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Can Environmental Education Supported by Augmented Reality (AR) Applications Improve the Environmental Awareness of Primary School Students?

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Abstract: It is thought that it would be appropriate to use augmented reality technology, which provides many educational advantages for effective environmental education. This research aims to examine the effect of environmental education using augmented reality (AR) applications on the knowledge, attitudes, and behaviors of primary school third-grade students towards the environment and to find out the children's views on AR. The case study design, one of the qualitative research methods, was used in the research. The research was carried out with seventeen primary school third-grade students from a public school in the 2021-2022 academic year. Environmental education was given to the selected class with augmented reality applications for six weeks. The data were collected with the 'Semi-Structured Interview Form' prepared by the researcher. Content analysis technique was used in the analysis of the data. According to the findings obtained from the interviews; it has been concluded that environmental education using AR applications is effective in the knowledge, attitude, behavior, and environmental awareness of third-grade students towards the environment. In addition to these, in the interviews; it has been determined that students have positive emotions towards AR reality applications; they want to use the applications in other lessons; AR applications facilitate their learning and positively affect their approaches towards living / non-living beings, the environment and environmental problems.

Keywords: Augmented reality, Environmental awareness, Environmental knowledge, Environmental attitude, Environmental behavior

Introduction

The environment is the habitat where living and non-living elements directly or indirectly affect humans (Erman, 2013). Just as the environment affects humans, humans also influence the environment. This interaction between the environment and humankind has been progressing healthily for centuries, but it started to deteriorate, particularly with industrialization and technological advancements. According to Akın (2009), major human-induced environmental pollution did not occur until the Industrial Revolution. However, with the Industrial Revolution, the rapid increase in industrialization and population led to an increased demand for raw materials and the reckless consumption of natural resources at the same rate.

Unplanned urbanization destroyed natural habitats and put many species at risk, while air, water, and soil pollution started to emerge. In other words, the balance between humans and the environment was disrupted after the Industrial Revolution, and significant environmental problems began to arise. These problems include pollution observed in fundamental elements of the environment such as air, water, and soil, as well as light, noise, electromagnetic, and radioactive pollution, and the possible effects of these problems such as global warming, climate change, the greenhouse effect, ozone depletion, acid rain, and a decrease in biodiversity

(Çavuş Güngören, 2022). When examining the causes of these problems, it is mostly seen that they stem from human impact. Karakaya (2016) states that environmental problems arise from individual and collective human activities. Therefore, to overcome existing problems and potential future problems, it is necessary to start with the humans who are the source of the problem. After all, the source of the problem is the solution itself. According to Ergin (2013), the effectiveness of measures taken against environmental problems can be achieved through the existence of citizens who have environmental awareness. Individuals who have a good understanding of the environment, display a positive attitude towards it, and behave responsibly – in other words, individuals who have environmental awareness – are the most important source of solutions that can stop the deterioration of the environment and turn it into a positive direction.

As the increase in environmental problems became a global threat, particularly in the last 50-60 years, national and international focus on this issue has started to intensify. In national and international events such as congresses, symposiums, and panels, environmental education has emerged as the most important topic for solving environmental problems, leading governments to integrate environmental education into their educational systems. This is because individuals are at the center of environmental problems, and education has been recognized as the most effective way to develop long-lasting behaviors that align with desired environmental outcomes. Environmental education aims to cultivate individuals with environmental awareness. The goals of environmental awareness include environmental knowledge, positive attitudes toward the environment, and environmentally beneficial behaviors (Erten, 2005). In other words, the purpose of environmental education is to cultivate individuals who have the necessary knowledge about the environment, display positive attitudes toward the environment, and demonstrate beneficial behaviors towards the environment. Environmental awareness consists of three sub-dimensions.

Environmental knowledge refers to the level of knowledge regarding the elements of the environment, global issues, types of environmental pollution, and the preservation of the existing biosystem (Yıldırım, 2019). Environmental attitudes encompass individuals' positive or negative attitudes and thoughts towards environmentally beneficial behaviors, including fears, anger, restlessness, value judgments, and readiness to contribute to solving environmental problems (Erten, 2004). Environmentally friendly behavior is defined as the ability to take action for the conservation of the environment and the solution of environmental problems, as well as translating environmental knowledge and positive attitudes towards the environment into actions (Candan, 2015). Instilling environmentally friendly behavior is the most important criterion of environmental education (Arslan, 2022). According to Erten (2004), even if someone possesses all the knowledge about the environment, it is meaningless if they do not display environmentally friendly behaviors. The crucial issue here is the transformation of environmental knowledge and attitudes towards environmentally friendly behaviors.

To overcome environmental problems, there is a need for a tool that aims to cultivate individuals with environmental awareness, and this tool is environmental education (Erten, 2012). Environmental education is the development of environmental awareness in all sections of society, aiming to create sensitivity towards the environment and instill lasting and positive behavioral changes (Eroğlu & Keleş, 2009). According to Güven (2013), effective, planned, and goal-oriented environmental education is needed to cultivate individuals with knowledge and awareness of environmental problems. As a result of environmental education, individuals in society will perceive themselves as part of the solution rather than part of the problem, and many problems can be overcome by increasing environmental sensitivity (Karataş & Karabağ, 2013). According to Park, Boo, and Park (2022), environmental education not only involves providing students with information about the environment but also influences their attitudes and behaviors towards the environment. The primary objectives of environmental education, according to Gülay and Öznacar (2010), are to develop correct attitudes, behaviors, and skills related to the environment, make individuals environmentally literate, and increase awareness and sensitivity towards the environment.

Providing environmental education to children at an early age is crucial in solving environmental problems and preventing the emergence of new ones (Dilli, Bapoğlu Dümenci, & Turgut Kesebir, 2018; Atabek Yiğit, Balkan Kıyıcı, & Yavuz Topaloğlu, 2019). According to Liefander and Bogner (2014), environmental education can be more effective in young children, and its effectiveness decreases as age advances, making it more challenging to implement. Additionally, environmental education is a lifelong process, and it needs to start at an early age to build a strong foundation. Considering that education begins in the family, environmental education also begins in childhood within the family. However, not every individual may have family members with sufficient knowledge and environmental awareness. This means that individuals may not receive equal levels of environmental education in their families and may not develop an environmental consciousness. This is where schools come into play. According to Mustam and Daniel (2016), formal environmental education provided in schools is more likely to lead to environmentally friendly behaviors.

The most crucial formation for the development of environmentally conscious societies takes place in primary school years (Çelikler, Aksan, & Yenikalaycı, 2017). However, there are also limitations to primary education in terms of environmental education. In Turkey, there is no separate subject dedicated to the environment in primary schools. Environmental topics are predominantly covered within the curriculum of science lessons. The abstract nature of environmental concepts poses limitations for elementary school children who are in the concrete operational stage cognitively. Moreover, the traditional methods used in teaching negatively affect students' attention and motivation. In environmental education, out-of-school learning environments or nature experiences are vital (Bögeholz, 2006; Özdemir, 2010; Okur, 2012; Sarışan Tungaç, 2015). However, there are disadvantages to out-of-school learning environments, such as transportation difficulties, financial constraints, overcrowded classes and challenging control, potential hazards, time constraints, and difficulties in covering all the topics (Kubat, 2018; Ocak & Korkmaz, 2018). In addition to these limitations, there are also certain requirements for effective environmental education.

Environmental education increases students' environmental knowledge and awareness when it is provided in a visual, auditory, and practical way in early childhood (Tahiroğlu, Yıldırım, and Çetin, 2010). In environmental education, active teaching processes such as establishing the relationship between what is learned and life, meeting individual needs, and providing motivation must be taken into account. This can be possible by emphasizing a constructivist learning approach and innovative learning situations that will provide students with active participation in environmental education (Özdemir, 2007). In addition, it may not be possible to reach many topics related to the environment. According to Özdemir and Uzun (2006), to provide effective learning, it is necessary to either implement educational situations in the outside world or to bring the outside world to the educational environment. Against all these negativities, limitations, and requirements, it is necessary to use modern teaching technologies/materials that will enrich the educational environment and increase attention and motivation to the highest level.

In line with the developing technology, one of the technologies used in educational environments, especially in recent times, is augmented reality. Augmented reality (AR) is a technology in which real and virtual objects coexist simultaneously (Matcha and Rambli, 2013). With augmented reality technology, virtual objects can be displayed with glasses or mobile devices such as phones and tablets by integrating them into the real environment and interaction with these objects can be provided. Augmented reality technology has many educational benefits, such as increasing student success and motivation (Budiman, 2016; Saez Lopez et al., 2019; Iatsyshyn et al., 2019; Dikkartin Övez and Sezginsoy Şeker, 2022), providing a sense of reality (Carmigniani et al., 2011; Küçük, Kapakin, and Göktaş, 2015), providing experiences that are not possible in real life (Wu et al., 2013; Garzon, Pavon, and Baldiris, 2019; Seçkin Kapucu and Yıldırım, 2019; Khan, 2019; Eginli and Nacaklı, 2020), addressing all senses (Craig, 2013), making abstract concepts concrete (Arıcı, Yılmaz, and Yılmaz, 2021; Faridi, 2020), providing learning by having fun (Lu and Liu, 2015; Peder Alagöz, 2020; Ekiçi and Yeşilbursa, 2021), making learning eye-catching and effective (ChanLin, 2018; Boz, 2019; Garzon, 2019; Ekiçi and Yeşilbursa, 2021), and making it easier to understand topics, concepts, and content (Garzon, 2019; Saez Lopez, 2019; Karakaş, 2020; Arıcı et al., 2021).

When the limitations and requirements of environmental issues, the general characteristics of primary school children, and the educational benefits of augmented reality technology are evaluated together; It is thought that the use of augmented reality applications in environmental education will be effective. When the literature is examined, it is seen that there are not enough studies on environmental awareness and augmented reality at the primary school level. There has never been any study in the country where these two subjects were studied together; It has been determined that there are a limited number of studies abroad. The scarcity of studies in the literature on environmental awareness and augmented reality has made this study important.

This work; to raise environmental awareness at an early age, to guide researchers who want to work on environmental education and augmented reality in primary school; It is important in terms of introducing augmented reality technology, some augmented reality applications, and some activities that can be done with these applications to teachers and researchers. At this point, this research aims to examine the views of the effects of environmental education given using augmented reality applications on the environmental knowledge, attitudes, and behaviors of primary school third-grade students. For this purpose, answers were sought for the following two research questions:

1. What are the students' views on environmental education supported by augmented reality applications?
2. What effect does environmental education, in which augmented reality applications are used, have on the environmental knowledge, attitudes, and behaviors of primary school third-grade students?

Method

In this study, in which the effect of environmental education given by using augmented reality applications on the knowledge, attitudes, and behaviors of primary school third-grade students, and the views of children, the case study design, which is one of the qualitative research methods, was used. A case study is a detailed examination of an event with any possible method, in all its aspects (Yılmaz & Arık, 2022). Events in the case study; it is tried to be described in a multi-dimensional way in its natural environment, under time constraints (Punch, 2005, Hancock & Algozzine, 2006, Creswell, 2007). It is used to define and see the details that make up an event, to develop possible explanations for an event, and to evaluate an event (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz, & Demirel, 2020). The effects of environmental education and children's views on this subject were tried to be examined in depth through AR-supported applications, which is the variable discussed in this study.

Study Group

The study group of the research; consists of 17 primary school third-grade students from a public school located in the Gülyalı district of Ordu province in the 2021-2022 academic year. Since mobile devices will be used during the application process, it was taken into account that the students to be selected for the study group have mobile devices that they own or that can be used in their schools. In addition, due to reasons such as the continuing effect of the COVID-19 pandemic, the longer the activities to be done with mobile devices as the number of students increase, and the difficulty of obtaining these devices; a class with a low number of students was selected.

Data Collection and Analysis

Environmental education was given to the study group by using augmented reality applications for six weeks (18 class hours). After six weeks of practice, a six-item semi-structured interview form was prepared by the researcher to get the opinions of the students on augmented reality applications and to shed light on the changes in environmental attitudes, behaviors, and knowledge dimensions as a result of environmental education through augmented reality. Semi-structured interviews allow the interviewee to express himself and provide in-depth information when necessary; it can affect the flow of the interview with side or sub-questions according to the flow of the interview and enabling the person to detail their answers; It has advantages such as providing time flexibility (Türnüklü, 2000; Büyüköztürk et al., 2020; Yıldırım & Şimşek, 2021). In the preparation of the form, the opinions of a classroom teacher, a Turkish teacher, and two field experts were taken and necessary arrangements were made in line with the feedback. To test the intelligibility of the questions, a preliminary application was made and it was determined that all the questions were understood. The interview was conducted with all students (n=17) in the study group. Before the interviews, necessary permissions were obtained and a voice recorder was used. The recordings were then transcribed. Two field experts were consulted to confirm the accuracy of the written transcript. In the analyses, code names (S1, S2, …, S17) were used for the students to ensure anonymity. The content analysis method was used in the analysis of the data. Content analysis; It is the process of bringing together and organizing similar data around certain concepts and themes. In content analysis, themes are found after data is coded; After the codes and themes are arranged, the findings are defined and interpreted (Şimşek, 2018). In this direction, firstly the data was coded, and then themes were created with similar codes. After the data were organized according to codes and themes, the findings were interpreted and conclusions were drawn. Analysis results are expressed with frequency values.

Findings

In this section, the findings related to each sub-problem are given below, respectively.

Students Views on Augmented Reality Applications

After the implementation process of the research was completed, with semi-structured interviews with all the students in the study group where environmental education was carried out with augmented reality applications; It is aimed to determine the thoughts of students about augmented reality applications. First of all, the children in the experimental group were asked how the use of augmented reality applications in the teaching of the

lessons made them feel. The frequency information of students' feelings about augmented reality applications is given in Table 1.

Table 1. Frequencies regarding students' feelings about AR applications

Theme	Code	*f*
Emotions	Good/Well	11
	Happy	8
	Funny	7
	Exciting	6
	Curious	3
	Pleasant	2

According to Table 1, for the question "How did you feel about the use of augmented reality applications in the teaching of the lessons?", 11 of the students answered good/beautiful, eight were happy, seven were fun, six were excited, three were curious, and two were pleasant. Accordingly, no negative emotional feedback was received from any student regarding the use of augmented reality applications in the course; It was observed that all of the students felt positive emotions towards the use of AR applications. Some of the students' views on how the use of AR applications in the course makes them feel are given below.

Table 2. Students' views on how AR applications used in the teaching of the course

Student	Quotation
S3	"I felt good, I was happy. I am pleased."
S4	"It was fun, I had a lot of fun, it was beautiful."
S5	"I felt good. I felt excited. I was curious."
S7	"I felt good. I thought the animals were real, they were standing next to me. I felt a real environment."
S8	"I felt that I loved nature. I felt good, I was happy."
S9	"I felt enjoyable. I felt excited. I am happy too."
S11	"I had so much fun, I was excited and curious."
S12	"I felt that I loved living things in nature. I felt that I loved this lesson very much. I was very excited in our first lesson. I got used to it in the next lessons. I tried to use apps at home as well."
S17	"I felt so good. It was exciting and it made me wonder."

Statistical information regarding the students' views on the augmented reality applications making their learning easier/difficult and their willingness/unwillingness to use AR applications in other lessons are given in Table 3.

Table 3. Frequency of students' opinions regarding augmented reality applications

Theme	Code		*f*
Learning	make it easy		17
	make it difficult		0
		Total	17
Desire to use in other lessons	want		17
	do not want		0
		Total	17

According to Table 3, all of the students (n=17) stated that the use of augmented reality applications facilitated their learning and they wanted to use it in other lessons.

Table 4. Student views regarding AR applications making learning easier/difficult

Student	Quotation
S6	"It made it easy. Because I learn better by having fun."
S7	"It made it easy. Because it was easier to work with tablets."
S8	"It made it easy. Because it felt real."
S9	"It made it easy. I learned more easily because I had fun."
S10	"It made it easy. Its processing with tablets and phones has been effective."
S13	"It made it easy. Because I learn more easily when I'm having fun."
S14	"It made it easy. Because it's applied as if it were real life."
S15	"It made it easy. It's nice to have it on a tablet. I also applied it at home."
S16	"It made it easy. He was showing everything one by one."
S17	"It made it easy. Because animating using a tablet was impressive."

Statistical information about the reasons for students who want to use augmented reality applications in other courses and their views on which courses they want to use are given in Table 5.

Table 5. Frequency information of students' reasons for desiring to use AR applications in other courses and their opinions about the courses they want to use

Theme	Code	*f*
Reason for the desire to use AG	Have fun	8
	Make learning easier	7
	Like	2
	Love Turkish lesson	2
	Boring math class	1
	Adding joy to lessons	1
Lesson	Turkish	14
	Life Sciences	12
	Maths	10
	All lessons	5

According to Table 5, all of the students (n=17) stated that they wanted to use augmented reality applications in other lessons. When asked why they want to use augmented reality applications in other courses; According to Table 5, eight of the students answered that it was fun, seven of them made learning easier, two of them liked the Turkish lesson, two of them liked it, one of them added beauty, and one of them answered that the mathematics lesson was boring.

According to Table 5, all of the students (n=17) stated that they wanted to use augmented reality applications in other lessons. When asked why they want to use augmented reality applications in other courses; According to Table 5, eight of the students answered that it was fun, seven of them made learning easier, two of them liked the Turkish lesson, two of them liked it, one of them added beauty, and one of them answered that the mathematics lesson was boring. As for the question about the courses they want to use augmented reality applications; 14 of the students answered in Turkish, 12 in life sciences and 10 in mathematics, five of them stated that they would like to use it in all lessons. “Would you like to use augmented reality applications in other lessons? In which lessons would you like to use it? From where?" Some of the answers given by the students to the question are given below.

Table 6. Student opinions on AR applications in using for other lessons and their reasons

Student	Quotation
S1	"Yes. Turkish, life science. To learn easily, to have fun.”
S2	"Yes. Life science, Turkish. Because I learn more easily.”
S5	"Yes. In every lesson. Because it's more fun and I can learn easily.”
S6	"Yes. Maths. I don't like math class because it's boring. I think it will be fun if we work with AG.”
S7	"I would have liked to. In all classes. Because I liked the animation of beings and I had fun. “
S8	"I would have liked to. Maths. Because math is hard. Easy to learn.”
S10	"Yes. In all classes. Because the lessons would be even more fun.”
S12	"Yes. Mathematics, life studies, Turkish. Since I don't like math, I would like it because I like it more. Because we do fun activities.”
S13	"Yes. Mathematics, life science, briefly in all courses. Because I'm having fun and who wouldn't want to have fun."
S14	"Yes. Mathematics and Turkish. Because we would see the difficulties in mathematics with video and we would learn easily. In Turkish, if our reading is bad, we can use it to correct our reading.”
S17	"Yes. Life science. Because at that time, the animation would be done and we would learn easily.”

The Effect of Environmental Education Using Augmented Reality Applications on Students' Environmental Awareness

After the implementation process of the research was completed, with semi-structured interviews with all the students in the study group where environmental education was carried out with augmented reality applications; It is aimed to determine the changes in environmental awareness of students after augmented reality applications. The frequency information of the students' views about the effect/not effect of the environmental education given using AR applications on the approach to living/non-living things and the changes in their interests towards the environment and environmental problems are given in Table 7.

Table 7**.** Frequency information of students' opinions on the effects/failure of the effects of environmental education given using AR applications

Theme	Code	*f*
Approach to living/non-living things	Affected	17
	Not affected	0
Interest in the environment and environmental problems	Positive change/Increased interest	17
	Adverse change/Decreased interest	0

According to Table 7, all of the students (n=17) stated that the environmental education given using augmented reality applications affected their approach to living/non-living things; They stated that they experienced an increase/positive change in their interest in the environment and environmental problems. “Have augmented reality applications affected your approach to animate/inanimate objects? Some of the answers given by the students to the question "If it did, how did it affect it?" are shared below.

Table 8. Student opinions on students’ approach to living/inanimate beings

Student	Quotation
S1	"Impressed. To love animals, to give them food, not to hit them.”
S4	"Impressed. I now recycle the garbage.”
S5	"Impressed. I used to treat living things badly, now I treat them better.”
S6	"Impressed. I'm warning everyone. We adopted the cat. I am interested in plants.”
S7	"Impressed. For example, I was not watering the plants, now I am watering them. I started to love animals more, I give water and food to the animals on the street.”
S8	"Impressed. I didn't know before that trees were cut down and turned into fields, now I know. I learned that plants breathe. I learned about his other features.”
S9	"Impressed. Well, impressed. I became more sensitive than before.”
S11	"Impressed. I used to think that the air and the soil were alive, but now I've learned. I inform my friends about living and non-living things.”
S12	"Impressed. Normally I didn't like some animals, but now I love all animals.”
S13	"Yes. I got more information. I'm kinder to animals."
S14	"Impressed. I used to be afraid of the bird in our house, now I can pick it up without being afraid of it. I don't get mad at him when he bites my hand, and he's used to me. I pour the water that I cannot drink into the bottom of the plants. I feed the cats and dogs.”
S15	"Impressed. I plant and water the plants. I feed stray dogs.”

The frequency information of the students' views on environmental gains as a result of environmental education using AR applications is given in Table 9.

Table 9. Frequencies of students' opinions on environmental acquisitions as a result of environmental education using AR applications

Theme	Code	*f*
Academic achievement	Environmental information	7
Eco-friend Behaviors	Keeping the environment clean	15
	Feeding living things	13
	Treating living things better	9
	Recycle waste	8
	Warn people about environmental pollution	4
	animal adoption	3
	Nest for animals	3
	Treating animals	2
	Planting trees	2
	Making a financial contribution to the protection of living things	1
	Information about living and non-living things around	1
	Taking care of plants	1
Values and Attitudes	Loving living things	6
	Be sensitive	6
	Empathy	2

When the academic achievement theme in Table 9 is examined, the students stated that they gained knowledge about the environment as a result of the environmental education given using augmented reality applications.

The opinions of the students that they have gained knowledge about the environment as a result of the environmental education given by using augmented reality applications are given below.

Table 10. Students' opinions on environmental knowledge as a result of AR-supported environmental education

Student	Quotation
S2	"If we pollute the environment, our world will be polluted."
S7	"I learned that perfumes harm nature."
S8	"I learned that global warming will bring the end of our world. I didn't know before that trees were cut down and turned into fields, now I know. I learned that plants breathe. I learned about his other features."
S10	"I learned good manners."
S11	"I didn't know about global warming before and now I know. I learned many problems for the first time. I used to think that the air and the soil were alive, now I know."
S13	"I learned more. I already knew about environmental issues, but I learned more. If the garbage is ingested by living things, they can get stuck in their throat and die."
S17	"I learned that we shouldn't pollute the forests."

Looking at the theme of environmentally friendly behaviors in Table 9; Keeping the environment clean (n=15), feeding living things (n=13), warning people about environmental pollution (n=13), treating living things better (n=9), recycling waste (n=8), animals to make a home for people (n=3), to adopt animals (n=3), to protect animals (n=2), to treat animals (n=2), to plant trees (n=2), to inform about living and non-living things around (n=2). n=1), contributing financially (n=1), and taking care of plants (n=1) for the protection of living things. Some of the opinions of the students showing that they have gained environmentally friendly behavior as a result of environmental education using augmented reality applications are given below.

Table 11. Students' eco-friend behaviors as a result of AR applications and environmental education

Student	Quotation
S1	"When I see an animal and it is cold, I make a nest and feed it. I throw garbage and waste in the trash or recycle."
S2	"I do not throw garbage into nature. I give food when the living is hungry."
S4	"I feed the animals. I used to throw the garbage in the trash, now I recycle it."
S5	"I used to treat living things badly, but now I treat them better. When I find an animal outside, I take it to our house. I tell my mother if there is an emergency, we take her to the vet. I keep nature clean. I don't throw garbage into the water."
S6	"I'm warning everyone. We adopted the cat. I am interested in plants. My grandfather was always burning the stove. I warned him, he doesn't hurt that much anymore about air pollution. I feed the living. I take medicine for sick creatures. I feed the living and water the plants."
S7	"For example, now I collect the garbage around. For example, I was not watering the plants, now I am watering them. I warn people who apply perfume. I feed the living. Sometimes I nest them. I send waste batteries for recycling. I recycle the waste."
S8	We took our cat from the street and fed it. I water the plants. I protect animals."
S10	"I started to warn people who pollute nature. I do not pollute nature. I feed the living. I help those who need help. If I see garbage on the floor, I throw it in the trash."
S11	"I feed the animals. I do not throw garbage in nature. I plant trees. I inform my friends about living and non-living things."
S12	"I used to throw my garbage out all the time, now I throw it in the recycling bins. I used to pluck the plants, but I don't anymore. I take the animals that need help home, give them milk and feed them. I take care of my cats and dogs."
S14	"For example, when I see a starving cat and dog, I put milk in front of it. I bathe them. I used to be afraid of the bird in our house, now I can pick it up without being afraid of it. I don't get mad at him when he bites my hand, and he's used to me. I pour the water that I cannot drink to the bottom of the plants."
S15	"I feed the animals; I give them water. I love them and they love me too. I spend 2-3 TL a day for them. I throw the garbage in the trash. I recycle the waste."
S16	"If I see someone throwing garbage around, I will warn them. I tell him to throw his waste in the recycling bins."

When we look at the values and attitudes in Table 9; It is seen that the students gave the answers to love living things (n=6), being sensitive (n=6), and empathy (n=2). Some of the values and attitudes that the students stated that they gained as a result of environmental education using augmented reality applications are given below.

Table 12. Students view on the value and attitude towards the environment as a result of AR applications and environmental education

Student	Quotation
S3	"I am more affectionate towards animals."
S7	"I started to love animals more."
S9	"I am more sensitive than before."
S11	"I was very sad after seeing those who pollute nature."
S12	"Normally I didn't like some animals, but now I love all animals. I saw factory fumes on the way to the market and I didn't like that situation."
S13	"I am more interested in these issues. I was very sad to see that the campers left their garbage in the forests and left."
S15	"I used to be interested, but now I'm more interested."
S17	"I got closer to living things."

As can be seen from the answers of the students, many children stated that they are now more interested and sensitive to living things. Moreover, they stated that they felt closer to living things. It is thought that this situation is due to their better assimilation of living conditions.

Results and Discussion

In this research, students' views and effects on environmental education through augmented reality applications were examined. The results of the research and the discussions based on these findings have been tried to be explained within the scope of the relevant literature. In this context, the conclusion and discussion part of the research; was discussed based on the findings related to the sub-problems of the research.

In the first sub-problem of the research, students' views on augmented reality applications were examined. According to the findings, all of the students have positive emotions towards the use of AR applications. Students stated that they felt curious about using AR applications (See Table 1). One of the educational benefits of augmented reality applications is that it increases motivation towards the lesson (Radu, 2012; Dibrova, 2016; Akçayır & Akçayır, 2017; Boz, 2019; Arıcı et al., 2021). In intrinsic motivation, one of the motivation types, the sense of curiosity is at the forefront, and the learning period of students who are motivated in this way is extremely fast (Belo, Van Driel, & Verloop, 2010). In addition, students stated that it is fun to use augmented reality applications in lessons (See Table 1). There are studies in the literature that students find AR applications fun (Karakaş, 2020). Looking at the other answers of the students; it is seen that the majority of them gave happy, good/well, and exciting answers (See Table 1). It is thought that students who have a high sense of curiosity and excitement, participate in the teaching process with fun, feel happy and good will be more willing to the lesson, will actively participate in the lesson, and have high motivation. In addition to these, a student; stated that he felt as if the animals he saw on the screen were standing next to him during AR applications. This again supports the studies stating that AR technology provides a sense of reality (Carmigniani et al., 2011; Küçük et al., 2015).

When the findings related to the facilitation/difficulty of students' learning by using AR applications are examined; It was concluded that the use of augmented reality applications facilitated students' learning (See Table 3). This result is similar to studies showing that AR technology facilitates the understanding of subjects, concepts, and contents (Akçayır and Akçayır, 2017; Boz, 2019; Karakaş, 2020; Arıcı et al., 2021). In the answers given by the students; they stated that they learned by having fun, adding a sense of reality, and using mobile devices made it easier for them to learn (See Table 4). When the answers to the question of whether they want to use AR applications in courses other than science are examined, it can be concluded that all of the students wanted to use augmented reality applications in other lessons as well (See Table 3). In studies where augmented reality is used, it is seen that students want to use AR technology in courses other than the applied course (İzgi Onbaşılı, 2018; Karadavut, 2021; Creator, 2022). When asked which courses they would like to use, it is determined that it is desired to be used in all courses as well as Turkish, life studies, and mathematics courses (See Table 5). When asked why they want it, since it is funny; it facilitates learning; they find the mathematics lesson boring and they do not like it; they like the Turkish lesson and they like AR applications (See Table 5). It is concluded that students who experience augmented reality technology want to continue this experience. Additionally, it has been concluded that environmental education with augmented reality applications is effective on students' environmental knowledge. In the answers given by the students to the interview questions; they stated that they learned the truth of some existing false information about the environment, that they had access to new information in addition to their existing information as a result of the

application, and that they learned many information about the environment for the first time (See Table 10). Similar to this study, there are studies illustrating that augmented reality technology increases environmental knowledge (Koutromanos, Tzortzoglou, & Sofos, 2018; Theodorou et al., 2018; Safitri et al., 2022).

Moreover, the results of this study reveal that environmental education with augmented reality applications is effective on students' environmental behavior. Considering the answers given by the students to the semi-structured interview questions; it has been determined that they have acquired different behaviors in addition to the behaviors that are aimed to be developed in the Primary School Science Curriculum and included in the scale (See Table 9). Keeping and protecting the environment in which they live in the Primary School Science Curriculum; being thrifty in the use of resources, acquiring awareness of savings and gaining individual responsibility; In the scale used, behaviors such as warning those who pollute nature and harm living things, being thrifty and gaining recycling awareness are included. In addition to these, looking at the answers given by S4 S5, and S12; He stated that while he was always throwing his garbage out, he now throws it in the recycling bins and that he used to pluck the plants, but not anymore. These answers given by the students show that some negative behaviors towards the environment turn into eco-friendly behaviors after environmental education through AR. Therefore, it shows the effect of environmental education on environmental behavior with augmented reality applications. In addition to these, S15 stated in his answer that he spends 2-3 TL per day for animals. According to Erten (2012); It is called environmentally friendly behavior that individuals make financial contributions (both physical and monetary expenditures, etc.) to reduce or eliminate environmental problems when necessary. It should be taken into account how much people can sacrifice materially or morally for an environmentally beneficial behavior. Accordingly, the answer to S15 can be shown as an example of environmentally friendly behavior that is not included in the Primary School Science Curriculum. When the answers of the students were examined; It was also determined that different behaviors such as feeding living things, owning animals, treating animals, building a nest for animals, informing people about living and non-living things, and planting trees were also exhibited by the students (See Table 9). Studies illustrate that augmented reality technology can improve environmentally sensitive behaviors (Safitri et al., 2022) and have a positive effect on environmental behaviors (Aliabadi, Jafari, & Ardakani, 2021).

As another outcome of the study, it has been concluded that environmental education with augmented reality applications is effective on students' attitudes towards the environment. When the answers given by the students to the semi-structured interview questions are examined; It has been determined that there are changes in some values and attitudes as well. For example, S3; was more affectionate towards animals, S7; started to love animals more, S9; behaved more sensitively than before, S12; normally doesn't like some animals but now he loves all animals; S13 said that he was more interested in these issues and was very upset when he saw that the campers left their garbage in the forests, S15; In the past, he was also interested, but now he is more interested, S17; He stated that he got closer to living things. From these answers of the students, after environmental education with AR applications; It is understood that their current attitudes have improved further and some of their negative attitudes have turned into positive ones. This shows that environmental education given through augmented reality has a positive effect on attitudes towards the environment. When the literature is examined, there are similar studies that augmented reality is effective in developing attitudes toward the environment (Lee & Yoon, 2020; Aliabadi, Jafari & Ardakani, 2021). Furthermore, in terms of students' attitudes towards living/non-living things; It can be stated that there is an increase/positive change in their interest in the environment and environmental problems (See Table 7). When the answers of the students are examined, it is seen that this effect is positive; It has been determined that students are more sensitive, especially towards living things, acquire some new positive behaviors and turn their negative behaviors into positive ones (See Table 8). Within the scope of this research, it has been concluded that environmental education with augmented reality applications is effective on students' environmental awareness. From the statements by the students to the interview questions; it is seen that they have gained gains related to knowledge, attitude, and behavior, which are the sub-dimensions of environmental awareness (See Table 9). This result, Safitri and others in their study in 2022; is similar to the conclusion that augmented reality increases students' awareness of the environment.

In summary, it has been observed that using augmented reality applications, in environmental education has positive effects on environmental knowledge, attitudes, and behaviors of primary school third-grade students. Students found the augmented reality applications fun and interactive. Thanks to the applications, they increased their knowledge about the environment, developed awareness about environmental problems, and displayed positive attitudes. In addition, students stated that augmented reality applications facilitated their learning. As a result, this research has shown that the use of augmented reality applications has a significant potential in environmental education. Primary school third-grade students are positively affected by their environmental knowledge, attitudes, and behaviors with augmented reality-based environmental education. Therefore, it is recommended that educators use augmented reality technology in environmental education. It is important for

future research to further examine the impact of augmented reality applications on students of different age groups and different educational content.

Recommendations

Based on the results and experiences obtained in this research, the following suggestions have been made to guide researchers and practitioners in new studies on augmented reality and environmental education. Both in Turkey and at the international level; It is seen that studies examining the effect of environmental education on environmental awareness through augmented reality technology are not sufficient. For this reason, it is recommended to conduct studies on this subject in different classes at different grade levels. Additionally, in this study, the students expressed their opinion that they want augmented reality applications to be used in other lessons. In this direction, it is recommended to integrate augmented reality technology into the curriculum of all courses. Adding augmented reality technology to the curriculum and teaching it as a course in education faculties or including it as a separate subject in the courses. At the same time, it is recommended to give in-service training to teachers about augmented reality technology and its applications. These trainings will lead to active use of AR technology in all courses. Lastly, only primary school students were included in this study and their opinions were taken as basis. In addition, the application process was carried out by the researcher. In similar studies, the application process can be carried out by the teacher of the course and the opinions of these teachers about the research can be consulted. In this way, the students' answers can be compared with the teachers' answers.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

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