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The Effects of Augmented Reality in a 7th-Grade Science Lesson on Students' Academic Achievement and Motivation

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ABSTRACT This study examines the effects of a seventh-grade science course supported by augmented reality technologies on students' academic achievement on elements and compounds, their motivation towards the science course, and their motivation toward the augmented reality materials used. The study was conducted with the quasi-experimental design of the quantitative research method. The research sample consists of 50 seventh-grade students, 25 in the experimental group and 25 in the control group, studying in a public school. As data collection tools, academic achievement tests, motivation scale for learning science, and motivation scale for the materials used were utilized. In addition, the collected data were analyzed with the SPSS 24.0 program. As a consequence of the research, it was discovered that augmented reality technologies boosted students' academic success and motivation toward science learning ($p<0.001$). In addition, students' motivation toward augmented reality materials was also found to be high.

Keywords Augmented-Reality, Science and Technology, Science Class, Elements and Compounds

1. INTRODUCTION

Nowadays, technological developments affect the field of education and all areas of life. The use of technology in education provides students with visual and auditory rich learning environments and easy access to information. It has been presented that using technology in educational environments increases students' academic success, provides student-centered education, and is effective in attracting attention (Guntur, Setyaningrum, Retnawati, & Marsigit, 2020; Sumadio & Rambli, 2010). This rapid development of technology requires constant renewal and updating of the materials used in education. Properly organized educational environments offer content-rich learning experiences and the opportunity to make sense of information correctly (Yaşar, 1998). It is acknowledged that the current education programs in Turkey are insufficient to meet the expectations of the students and that our education system must keep up with the developing technological process, which has become a necessity (Somyürek, 2014). In this context, it has been demonstrated by studies that the appliance of augmented reality technology in education, which dates back to the 1950s and has been increasingly used in recent years, is a technology that gives positive results (Di Serio, Ibáñez, & Kloos, 2013; Kerawalla, Luckin, Seljeflot, & Woolard, 2006; Osadchyi, Valko, & Kuzmich, 2021; Van Krevelen & Poelman, 2010). The definition of augmented reality was first made by Azuma (1997). It is the simultaneous and three-dimensional visualization of virtual objects in natural environments. If the reality is high in the environment used, it can be defined as augmented reality, and if the virtuality is high, it can be defined as augmented virtuality (Milgram & Kishino, 1994).

The results of studies using augmented reality technologies encourage using these technologies in educational environments (Roopa, Prabha, & Senthil, 2021). The fact that AR technologies appeal to more than one sense organ of students and create reality is seen as an opportunity to create enriched educational environments that are important for students (Lai & Hsu, 2011; Luckin & Fraser, 2011). While the use of AR technologies in developed countries started in the 20th century, this technology started to be used in Turkey, especially in the 21st century and gained popularity over these years. The first academic studies were also seen after the 2000s. However, in recent years, studies in the fields of "mathematics, chemistry, pre-school, astronomy, biology,

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language education, history, physics" have been encountered in education. When the literature was examined, the effects on different variables such as academic achievement, motivation, participation in the course, attracting attention, permanence, and misconception were examined, and it was seen that positive results were obtained (Abdüsselam & Karal, 2012; Ardito, Buono, Costabile, Lanzilotti, & Piccinno, 2009; Dunleavy, Dede, & Mitchell, 2009; Fleck, Hachet, & Bastien, 2015; Huang, Chen, & Chou, 2016; Matcha & Rambli, 2013; Perez-Lopez & Contero, 2013; Kaufmann & Schmalstieg, 2002; Şahin & Güler, 2021).

Changes and developments in technology are also effective in shaping educational environments. When the studies aiming to reveal the results of the use of AR technologies in educational environments are examined, it is seen that this technology gives positive results as it "increases students' success, makes learning fun, increases motivation, makes abstract concepts concrete, increases cooperation, can be used in teaching experiments that can be dangerous or small objects that are difficult to observe in the classroom, it allows the students to learn at his/her own pace and reduces misconceptions" (Chen & Wang, 2015; Övez, & Şeker, 2022; Durak & Karaoğlan Yılmaz, 2019; Fleck & Simon, 2013; Kızılca, 2019; Núñez et al., 2008; Squire & Klopfer, 2007; Tomi & Rambli, 2013; Wojciechowski & Cellary, 2013;).

In this century, which can be called the digital century, the roles of teachers and students are changing by gaining different dimensions 21st century children are born in an environment where technology is frequently used in every field in a world woven with virtual networks surrounding them. For this generation, called digital natives, not to get lost in the endless information stack on the internet, it is necessary to direct their efforts on how to use technology, reach accurate and reliable information and integrate the information they have learned into their daily life. In this context, teachers are expected to have high levels of interaction with students (Bilgiç, Duman, & Seferoğlu, 2011). From this point of view, it is necessary that the learning environments of the Z generation learners, who have awakened in the digital age, should not remain in the traditional structure (Somyürek, 2014). It is stated that technology will have a great place in education with the integration of developing technology into educational environments (Cuban, Kirkpatrick, & Peck, 2001). With the FATIH (Movement to Increase Opportunities and Improve Technology) project in Turkey, integrating technology into educational environments has started and has come a long way (MEB, 2019). The use of technology in education is accepted as an indicator of high quality and qualified education (Çakır & Yıldırım, 2009). In particular, the fact that there are many abstract concepts in science lessons and that secondary school students are still in the transition phase from the substantial period to the abstract period creates difficulties in learning these concepts (Kıncal & Yazgan-Akan, 2010). At this point, it is essential to integrate new technologies that can be used in teaching into the education system. Augmented reality technology, which has become widespread in almost every field in recent years, should also be used in educational environments, and its results should be presented. In this study, the effects of augmented reality technologies in education were tried to be revealed. In this study, the effect of a science course supported by AR applications on students' academic achievement, their motivation to learn science, and their motivation for the applications used was examined.

In relation to this, answers to the following questions were inquired:

(1) Is there a significant difference in the results obtained from the academic achievement scores of the experimental and control groups before and after the application?

(2) Has there been a change in the motivation of the experimental group students towards learning science before and after the application?

(3) What is the level of the experimental group students' attitudes towards AR applications?

(4) What is the motivation of the experimental group students towards the material used?

2. METHOD

2.1 Research Design

The research method is the quantitative research method, and the quasi-experimental design with a pretest-posttest control group was used as the research design. This design is defined as studies in which groups matched according to specific data are randomly assigned as experimental and control groups (Fraenkel, Wallen, & Hyun, 2012). In this study, while the lesson was taught with AR applications in the experimental group, the lesson was explained with traditional methods in the control group. The reason for choosing the quasi-experimental design is to reveal the effect of AR applications used in the experimental group.

2.2 Participants

The accessible universe of this study is seventh-grade students in a district of Kocaeli province and the sample is 50 seventh-grade students. It is difficult to apply to the population for various reasons, such as the difficulty of access, so a sample is created. While creating the sample, 10% of the accessible universe, ten times the number of items in the scale, or the number of samples obtained from G-power analysis are taken as a basis (Pallant, 2020). While the sample was being created, the convenience sampling method was chosen from the purposeful sampling methods. This is because of the lengthy application and data collection process, so students from the school where the researcher works were determined. While determining the sample, the two closest classes in which the same teacher attended the class and the average science course grades of the previous year were chosen.

2.3 Data Collecting Tools

The questions are taken from the achievement control tests prepared by the Ministry of National Education, Assessment, Evaluation, and Exam Services General Directorate and were used as an achievement test with the permission of the relevant authority and without making any changes. The scale created by Dede and Yaman (2008) was used as a motivation scale for learning science. The reliability coefficient of the whole scale was calculated as α = 0.80. Augmented Reality Applications Attitude Scale was developed by Küçük, Yılmaz, Baydaş, and Göktaş (2014). It consists of three factors: satisfaction with the scale, anxiety to use, and willingness to use. While the reliability

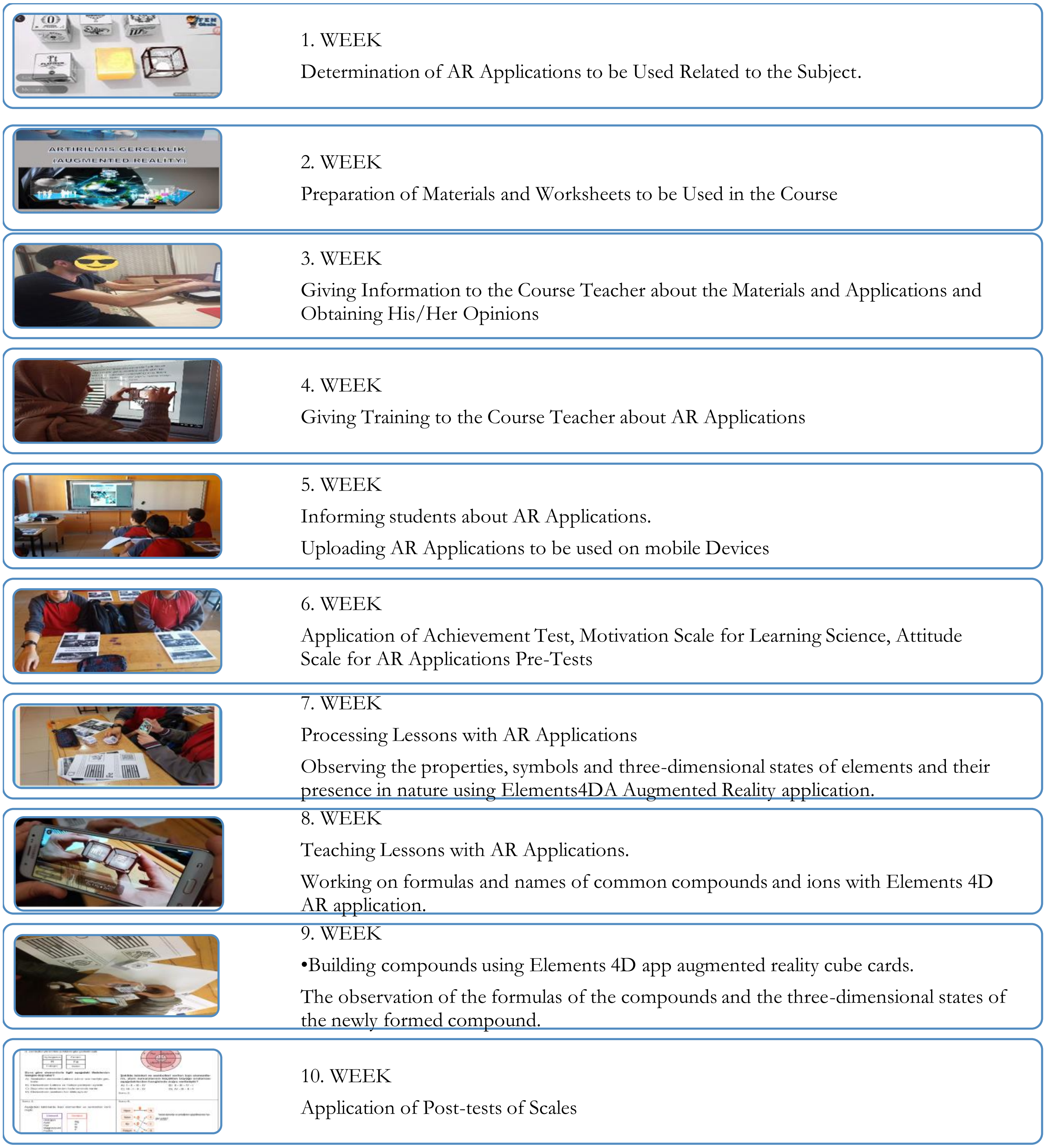

Figure 1 Application stages of the research

Table 1 Data collection tools

Data Collection Tools	Experimental Group	Control Group
Academic Achievement Test	✓	✓
Augmented Reality Applications Attitude Scale	✓	
For Learning Science Motivation Scale	✓	✓
Material Motivation Scale	✓	

Table 2 The tests used in the analysis of sub-problems

SUB- PROBLEM	İndependent Samples t-test	Paired Samples t-test	Mean/ Frequency/ Percent
Is there a significant difference in the results obtained from the academic achievement scores of the experimental and control groups?	✓		
Is there a statistically significant difference between the motivation of the experimental group of students towards learning science and their pre-test and post-test scores before and after the application?		✓	
What are the attitudes of the experimental group of students towards AR applications?			✓
What is the motivation of the experimental group students towards the materials used?			✓

coefficient of the whole scale was α = 0.84; 1st factor α = 0.86; 2nd factor α = 0.83; the third factor was obtained as α = 0.64. Instructional Materials Motivation Questionnaire The 'Teaching Materials Motivation Questionnaire' developed by Keller in 1987 was used, and this questionnaire was readjusted into Turkish by Kutu and Sözbilir (2011). The scale consists of two factors: "attention and compliance" and "confidence and satisfaction". The reliability coefficient of each factor was obtained as 0.79 and 0.69, respectively, and the Cronbach Alpha reliability coefficient of the entire scale was found to be 0.83. Data collection tools to be used in the research are given in Table 1.

In the research, the subject of "Elements and Compounds" in the seventh-grade science course curriculum was chosen. The application phases of the research cover ten weeks, as seen in Figure 1. The workbooks are specially designed for each student, and special codes that can be visualized and animated in three dimensions when scanned with mobile devices are placed to use in the application process. In addition, activities were made with AR applications. In the first lesson, the researcher informed students about AR Technologies, their applications, and the ways of acquiring them. Then, elements 4D, AR Science Cards, and HP Reveal (Old Aurasma application) applications were used as augmented reality applications.

2.4 Worksheet Preparation

A suitable lesson plan and an application brochure have been prepared for the AR application phase. In addition to the theoretical information on elements and compounds, the application cards of Elements 4D, an AR application, are placed in the prepared application brochure. In this way, it is designed so that students can observe the symbols and formulas of these elements and compounds while learning the theoretical information about them. AR Science Cards, on the other hand, were supplied ready-made and given to the students in a way that each student could use individually. In addition, the HP Reveal application, mostly used as video-based, smart boards and QR codes in the classroom enabled the whole class to watch. In Figure 2, a sample page from the brochure is presented.

During the application, the students performed activities in the school for an average of 120 minutes with the Element 4D application, 120 minutes with the AR Science Cards, and 160 minutes with the HP Reveal Application. In addition, owing to the activity booklets prepared separate from this period, the students had the opportunity to use these applications at home on their own. Also, this period took an average of three weeks.

2.5 Data Analysis

In research, data collected from pre-test and post-test achievement tests, the AR attitude scale, the Motivation Scale for Learning Science, and the Material Motivation Scales were entered into the SPSS 24.0 program. The data were coded appropriately for the analyzes to be made in the SPSS 24.0 program. For example, code 1 for females and code 2 for males were used in the gender variable. Different statistical tests were applied to analyze the data (Table 2). The main purpose of quantitative research is to generalize the results to the population. In this context, necessary

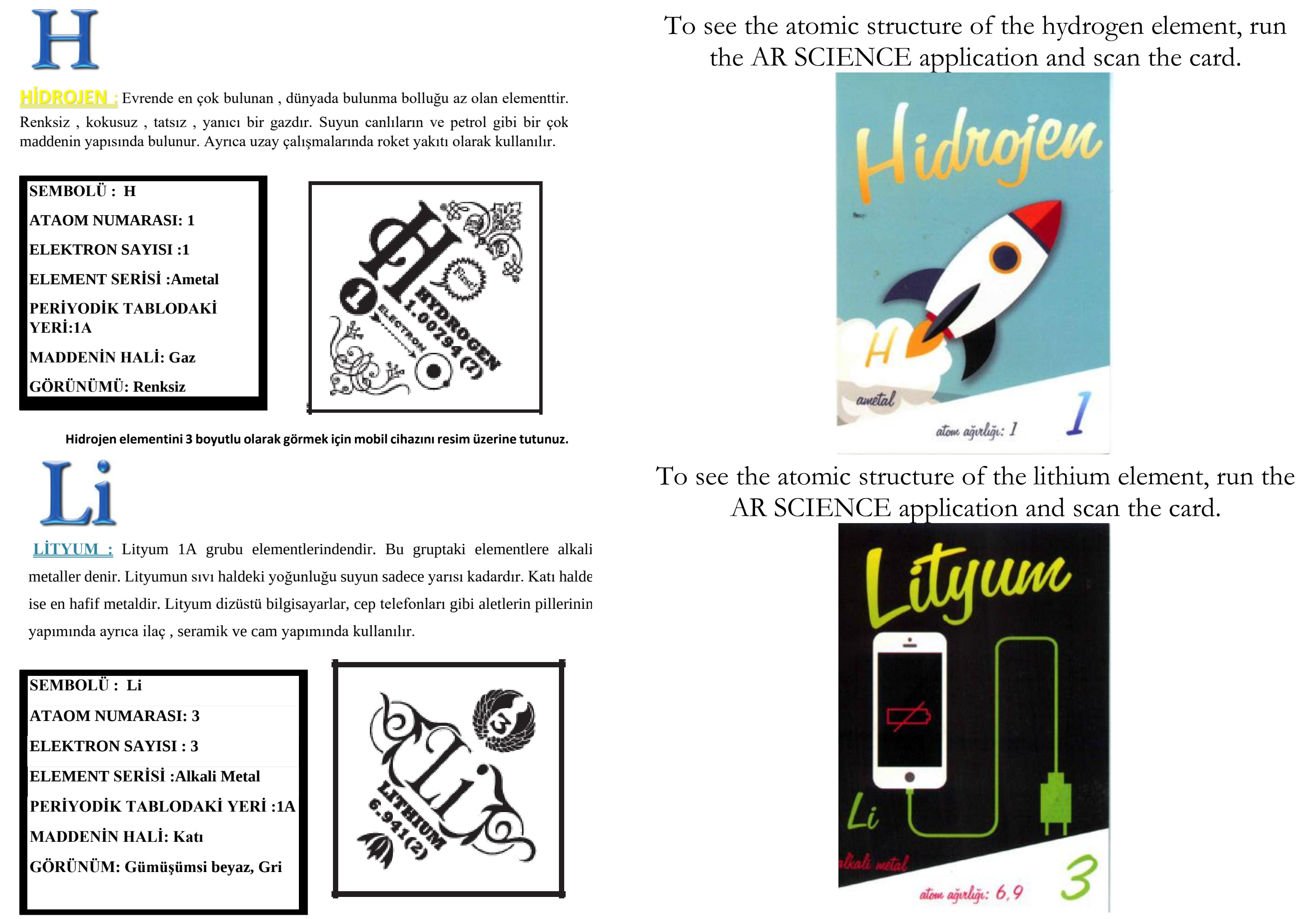

Figure 2 Sample page from the brochure prepared for the AR application

assumptions must be met to use parametric tests. In order to use parametric tests, the data must meet assumptions such as sufficient sample, normal distribution, and equality of variances. The data collected in the study were tested according to descriptive statistics (mean, trimmed mean, median, skewness, and kurtosis values) and whether they meet these assumptions. The analysis of the results obtained from the achievement test, which was applied to the control and experimental groups as pre-test and post-test, was made with the Independent Sample t-test, and it was determined whether there was a statistically significant difference between the groups. The motivation scale for learning science was applied to the experimental group as a pre-test and post-test, and the results were analyzed with the related samples t-test. In order to reveal the experimental group students' attitudes towards AR applications and their motivation for the materials used, the mean, standard deviation, frequency, and percentage values from descriptive statistics techniques were used.

3. RESULT AND DISCUSSION

This section includes descriptive and inferential statistical findings obtained from the data collected in the research. The results of both statistical analyzes are given together for integrity.

3.1 Determining the Effect of AR Applications on Academic Achievement

Independent groups t-test was used to answer the question, which is the first sub-problem of the research:" Is there a statistically significant difference between the academic achievement test pre-test and post-test scores of the experimental and control group students?". In this context, first of all, the assumptions of the t-test, which is a parametric test, of sufficient sample, normal distribution, and equality of variances were met.

According to Table 3, the mean, trimmed mean, and median values of the students in the experimental and control groups were close to each other, and the skewness and kurtosis values were between -1 and +1. It was discovered that these data demonstrated a normal distribution (Tabachnick & Fidell, 2013).

According to Table 4, the variances in the pre-test scores of the experimental and control groups are equal, but the variances in the post-test scores are not. There was no statistically significant difference between the pre-test achievement scores of the experimental and control groups ($p>0.05$). However, when the post-test success scores of

Table 3 Descriptive statistics table of academic achievement pre-test and post-test scores of experimental and control group students

Groups	Test Type	N	Mean	Trimmed mean	Median	Skewness	Kurtosis
Experimental Group	Ön Test	25	28.60	28.50	30.00	0.03	-0.62
Control Group	Ön Test	25	25.60	25.67	25.00	-0.13	-0.12
Experimental Group	Son Test	25	84.80	85.22	85.00	-0.65	0.95
Control Group	Son Test	25	66.80	66.77	70.00	-0.22	-0.87

Table 4 Results related to the academic achievement test pre-test post-test scores of the experimental and control group students

Independent Samples Test							
		Levene's Test for Equality of Variances		**t-test for Equality of Means**			
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**
Achievement test pre-test	Equal variances assumed	0.59	0.44	1.40	48.00	**0.17**	3.00
	Equal variances not assumed			1.40	47.39	0.17	3.00
Achievement test post-test	Equal variances assumed	13.91	0.00	4.28	48.00	0.00	18.00
	Equal variances not assumed			4.28	34.13	**0.00**	18.00

Independent Samples Test				
		95% Confidence Interval of the Difference		
		Std. Error Difference	**Lower**	**Upper**
Achievement test pre-test	Equal variances assumed	2.14	-1.30	7.30
	Equal variances not assumed	2.14	-1.30	7.30
Achievement test post-test	Equal variances assumed	4.21	9.54	26.46
	Equal variances not assumed	4.21	9.45	26.55

the experimental and control group students were examined, a statistically significant difference was found between the groups, and this difference was in support of the experimental group ($p<0.001$).

Similar results are found when the literature studies are examined (Kalemkuş & Kalemkuş, 2022; Omurtak & Zeybek, 2022). Peder Alagöz (2020) found a higher enhancement in the academic achievement of the experimental group in the study using AR applications at the seventh-grade level and in the unit of the particulate nature of matter. Çakır, Solak, and Tan (2015) also have findings that AR technologies increase academic success in their study of foreign languages. Ateş (2018), in his study investigating the effect of learning material created using AR technology in the unit "Particulate Structure of Matter and Pure Substances" on academic achievement, stated that the academic success of the experimental group students increased more. Güngördü (2018) examined the influence of AR applications on students' achievement and attitudes in studying the subject of the same unit, "Structure of the Atom and Atomic Models", and stated that there was a statistically significant difference. AR 3D visualization is reported to help students understand the structure and mechanisms of chemical compounds (Midak, Kravets, Kuzyshyn, Baziuk, & Buzhdyhan, 2021). Yetişir (2019), in his study on the circulatory system at the sixth-grade level, determined that AR applications increase academic success. The study on "composition of substances" in secondary school concluded that AR studies have a complementary effect on learning. (Cai, Wang, & Chiang, 2014). Shelton and Hedley (2002) found that after AR applications about Earth-Sun relations in an undergraduate geography course, students' understanding improved and misunderstandings decreased.

3.2 Determining the Effect of AR Applications on the Motivation of Students in the Experimental Group for Science Learning

Related samples t-test was used to answer the second sub-problem of the study, "Is there a statistically significant difference between the experimental group students' motivation for learning science and their pre-test and post-test scores?

For the second research question, when the descriptive statistics results of the experimental group students' motivation scale for learning science pre-test and post-test scores are examined, it is observed that the mean, trimmed mean, and median values are close to each other (Table 5). Again, the skewness and kurtosis values range from -1.5 to +1.5. All these values showed that the motivation for learning science pre-test and post-test scores displayed a

Table 5 Pre-test post-test descriptive statistics of motivation scores for learning science

Groups	Test Type	N	Mean	Trimmed mean	Median	Skewness	Kurtosis
Experimental group	Science motivation pre-test	25	92.68	92.68	94.00	-0.10	-1.14
Experimental group	Science motivation post-test	25	102.20	102.45	101.00	-0.52	0.27

Table 6 Table of the experimental group students' motivation scale pre-test post-test scores for learning science.
Paired Samples Test[a]

	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Science motivation pre-test Science motivation final-test	-9.52	7.80	1.56	-12.74	-6.30	-6.10	24.00	**0.00**

normal distribution. Again, sufficient sample size is available in each cell (N = 25).

When Table 6 is examined, the experimental group students' motivation scores for learning science before the application and their motivation scores for learning science after the application showed a statistically significant difference ($p<0.001$). The fact that the motivation scores for science learning have increased significantly makes us think that the technology used attracts students' attention and increases participation and thus motivation. For example, "Electrons were moving around compounds and elements. While they were making compounds, I saw how their formulas were made. Also, old shapes changed, and new shapes were formed" can be encountered when compounds were formed. In this case, it is observable that the students are curious. Similar studies conducted in the seventh grade, Çankaya (2019) concluded that AR applications increase motivation about the world and the universe. In their study, Chai et al. (2019) researched the influences of AR applications on students' learning and understanding of physics in the secondary school physics lesson, the subject of the magnetic field. They state that using AR applications to overcome the challenges specific to science teaching greatly stimulates students' motivation and concern in learning, encouraging them to learn more actively and comprehensively.

3.3 Determining the Attitudes of Experimental Group Students towards AR Applications

Descriptive analyses were made to answer the question: "What are the attitudes of the students in the experimental group?" which is the research's third sub-problem. The scale consists of three parts: satisfaction with AR applications, anxiety to use, and willingness to use it. There are seven positive statements about "use satisfaction" in the first factor of the scale to determine satisfaction with using AR applications. It was determined that the average of the answers given to these items was 4.67 out of 5 points. The high average indicates that the students are satisfied with AR applications. It was concluded that the average of the answers to the items related to the second factor of the scale, "Using Anxiety", which indicated six negative statements, was 1.14 out of 5 points. AR applications are complex, seen as a waste of time, make it harder to learn, seen as uninteresting, does not develop an attitude demonstrated with an average of 1.14. In the third sub-factor of the scale, the students' attitudes towards their willingness to use AR applications contain two positive statements. It was determined that the average of the answers given by the students was 4.76 out of 5 points. According to these results, it is seen that students want to use AR applications in other lessons and the future.

Regarding the AR applications on the scale used, the students were asked questions to determine their satisfaction with the AR applications used during the study, their anxiety while using them, and their desire to use them in the future. In this context, the experimental group of students expressed that they comprehended the lesson better when AR applications were used in the lesson. The objects or concepts formed in three dimensions during the study created a sense of reality so they could focus on the lesson better. The applications were interesting; they were pleased and enjoyed using AR applications. Yusoff and Dahlan (2013), one of the studies that correspond to this result in the literature, emphasized the attention-grabbing feature of AR technology in their study and stated that students are very willing to use AR materials. Chang and Liu (2013) stated that there is an affirmative relationship between the intention to use AR technology and the convenience of use. Dilmen and Atalay (2021) stated that the AR application makes the knowledge more permanent by concretizing the knowledge in their minds in the science lesson and proposing using it in other courses. In their study, Sırakaya and Sırakaya (2018) concluded that students could easily use AR materials and want to use these applications again in the future.

On the other hand, it has been observed that there are some problems in using AR applications. For example, in the HP Reveal application, there were some negative situations such as the video restarting when the relevant material or mobile devices move, the internet connection of the devices, the camera resolution of the mobile devices used, the light and sound in the classroom environment. However, despite some adverse conditions, the students stated that they enjoyed using the applications and would like to use them again. They also stated that using such applications in other courses would make them happy. In addition, when the literature is reviewed, studies state that students want to use AR applications again and find them easy to use without worry (Özarslan, 2013; Sin & Badioze-Zaman, 2010).

In the research, it is observed that the students want to use AR applications in their textbooks in the future. Furthermore, some studies show positive attitudes towards the applications of AR technologies not only in science but also in other fields. For example, Pozharina (2019) concluded that the motivation of the experimental group of students increased significantly because of the study she conducted with university students on the subject of writing in English using augmented reality technologies. Similarly, Erbaş and Demirer (2019), in their study using augmented reality applications in a biology lesson, concluded that the motivation of the experimental group students towards the lesson increased more. Khan, Johnston, and Ophoff (2019) are other researchers who concluded that AR applications increase students' motivation.

Similarly, in their study, Ibáñez, Di-Serio, Villarán-Molina, & Delgado-Kloos (2015) revealed that students better understand electromagnetism with augmented reality applications. Dünser, Walker, Horner, and Bentall (2012) concluded that it is beneficial in learning complex and abstract concepts. In their study, Cai et al. (2020) determined that the application provides interesting, fascinating, higher motivation, and more efficient learning. The attitude towards AR applications is positive due to the mobile AR applications they have made on middle school mathematics subject probabilities. It is seen that similar results take place in other studies in the literature. (Chin, Wang, & Chen, 2019; Ekiçi & Yeşilbursa, 2021; Radu, 2012; Ramazanoğlu & Solak, 2020).

3.4 Determination of Experimental Group Students' Motivation for the Material Used

The material motivation scale's descriptive statistics were made to answer the research's fourth sub-problem and how the students were motivated by the materials used. The material motivation scale consists of "attention and convenience" and "confidence and satisfaction". There are 11 statements about "attention and convenience" in the first factor of the scale. In the second factor of the scale, there are 13 statements about "confidence and satisfaction". The average of the answers given by the students to the "attention and compliance" factor was 4.49 out of 5 points. It is seen that the average of the "trust and satisfaction" factor, which is the other sub-dimension of the material motivation scale, is 4.48 out of 5 points.

In their study, Keçeci, Yildirim, & Zengin (2021) reported that although students did not have a clear idea about AR technologies at the beginning of the application, their thoughts changed over time and were influential in their course success. In his study, Sural (2018) states that it would be beneficial to popularize augmented reality in other learning materials. Çakır et al. (2015) used a material motivation questionnaire in their research to examine the effects of activities prepared with AR technology on students' academic success and motivation. As a result of their studies, they discovered a significant difference in the experimental group's academic achievement and motivation for the materials used between the control and experimental groups. In her study, Radu (2012) concluded that AR applications increase motivation and cooperation, thus making learning more accessible.

Similarly, Rambli, Matcha, and Sulaiman (2013) stated that students' participation in the lessons with AR applications increased, and they provided a fun environment. Ersoy, Duman, and Öncü (2016) stated that the students' motivation about the materials used in the lessons supported by AR applications at the secondary school level is high, affecting their success positively. In the literature, there are other studies with coinciding results with the research results (Ersoy et al., 2016; Di Serio et al., 2013; Mystakidis, Christopoulos, & Pellas, 2021; Perez-Lopez & Contero, 2013; Tanık Önal & Önal, 2021).

CONCLUSION

AR technologies, which can make these concepts concrete in lessons where the density of abstract concepts is known, can help students better understand these concepts, events, or phenomena. In this study, which deals with the particulate structure of matter unit of the seventh grade, it was discovered that the applications of augmented reality technology improved the students' academic achievement in a positive way, based on the findings obtained as a result of the application process. The reasons for the academic success increase of the experimental group are that AR technologies make objects, events, and phenomena visual in three dimensions and allow students to experience situations they would not have the opportunity to experience in a real-world environment. It was observed that the control group students had a certain amount of knowledge when given theoretical information about the elements. However, they did not have any information about what these elements looked like, their presence in nature, color, and smell. The fact that experimental group students had the opportunity to experience the specified properties of these elements through AR applications shows that it affects the recall and retention of information.

Among the reasons AR applications increase their motivation towards learning science positively, it is seen that it provides students with individual learning, increases their interest and motivation towards the lesson, and provides flexible working opportunities in terms of time. In addition, due to the combination of different alternatives such as pictures, audio, and video in the applications, the events and phenomena can make abstract concepts and events concrete in three dimensions, make the lesson fun, and the students are satisfied with using these applications. It is stated that students must be able to use these applications without difficulty and work independently. It is considered that students' attitudes towards augmented reality applications have developed positively due to reasons such as the interactive content of the application with the acquisitions, the practical and permanent learning, and the creation of an efficient learning environment.

Research results demonstrate that the material used increases the students' motivation towards the course for augmented reality applications, contributes to their academic success, allows flexible working with individual learning, and is convenient to use. As a result, it can be said that augmented reality applications contribute positively to the academic success of the students and their motivation toward the course. Furthermore, the students who use these applications have a high attitude towards the augmented reality applications, and their views are positive.

This study used three different augmented reality applications at a single grade level and specific to a subject. In science education, studies can be carried out at different grade levels, on different subjects, and with different augmented reality applications. While carrying out these studies, it is recommended that the quality of the mobile devices to be used is high, the ambient light is sufficient, and the internet infrastructure is vital. In addition, it is suggested that activities, where augmented reality applications can be used, should be placed in textbooks

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