The Effect of Augmented Reality based applications on achievement and attitude towards science course in distance education process

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Abstract

This study aims to enrich a theme in the science course in the distance education process with augmented reality-based applications and to examine the effects of these applications on students' achievement and attitudes in science courses. A single group pretest and posttest experimental design was used in this research. The research group consisted of 15 third grade students attending at a school in Siirt during the 2020–2021 academic year. In the research, AR-based applications were designed for some gains aimed at the "Electric Vehicles" theme in the science course and these applications were shown to the students through the Zoom program. This applications consist of 15 h, including pre and post test. Research data were collected through data sets obtained from success and attitude scales given before and after the application. The findings obtained from the research show that the students' achievement and attitudes towards the science course increased significantly with Augmented Reality (AR) based applications.

Keywords Augmented reality · Science · Distance education · Covid-19

1 Introduction

Science is a field that often shapes our daily life and has an impact on many decisions we make. Science that we use in a wide range from learning about our health to answering a child's question of why the sky is blue, aims to systematically examine the

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structure and behavior of the physical, social and natural world through observation and experiment. In general, science has a unique potential to make great discoveries, from cancer treatment to preventing different disasters. In addition, it also provides individual benefits in the acquisition of skills such as asking questions and problem-solving skills, applying what has been learned, collecting and organizing this information, making sense of the world we live in, developing critical thinking and communication skills. Considering these benefits of the science course for the students in their current and future life, it is seen that it is a course that should be carefully considered in the teaching process. So, it is necessary to use methods and techniques that will increase the motivation of students and motivate them to the lesson (Nurita et al., 2017; Rosa et al., 2019). One of the applications that will increase students' interest and motivation towards science lesson is gamification. Kalogiannakis et al. (2021) stated in their study that gamification generally increases scientific thinking skills, learning success, lesson participation and social interaction in science education, and prevents the decrease in motivation levels for this lesson. Hurşen & Baş (2019) state that the applications prepared to gamify the science course increase the level of motivation to learn, and students and families have positive opinions about gamification in the science course.

When the studies aimed at determining the methods and techniques used by teachers in science teaching were examined, it was observed that teachers generally used verbal activities and direct instruction method, and did not include much innovative teaching strategies in lessons. It was observed that some teachers used activities such as role playing, experimenting and educational games (Bardak & Karamustafaoğlu, 2016; Doğru & Aydoğdu, 2003; Güneş et al., 2011; Oyelekan et al., 2017; Şimşek et al., 2012; Taşkaya & Sürmeli, 2014). Studies show that the level of remembering skills acquired by students in science courses based only on the teacher's direct instruction method is poor (Kola & Langenhoven, 2015). Bok (2006) states that in lectures based on direct instruction method, students remember only 42% of the information they learned after the lesson, and this rate decreases to 20% a week later. These findings show that up-to-date and student-centered activities should be designed to make students more eager during the lesson. It is stated that in environments where modern technology and equipment are used, students' interaction and learning levels are higher, their skills of understanding and remembering concepts are more developed, and their interests and motivations are higher. In addition, the inclusion of visual expressions in the teaching process, the use of simulation or three-dimensional visualization tools make the concepts being taught more fun and understandable(Price & Lee, 2013; Raja & Nagasubramani, 2018).Since the inclusion of technology into learning environments brings many positive results, this study aims to examine the effect of AR-based applications, which have been used gradually in educational environments as a new technology-based learning method, on the attitudes and achievements of third grade students towards science course.

2 Literature review

2.1 Augmented reality

Augmented reality is defined as a three-dimensional technology that supports individuals to understand and perceive the real world surrounded by objects created in a virtual environment (Leung & Blauw, 2020). In other words, augmented reality is a three-dimensional computer-generated graphics that create a bridge between virtual and real environments (Diegmann et al., 2015). Augmented reality-based applications differ from virtual reality applications that are created in artificial environments that have no connection with the real world, since Augmented reality-based applications allow real-time interaction, where virtual and real exist together (Carmigniani & Furht, 2011; Azuma et al., 2001). Milgram et al. (1994) stated the structure of virtual reality and augmented reality applications as shown in Fig. 1.

2.2 A brief history of augmented reality

The concept of AR, which was first used by Thomas Caudell and David Mizell, has been used by some companies for display, but with the development of technology, access to phones and computers has become much easier, and it has been used in different environments (Johnson et al., 2010). Today, technological tools and applications are used in many fields from medicine to engineering, from scientific studies to art activities (Kapur, 2019). Augmented reality applications have also rapidly taken their place among these technology-based applications and started to be used in many fields. How the applications based on augmented reality started and what kind of innovations they offer from the beginning are presented below in a short timeline (Fig. 2).

2.3 Use of augmented reality in education

AR-based applications have become applications that can be used in educational environments and broadcasting industry as they have the potential of educational use and become more accessible to technological tools (Johnson et al., 2010; Danaei et al., 2020). Augmented reality based applications are used in many fields of teaching from mathematics, which is a lesson that requires students to think in three dimensions (Chao & Chang, 2018; Estapa & Nadolny, 2015; Munoz et al., 2015;
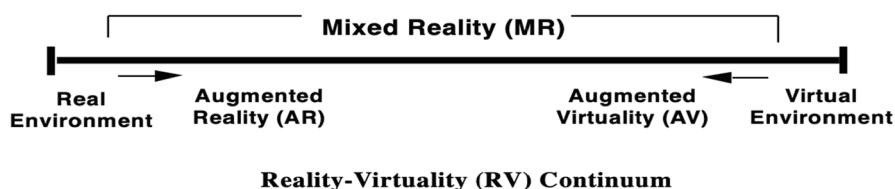

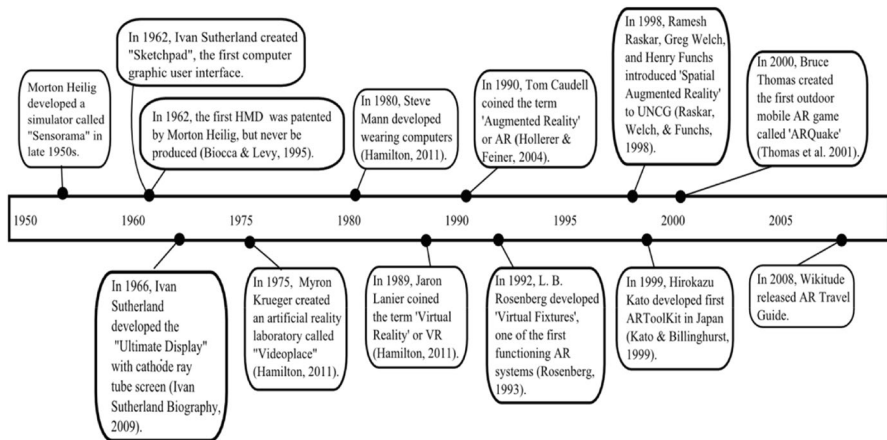**Fig. 1** Reality and virtuality process. Milgram et al. (1995)

Fig. 2 Augmented reality history in a short timeline. As cited by Yuen et al. (2011)

Yingprayoon, 2015) to reading activities where the levels of interest and motivation must be constantly kept high in order to improve students' comprehension skills (Abas & Zaman, 2011; Billinghurst & Dunser, 2012; Bursalı & Yılmaz, 2019; Çetin, 2020; Cheng, 2017; Cheng & Tsai, 2014; Moghadam et al., 2019) and to science courses, which include experiments and activities that would pose a dangerous situation even if it was possible to be done in real environments (Chen & Wang, 2015; Chiang et al., 2014; Delello, 2014; Kerawalla et al., 2006; Sırakaya & Sırakaya, 2018).

As an example of augmented reality-based applications, the studies given above generally include studies conducted for secondary school students and teachers. The intensity of such studies should be reduced to lower levels and applications should be developed especially for students in primary school period. Prensky (2001) states that individuals born since the beginning of the twenty-first century are digital native individuals. He states that these individuals are surrounded by computers, phones and digital games rather than tools such as printed materials and that individuals' constant interaction with such technologies causes them to think extraordinarily and to process information differently. In addition, the use of technology has various negative effects (Alhumaid, 2019). In order to eliminate these negative effects, the use of technology in educational environments should be carried out in a controlled manner. In order to achieve this, AR-based environments can be created under the supervision of a teacher (Harris et al., 2016). AR and similar technology-based applications can appeal to different senses of students (Bower et al., 2014). For this reason, providing technology-based environments to students at this level will ensure that their interest and motivation remain high and they become more successful academically. As a matter of fact, researches indicate that AR-based applications increase academic achievement (Contero & Lopez, 2013; Hwang et al., 2015; Tosik & Atasoy, 2017; Petrov & Atanasova, 2020) and keep interest and motivation high (DiSerio et al., 2013; Chen et al., 2017; Bistaman et al., 2018) in primary school. The results of these studies are similar to the above inferences. Although many

AR-based applications have been developed for educational purposes, very few of them are adapted to classroom environments (Cuendet et al., 2013). Considering the benefits of AR-based research, this rate should be increased and more studies should be included in this field.

2.4 The importance and purpose of this study

When the studies on the use of AR in education are examined, it has been observed that these studies affect many dimensions in individuals' educational processes. AR-based applications make a significant difference in terms of academic achievement, which can be expressed as one of the most important of these dimensions. Sırakaya & Kilic Cakmak (2018) stated in their experimental study that AR-based applications can increase academic success. In a similar study by Tosik & Atasoy (2017), it is stated that AR-based applications increase academic success.

Another dimension that AR affects the student in this process is the attitude towards the lesson. It is seen that the students' attitudes towards the courses prepared with ar-based applications are generally positive. Karagozlu et al. (2019) state that students are satisfied with the augmented reality-based applications prepared for the science lesson, they find these applications interesting and they want to use these applications in the future. In a similar study by Şahin & Yılmaz (2020), it is stated that augmented reality-based applications help to show a more positive attitude towards the lesson. In today's education system, it is observed that augmented reality-based applications have quickly gained a place in the science course, as in many courses, increase academic success and help students gain a positive attitude towards the course. So, this study aims to prepare AR-based applications that support the outcomes to be obtained from the "Electric Vehicles" theme included in the science course of primary school 3rd grade students, and to examine the effects of these applications on attitude and academic achievement towards the science course. Due to the ongoing Covid-19 pandemic, the research was conducted with online applications. The research questions are as follows:

1) Do AR applications affect the science course achievement of third grade students?
2) Do AR applications affect the science attitudes of third grade students?

3 Method

In this section, research design, participant group, data collection tools, experimental processes and analysis of data are included.

3.1 Research design

In the study, a single group pretest–posttest experimental design, one of the experimental research designs, was used to determine in which way the science course designed with augmented reality-based applications affected students' achievement and attitudes. Experimental designs are one of the frequently preferred methods in educational research in terms of presenting information, in other words, creating new knowledge (Cook et al., 2008). In this study, an experimental design was preferred because a new method was applied to support an existing program. Experimental designs are grouped under three headings according to the selection of the participants: real experimental design, weak experimental design and quasi-experimental design. Büyüköztürk et al. (2011) state that school administrations generally do not allow random assignments in studies where new methods are tested. Experimental designs -for which random assignment cannot be made- are expressed as weak experimental designs (Büyüköztürk et al., 2011; Aydın et al., 2019). Within the scope of this study, considering the teacher who will conduct the relevant course is a classroom teacher, the students' characteristics, the attitude of the school administration against random sampling and the purpose of the study, a single group pretest-post-test pattern was used.

Considering the specified design, pre-tests were applied to determine the effect of AR-based applications on students' success and attitudes in science course. After this pre-test, AR-based intervention program was applied to increase the success and attitudes of the students towards the science course. Post-tests were applied to determine the effectiveness of the applied program. The purpose of these procedures is to determine to what extent the applied program affects students' success and attitudes. Experimental design steps of intervention program was shown in Table 1.

3.2 Participants

The participants of the study consists of 15 primary school third grade students studying in the city center of Siirt in 2020–2021 academic year. 7 of 15 participants are girls while 8 of them are boys. These students were selected by using the convenience sampling. Convenience sampling is a practical and fast method (Yıldırım & Şimşek, 2011). The fact that schools are closed during the lockdown caused inability to find sufficient and suitable participants in the distance education process, and difficulty in collecting data therefore convenience sampling method was used. In the

Table 1 Experimental design steps

Group	Pre-test	Intervention	Post-test
Student group	-Science achievement test -Attitude scale for science course	Creating AR based activities with online courses	-Science achievement test -Attitude scale for science course

study, third grade students were preferred considering the attention span of the students in the learning processes. When the studies in the literature are examined, it is stated that the attention spans of the students are related to their age, they can control their attention as they get older and their attention span increases (Flavell, 1986; Çiçekçi & ve Sadık, 2019). Considering that the study was conducted in an online education environment, it was thought that distraction might be easier in the first and second grades of primary school and their attention spans would be much shorter, and this situation could be reflected in the study negatively.

3.3 Data collection

In the study, the achievements of the students in science and their attitudes towards this course were determined. In order to determine the success of the participants in the science course, an achievement test was developed in line with the opinions of a science expert, a specialist in classroom teaching and an assessment and evaluation expert together with the relevant course teacher. The developed science achievement test includes the acquisitions in the "Electric Vehicles" theme and consists of 14 items. The highest score that students can get from this test is "14", while the lowest score is "0". The items of the achievement test consist of three options. An example question regarding the achievement test is given in Fig. 3.

In order to determine the attitudes of students towards the science course, "Attitude Scale towards Science and Technology Course" developed by Kenar & Balcı (2012) was used. The scale shows a 3-factor structure as "Interest", "Enjoying" and "Continuing to study" and consists of 12 items. The scale is in 5-point likert type such as "I strongly disagree (1)", "I do not agree (2)", "I am undecided (3)", "I agree (4)" and "I completely agree (5)". As a result of the scale development study, Kenar & Balcı (2012) found that three factors explained 60% of the total variance of the scale, and item load values ranged from 53 to 86. In addition, it is observed that the reliability value of the scale is determined as 83.

3.4 Experimental process of the research

The research consists of 4 stages. These stages are preparation, course design, application and evaluation (Fig. 4).
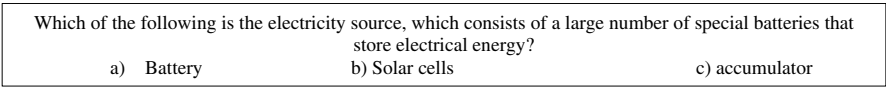
Which of the following is the electricity source, which consists of a large number of special batteries that store electrical energy?		
a) Battery	b) Solar cells	c) accumulator

Fig. 3 An example question of the achievement test

Fig. 4 Experimental process steps

3.4.1 Preparation

At this stage, ethics committee approval was obtained prior to the data collection process. The research was conducted only with students who wanted to participate voluntarily. In addition, the faces of the participants are covered in the shared photos so that they are not exposed. Petousi & Sifaki (2021) state that ethical mistakes affect the entire research negatively. In this study, attention has been paid to such issues, which were stated in order to prevent violations of scientific and ethical rules. A needs analysis also was conducted to determine the level of students' expectations for the course, and what they need in order to pass the courses more efficiently in the online environment during the Covid-19 process. As a result of the needs analysis, they stated that students were bored with the lessons taught in online environments, and that different course materials or technology-supported course materials could prevent them from getting bored.

3.4.2 Course design

After analyzing the demands and needs of the students, it was decided to design the Science curriculum with technology-supported augmented reality-based applications. The Science course is designed as a 4-week program that includes augmented reality-based activities prepared for the acquisitions of the "Electric Vehicles" theme. During the design phase of the program, there was a constant exchange of ideas with an expert in science, a classroom teacher, a specialist in curriculum development, and a researcher with augmented reality application experience.

3.4.3 Application

Before the designed four-week program was implemented, students were informed about augmented reality and had an orientation course where pre-tests were applied. After this course, the course phase with the theme of "Electric Vehicles" was started. Table 2 contains information on the details of the course designed as four weeks.

Some of the AR-based application examples designed to examine the effects on academic achievement and attitude in the application process are presented below (Figs. 5, 6, 7, 8, 9 and 10).

3.4.4 Evaluation

At this stage, general opinions were taken about the way of teaching the course. Students' opinions regarding whether the course has reached its aim or not were noted and posttest applications were implemented.

3.5 Data analysis

SPSS 25 package program was used in the analysis of the data. Shapiro–Wilk normality test was applied to determine whether the data showed normal distribution. It is stated that it would be appropriate to apply the Shapiro–Wilk Test for samples less than

Table 2 Theme, acquisition, activities and products in the implementation process

| Weeks	Theme	Acquisition	Activities	Product
1.week	Electric vehicles	Describes the importance of electricity in daily life by giving examples from the close environment of electrical equipment	Displaying tools such as television, water heater, ventilator, telephone in augmented reality	To be able to give various examples of electric vehicles used in daily life
2.week	Electric vehicles	Focuses on city electricity, battery and accumulator etc.as electricity sources	Battery and accumulator to be shown in the AR environment by adding animation	Realizing that city electricity, battery and accumulator are different sources of electricity
3.week	Electric vehicles	Emphasizes dangers such as electric shock, malfunction and fire that may be caused by electric vehicles, open cables, inserting metal objects into sockets and contact of transmission lines with water	Simulation of an individual inserting a metal object into the socket in an AR environment	Having the necessary information to protect against possible electrical hazards
4.week	Electric vehicles	Classifies electrical equipment according to the electricity sources they use	Preparation of animated AR environments related to wind mill and solar energy systems	Classification of electrical equipment according to the electricity sources used
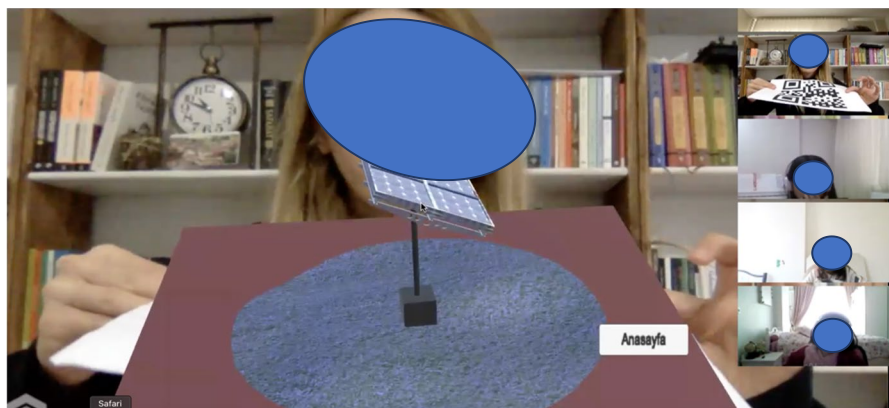
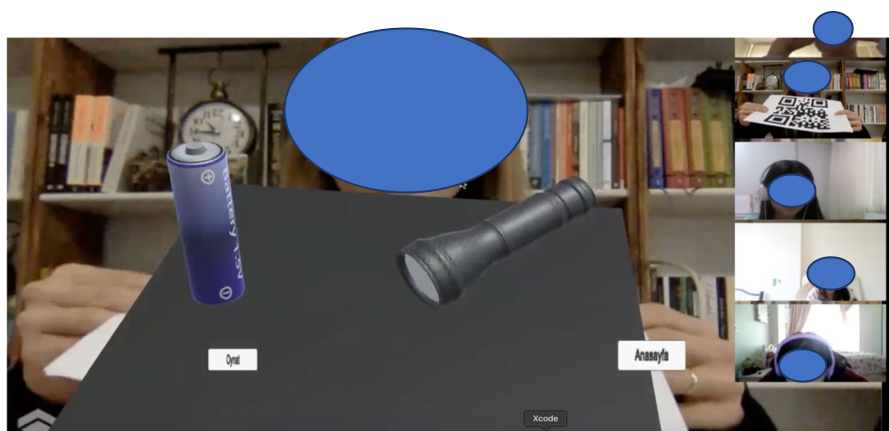**Fig. 5** AR based activity examples (Obtained in the implementation process)

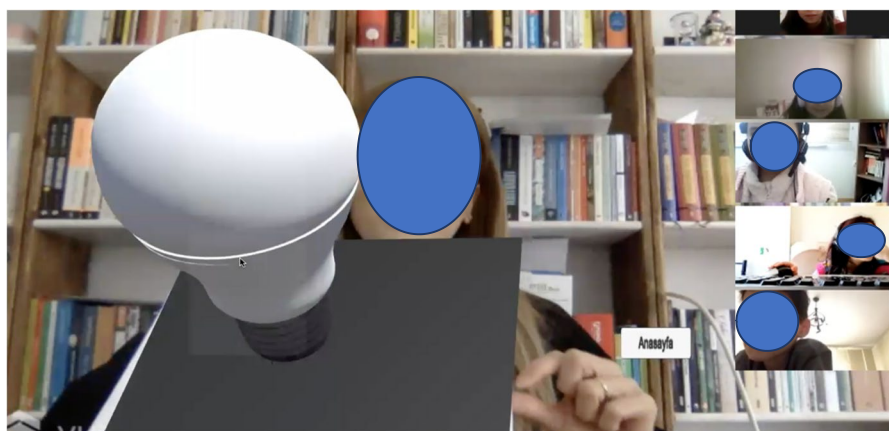**Fig. 6** AR based activity examples (Obtained in the implementation process)

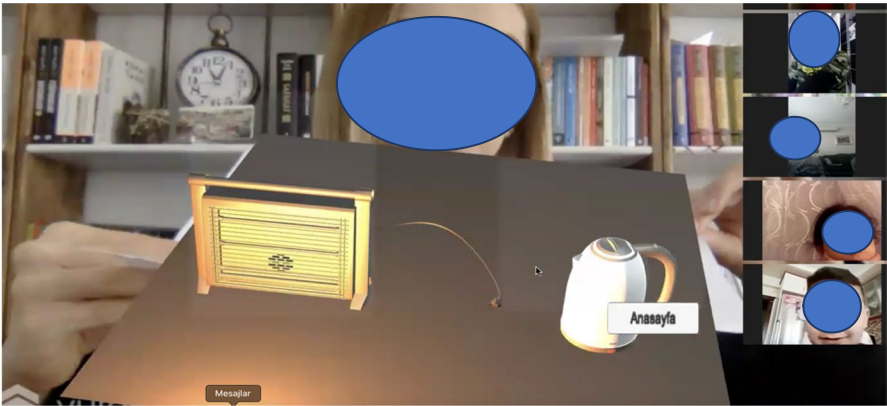**Fig. 7** AR based activity examples (Obtained in the implementation process)

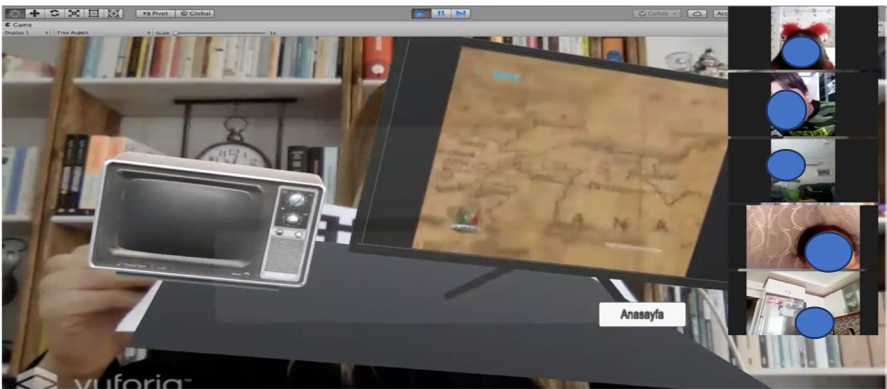**Fig. 8** AR based activity examples (Obtained in the implementation process)

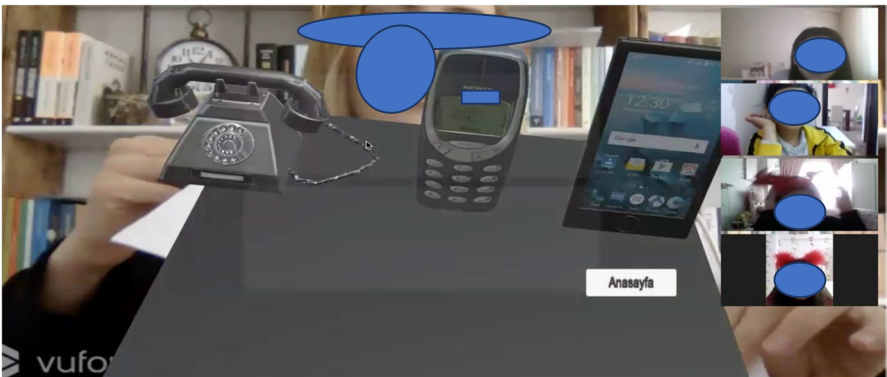**Fig. 9** AR based activity examples (Obtained in the implementation process)

Fig. 10 AR based activity examples (Obtained in the implementation process)

50 participants (Büyüköztürk, 2011). Since the participant group consisted 15 students, the Shapiro–Wilk Test was used. It has been observed that the data set has a normal distribution. In addition, one sample t test was used in the analysis of the data. One sample t tests are used to test whether the mean of two related samples are different from each other (Büyüköztürk, 2011). Similarly, Baykul & Güzeller (2013) stated that if the pre-test and post-test applications used in experimental designs are performed on the same group, the use of a single sample t-test would be appropriate.

4 Findings

This section consists of the effects of the developed science program based on augmented reality on the variables of "academic achievement" and "science course attitude" of the students.

4.1 Findings related to academic achievement

The single sample t-test was used to determine the effect of the science course designed according to augmented reality on the academic achievement of students in Table 3. Table 3 shows the participants' pretest–posttest success score mean, standard deviation, degree of freedom, t value and p significance level.

Table 3 examines the differentiation status in terms of success of the Science course designed according to augmented reality in online courses. When the analysis results are examined, it has been determined that the augmented reality statistically increases the achievement of students in science(t(14) = -11,60, p < ,01).In other words, augmented reality increases success in online courses in distance education process.

4.2 Findings related to attitude

The single sample t-test was used to determine the effect of the science course designed according to augmented reality on the attitude of students in Table 4. Table 4 shows the participants' pretest–posttest success score mean, standard deviation, degree of freedom, t value and p significance level.

Table 3 The effect of AR applications on science achievement	Intervention	Mean	Number of students	sd	df	t	p
	Achievement pre-test	8,40	15	1,92	14	-11,60	,00
	Achievement post-test	11,73	15	1,58			

Table 4 The effect of AR applications on science course attitude

Sub-dimensions and Intervention	Mean	Number of Students	sd	df	t	p
Interest pre-test	11,60	15	5,33	14	-8,60	,00
Interest post-test	25,40	15	5,63			
Enjoying pre-test	10,13	15	1,60	14	-2,185	,045
Enjoying post-test	12,13	15	3,36			
Continuing to study pre-test	12,47	15	1,96	14	-,216	,83
Continuing to study post-test	12,60	15	1,50			
Total pre-test	34,20	15	5,32	14	-9,18	,00
Total post-test	50,13	15	8,18			

In Table 4, the differentiation status in terms of attitude of the Science course designed according to augmented reality in online courses is examined on the basis of dimensions and total points. When the analysis results were examined, it was determined that the augmented reality provided a statistically significant increase in the sub-dimensions of students' science attitude on the basis of interest(t(14) = -8,60, p < ,01), enjoyment(t(14) = -2,185, P < ,05) and total score(t(14) = -9,18 p < ,01).On the other hand, no significant increase was found in continuing to study sub-dimension(t(14) = -,216, p > ,01).In other words, it was observed that AR-based activities designed in online courses during the distance education process increased the interest, enjoyment and attitude towards science course. It was found that it did not affect the attitude of continuing to study.

5 Discussion

This study aimed to examine whether the activities designed in AR-based environments in the science course have any effect on the attitudes and academic achievement of primary school 3rd grade students towards the science course. For this purpose, activities designed in AR-based environments for the acquisitions under the theme of "Electric Vehicles" in the 3rd grade science course were presented to the students. When the results of the research were examined, it was observed that AR-based activities for the science course increased the course success. It is thought that the main reason for the increase in course success is that AR applications concretize abstract concepts and increase students' motivation. Subjects in science courses are generally based on abstract concepts and situations making it difficult for students to understand these concepts(Syawaludin et al., 2019).As a matter of fact, when the studies in the relevant literature are examined, it has been observed that AR-based applications are a successful method in concretizing abstract concepts (Walczak et al., 2006; Sayed et al., 2011; Özdemir, 2017; Tulgar, 2019) and keeping students' motivation level high (Singhal et al., 2012; Chiang et al., 2014; Huang & Liaw, 2014; Ibanez et al., 2015; Torregrosa et al., 2015; Solak & Çakır, 2016; Khan et al.,

2019). Özdemir (2017) states that AR-based applications are an important method in concretizing abstract concepts and that they contribute positively to learning since it is a method with a high sense of reality. Köse et al. (2013) stated that AR-based applications provide students with suitable environments to facilitate understanding of the concepts related to courses with the help of three-dimensional models, so that students can directly observe these concepts instead of visualizing them. Students generally think that the subjects related to science are more abstract and that in order to learn, it is necessary to have deeper meaning and visualization skills (Saidin et al., 2015).

In this study, wind mills, which are unlikely to be seen in daily life by students, solar energy systems and the moment of being caught in electrical current were transferred to the AR environment, making them more concrete and easier to understand in students' minds. This situation may have increased the academic success of the students.

The data collection tool used to determine students' attitudes towards science course consists of sub-dimensions of interest, enjoying the lesson and continuing to study. As a result of the analysis, it is seen that AR-based activities increase the interest in science course and the attitude towards enjoying the course. It is thought that the fact that AR-based applications increase the level of interest and enjoyment of the lesson is due to the fact that these applications increase the students' sense of curiosity, help them understand abstract concepts, and provide experiences that they cannot have in real life conditions. It has also been expressed in the studies conducted by different researchers that AR-based applications are an important aid in learning and teaching processes, increasing academic success and curiosity, and making abstract concepts concrete (Akçayır & Akçayır, 2017; Radu & Schneider, 2019; Yılmaz & Göktaş, 2018). Lee (2012) states that when AR-based activities are prepared in a meaningful way, they provide suitable environments for learning that increase the level of fun and motivation. He also states that the environments with AR-based activities attract, inspire and excite students. As a matter of fact, when different studies in the literature are examined, it is observed that AR-based applications increase the sense of interest, motivation, and curiosity (Kerawalla et al., 2006; Chiang et al., 2014; Aitamurto et al., 2018; Almenara et al., 2019; Khan et al., 2019). These studies are in line with the results of the research. When the results of the continuing studying sub-dimension of the attitude scale were examined, it was seen that the activities designed in AR-based environments had no effect on the attitude to continue studying. This result is thought to stem from the high intrinsic motivation of students towards studying. Intrinsic motivation can be defined as individuals' trying to learn what is important to them without any external purpose. Intrinsic motivation pushes the individual to learn without any reward. This is because the need to learn is completely sincere and dependent on one's own desires (Dakhi & Damanik, 2018). In this study, it was seen that students' willingness to continue studying science course was not dependent on AR-based applications, and they continued to study with or without these environments. This situation shows that the students who were applied to the application consisted of students with high intrinsic motivation for the science course.

6 Conclusion

The fact that the science lesson consists of abstract concepts shows that students may have problems in understanding the lesson and forming a positive attitude towards this lesson. In this study, Ar-based applications were used to overcome these problems. In this process, Unity program was used in order to facilitate some acquisitions in the theme of "Electric vehicles" in the science course. Through this program, the visuals in the theme have been transferred to the augmented reality environment by adding some animations. During the process of distance education due to Covid-19, these applications, which were prepared to increase the motivation and academic success of the students were integrated into the zoom program. With the screen sharing feature, students are allowed to see these objects in three dimensions from their own computers. These augmented reality-based environments were presented to students for four weeks. In order to determine the effectiveness of the program, an attitude scale and achievement tests were applied to the students at the beginning and end of this process. As a result, it was seen that AR-based applications positively affected the academic achievements and attitudes of the students towards the science course.

7 Suggestions

As a result, it was observed that AR-based applications increased academic achievement and attitude towards science course. A different research can be done in courses with too many abstract concepts that students have difficulty understanding. This research has been a study covering the acquisitions of only one theme of the science course. Similar studies that extend over a longer period can also be conducted by considering more than one theme in science or other courses. Marked augmented reality technology was used in this study. By using markerless augmented reality technology, much more realistic studies that students will enjoy more can be exercised.

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