in two kindergartens in the same school determined by random assignment. Five different checklists determined by the researchers were used as data collection tools. Pre-tests and post-tests were conducted just before and just after the interventions with the pre-prepared checklists. The data were analyzed using the nonparametric Mann-Whitney U test used in the analysis of quantitative data. As a general result of the research, it was concluded that the activity processes planned with augmented reality application created a significant difference compared to the activity processes planned with traditional methods and provided higher learning. Looking at the themes separately, there was a significant difference in favor of the experimental groups in the themes of the cycle of water and rain formation, the life cycle of plants, and the food chain, while there was no significant difference between the knowledge levels of the experimental and control groups in the themes of the life cycle of the frog and sea creatures.

Keywords: Augmented reality, science learning, preschool education, technology integration, Quiver

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Introduction

In a world that changes and develops more and more every day, technological developments also affect life directly or indirectly (İçli, 2001). The effects of this developing and changing technology are also reflected in education and pave the way for the use of technology in education (Lawless & Pellegrino, 2007). The use of technology in education today is used in various ways at different levels and in different areas of education (Çaydere & Akgün, 2023). The various conveniences and benefits offered by technology make it attractive to use technology in education (Haleem et al., 2022). Studies have revealed that the use of technology in education has a positive effect on students' motivation, increases interest and allows learning to be more effective (Alpar et al., 2007; Balcı & Eşme, 2001; Huang et al., 2019).

Even if the main purpose of the development of technology is not education, educators try to make education suitable for the age by integrating technology into education with new ideas (Collins & Halverson, 2018). In developed countries abroad, economic budgets are increased every year for investments in technological equipment in education (Carlsen et al., 2016). Educational videos, projections, computer-aided applications and software, animations and educational games are among the first technological elements and equipment integrated into education that come to mind. In the following years, the latest technologies such as artificial intelligence, augmented reality, wearable technology, 3D printers, robots, virtual reality, nano devices, drone technologies, etc... are likely to lead to innovations by meeting with education (Hernandez-de-Menendez, Escobar Díaz & Morales-Menendez, 2020).

It is an important issue to determine how to achieve results by using different technological developments in education (West, 2012). In order to improve technology integration in education, new technologies should be adapted to education and their effectiveness should be measured (Ghavifekr & Rosdy, 2015). One of the new technological developments is augmented reality technology. Thanks to augmented reality, three-dimensional realistic images can be created in a virtual environment (Somyürek, 2014). Although augmented reality technology, which is one of the new technological developments, is a new development, it has started to be used in different branches such as health, military, art, engineering, etc. in the world and in our country (Keleş & Yavuz, 2022). Educational applications are among the leading studies that have been developed using augmented reality technology (Saidin & Halim, 2015). These applications can be used as educational materials for almost every age and field (İçten & Güngör, 2017).

Utilizing augmented reality in various subjects and activities in preschool education can provide more interesting and fun learning opportunities for children (Aydoğdu & Kelpsiene, 2021). In science education, which is an important part of preschool education content and aims to help children understand nature and the environment, gain scientific thinking skills, develop creative thinking skills, and develop their interest in science, augmented reality technology can contribute to children's learning by concretizing teaching with three-dimensional images (Kahriman Pamuk et al., 2020). Also, Wu et al. suggest that as abstract notions may be transformed into visualization structures, augmented reality (AR) can help teach science and mathematics.Piaget emphasizes that in the pre-processing period (2-7 years), which covers the preschool period, children have concrete thinking skills and learn information through concrete learning (Bliss, 1995). Concrete educational applications with augmented reality make it more attractive to integrate this technology into preschool education (Kahriman Pamuk et al., 2020).

Science education begins with the child's interaction with his/her natural environment; this process continues with curiosity, exploration and research (Spektor-Levy et al., 2013). Science teaching activities in the preschool period aim to develop a sense of curiosity in children, develop their research and investigation skills, and help them recognize nature and the environment through observation skills (Ünal & Akman, 2006). In preschool science education, it is aimed to provide children with information about events and phenomena that are effective in daily life, to understand and make sense of nature, and to create a basic level of recognition and foundation for science in children (Uyanık Balat & Önkol, 2011). Through science teaching and experiments, it is aimed to provide children with cognitive gains in the preschool education program such as making predictions about objects and events, establishing cause and effect relationships, paying attention, sorting and comparing skills. Science teaching in the

preschool period should be organized in a way that children can actively participate in order to be a science teaching suitable for children's development (Önal & Sarıbaş, 2019).

Technology should be integrated into preschool science teaching (Kewalramani & Havu-Nuutinen, 2019). Visual materials and explanations may not be sufficient in necessary science subjects. Especially in young age groups in the pre-processing period, teaching should be supported with concrete materials as much as possible (Usta, 2021). STEM activities that can enable concrete learning have started to be included in education from an early age and it is thought that augmented reality studies that will enable concrete learning will contribute to this field (Keleş & Yavuz, 2022). The difficulty of presenting most science subjects concretely to children causes problems in science teaching. Science teaching by utilizing augmented reality applications that can provide three-dimensional learning can be used as a new method in this regard (Özdamlı & Karagözlü, 2018).

There are only a few augmented reality applications with relevant content suitable for the preschool period. One of these applications, Quiver, can be used for this purpose. Quiver application is a special augmented reality application that can be run on smart mobile devices with coloring pages containing various topics and visuals, and after printing, the coloring pages are matched with the mobile device and the coloring colors are exactly the same color on the mobile device screen. Using this application, it is aimed to investigate how science learning activities will have an effect compared to traditional science learning activities and how the use of augmented reality technology in science learning will give results about the effects of learning on children compared to possible conventional science activities.

In order for the education given in the preschool period to be appropriate for the age, it is necessary to utilize technology in the right way (Ozel, 2019). The use of technologies based on new interaction paradigms to teach children is becoming more and more popular around the world because children are moving towards a new level of interaction with technology, so there is a need for educational content through the use of new, attractive technologies (Quesenberry et al., 2016). Instead of a computer program using traditional technological techniques (mouse, keyboard, computer, etc.), testing the use of augmented reality technology, which is a product of recent technological developments as a new idea for learning preschool topics, and revealing its effects can be an important issue for technology integration in preschool period (Aydoğdu & Kelpsiene, 2021).

The use of this augmented reality technology, which appeals to visual intelligence, in preschool education can be considered as a new idea. When the studies conducted in general are examined, it can be said that augmented reality technology has managed to attract a lot of attention in recent years in both the academic, educational and private sectors and promises a promising future (İçten & Güngör, 2017). Although the use of this field in our lives is currently low, it is predicted that it will have an important place in our daily lives in the future. When we look at the number of studies conducted abroad, it is slightly higher than the augmented reality research conducted in Türkiye (İçten & Güngör, 2017). When the related literature is examined, although there are a few studies on the use of augmented reality in preschool period in Türkiye, the related studies are almost non-existent especially for preschool period and there are not enough resources. In fact, when the literature was reviewed, even though there is a study about preschool teachers' opinions on the use of Augmented Reality application in preshool science education (Ozdamlı & Karagozlu) no research on the effect of using augmented reality on science learning in preschool period was found yet. This emerges as an original and new research subject area that is thought to contribute to the field and needs to be investigated.

For this reason, the aim of this study is to reveal the effects of using Quiver, an augmented reality application, in preschool science learning compared to traditional science learning methods. Within the scope of this research, the following questions were aimed to be answered.

- What is the effect of Quiver application on the learning of the theme of water cycle and rain formation?
- What is the effect of the Quiver application on the learning of the theme of the development of plants?
- What is the effect of the Quiver application on the learning of the theme of sea creatures?
- What is the effect of the Quiver application on the learning of the theme of frog development stages?

- What is the effect of the Quiver application on the learning of the food chain theme?

Method

Research Design

In this study, a quasi-experimental design with a pretest-posttest control group was used, which is one of the quantitative research methods. In the quasi-experimental design, research is conducted using two pre-existing groups and it is used in cases where random assignment cannot be made. Quasi-experimental designs are like an imitation of real experimental designs (Metin, 2014). In educational research, it is generally difficult for researchers to conduct real experimental studies, the most important reason being that there are obstacles to the unbiased distribution of people to groups in school and classroom environments (Metin, 2014). In the study, one of the randomly selected classes was the control group and the other was the experimental group. In both groups, pre-tests and post-tests were administered individually just before and just after the applications.

Study Group

In the 2022-2023 academic year, the study group consisted of the children of 2 kindergartens consisting of 60-72 month-old children with a similar socioeconomic level in a state primary school affiliated to the Ministry of National Education in Sultanbeyli district of Istanbul. The convenience sampling method was used to select the study group. In convenience sampling, the sample is determined by using readily available items (Baltacı, 2018). Experimental and control groups were selected randomly at the same school in Istanbul to prevent any potential infusion into the results. To protect children's educational rights, all data collection processes were completed after official school hours with permission from their parents.

The gender and age group information of the participants in the experimental and control groups are given in Table 1.

Table 1.
Age and gender of the children in the experimental and control groups

Age	Gender	Experimental Group (n)	Control grubu (n)
60-72 month	Female	12	10
60-72 month	Male	9	10

As seen in Table 1, a total of 40 preschool children participated in the study, 12 girls and 8 boys aged 60-72 in the experimental group and 10 girls and 10 boys aged 60-72 in the control group, 20 children in each group.

Data Collection Tools

The 5 science themes of the research 5 science education topics in the daily plans that teachers have not yet implemented in the content of the plans belonging to the curriculum implemented by the teachers in accordance with the achievements and indicators of the 2013 MEB preschool education program were selected as the themes of the research. While these 5 themes were selected both educational programsand the Quiver application's themes were compared, and since these 5 themes overlapped they were selected for this study.

The Quiver application is a special augmented reality application that can be run on smart mobile devices with coloring pages containing various topics and visuals, and after printing, the coloring pages are matched with the mobile device and the coloring colors are exactly the same color on the mobile device screen for three-dimensional animation.

Table 2.
Control list of water life cycle

Water Cycle and Rain Formation	Answer
Knows sunlight hits the water bodies on the surface of the earth and evaporates the water.	
Knows water turns into vapor with increasing tempature.	
Knows vapor is the gaseous state of water.	
Knows evaporated water rises to the sky.	

Table 2 continuing

Knows the vapor that rises to the sky turns back into water when it cools and turns into raindrops.
Knows the water that turns into water at high altidues forms raindrops and descends to the ground.

The checklists, which are data collection tools, were developed specifically for this study by two researchers who are experts in the field based on the content of the Quiver application and the 2013 MoNE preschool education program and reviewed related literature. Two different expert opinions were then obtained. The checklists consist of items that try to reveal whether the topic to be taught in the related theme has been learned or not. These lists were used by assigning 1 point for each item that children were able to learn and 0 points for those that they could not learn.

Data Collection Process

In order to collect the data of the study, ethical permission was obtained from Mehmet Akif Ersoy University Non-Interventional Clinical Research Ethics Committee with decision number 2023/230 on 05/04/2023. Then, two kindergartens within a public school affiliated with the Ministry of National Education in Istanbul Sultanbeyli district center were selected as the participants of the study. Permission was obtained from the parents of the participants with the necessary informed consent form. Five preschool science education topics in the content of the plans implemented by the teachers in accordance with the achievements and indicators of the MEB preschool education program were selected as the themes of the study. The study was planned to investigate one theme each week and a five-week implementation process was completed. In this process, the one-week program implemented in both the experimental and control groups is given in detail below.

The theme of the first week of the study, the cycle of water, was presented by the same researcher to the children in both the experimental and control groups by explaining the cycle of water with the same expressions. The expressions of the researcher's narration are as follows: 'Water heats up thanks to sunlight, evaporates and rises to the sky. The gas state of water is called vapor. When this vapor that rises to the sky meets cold air in the sky, it condenses and turns into water droplets again, and since these water droplets become heavier, they can no longer stay in the sky and descend to the ground as rain. In order to measure the knowledge levels of the experimental and control groups, pre-tests were administered before the research and post-tests were administered after the research to measure their knowledge levels and the data obtained were statistically calculated and tabulated.

Experimental Group

In the experimental group, the activity was carried out on the relevant worksheet of the Quiver application. The researcher explained the subject to the children with the narration technique through the visual on the Quiver worksheet. After the subject was explained, the children colored the relevant worksheet and the teacher asked each child to color in turn by animating it in 3D with the Quiver augmented reality application on the phone. No other work was done on the subject in the experimental group.

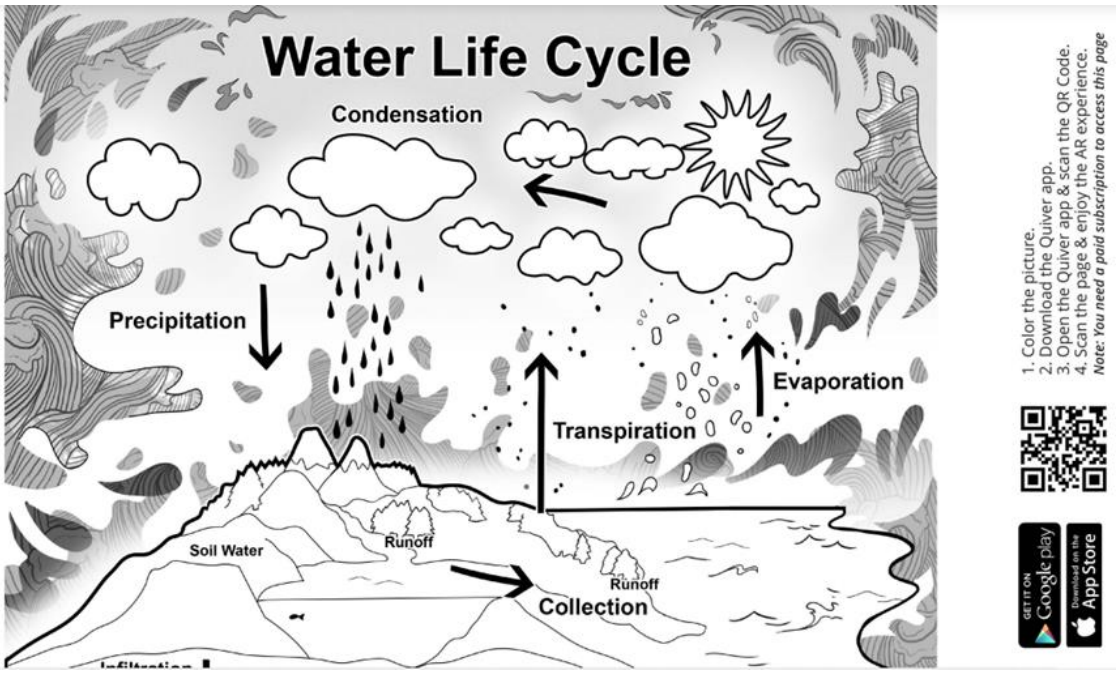

Figure 2. Quiver Coloring Page Example (Water Life Cycle)

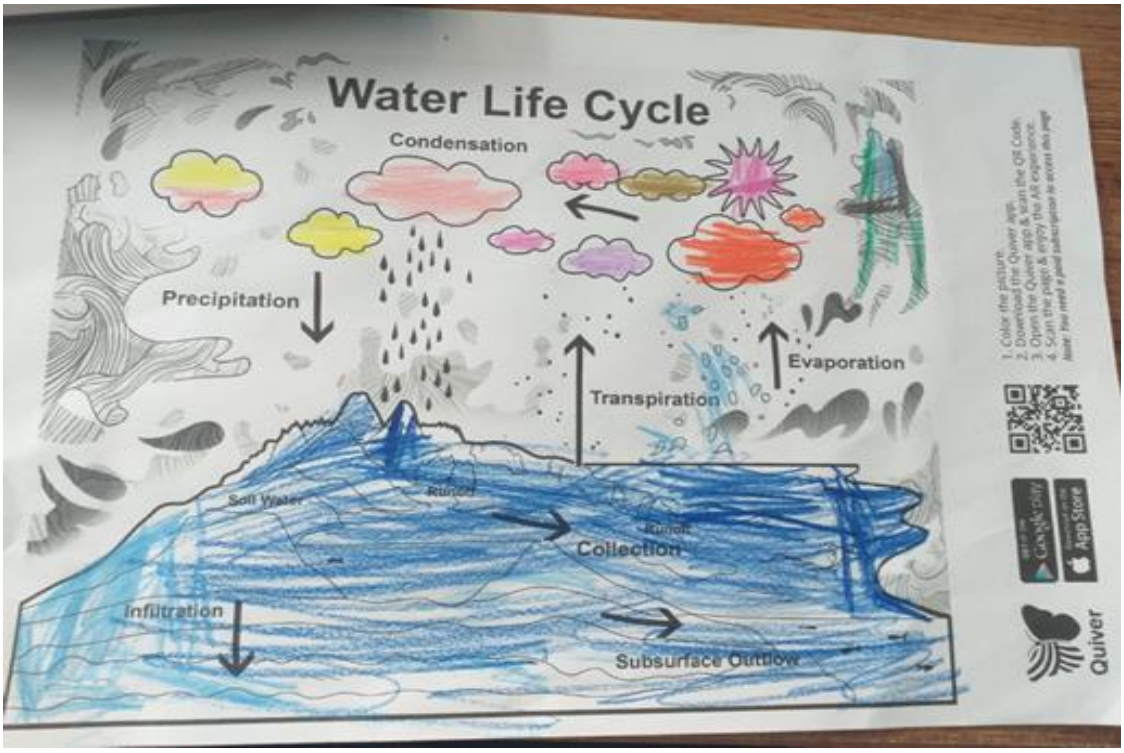

Figure 3. Painted Quiver Coloring Page (Water Life Cycle)

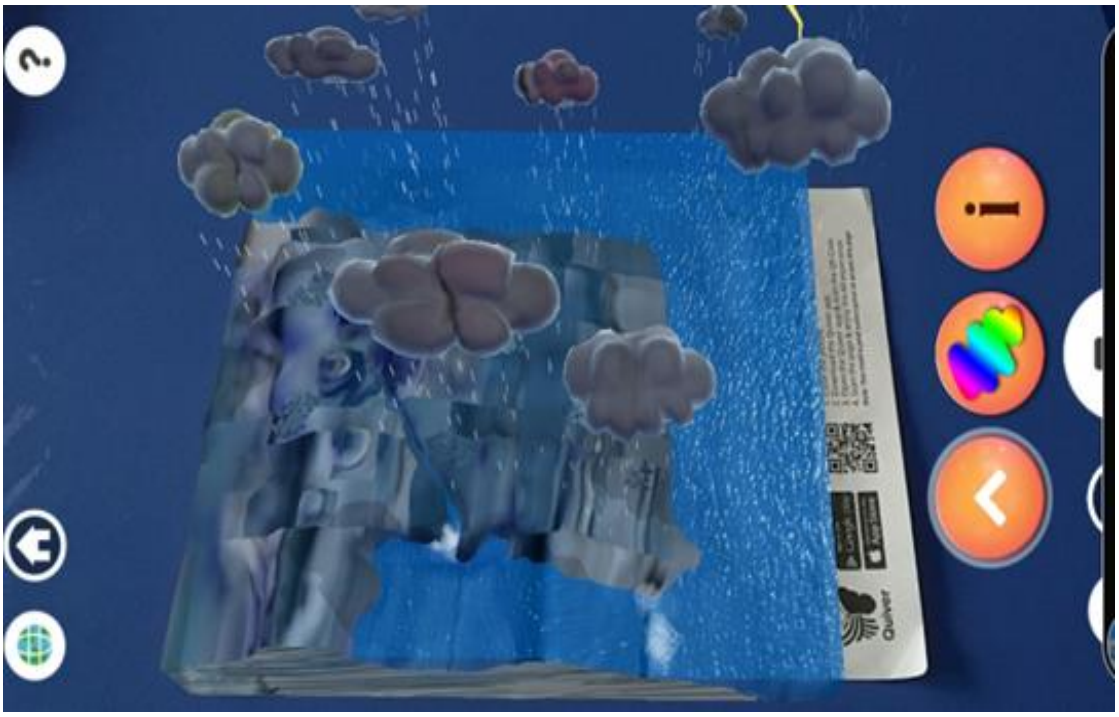

Figure 4. Applied Quiver Coloring Page (Water Life Cycle)

Control Group

In the control group, the researcher presented the water cycle graph that she had prepared beforehand to the children using the same verbal expressions as in the experimental group, and then conducted a rain formation experiment. A jar was filled with hot water, cling film was stretched over the jar and a saucer filled with ice was placed on top of the jar, and the setup was placed on the table and observed with the children. The hot water evaporated up to the surface of the cling film and turned into water droplets. After the experiment, a coloring page about the formation of rain was distributed to the children and coloring was done.

Figure 5. Control Group Rain Formation Visiualization

Figure 6. Control Group Rain Formation Experiement

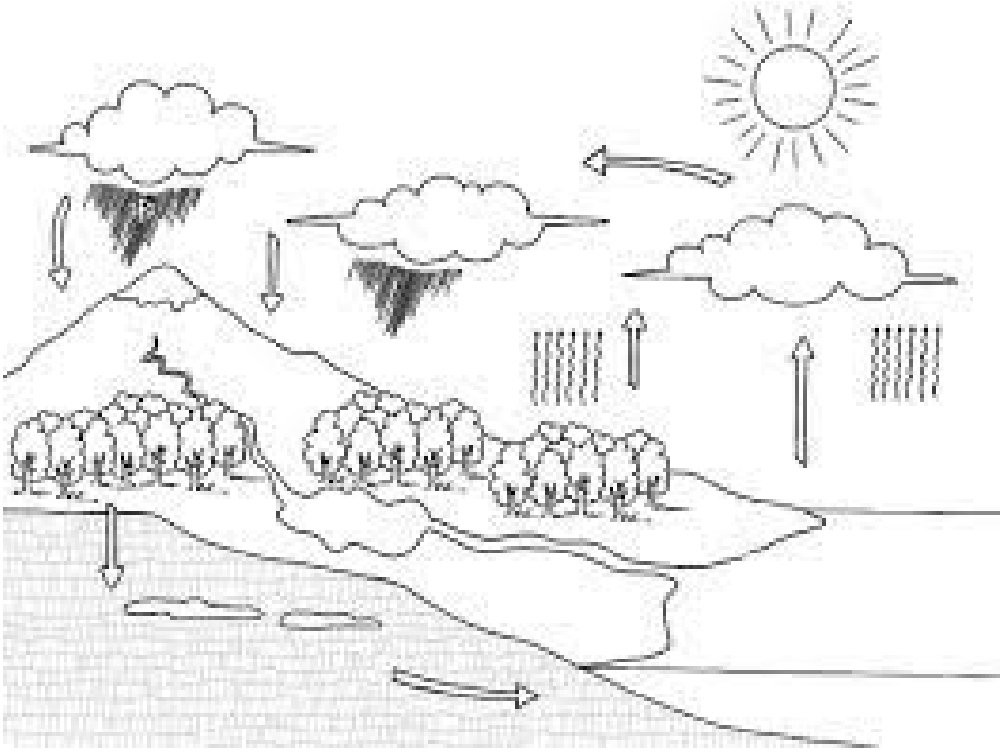

Figure 7. Control Group Rain Formation Coloring Page

Data Analysis

After the data were collected with the checklists, it was tested to see if the data were normally distributed. Since the data did not show normal distribution, which were shown in the Table 3 and Table 4, the data were analyzed using the nonparametric Mann Whitney test used in the analysis of quantitative data.

Table 3.
Descriptive statistics of experimental group

	n	Min	Max	Mean	Sd	Skewness		Kurtosis	
	Stat	Stat	Stat	Stat	Stat	Stat	Std. Error	Stat	Std. Error
Pre-test	99	,00	9,00	1,8600	2,55452	4,106	,243	25,828	,481
Post-test	100	,00	9,00	5,3400	2,31983	-,817	,241	,058	,478

Table 4.
Descriptive statistics of control group

	n	Min	Max	Mean	Sd	Skewness		Kurtosis	
	Stat	Stat	Stat	Stat	Stat	Stat	Std. Error	Stat	Std. Error
Pre-test	99	,00	7,00	2,2222	2,43670	,863	,243	-,720	,481
Post-test	99	,00	8,00	4,4951	2,95864	-,066	,243	-,697	,481

Validity and Reliability

Reliability is the consistency or reproducibility of measurements acquired from a given population or sample using a test or measuring tool (Bademci, 2019). In order to ensure reliability by creating a reusable checklist as a measurement tool, two separate expert opinions were utilized while creating the checklists as Yıldırım and Şimşek (2008) suggested. Furthermore, validity refers to how well theory and evidence support the suitability and adequacy of the usage and intended interpretation of measurements generated from a test or measurement instrument applied to a certain population or sample (Bademci, 2019). In order to ensure validity, the interventions were conducted in the same classroom environment, in classrooms implementing the same curriculum plan, with children of the same age group and with the same number of class members, for the same duration, by the same researcher, with the same verbal expressions and on the same days. Data were collected from the children immediately before the start of the study and immediately after the end of the study without intervening time. Finally, when the questions on the checklist were not understood by the children, they were explained by the researcher in a way that they could understand, and it was tried to reveal whether the child had the information in the most objective way since Streubert and Carpenter (2011) stated that to strengthen the objectivity of the research, it was required that there be no researcher biases.

Findings

Findings Obtained from Analyzing the Total Data of the Study

The total data of all themes were taken, statistically calculated and Mann Whitney U test was performed and the results were written in Table 5 and Table 6. When Table 5 is examined, the pre-test results of the control and experimental groups are given. It is concluded that there is no significant difference between the two groups.

Table 5.
Mann Whitney U analysis of the pretests of the data obtained from all themes

Groups	n	X	Mean	Sd	p	U
Experimental	20	1.86	94,59	2,55		
Control	20	2.22	106,41	2,44	0,122	4409,000

*p>.05

When the post-test results are compared with the pre-test results, it is seen that the arithmetic averages of both the control group and the experimental group increased. The arithmetic mean of the experimental group was 5.34, while the mean of the control group was 4.49. Although the arithmetic mean of the control group was higher than the experimental group at first, when the post-tests were analyzed, it was seen that the arithmetic mean of the control group was lower than the experimental group. In summary, when the results obtained from the tables are interpreted, it is seen that the class using the augmented reality application achieved significantly higher success than the class using traditional methods.

Table 6.
Mann-Whithey U analysis of the post-tests of the data obtained from all themes

Groups	n	X	Mean	Sd	p	U
Experimental	20	5.34	92.14	2.32		
Control	20	4.49	108.87	2.96	0.038	4163.500

*p<.05

Findings Obtained from Analyzing the Theme of Water Cycle and Rain Formation

When the data in Table 7 are examined, it is seen that there is no significant difference between the pre-test achievement scores of the students before the application started, and these results are suitable for the purpose in terms of determining the effectiveness of the teaching technique applied.

Table 7.
Pretest Mann Whitney U test results of the experimental and control groups on the theme of rain formation and water cycle

Groups	n	X	Mean	Sd	p	U
Experimental	20	0.6	20.90	1.42		
Control	20	0.5	20.10	1.14	0.84	192.000

*p>.05

Table 8 shows that there was a significant difference between the groups as a result of the studies. When the data are analyzed, it is concluded that the process applied with Quiver augmented reality application provides significantly higher learning.

Table 8.
Post-test Mann Whitney U test results for the experimental and control groups on the theme of rain formation and water cycle

Groups	n	X	Mean	Sd	p	U
Experimental	20	4.25	24.98	2.02		
Control	20	2.55	16.03	2.01	0.014	110.000

*p<.05

Findings Obtained from Analyzing the Theme of Life Cycle of Plants

Table 9 shows that there was a significant difference between the two groups at the beginning and this difference in knowledge level was in favor of the control group.

Table 9.
Pre-test Mann Whitney U test results for the life cycle of plants theme

Groups	n	X	Mean	Sd	p	U
Experimental	20	0.0	15.0	0.00		
Control	20	1.25	26.0	1.39	0.00	90.000

*p<.05

Table 10 shows that there is no longer a significant difference between the two groups. Although the initial knowledge level of the class in which the activity was carried out with the Quiver augmented reality application was lower, it is seen that the learning level increased to a higher level after the activity. Quiver augmented reality application increased the learning level compared to traditional methods.

Table 10.
Post-test Mann Whitney U test results for the life cycle of plants theme

Groups	n	X	Mean	Sd	p	U
Experimental	20	3.85	23.43	2.25		
Control	20	2.65	17.58	1.72	0.106	141.500

*p<.05

Findings Obtained from Analyzing the Theme of Sea Creatures

Table 11 shows that there was no significant difference between the two groups before the activities.

Table 11.
Pretest Mann Whitney U test results of the experimental and control groups for sea creatures theme

Groups	n	X	Mean	Sd	p	U
Experimental	20	6.05	21.80	0.99		
Control	20	6.30	19.20	0.80	0.45	174.000

*p>.05

When the post-test results are analyzed, it is concluded that there is no significant difference between the two groups as a result of the activities. It is understood from this table that augmented reality applications in the theme of sea creatures did not create a significant learning difference compared to traditional methods.

Table 12.
Post-test Mann Whitney U test results for the experimental and control groups on the theme of sea creatures

Groups	n	X	Mean	Sd	p	U
Experimental	20	7.85	19.98	0.48		
Control	20	7.95	21.03	0.22	0.53	189.500

*p>.05

Findings Obtained from Analyzing the Theme of the Frog's Life Cycle

When we look at Table 13, it is seen that there is no significant difference between the experimental and control groups when we look at the pre-test results of the experimental and control groups about the life of the frog, and even the arithmetic averages are close to each other. It is seen that the pre-test knowledge levels are similar.

Table 13.
Mann Whitney U pre-test results of the experimental and control groups for the frog life stages theme

Groups	n	X	Mean	Sd	p	U
Experimental	20	7.85	19.98	0.48		
Control	20	7.95	21.03	0.22	0.53	189.500

*p>.05

When the post-test results of the experimental and control groups are analyzed in Table 14, there is no significant difference between the two groups. It can be said that both the control group in which the traditional method was applied and the experimental group in which the Quiver application was used had similar levels of learning. In summary, there was no learning difference in this theme between the activities carried out with the traditional method and the activities carried out with the Quiver method.

Table 14.
Mann Whitney U post-test results for the experimental and control groups on the theme of frog life stages

Groups	n	X	Mean	Sd	p	U
Experimental	20	4.85	20.08	1.89		
Control	20	5.40	20.93	2.47	0.815	191.500

*p>.05

Findings Obtained from Analyzing the Theme of the Food Chain

When the pre-test statistical calculations of the food chain theme were examined, it was concluded that the arithmetic averages of the two groups were close and there was no significant difference between the two groups since the p value was greater than 0.05.

Table 15.
Mann Whitney U pre-test results of experimental and control groups for food chain theme

Groups	n	X	Mean	Sd	p	U
Experimental	20	0.30	19.55	0.80		
Control	20	0.45	20.45	0.88	0.462	181.00

*p>.05

When Table 16 is interpreted, it is seen that there is a significant difference between the two groups when the post-test statistical calculations of the food chain theme are analyzed. In this theme, the

experimental group, the class taught with the Quiver application, was significantly more successful than the control group.

Table 16.
Mann Whitney U post-test results of the experimental and control groups for the food chain theme

Groups	N	X	Mean	Sd	p	U
Experimental	20	5.90	24.40	2.07		
Control	20	3.90	16.60	3.37	0.032	122.00

*p<.05

Discussion, Conclusion, and Suggestions

In the developing and changing world, technology leads to new changes in human life every day. One of the changes that technology has made in human life is the change it has made in the field of education. Augmented reality technology emerged with the meeting of augmented reality technology with education has affected education through technology-based educational applications.

In this study, the effect of the use of augmented reality in science education in preschool period was aimed to be investigated and a 5-week application process was carried out. As a result of the research, it was concluded that the activity processes planned with augmented reality application created a significant difference compared to the educational practices planned with traditional methods and provided higher learning. When the literature is examined, most of the relevant research results show that augmented reality applications have a positive effect on achievement (Çevik et al., 2017; Doğan, 2016; Göçer & Kurt 2020.) The research conducted in the world on augmented reality, the number of which is increasing day by day, reveal that the use of augmented reality makes a positive difference in education compared to traditional methods (Yılmaz & Gözüm, 2023). In all of the themes of the research, it was concluded that the use of augmented reality application contributed to success and provided learning in children, but this result was not significant in every theme.

When the separate findings of the themes of the research are examined, it was revealed that augmented reality applications made a significant positive difference compared to traditional methods in the theme of the cycle of water and rain formation. In a study conducted, it was determined that compared to the organ models used within the scope of science course, lessons with augmented reality application increased achievement more than this traditional method (Akkiren, 2019).

The results of the theme of life cycle of plants showed that children in the control group had more learning outcome rather than children in the experimental group. However, two different planetarium software, Celestia and Stellarium, were examined in science education in preschool period and the use of both software accompanied by a guide was found to be beneficial for children's science learning. In particular, Stellarium software is more understandable to children than Celestia software in terms of astronomy concepts such as the formation of day and night, the shapes of the planets, and the phases of the moon (Yıldız, 2021).

In the sea creatures theme of the research, as a result, the achievements increased in the class where the application was made with augmented reality application and in the class where the application was made with the traditional method compared to the first situation, but the learning level of the class with augmented reality application did not differ significantly and highly compared to the class with the traditional method. In a study, there are studies that show that the learning of the lessons applied with augmented reality and the lessons applied with traditional methods increased significantly compared to the learning in the first situation, but the lessons taught with augmented reality were not effective enough to make a significant difference from the lessons taught according to traditional methods (Arslan & Elibol, 2015; Baysan & Uluyol, 2016).

In the theme of the life stages of the frog, the activity process applied with the traditional method and the activity processes with the augmented reality application revealed very close results and the positive effect of both applications on achievement was at a similar level. Some of the studies conducted were similar to these results. Some studies report that augmented reality applications do not have a significant effect on achievement, but still have a positive effect. In a study of 4th grade students, it was revealed that augmented reality applications had a positive effect on their math course achievement (Akın, 2022).

In a study conducted by Korucu, Gençtürk and Sezer (2016) to measure the effect of augmented reality on students' academic achievement, the results showed that the effect of augmented reality on academic achievement was positive. Research with similar results support the results in these themes. Studies show that the application of augmented reality technology in education gives positive results (Ateş & Garzon 2023; Güler, 2022; Somyürek, 2014).

For the theme of the food chain, the results showed that the experimental group, which was taught by Quiver application was more successful than the control group, which was taught by traditional methods. Similarly, Han, Jo Hyun, and So (2015) reported in a study that augmented reality increased concentration and attention skills in students. Another result of another study revealed that activities with augmented reality have a positive effect on children's cognitive gains (Cheng & Tsai, 2014). In a similar study, it was reported that the use of augmented reality in education increases attention and motivation and arouses curiosity in students (Di Serio, Ibáñez & Kloos, 2013).

In conclusion, the findings of this study showed that when augmented reality applications are used in the science learning of preschool children, more learning occurs compared to traditional methods.

The following recommendations were made within the scope of this research:

- The Ministry of National Education (MoNE) should encourage and educate in-service teachers to integrate AG into their teaching and learning process since the findings proved that augmented reality increases science learning.
- Further, investments should be made in augmented reality in education. For instance, this augmented reality application, which is understood to concretize abstract subjects in the preschool period, can be presented to children by turning them into games with different educational software.
- For educators, in this study, it was revealed that the use of augmented reality made a difference in learning. In this context, pre-service teachers should be trained and prepared to integrate augmented reality into the lesson to make learning permanent.
- Finally, for researchers, further studies can be conducted with different samples and/or different subjects such as AG effects on math learning etc. Also, qualitative research would expose the process of children's learning while they are using AG application in detail.

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Ethics statement: In this study, we declare that the rules stated in the "Higher Education Institutions Scientific Research and Publication Ethics Directive" are complied with and that we do not take any of the actions based on "Actions Against Scientific Research and Publication Ethics". At the same time, we declare that there is no conflict of interest between the authors, which all authors contribute to the study, and that all the responsibility belongs to the article authors in case of all ethical violations.

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