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Artırılmış Gerçeklik Teknolojisinin Fen Bilimleri Dersinde Çevresel Düşünce, Çevresel Davranış ve Çevreye Yönelik Tutum Değişkenlerine Etkisi

The Effect of Augmented Reality Technology on Environmental Thinking, Environmental Behavior and Attitude toward Environment Variables in Science Lesson

ÖZ

Fen öğreniminde teknolojinin kullanımı oldukça yaygındır. Yaygın olarak kullanılan bu teknolojilerden birisi de artırılmış gerçeklik (AG) teknolojisidir. Bu araştırma AG teknolojisinin öğrencilerin çevreye yönelik tutum, çevresel düşünce ve çevreye yönelik davranışları üzerindeki etkililiğini ayrıca bu değişkenler arasındaki ilişkiyi incelemeyi amaçlamaktadır. Araştırma çevreye karşı olumlu davranış, düşünce ve tutum sahibi bireylerin yetiştirilmesini AG teknolojisi kullanımıyla desteklediği için literatürde anlamlı bir yere sahip olacağı söylenebilir. Araştırma süreci, yarı deneysel desendeki ön test ve son test kontrol gruplu modele göre düzenlenmiş, bir deney ve bir kontrol grubu ile yürütülmüştür. Deney grubunda AG teknolojisi kullanılırken, kontrol grubunda mevcut program uygulanmıştır. Örneklem, 27 Kontrol grubu ve 26 Deney grubu olmak üzere 5. Sınıfta öğrenim görmekte olan 53 katılımcıdan oluşmuştur. Çalışmada veriler çevresel tutum ölçeği ile toplanmıştır. Araştırmadan elde edilen veriler MANOVA ve korelasyon analizine tabi tutulmuştur. Sonuçlar AG kullanımının ortaokul öğrencilerinin çevreye yönelik tutum, düşünce ve davranışlarına olumlu katkı sağladığını göstermiştir. Ek olarak deney ve kontrol gurubunda çevresel tutum, davranış ve düşünce değişkenlerinden bazıları arasında pozitif veya negatif ilişkiler olduğu belirlenmiştir. Araştırma sonuçlarına göre, ortaokul fen bilgisi dersleri kapsamında çevreye karşı olumlu düşünce, davranış ve tutum geliştiren bireyler yetiştirmek için AG teknolojisinin derslerde kullanılması önerilmektedir.

Anahtar Kelimeler: artırılmış gerçeklik, çevresel tutum, çevresel düşünce, çevresel davranış, fen eğitimi

ABSTRACT

The use of technology in science learning is quite common. One of these widely used technologies is Augmented reality (AR) technology. This research was purposed to examine the effectiveness of AR technology on students' attitudes, thinking, and behaviors toward the environment and to examine the relationship between these variables. The research will have a meaningful context in the literature as it supports raising individuals with positive behaviors, thinking, and attitudes toward the environment. The research process was arranged according to the quasi-experimental design's pre and post-test control group model. It was conducted with an experiment and a control group. While AR technology was used in the experimental group, it was applied to the existing program in the control group. The sample consisted of 53 participants in the 5th grade, which are 27 students in the Control group and 26 in the Experimental group. In the study, data was collected with the environmental attitude scale. MANOVA and correlation coefficient analyzed data collected in the context of research. The results showed that using AR positively contributes to secondary school students' attitudes, thinking, and behaviors toward the environment. In addition, it was determined that there were positive or negative relationships between some of the environmental attitudes, behavior, and thinking variables in the experimental and control groups. According to the research results, it is recommended to utilize AR technology in lessons to raise individuals who develop positive thinking, behaviors, and attitudes towards the environment within the context of secondary school science lessons.

Keywords: augmented reality, environmental attitude, environmental thinking, environmental behavior, science education

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Introduction

The origin of environmental problems is humans' destruction of natural resources (Choudhary et al., 2015). Solving environmental problems and protecting the environment is critical in solving environmental problems; those growing individuals who are susceptible to the environment and exhibit positive behavior toward the environment (Paco & Raposo, 2009; Straughan & Roberts, 1999). However, environmental problems can be solved by directing people to know the environment, improving their knowledge, and reflecting this information in their behaviors and thinking (Zheng et al., 2018). This change in knowledge, behavior, and thinking is possible with education. More permanent solutions can be produced by starting education at an early age. Thus, it may be easier for children who will encounter problems to be encountered in the future to be aware of this situation at an early age and to find solutions to environmental problems arising from today's actions, the problems they will eventually be affected by (Michalos et al., 2012; Olsson et al., 2015). As future scientists, consumers, policymakers, and voters, today's juveniles will be responsible for improving the environment, and they will be the ones who will determine the environmental policies of the future and see their effects (Ferrer-Balas et al., 2010). For this reason, it is seen that efficient environmental education is essential to school-age students. In addition, the fact that individuals' attitudes toward the environment begin to improve in early childhood (Ernst & Theimer, 2011; Gifford & Sussman, 2012) makes it essential to acquire these skills during the primary education period.

Environmental attitude is defined by Liu and Huang (2016) as expressing a personal point of view on the environment and all topics connected to the environment. According to Schultz and Schultz (2016), environmental attitude includes the natural environment, environmental protection, environmental responsibility, and environmental ethics. Boley et al. (2017) expressed environmental attitude as personal and organizational traits that require dedication and are necessary to protect the environment. In other words, environmental attitude is stated as the good or bad, positive or negative judgments of people towards the environment (Masud et al., 2017). According to Idajati et al. (2016), environmental attitude is people's views about their responsibility and role in the environment. In addition, Idajati et al. (2016) stated that there is an emotional tendency for or against liking or disliking, which emerges due to the awareness created with stability, continuity, and consistency in opinions. Wang (2015) expressed environmental attitude as an individual's consistent and permanent psychological perception.

According to the literature review, in studies examining environmental behavior, thinking, and attitude change, it can be said that while thinking affects behavior, behaviors also affect attitude, and attitudes also affect behavior change (Allen & Ferrand, 1999; Ajzen & Fishbein, 1980; Ajzen, 1987; Diekmann & Franzen, 1999; Kollmuss & Agyeman, 2002; Norberg et al., 2007). Yayla et al. (2022), it was stated that tourists' sensitivity towards the environment affects their attitudes towards the environment. The study focused on the relationship between purchasing environmental products and environmental attitudes of tourists and differs from our research in terms of sample, subject area and disciplines. In the study conducted by Johnson and Manoli (2010), the relationship between curricula and environmental attitudes was investigated and it was stated that there was a relationship between these concepts, and when curricula in different countries were examined, students' environmental attitudes were affected by curricula. However, despite the studies, more than definitive answers could be found (Kollmuss & Agyeman, 2002). However, in these studies, there are statements about how environmental education should be to gain individuals the concepts of environmental thinking, environmental behavior, and attitude

toward the environment. Environmental thinking and behaviors; In addition, improving the ability to raise individuals with positive attitudes in educational environments: this education: attract students' attention (Batres Quevedo, 2020; Kim et al., 2018), uses technologies that increase learning performance (Chang et al., 2011; Chen & Huang, 2009; Jormanainen et al., 2018) also depends on the use of techniques and technologies that provide positive attitudes towards the lesson (Chang et al., 2011; Marcinkowski & Reid, 2019), and the use of techniques or technologies that provide the demonstration of unsuitable or dangerous situations in the classroom environment (Kost & Peabody, 2021). Considering the educational contributions of augmented reality (AR) technology, these expressions are closely related.

Azuma (1997) expressed AR technology as a three-dimensional visualization in which real and virtual environments are presented simultaneously. According to Milgram and Kishino (1994), it is expressed as the use of virtual objects in natural environments. According to another definition, AR is a technology in which individuals interact with the natural world instead of causing the real world to change, and virtual objects are used in natural environments (Zhu et al., 2004). AR technology can also be expressed as a technology that enables the visualization of predefined virtual content to a sign, image, or location as a three-dimensional model utilizing cameras (Cheng & Tsai, 2013). AR technology has become widespread in engineering, architecture, medicine, marketing, and many other fields (Furth, 2011), contributing to educational environments (Arıcı et al., 2019). AR technology increases students' interest in the lesson (Arıcı et al., 2021; Putz-Egger et al., 2022; Rodríguez, 2022), develops a positive attitude toward the lesson (Arıcı et al., 2021; Çetin, 2019; Sırakaya & Sırakaya, 2018), increasing learning performance (Echeverría et al., 2012; Huang et al., 2019), providing a demonstration of dangerous situations (Catal et al., 2020; Rossi et al., 2020; Yılmaz & Göktaş, 2018), concretizing abstract concepts (Gausemeier, 2011; Jeong, 2018; Vergara et al., 2019) are some of the educational contributions expressed. Especially considering these contributions, it was thought that AR technology could support the development of thinking, behaviors, and attitudes toward the environment in science education. It aimed to examine the relations of these variables with each other. Since it is not possible to examine the extinct and endangered creatures in their natural environment or to visit them in the zoo, AR technology has been used because it enables these creatures to be brought to the classroom environment by interacting with 3D models. In this context, it is thought that the participants will develop positive attitudes, thoughts and behaviors towards the environment by interacting with living things. In addition, the number of studies in which AR technology is used in studies on environmental education within the scope of science education is limited. When we look at the studies on environmental education in the web of science, it is seen that this number is only three with a simple search. From these studies, Huh et al. (2020) used AR technology to examine students' attitudes toward delicate dust-related issues and seek student opinions. They stated that AR had a positive effect on attitude change from student expressions. Hsu and Feng (2019) stated that AR and attitude affect behavior. Sun et al. (2022) stated that using AR technology in the environment provides attitude development. These studies were not evaluated in terms of environmental thinking, environmental behavior, and environmental attitude variables. They were conducted on environmental issues and generally worked within the scope of attitude, behavior, and thinking variables. Therefore, it is clear that the study is original research. The research questions of the study conducted to examine the effect of AR technology in science education on the thinking, behaviors, and attitudes of secondary school students towards the environment and the relationship between these variables are as follows:

1- Is the experimental group using AR technology statistically significant from the control group in terms of environmental thinking, environmental behavior, and environmental attitude?

2- How is the relationship between AR technology use and environmental attitudes, thinking, and behavior variables affected?

1. Method

1.1. Research Design

The research was carried out with the permission approval numbered 06.04.2022 and 47257547 from Erzurum Provincial Directorate of National Education. The research conducted to investigate the effect of AR technology on environmental thinking, environmental behavior, and attitude towards the environment, as well as the relationship between these variables, is quasi-experimental. In the study carried out within the content of the 5th- grade science course, implementations were carried out with an experiment and a control group. The quasi-experimental design is the design in which pre-assigned participants are included in the determination of the groups, and the groups are randomly determined as experiment or control (Creswell, 2017). Since one of the two branches of a school was chosen as the experimental group and the other as the control group, the study is suitable for the quasi-experimental design. One of the 5th graders at school was chosen as the control group and the other as the experimental group. While AR technology was used in teaching animal biodiversity in the experimental group, the instruction method suggested by the Ministry of National Education (MNE) was used in the control groups. In the control group, the lessons were conducted within the scope of inquiry-based learning as suggested. In both groups, teaching was carried out in a way that the content of the course and the scope of the acquisition was the same. Lessons in groups were conducted by the researcher. The practical design of the research is shown in Figure 1.

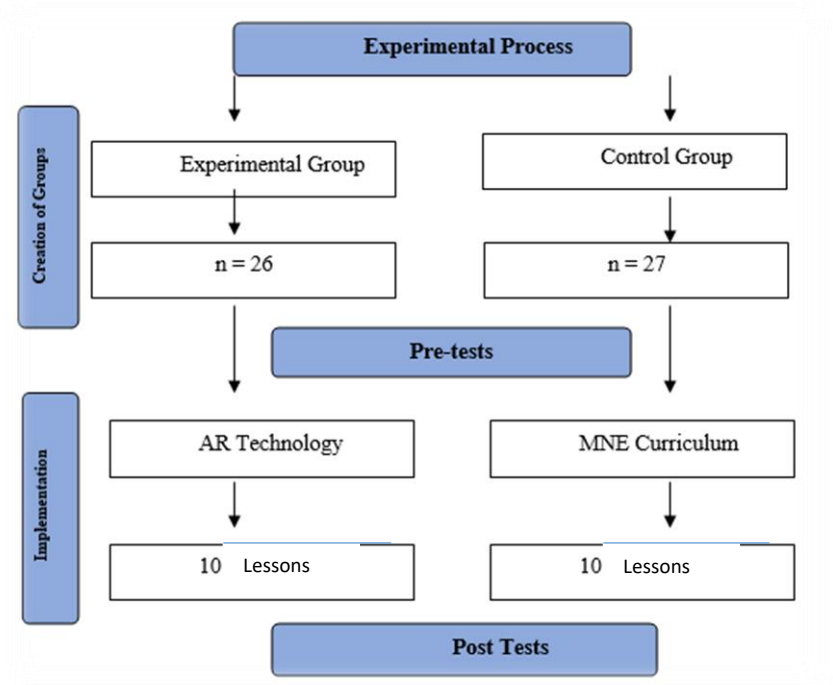

Figure 1. Experimental Process of the Research

1.2. Participants

Participants in the research were chosen by a convenience sampling method. The convenience sampling method: time, cost of transportation Etc. is used in selecting an easily accessible sample by considering the variables (Mcmillan & Schumacher, 2011). Since the research was carried out at a school close to the researcher's place of work, the sample was determined with this sampling. The participant group in which the research was conducted in the students attending the 5/A and 5/B branches of a public school. The research sample consisted of 53 participants. Of these participants, 26 students formed the experimental group, while 27 formed the control group. While 12 students of the experimental group are girls, 14 students are boys. Finally, among the participants in the control group, 13 students were girls, and 14 were boys. Students demonstrating their participation in the research are in the 10-11 age group.

1.3. Data collection tool

In the scope of the research, the scale presented to the literature with the research conducted by Uzun and Sağlam (2006) was used for data collection. The scale, whose response time was determined as one lesson hour, was applied to students who expressed participants within the scope of the research as a pre and post-test before and behind the interventions. Information about the scale is given below.

The scale can be used as two separate scales as "Environmental Behavior Scale" and "Environmental Thinking" scale..	Environmental Behavior Sub-Scale consists of three sub-factors as "Environmental Concern", "Environmental Sensitivity" and "Environmental Consciousness".	Environmental Thinking Sub-Scale consists of "Environmental View", "Environmental Pollution" and "Environmental Problems" factors.	The Environmental Attitude Scale is a 5-point Likert scale. It consists of 27 items. The Cronbach's alpha reliability coefficient of the scale is 0.80.	The cronbach alpha reliability coefficient of the Environmental Behavior Sub-Scale is =0.88. The scale consists of 13 items.	Cronbach alpha of the Environmental Thinking Subscale reliability coefficient = 0.80. The scale consists of 14 items.

Figure 2. Information on the Environmental Attitude Scale

1.4. Augmented Reality Technology Used in the Study

Within the scope of the research, the AR application developed on biodiversity was used. In the AR application, there are some living things in our environment and those that are extinct or in danger of extinction. The application includes information about animals and 3D models. Figure 3 shows the visuals of the application.

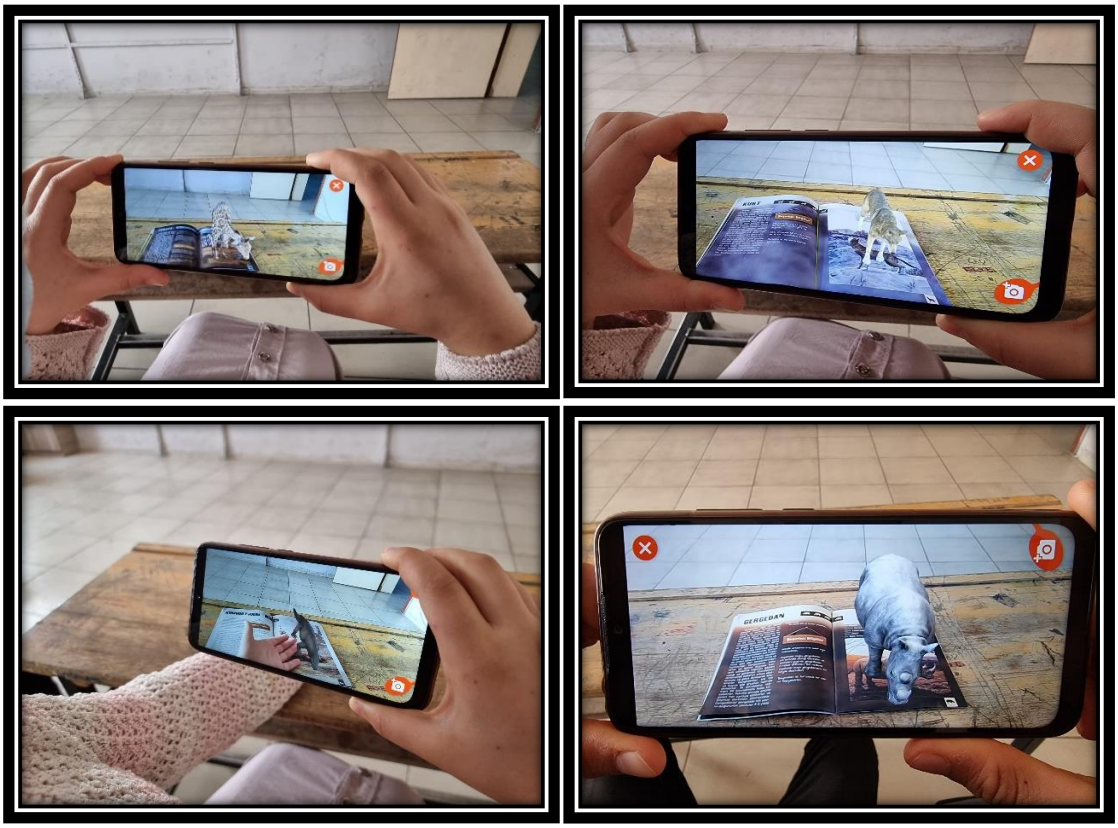

Figure 3. Some Images of the AR Technology

1.5. Data analysis

Investigation of the data acquired in line with the research carried out was completed using the program SPSS 22. For the analysis processes of the data collected in the context of the research carried out, MANOVA was used to compare the environmental attitude, environmental behavior, and environmental thinking, pre-post test scores of the control and experimental groups, while it was used to decide whether there was a relationship between the environmental attitude, environmental behavior, and environmental thinking post-test scores of the control, and experimental groups, correlation analysis was used. MANOVA (sample size, normality, extreme values, linearity, regression homogeneity, multicollinearity and uniqueness, homogeneity of variance-covariance matrices) and correlation (level of measure, normality, related pairs, linearity, independence of observations, covariance, loss) of the data obtained from the research The condition of meeting the assumptions required for the data) analysis was examined, and it was determined that the observed values met all the necessary conditions for both analyzes.

1.6. Reliability and validity

According to McMillan and Schumaher (2010), for the validity and reliability of the research, data were collected with a measurement tool with valid and reliable values. The obtained data were analyzed with appropriate data analysis methods, and the assumptions of the analyzes were tested. The technique and process of the research are clearly stated. In the study, the lessons in the experimental and control groups were conducted by the researcher.

2. Findings

2.1. Is the experimental group using AR technology statistically more important than the control group in terms of environmental thought, behavior, and attitude? Findings of the sub-problem.

MANOVA was conducted to investigate the difference between the practices in the control and experimental groups regarding environmental thinking, environmental behavior, and attitude toward the environment. Three dependent variables were included in the analysis. These are environmental behavior, environmental thinking, and attitude toward the environment. Before MANOVA was performed, preliminary analyzes were carried out to check the assumptions of linearity, normality, multicollinearity, univariate and multivariate outliers, and homogeneity of variance-covariance matrices. Moreover, no violations were detected. After the necessary steps for the analysis were completed, descriptive statistics of the findings obtained from the research were calculated with the MANOVA process. Descriptive statistics of the findings obtained from the research are presented in Table 1.

		Group	**M**	**SD**	**n**
Pre-tests	Behavior	Experiment	35.88	8.29	26
		Control	37.74	6.17	27
	Thinking	Experiment	50.42	10.23	26
		Control	48.96	8.06	27
	Attitude	Experiment	86.31	10.77	26
		Control	86.70	9.26	27
Post-tests	Behavior	Experiment	49.35	4.77	26
		Control	39.33	5.97	27
	Thinking	Experiment	62.04	5.12	26
		Control	49.93	7.50	27
	Attitude	Experiment	111.38	5.46	26
		Control	89.26	9.17	27

Table 1. Descriptive Statistics of the First Sub-Problem

When Table 1 is examined, in terms of pre-test scores, the experimental group's behavior score is (M=35.88, SD:8.29), the thinking score is (M:50.42, SD:10.23), and the attitude score is (M=86.31, SD=10.77); it is seen that the control group behavior score is (M=37.74, SD:6.17), the thinking score is (M=48.96, SD=8.06) and the attitude score is (M=86.70, SD=9.26). In terms of post-test scores, the experimental group behavior score is (M=49.35, SD=4.77), the thinking score is (M=62.04, SD=5.12), and the attitude score is (M=111.38, SD=5.46); it was seen that the control group behavior score is (M=39.33 SD=5.97), the thinking score is (M=49.93 SD=7.50), and the attitude score is (M=89.26, SD=9.17). When the average scores were examined, it was seen that the control group and experimental group averages were tight to each other in the pre-

tests in terms of all variables. In contrast, the experimental group scored higher in the post-test point averages.

Tests	Multiple Test	Value	F	p	R
Pre-test	Wilks' Lambda	.98	.47	.62	.01
Post-test	Wilks' Lambda	.30	55.83	.00*	.69

* It is significant at the p<0.5 level.

Table 2. Multiple Comparisons of MANOVA

When Table 2 is reviewed, it is understood that the results of the data acquired from the pre-tests of the dependent variables of the research, expressing the control and experimental group, are equivalent, and these values do not indicate statistical significance ($F_{(2.50)}$=.47, p=.623; Wilks' Lambda=.98; R=.019). It was examined that there was a significant difference between the groups in terms of post-tests in favor of the experimental group ($F_{(2.50)=}$55.83, p=.000; Wilks' Lambda=.309; R=.69). To determine which variables difference, which was found to be statistically significant among the groups in terms of post-tests, was observed, the effects between groups were examined. The findings showing the intergroup effects of MANOVA are presented in Table 3.

Tests	Dependent Variables	Mean Squares	df	F	p	R	R (Adjusted)
Pre-test	Behavior	45,633	1	.861	.358	.017	-.003
	Thinking	28,238	1	.335	.565	.007	-.013
	Attitude	2,077	1	.021	.886	.000	-.019
Post-test	Behavior	1327,927	1	45.213	.000*	.470	.460
	Thinking	1943,262	1	46.774	.000*	.478	.468
	Attitude	6483,982	1	112.810	.000*	.689	.683

*It is significant at the p<0.5 level.

Table 3. Between Groups Effects of MANOVA

When Table 3 is examined, it is understood that the results of the data acquired from the pre-tests of the dependent variables of the research, expressing the control and experimental group, are equivalent, and these values do not indicate statistical significance. A difference that can be expressed as statistically significant was found between the control and experimental groups in terms of post-tests for combined dependent variables. When the results obtained for the dependent variables are evaluated separately, when the statistical significance values are examined using a Bonferroni adjusted alpha level of .017, it is found that the difference is $F_{(1, 52)}$=46.77, p=.00, R=.478 in favor of the experimental group. In terms of environmental behavior, $F_{(1.52)}$=45.21, p=.00, R=.470, the difference was in favor of the experimental group. In terms of attitude toward

the environment, it is seen that the difference is in favor of the experimental group as $F_{(1.52)}$=112.81, p=.00, R=.689. When we look at the eta square (R) values, it is seen that they are at a high level of influence compared to Cohen (2013).

2.2. How is the relationship between AR technology use and environmental attitudes, thinking, and behavior variables affected? Findings of the sub-problem.

The level of relationship between environmental thinking, environmental behavior, and environmental attitude variables was examined with Pearson product-moment correlation coefficient. Normality, linearity, and covariance assumptions were checked by preliminary analysis. The findings from the correlation analysis are presented in Table 4.

				Behavior	**Thinking**	**Attitude**
Pre-test	**Experimental**	**Behavior**	r	1	-.339	.449*
			p		.091	.022
		Thinking	r	-.339	1	.689**
			p	.091		.000
		Attitude	r	.449*	.689**	1
			p	.022	.000	
	Control	**Behavior**	r	1	-.172	.515**
			p		.392	.006
		Thinking	r	-,172	1	,756**
			p	.392		.000
		Attitude	r	.515**	.756**	1
			p	.006	.000	
Post-test	**Experimental**	**Behavior**	r	1	-.392*	.507**
			p		,048	,008
		Thinking	r	-.392*	1	.595**
			p	.048		.001
		Attitude	r	.507**	.595**	1
			p	.008	.001	
	Control	**Behavior**	r	1	-.089	.579**
			p		.660	.002
		Thinking	r	-.089	1	.761**
			p	.660		.000
		Attitude	r	.579**	.761**	1
			p	.002	.000	

* Correlation is significant at the 0.05 level.

** Correlation is significant at the 0.01 level.

Table 4. Pearson Moments Correlation between Group and Variables

According to Cohen (2013), r=.10-.29 is little, r=.30.-.49 is medium, and r=.50-.1.0 shows a considerable relationship strength. In the study, comparisons were made according to these values. When the pre-tests were examined in line with the findings in Table 4, it was understood that there was a positive and significant relationship between the attitude variable and the thinking or behavior variables for both groups. These values were r=.45, n=26, p<.05 for the experimental group attitude-behavior correlation, while r=.51, n=27, p<.01 in the control group. The correlation between attitude and thinking was determined to be r=.68, n=26, p<.01 in the experimental group, and r=.75, n=27, p<.01 in the control group. According to these results, a high level of environmental thinking and behavior is associated with a high environmental attitude. While the findings in Table 4 showed no significant relationship between the thinking and behavior variables in the experimental and control groups in terms of pre-tests, it was understood that these values had a negative correlation. When the correlation between the thinking and behavior variables of the experimental group was examined in the pre-tests, it was understood that r=-.33, n=27. In contrast, the correlation value between the thinking-behavior of the control group was r=-.17, n=27. When the post-tests were examined, it was determined that both groups had a positive and significant relationship between the attitude variable and the thinking or behavior variables. These values were r=.50, n=26, p<.01 for the experimental group attitude-behavior correlation, while r=.57, n=27, p<.01 in the control group. The correlation between attitude and thinking was determined to be r=.59, n=26, p<.01 in the experimental group, and r=.76, n=27, p<.01 in the control group. These results are associated with a high level of environmental behavior, environmental thinking, and environmental attitude. When Table 4 continued to be examined, it was determined that there was a negative relationship between thinking and behavior variables in the experimental group regarding post-tests. Still, it was understood that this relationship was between significant values and had a moderate level (r=-.39, n=26, p<.01) . This situation is associated with a high level of environmental behavior and a low level of environmental thinking. In the control group, it was determined that the relationship was negative but not at a significant level (r=-.08, n=27). In addition, the coefficient of determination was calculated to determine how much variance the variables shared. The r-value is squared and transformed into a percentage to calculate a coefficient of determination (Pallant, 2017). Accordingly, when the experimental group's post-tests were examined, it was determined that environmental behavior and environmental thinking shared a 15.21% variance. These values showed that behavior, and thinking variables overlapped. It showed that thinking and behavior had a moderate level of overlap. Pallant (2017) has a rate below 25% in many studies in social sciences. Therefore, although the variance sharing between thinking and behavior variables is not significant, the variance sharing between them is at an acceptable level compared to studies in the area of social sciences.

Conclusion and Discussion

In the study carried out to scrutinize the effect of AR technology on the development of thinking, behavior, and attitude towards the environment in science education and the relations of these variables with each other, the first control and experimental groups were compared in terms of

their environmental thinking, environmental behavior and attitude towards the environment variables. The research is limited to the 5th- grade biodiversity topic and 10 lesson hours. In the study, it was assumed that the students answered the scales sincerely. In the study, in which the groups were identical in terms of pre-tests when the post-tests were examined, it was determined that the experimental group had more statistically significant results than the control group. In line with the results obtained from the study, it was seen that the use of AR technology is effective in changing environmental thinking, environmental behavior, and attitude towards the environment. The fact that AR technology develops positive thinking towards the environment can be clarified because AR technology demonstrates situations that cannot be shown in the classroom environment, and the participants examine the concepts interactively. The use of interactive teaching materials in the classroom positively affects the development of environmental thinking compared to traditional education (Kost & Peabody, 2021). The fact that AR technology enables positive environmental behavior can be clarified by the fact that AR technology is effective in behaviors. AR technology in educational environments positively affects behavior change (Babur, 2016). The positive attitude of AR technology toward the environment can be clarified by the fact that AR technology provides students with a positive attitude toward AR technology and offers an exciting learning experience. Many studies have shown that participants develop positive attitudes toward AR technology (Atalay & Akgün, 2020; Küçük et al., 2014). A positive attitude towards the practice may have affected a positive attitude toward the environment. In many studies, AR technology provides an engaging learning environment (Arıcı et al., 2021; Majid & Aini, 2013; Tatzgern et al., 2015) and provides a positive attitude toward the course and subject in which AR is used (Atalay & Akgün, 2020; Küçük et al., 2014; Yetişir, 2019). Since this study was conducted on the environment, it can be stated that the participants had exciting learning experiences on the subject, and their positive attitudes toward the environment were supported.

Another result of the study is a positive and statistically significant relationship between environmental behavior and environmental attitude, environmental thinking, and environmental attitude variables in the experimental and control groups in the pre-and post-tests. The results obtained from the study showed that the environmental attitude variable has a common variance with the environmental behavior and environmental thinking variables. These results indicated that having a positive attitude toward the environment will lead to a positive thinking toward the environment. In addition, the results showed that having a positive attitude toward the environment supports exhibiting positive behavior toward the environment. However, according to the results of the research, it has been revealed that having positive thinking toward the environment does not support exhibiting positive behavior toward the environment. Although there is a negative relationship between environmental behavior and environmental thinking scores in the control and experimental group pre-and post-tests, this relationship is significant and moderate only in the experimental group post-test. The rate of sharing the common variances of this critical relationship is also at an intermediate level. These results can be interpreted as always being in a positive mindset will not lead to positive behavior. The use of AR technology can explain this difference. It can be said that AR technology has supported the participants' awareness of the inconsistency of their thinkings with their behaviors. The relationship between thinking and behavior in the control group was not significant. Despite this, the fact that there is a negative relationship in the control group, but this relationship is not substantial, can be explained by the fact that the participants stated statements that would get approval instead of expressing honest thinking. In this respect, it can be said that AR technology supports revealing the participants'

natural behaviors and beliefs instead of the expressions accepted by society. In the studies in the literature, the debate continues in studies about the effect of environmental review on environmental behavior, while some researchers reported that ideas turn into behavior (Roubal, 2022; Smolova, 2019; Ucisik Erbilen, 2013; Zhang & Xiao 2023), while some researchers reported that environmental review does not turn into environmental behavior (Roubal, 2022; Smolova, 2019; Ucisik Erbilen, 2013). Kollmuss and Agyeman, 2002). This situation confirms the results obtained from the research. Although both variables have a positive relationship, this situation is still open to discussion. In addition, it can be said that some other variables that affect environmental behavior are also effective in this situation. For example, Kollmuss and Agyeman (2002) stated that ecological behavior is too complex to be visualized through a single frame or diagram. They said that there are demographic factors, economic factors, social, knowledge, awareness, values, attitudes, and responsibilities. They also stated that developing a model to explain all these and more is impossible. In order to improve this situation, students can be supported to exhibit positive behaviors towards the environment by using various techniques that affect the development of thinking in science classes (Yılmaz et al., 2017).

The study was conducted to examine the effects of AR technology on the development of thinking, behavior, and attitude toward the environment in science education. The relationships between these variables are limited to the 5th grade science course and biodiversity. In addition, the research carried out is limited to 10-course hours, and the effectiveness of the AR application users can also be expressed as a limitation. Finally, the following recommendations are presented in line with the outcomes obtained from the study.

- The use of AR technology in the subject of biodiversity in the 5th-grade science course supports the environmental thinking and environmental behaviors of the students. Also, it has a positive effect on their environmental attitudes. For this reason, it is recommended to use AR technology for students to gain these variables.
- In the use of AR technology, it should be ensured that every one of the students actively experiences this experience.
- Necessary preliminary information should be provided for students experiencing AR for the first time to obtain high efficiency from using the application.
- In future studies, scale development studies that include as many variables as possible can be carried out to create more comprehensive models to measure what affects environmental behavior.
- In future studies, environmental attitudes will be analyzed by variables such as demographic, economic, social, Etc. It can be investigated in terms of how it affects environmental thinking and behavior.
- For the efficient use of the application, attention should be paid to the controls of the tablets (Charging, software and camera updates, etc.).
- Students should be informed about the objectives of the course and they should be made aware that AR technology is used for educational purposes.

References

Allen, J. B., & Ferrand, J. L. (1999). Environmental locus of control, sympathy, and pro-environmental behavior: A test of Geller's actively caring hypothesis. *Environment and Behavior*, *31*(3), 338-353.

Arici, F., Yildirim, P., Caliklar, Ş., & Yilmaz, R. M. (2019). Research trends in using augmented reality in science education: Content and bibliometric mapping analysis. *Computers & Education*, *142*, 103647.

Arici, F., Yilmaz, R. M., & Yilmaz, M. (2021). Affordances of augmented reality technology for science education: Views of secondary school students and science teachers. *Human Behavior and Emerging Technologies*, *3*(5), 1153-1171.

Atalay, E., & Akgün, F. (2020). Investigation of High School Students' Attitudes towards the Use of Augmented Reality Applications in Biology Teaching. *Journal of Erzincan University Faculty of Education*, *22*(3), 606-631.

Ajzen, I. (1987). Attitudes, traits, and actions: Dispositional prediction of behavior in personality and social psychology. In *Advances in experimental social psychology*, 20(1), 1-63. Academic Press.

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and Predicting Social Behavior*. Englewood Cliffs, New Jersey: Prentiss-Hall.

Azuma, R. T. (1997). A survey of augmented reality. *Presence: teleoperators & virtual environments*, *6*(4), 355-385.

Babur, A. (2016). *The effect of augmented reality, simulation and real object use on learning achievements, motivations and psychomotor performances* (Unpublished doctoral dissertation). Sakarya University, Sakarya.

Batres Quevedo, J. A. (2020). Environmental Education in the Place of Interest and with the Participation of the People Involved. *Letras Verdes, Revista Latinoamericana de Estudios Socioambientales*, (28), 106-124.

Boley, B. B., McGehee, N. G., & Hammett, A. T. (2017). Importance-performance analysis (IPA) of sustainable tourism initiatives: The resident perspective. *Tourism Management*, *58*, 66-77.

Candrea, A. N., & Hertanu, A. (2015). Developing ecotourism destinations in Romania. A case study approach. *Bulletin of the Transilvania University of Brasov. Economic Sciences. Series V*, *8*(2), 163.

Catal, C., Akbulut, A., Tunali, B., Ulug, E., & Ozturk, E. (2020). Evaluation of augmented reality technology for the design of an evacuation training game. *Virtual Reality*, *24*(3), 359-368.

Chang, C. S., Chen, T. S., & Hsu, W. H. (2011). The study on integrating WebQuest with mobile learning for environmental education. *Computers & Education*, *57*(1), 1228-1239.

Chen, H. R., & Huang, M. J. (2009, March). The effect of blended learning model for elementary school environmental education. In *2009 First International Workshop on Education Technology and Computer Science* (Vol. 3, pp. 96-100). IEEE.

Cheng, K. H., & Tsai, C. C. (2013). Affordances of augmented reality in science learning: Suggestions for future research. *Journal of science education and technology*, *22*(4), 449-462.

Choudhary, M. P., Chauhan, G. S., & Kushwah, Y. K. (2015, February). Environmental degradation: causes, impacts and mitigation. *In National seminar on recent advancements in protection of environment and its management issues* (NSRAPEM-2015).

Chuang Y, Xie X, Liu C (2016) Interdependent orientations increase pro-environmental preferences when facing self-interest conflicts: The mediating role of self-control. *Journal of Environmental Psychology*, 46: 96-105.

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Routledge.

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Çetin, S. (2019). *The effect of augmented reality applications on the academic achievement, attitudes and spatial visualization skills of secondary school students in the technical drawing course* (Master's thesis, Bursa Uludağ University).

Diekmann, A., & Franzen, A. (1999). The wealth of nations and environmental concern. *Environment and behavior*, *31*(4), 540-549.

Do Paco, A., & Raposo, M. (2009). "Green" segmentation: an application to the Portuguese consumer market. *Marketing Intelligence & Planning*.

Echeverría, A., Améstica, M., Gil, F., Nussbaum, M., Barrios, E., & Leclerc, S. (2012). Exploring different technological platforms for supporting co-located collaborative games in the classroom. *Computers in Human Behavior*, *28*(4), 1170-1177.

Ernst, J., & Theimer, S. (2011). Evaluating the effects of environmental education programming on connectedness to nature. *Environmental Education Research*, *17*(5), 577-598.

Ferrer-Balas, D., Lozano, R., Huisingh, D., Buckland, H., Ysern, P., & Zilahy, G. (2010). Going beyond the rhetoric: system-wide changes in universities for sustainable societies. *Journal of Cleaner Production*, *18*(7), 607-610.

Furht, B. (Ed.). (2011). *Handbook of augmented reality*. Springer Science & Business Media.

Gao, Y. (2018). To study the relationship between environmental education and environmental behavior based on environmental attitude. *Ekoloji*, *27*(106), 627-634.

Gausemeier, J., Berssenbrügge, J., Grafe, M., Kahl, S., & Wassmann, H. (2011). Design and VR/AR-based testing of advanced mechatronic systems. In *Virtual Reality & Augmented Reality in Industry* (pp. 1-37). Springer, Berlin, Heidelberg.

Gifford, R., & Sussman, R. (2012). Environmental attitudes. In S. D. Clayton (Ed.), *The Oxford handbook of environmental and conservation psychology* (pp. 65–80). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199733026.013.0004

Heimlich, J. E., & Ardoin, N. M. (2008). Understanding behavior to understand behavior change: A literature review. *Environmental education research*, *14*(3), 215-237.

Hsu, J.L. and Feng, C.-H. (2019), "Evaluating environmental behaviour of the general public in Taiwan: Implications for environmental education", *International Journal of Comparative Education and Development*, 21(3), 179-189. https://doi.org/10.1108/IJCED-11-2018-0049

Huang, T. C., Chen, M. Y., & Hsu, W. P. (2019). Do learning styles matter? Motivating learners in an augmented geopark. *Journal of Educational Technology & Society*, *22*(1), 70-81.

Huh, J. R., Park, I. J., Sunwoo, Y., Choi, H. J., & Bhang, K. J. (2020). Augmented Reality (AR)-Based Intervention to Enhance Awareness of Fine Dust in Sustainable Environments. *Sustainability*, *12*(23), 9874. http://dx.doi.org/10.3390/su12239874

Idajati, H., Pamungkas, A., & Kukinul, S. V. (2016). The level of participation in Mangrove ecotourism development, Wonorejo Surabaya. *Procedia-Social and Behavioral Sciences*, *227*, 515-520.

Jeong, Y., Kim, H. J., & Nam, T. J. (2018, April). Mechanism perfboard: An augmented reality environment for linkage mechanism design and fabrication. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (pp. 1-11).

Johnson, B., & Manoli, C. C. (2010). The 2-MEV scale in the United States: a measure of children's environmental attitudes based on the theory of ecological attitude. *The Journal of Environmental Education*, *42*(2), 84-97.

Jormanainen, I., Toivonen, T., & Nivalainen, V. (2018). A smart learning environment for environmental education. In *Challenges and Solutions in Smart Learning* (pp. 13-16). Springer, Singapore.

Kim, H. T., Kim, J. G., & Kim, C. (2018). Emotional intimacy with nature and life & intellectual interest in life of pre-service biology teachers for environmental education. *Journal of Biological Education*, *52*(3), 236-247.

Kollmuss, A., & Agyeman, J. (2002). Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior?. *Environmental education research*, *8*(3), 239-260.

Kost, K., & Peabody, S. (2021). Environment and Engagement in German Studies: Projects and Resources for Critical Environmental Thinking. *Die Unterrichtspraxis/Teaching German*, *54*(2), 245-256.

Küçük, S., Yilmaz, R., Baydas, Ö., & Göktas, Y. (2014). Augmented reality applications attitude scale in secondary schools: Validity and reliability study. *Egitim ve Bilim*, *39*(176).

Lu, A. C. C., Gursoy, D., & Del Chiappa, G. (2016). The influence of materialism on ecotourism attitudes and behaviors. *Journal of Travel Research*, *55*(2), 176-189.

Liu CH, Huang YC (2016) A natural capital model of influences for ecotourism intentions and the buffering effects of emotional values. *Journal of Travel & Tourism Marketing*, 1-16.

Majid, A., & Aini, N. (2013, November). Application of Mobile Augmented Reality in a Computer Science Course. In *International Visual Informatics Conference* (pp. 516-525). Springer, Cham.

Marcinkowski, T., & Reid, A. (2019). Reviews of research on the attitude–behavior relationship and their implications for future environmental education research. *Environmental Education Research*, *25*(4), 459-471.

Masud, M. M., Aldakhil, A. M., Nassani, A. A., & Azam, M. N. (2017). Community-based ecotourism management for sustainable development of marine protected areas in Malaysia. *Ocean & Coastal Management*, *136*, 104-112.

McMillan, J. H., & Schumacher, S. (2010). Research in Education: Evidence-Based Inquiry, MyEducationLab Series. *Pearson*.

Michalos, A. C., Creech, H., Swayze, N., Maurine Kahlke, P., Buckler, C., & Rempel, K. (2012). Measuring knowledge, attitudes and behaviours concerning sustainable development among tenth grade students in Manitoba. *Social indicators research*, *106*(2), 213-238.

Milgram, P., & Kishino, F. (1994). A taxonomy of mixed reality visual displays. *IEICE Transactıons on Information and Systems*, *77*(12), 1321-1329.

Norberg, P. A., Horne, D. R., & Horne, D. A. (2007). The privacy paradox: Personal information disclosure intentions versus behaviors. *Journal of consumer affairs*, *41*(1), 100-126.

Olsson, T., Jakkila, J., Veijalainen, N., Backman, L., Kaurola, J., & Vehviläinen, B. (2015). Impacts of climate change on temperature, precipitation and hydrology in Finland–studies using bias corrected Regional Climate Model data. *Hydrology and Earth System Sciences*, *19*(7), 3217-3238.

Pallant, J. (2017). *SPSS User Guide, Step by Step Data Analysis with SPSS*. Translated by: Balci S, Ahi B.

Putz-Egger, L. M., Beil, D., Dopler, S., & Diephuis, J. (2022). Combining Gamification and Augmented Reality to Raise Interest in Logistics Careers. *Applied Sciences*, *12*(18), 9066.

Rodríguez, C., Sevilla, J., Obeso, Í., & Herrera, D. (2022). Emerging Tools for the Interpretation of Glacial and Periglacial Landscapes with Geomorphological Interest—A Case Study Using Augmented Reality in the Mountain Pass of San Isidro (Cantabrian Range, Northwestern Spain). *Land*, *11*(8), 1327.

Rossi, M., D'Avenio, G., Morelli, S., & Grigioni, M. (2020, June). Augmented reality app to improve quality of life of people with cognitive and sensory disabilities. In *2020 IEEE International Workshop on Metrology for Industry 4.0 & IoT* (pp. 59-62). IEEE.

Roubal, O. (2022). The ethıcal consumer and the relıgıous nature of envıronmental thınkıng. *European Journal of Science and Theology*, *18*(1), 113-124.

Semprebon, E., Mantovani, D., Demczuk, R., Maior, C. S., & Vilasanti, V. (2018). Green consumption: a network analysis in marketing. *Marketing Intelligence & Planning*, 37(1), 18-32.

Schultz DE, Schultz H, (2016). *IMC-The Next Generation.* New York: McGraw-Hill Education.

Smolova, L. (2019). Types of thinking and their value for ecological education. *Psychology. Journal of Higher School of Economics*, *16*(1), 50-66.

Sini M, Peter T, Caroline S (2015) Estimating indigenous cultural values of freshwater: A choice experiment approach to Māori values in New Zealand. *Ecological Economics*, 118: 207–214

Sırakaya, M., & Sırakaya, D. A. (2018). Artırılmış gerçekliğin fen eğitiminde kullanımının tutum ve motivasyona etkisi. *Kastamonu Eğitim Dergisi*, *26*(3), 887-905.

Straughan, R. D., & Roberts, J. A. (1999). Environmental segmentation alternatives: a look at green consumer behavior in the new millennium. *Journal of consumer marketing*.

Sun, C., Fang, Y., Kong, M., Chen, X., & Liu, Y. (2022). Influence of augmented reality product display on consumers' product attitudes: A product uncertainty reduction perspective. *Journal of Retailing and Consumer Services*, *64*, 102828.

Tatzgern, M., Grasset, R., Veas, E., Kalkofen, D., Seichter, H., & Schmalstieg, D. (2015). Exploring actual world points of interest: Design and evaluation of object-centric exploration techniques for augmented reality. *Pervasive and mobile computing*, *18*, 55-70.

Ucisik Erbilen, S. (2013). The participation in ecological activities and its influence on high school pupils' attitude towards the environment: Famagusta case. *Eurasian Journal of Educational Research*, (53/A), 107-118.

Uzun, N., & Sağlam, N. (2006). Orta öğretim öğrencileri için çevresel tutum ölçeği geliştirme ve geçerliliği. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *30*(30), 240-250.

Vergara, D., Extremera, J., Rubio, M. P., & Dávila, L. P. (2019). Meaningful learning through virtual reality learning environments: A case study in materials engineering. *Applied Sciences*, *9*(21), 4625.

Wang, W. C. (2015). Visitor perception, interpretation needs, and satisfaction of eco-tourism: the case of Taijiang National Park, Taiwan. *Enlightening Tourism. A Pathmaking Journal*, *5*(2), 180-200.

Yayla, Ö., Keskin, E., & Keles, H. (2022). The relationship between environmental sensitivity, ecological attitude, and the ecological product purchasing behaviour of tourists. *European Journal of Tourism, Hospitality and Recreation*, *12*(1), 31-45.

Yetişir, H. (2019). *The effect of augmented reality applications with mobile devices on students' academic achievement, attitude and persistence* (Master's thesis, Niğde Ömer Halisdemir University/Institute of Educational Sciences).

Yılmaz, M., Arıcı, F., & Dilber, R. (2017). Altı Şapkalı düşünme tekniğinin 7. sınıf öğrencilerinin akademik başarılarına etkisi. *Researcher: Social Science Studies*, *5*(8), 128-139.

Yılmaz, R. M., & Göktaş, Y. (2018). Using augmented reality technology in education. *Cukurova University Faculty of Education Journal*, *47*(2), 510-537.

Zhang, W., & Xiao, H. Z. (2023). Ecological discourse as a new indicator for improving individual ecological behaviour in environmental protection: an ecolinguistic continuum perspective. *Environment, Development and Sustainability*, 1-19.

Zheng, W. L., Wang, J. W., & Zhang, X. (2018). Effects of environmental cognition and environmental attitude on environmental behavior of ecotourism. *Ekoloji*, *27*(106), 1743-1749.

Zhu, W., Owen, C. B., Li, H., & Lee, J. H. (2004). Personalized in-store e-commerce with the promopad: an augmented reality shopping assistant. *Electronic Journal for E-commerce Tools and Applications*, *1*(3), 1-19.

Çatışma beyanı

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