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The effect of using augmented reality based teaching material on students' academic success and opinions*

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ABSTRACT

The purpose of this research is to determine the effect of course material developed with augmented reality (AR) technology in teaching subjects related to coding on students' academic achievement, their level of permanence in learning and their opinions on the process. The mixed method was used in the study. In the quantitative dimension of the research, semi-experimental design with pretest-posttest control group, and in qualitative dimension phenomenology pattern were preferred. The quantitative data of the research were collected with the achievement test and the qualitative data were collected with a semi-structured interview form. The study group consists of 64 students attending a university in Computer Programming department in Turkey. There are 34 students in the experimental group and 30 students in the control group. The prepared achievement test was applied to the students as pretest, posttest and permanence test. After the application, interviews were made with 15 students selected from the experimental group. As a result of the research, it is seen that the academic achievement and permanence levels of students in the experimental group using AR course material for teaching coding education are higher than the students in the control group. According to the results obtained from the qualitative dimension of the research, it has been determined that AR technology provides many advantages such as efficiency, permanence, comprehensibility and convenience on learning; accordingly, it has been suggested that it should be expanded in different courses and fields.

Keywords: Augmented reality, virtual reality, coding education.

* This study is based on Erhan Özmen's master thesis conducted under the supervision of Ayşe Ülkü Kan.

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INTRODUCTION

Societies show their determinant to development and progress with the importance they attach to science and technology. Human beings have lived an integral life with technology since the day they were born. In ancient times, the drawings, carvings and tools from wood and stone in the living space of people were considered as part of the technology. As a result of the industrial revolution, technology has become a whole with the society that has undergone serious changes. The changes that have taken place have led the people, and the people have led the technology (Aksoy, 2003). These developments have increased the connection of many fields with technology. One of these areas is education (Küçük et al., 2014). Therefore, as a result of transformations in technology, it has become a necessity to make certain changes in education. Accordingly, differences have emerged in the needs of the individuals and the system, and education systems have become a system that internalizes daily and rapid learning instead of traditional understanding (Ekici, 2012). While these transformations revealed new learning approaches, they brought the fact that these approaches needed to their own learning environments. Technology has changed the world over time and societies have also diversified in teaching in order to adapt to the changing world (Göktaş et al., 2012). This situation has put the concept of educational technology into our lives. Educational technology is the systematic use of technology output in the field of science and behavioral science, in order to enable students to learn (Alpar, Batdal and Avcı, 2007).

According to Alkan (1998), educational technology is the process of designing, teaching and transforming learning-teaching activities from beginning to ending. Considering these definitions, it can be stated that educational technology is a functional system that integrates theoretical knowledge and educational practices.

While technology develops day by day and incorporates various hardware and software innovations, it tries to develop virtual environments by including many visual and three dimensional elements. These virtual environments become useful in education by offering the opportunity to practice to the learners (Kayabaşı, 2005). Thanks to the environment provided by mobile devices, people have produced many new technologies to meet their needs. Augmented Reality (AR) technology is one of these technologies. Although its name has been mentioned in the field of technology for many years, AR is known as a new concept for the field of education (Uluyol and Eryılmaz, 2014). AR is the addition of digital data produced by a computer to the real world or overlapping digital data with the real world image (Johnson et al., 2011). This technology provides educational environments where students can share in the group and comprehend abstract concepts more easily (Lave and Wenger, 1991). In addition, this technology is preferred because it attracts students' attention, increases motivation, gives special experiences to students, and embodies the abstract concepts in the virtual world to the real world (Abdüsselam and Karal, 2012; Sáez-López et al., 2020). AR has advantages such as making environments understandable by visualizing complex connections, experiencing situations that are difficult to reach and risky in real life, learning by having fun and ensuring effective participation (Yılmaz, 2014; Elmas et al., 2020). Using AR technology, many environments can be offered to the learner to experience a life-like experience. The AR-based learning environment not only provides students with a new learning environment but also gives students the opportunity to interact with the material (Cai et al., 2021). This can be an opportunity to increase the academic success of students who have difficulty in practice-based lessons. The fact that it is easy to access mobile technologies has brought more attention to AR applications today (Güngör and Kurt, 2014).

AUGMENTED REALITY

AR can be defined as the process of displaying real-world images with various technological devices by enhancing them with virtual items (Demirer and Erbaş, 2015). With a different perspective, AR technology is the environment created by the simultaneously interaction of virtual objects created by the help of digital devices with real objects (Azuma, 1997). Sırakaya and Seferoğlu (2016) express AR as a synchronous and mixed reality environment created by using real world environment and virtual objects. There are many AR definitions in which the concepts of being interactive, synchronous, vivid, and unique to the environment are common (Barhorst et al., 2021). AR is aimed to enrich the real world environment with the help of computers and mobile devices (Gürel, 2021). Considering all these definitions, it can be said that AR is to produce a mixed environment and make the reality even more real by simultaneously using the real world environment with the virtual world objects. In the light of these explanations, it can be stated that AR definitions are generally based on three bases. These are:

1. Togetherness of real and virtual
2. Synchronous interaction
3. Three dimensionality

Togetherness of real and virtual explains that virtual objects are built on objects in the real world and appear to be together in the same environment. Synchronous interaction means that virtual objects can be accessed simultaneously with real world data. The realization of this unity in three dimensions is explained by three dimensionality (Azuma, 1997). This technology was first pointed out by the well-known American novelist of the 18th century L. Frank Baum in the novel of *The Wonderful Wizard of Oz* (Doğan, 2016). Later in 1992, the first to mention the concept of “Augmented Reality”, AR, was Thomas Caudell and his friend David Mizell (Caudell and Mizell, 1992). AR is a technology that can be mixed with virtual reality technology because it contains virtual objects. In AR technology, while virtual objects are blended with real environment, a new environment is created; in virtual reality, environment becomes completely digital (Azuma, 1997). Technologies used in AR offer users an environment where they can better understand the real world, instead of putting users in a completely independent environment with the real world (Billinghurst, 2002). In addition, AR aims to strengthen its ties with the real world by enabling users to feel the emotions that they cannot feel in the real world (Azuma, 1997). The reality and virtuality diagram created by Milgram and Kishino (1994) to show the position of AR technology in real and virtual environment is shown in Figure 1.

When Figure 1 is examined, the actual environment is located on the left side of the diagram; it is understood that the AR environment is reached by adding virtual data to the real environment as you go to the right. When looking at the right part of the diagram, the dominance of virtual environments can be seen. Unlike AR, this time, increased virtuality is created by adding real objects to the virtual environment. When looking at the real-virtual continuity diagram, it can be observed that the real environment decreases from left to right and turns into a virtual environment. AR is also an important part of this

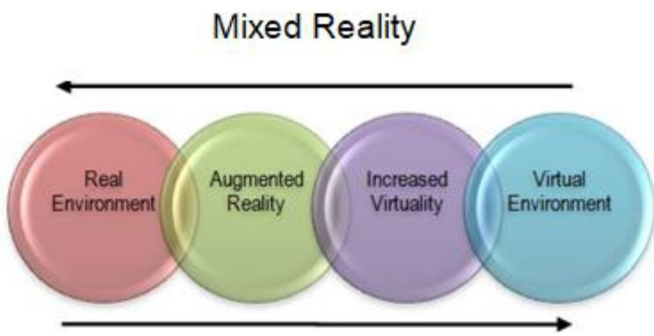

Figure 1. Real-virtual continuity diagram (Milgram and Kishino, 1994).

diagram.

As the AR technology completes its development, its usage areas increase at the same rate. The fact that this technology is visually strong and attracts attention increases its usage in many areas (İçten and Bal, 2017). Although AR was originally used in military, medicine and industry like many technologies; it has become a widespread technology over time (Caudell and Mizelli 1992). It is predicted that this technology will become more widespread in the future and will become one of the most important technologies (İbili and Şahin, 2013). AR is widely used in the field of military, commercial, cultural and artistic, advertising, entertainment, health and education.

Types of AR

AR technology is examined in two categories according to its working principle and purpose. These are location-based and image-based AR systems (Cheng and Tsai, 2013). In the image-based AR system, certain codes are transformed into three-dimensional objects after they are analyzed through AR technology applications. Image recognition techniques are used to determine the location of three-dimensional objects to be added (İçten and Bal, 2014). The fact that many devices have cameras in their own and various AR libraries that are easy to access have enabled the development of picture-based applications in AR (Karal and Abdülsselam, 2015). In location-based AR technology, virtual elements are positioned to real-world areas by means of position information of objects (Azuma et al., 2001). In this system, virtual data is displayed by taking into account the object positions instead of the image recognition techniques differently from the picture-based system. The main difference between the two AR systems is the methods of displaying virtual data.

Using AR in education

AR technology is a technology that has newly started to be used in the field of education. This technology is a new discovery for education, although its history dates back to old times (Fleck et al., 2015). In order for the education to reach its purpose, the learners must be involved in the learning activity. The student can only carry out learning activities in which s/he enjoys and directly involve in the process. AR and similar technologies should be used to include the concept of interaction in education (Taşkıran et al., 2015; Koç et al., 2021). It is only possible with AR technology to embody some abstract concepts, to give chance to new learning insights and to interact with learning activities, to integrate virtual learning materials with the real world (Özarslan, 2013). It is seen that stereotyped methods are got rid of with AR technology in education (Kerawalla et al., 2006). It is said that AR technology gets a different dimension to education and has a significant benefit (Row, 2015). Some of the benefits of AR in education can be listed as follows:

1. It provides the opportunity to use educational environments that are difficult and expensive to reach and objects that cannot be used under normal conditions (Kerawalla et al., 2006; Sivri and Arı, 2020).
2. It increases the interaction of students in the course with the help of three-dimensional objects (Abdüsselam and Karal, 2012; Delello, 2014; Redondo et al., 2020).
3. It makes complex issues that are difficult to understand simpler with the help of three-dimensional virtual objects (İbili and Şahin, 2013; Sáez-López et al., 2020).
4. It provides safe implementation of practices that may pose a danger in education (Wojciechowski and Cellary, 2013).
5. It provides a more effective understanding of topics and concepts (Abdüsselam, 2014).
6. It improves students' motivation by increasing their interest in the subject (Delello, 2014; İbili and Şahin, 2013; Estudante and Dietrich, 2020).
7. It offers students a rich environment where they can reach the virtual and real world at the same time (Cai et al., 2014).
8. It positively changes students' attitudes towards the subject (Delello, 2014; Taşkıran et al., 2015; İbili and Şahin, 2013; Demitriadou et al., 2020).
9. It eliminates misconceptions that can be considered as obstacles in education (Fleck et al., 2015).
10. It transforms learning activity into fun (Taşkıran et al., 2015; Dalim et al., 2020).

Considering the items above, it can be said that AR technology contributes to developing a positive attitude towards the lesson by making the lesson fun and interesting, increasing the motivation and learning the concepts that are difficult to learn effectively. In addition, it is seen that AR increases the interaction within the lesson by performing dangerous and difficult-to-reach applications with the help of three-dimensional objects. Many AR based applications have been developed in education. These practices have spread to different areas of education. Many applications for teaching have been carried out in English, physics, chemistry, mathematics, astronomy, geography and similar fields using AR technology. “Magicbook”, which aims to take children to different worlds with the help of glasses and tablets, is one of these applications (Somyürek, 2014). Similarly, another AR application that provides students with three-dimensional course material is LearnAr. This application obtains three-dimensional documents by using an internet browser through a barcode and a similar pointer (Alliaban, 2015). Another AR application is Fetch, which offers students the opportunity to use three-dimensional visuals while solving the math problem. This application enables students to have an effective learning and fun while solving the math problem (Arlington, 2011). In another application, İbili and Şahin (2013) aimed to determine the effect of using AR technology on spatial shapes on the success of the learner and their opinions against mathematics in the software named ARGE3D. In addition, there are many studies on AR in recent years. Koç et al. (2021) utilized AR technology to improve students' foreign language writing skills and found that this technology increases student success. In another study, researchers performed geographic visualization using AR technology and evaluated its effectiveness in the light of spatial cognitive theory (Gardony et al., 2021). Boboc et al. (2021) examined the effect of AR technology on the learning of mechanism science and students' attitudes towards AR technology. As a result of this examination, positive results were obtained. Chin and Wang (2021) examined the effect of AR technology cultural heritage issues on learning and conducted an experimental study. In the study where he used an AR-based mobile tour system, he concluded that the learning success of the students was higher. Another AR application is AROSE which was developed to discover students' self-efficacy and physics learning levels. According to the results, it has been revealed that AR technology has positive effects on physical learning and self-efficacy (Cai et al., 2021). There are many AR applications that contribute to education but these applications have serious benefits as well as some limitations (Wu et al., 2013). In order to minimize these limitations, while using AR technology in education, applications should be written taking into account the learning outcomes and experts should be worked with in the field of education (Chen et al., 2012). However, the fact that AR technology requires a certain technical infrastructure and the existence of problems that may occur in this technical infrastructure are serious limitations. However, these limitations will not change the potential of AR technology in education. As a result of the studies, it is predicted that AR technology will continue to exist in the field of education (Oh and Woo, 2008).

The rapid development of technology has enabled us to enter concepts such as programming, coding and software into our lives. It is very important to learn these concepts that form the basis of the computer's working system. In terms of the fact that many concepts used in coding education are abstract, the use of AR can be an effective way for coding education. The aim of this research is to improve the teaching material developed with AR technology in teaching subjects related to coding education; to determine the effect of university students on their academic success, permanence in their learning and their opinions on the process. The objectives are stated in two subtitles, quantitative and qualitative. The quantitative dimension of this research is carried out in accordance with the experimental design. In this context, the hypotheses of the research are listed below:

1. There is a significant difference between the pre-test and post-test scores of the students from the achievement test in the experimental and control groups.
2. There is a significant difference between the post-test scores of the students from the achievement test in the experimental and control groups.
3. There is a significant difference between the permanence scores of the students from the achievement test in the experimental and control groups.

The qualitative dimension objectives are listed below:

1. What are the opinions of students on AR course material used in subjects related to coding education?
2. What are the opinions of students about the contribution of AR course material to learning coding education?
3. What are the opinions of students regarding the difficulties they experienced when using AR technology in coding education?
4. What are the opinions of the students regarding the benefits of using AR technology in coding education?
5. What are the opinions of students regarding the different use of AR technology in education?
6. What are the opinions of students regarding the usability of AR technology in different fields except education?

MATERIALS AND METHODS

Model of the research

In this research, a mixed method using qualitative and quantitative data was used. Mixed method research is expressed as a combination of qualitative and quantitative approaches in a study or successive studies (Johnson and Onwuegbuzie, 2004). In general, mixed method is used while seeking answers to research questions that qualitative or quantitative research methods cannot answer alone (Fırat et al., 2014). In this study, sequential explanatory design was used in accordance with the mixed method. In the quantitative dimension of the research, nonequivalent control group from semi-experimental was used. In the qualitative dimension of the research, phenomenology pattern, one of the qualitative research patterns was used. Phenomenology is used to reveal facts that we are aware of but do not have a deep understanding about. It provides a suitable research ground to investigate a phenomena that individuals are familiar with but do not grasp in depth (Yıldırım and Şimşek, 2016). Phenomenology is a research method that uses subjective experiences to obtain information about a phenomenon (Kocabıyık, 2016).

Study group

The study group of the research was constructed one of the universities in Turkey from 1st class student of Computer Programming. One of the first classes of Computer Programming was determined as the experimental group and the other one as the control group. The experimental group consists of 34 students consist of 31 males and 3 females. The control group consists of 28 males and 2 females in total 30 students. Considering the students in the experimental and control groups, this research was conducted totally 64 students. Since AR applications require technological competence, the participants were chosen from the Department of Computer Programming. Since a full experimental design may cause difficulties in equalizing the groups, a quasi-experimental design was preferred. In this experimental study, the participants were randomly assigned two groups. Each group was randomly assigned to be the control and experimental group. In order to reveal the effect of AR applications, a qualitative dimension was added to the study. The qualitative data was collected through interviews. In the qualitative dimension of the study, after the completion of the experimental procedures, interviews were conducted with 15 students from all levels in the experimental group consisting of 5 in the lower, 5 in the middle and 5 in the upper group. While determining the student groups, the scores of the students from the achievement test were taken into consideration. In the qualitative dimension of this research, maximum diversity sampling was taken into account. The aim of maximum diversity sampling is to create a small sample and to reflect the diversity of individuals who may be a part to the problem studied in this sample (Yıldırım and Şimşek, 2016). The aim of maximum diversity sampling is to discover and define the common aspects of many differences related to the event and phenomenon studied (Neuman, 2014). In this direction, interviews were conducted with students who were selected voluntarily.

Data collection tools

In the research, "Achievement test" was used as pre-test, post-test, delayed post-test in order to measure students' success and permanence in learning. In order to reveal the effect of AR applications on student success and learning, an achievement test has been developed to cover the subjects that form the basis of coding in the first four weeks of the course of "Basics of Programming". While creating the success test, a question set was first created by considering the scope validity. After the validity and reliability procedures; the final version of the test consisting of 30 questions was occurred. The average item difficulty value of the achievement test consisting of 30 questions was .55, and the KR-20 reliability coefficient was .77. Distinguishing Power Index and difficulty index values of the items in the achievement test are shown in Figure 2.

According to the graph, it is seen that the distinguishing power index are in the range of 0.21 to 0.56. The Distinguishing Power Index is between -1 and +1 values. It can be said that as the index value approaches 0, the distinguishing power of the substance decreases, and closer to + 1, the distinguishing power increases (Bayrakçeçen, 2009). Since the achievement test items of the research are in this range, it can be said that the test is valid and reliable.

An interview form was created by researchers to collect data on the qualitative dimensions of studies. Interview was preferred as a qualitative data collection method in the study. Interviewing is preferred as an important source of data collection in studies where phenomenology pattern is preferred (Yıldırım and Şimşek, 2016: 71).

While creating the semi-structured interview form, first, a form consisting of 13 preliminary questions was prepared by the researcher. The questions were reviewed by experts (three faculty members in the field of educational sciences, two faculty members in the field of computer education, and three faculty members on language proficiency). After the expert revisions, seven questions were dropped out and the other six questions were revised grammatically if necessary. In the semi-structured interview, the researcher prepares questions about the interview before, but during or after the interview, it can be asked different questions and asked for detailed answers (Bogdan and Biklen, 2007).

Analysis of data

Analysis of the quantitative data of the research was carried out with the IBM SPSS v. 22 package program. In the analysis of quantitative data, arithmetic mean, standard deviation, percentage, frequency, dependent groups t test, independent groups t test were used. Before performing the analysis, the data was examined to determine whether the data was normally distributed. If the sample size is smaller than 35, Shapiro-Wilk test (Shapiro and Wilk, 1965), if larger than 35, Kolmogorov-Smirnov test is used (McKillup, 2012). Also, it is stated

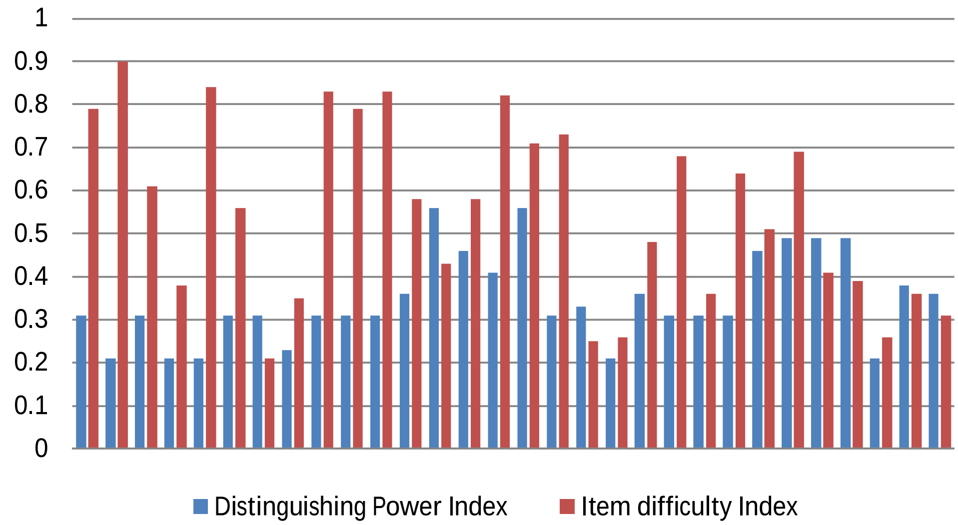

Figure 2. The distinguishing power index and difficulty index values of the items in the test.

that the Shapiro-Wilk test is the strongest test used to determine normality assumption (Shapiro et al., 1968). Therefore, Shapiro-Wilk test was used to test normality assumption. In addition, kurtosis and skewness values were examined (Büyüköztürk et al., 2019). According to the results, parametric tests were used.

In the analysis of qualitative data, content analysis method was used. Content analysis is a technique based on separating, comparing, systematizing, and interpreting the data obtained from various sources (Yıldırım and Şimşek, 2016). While conducting content analysis, attention is paid to the stages of coding data, finding themes, organizing codes and themes, defining and interpreting the findings (Yıldırım and Şimşek, 2016). Accordingly, while coding the data, students' sentences were divided into meaningful parts considering the interviews made with the students, and it was determined what each section meant conceptually. Depending on the codings that emerged later, common aspects were determined and the codes were categorized. Thus, thematic codes were created. In this process, the internal consistency of the codes with each other was taken into consideration. It was ensured that the codes fit together and become a whole; in other words, external consistency has been achieved in this way. In addition, the codes and themes were examined to determine they were connected to each other. To ensure validity, all these steps were carried out by three different people. In the last stage, the findings were interpreted. In order to ensure validity, two different persons conducted the analysis of the data together. In qualitative studies, different perspectives make sense for validity (Yıldırım and Şimşek, 2016). Using the reliability formula of Miles and Huberman (1994), the codices reached with the consensus and the non-consensus encodings were determined and the reliability level was found to be 90.01%. According to the coding controls that express the internal consistency, the codification between the coders is expected to be at least 80% (Miles and Huberman, 1994). While giving content analysis findings based on student interviews, direct quotations were used and examples from students' opinions were presented.

Procedures applied in the research process

The research was carried out on two groups as experimental and control groups. Two separate teaching materials have been developed to be used in both groups. While these materials are exactly the same in terms of content, the material used in the experimental group was supported by using AR technology. While the students in the experimental group were given basic coding training with the magazine created by using AR technology, the students in the control group were taught with the same content of magazine without using AR technology. The main difference between the two materials is that although they have the same textual information, one has video content that can be used thanks to AR technology. The research consists of three parts as pre-application process, application process and post-application process. The visual of the research process is shown in Figure 3.

After the preparation of teaching materials, students in the experimental group were given orientation training on the use of AR-supported material. In the continuation of this process, the achievement test prepared on the subject was applied to the students as a pre-test before proceeding to coding education. After this application, training was carried out with the use of AR supported materials for four weeks. In this process, students have read the icons on the course material supported by AR

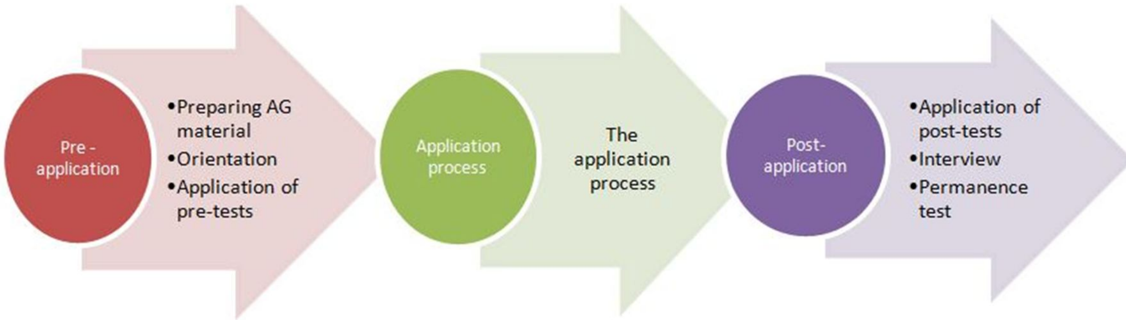

Figure 3. Model related to the application process.

technology with the help of mobile devices (tablet, phone etc.) and reached the course videos related to coding. At the end of the four weeks, achievement test was applied to both groups as a post-test. After this application, interviews were made with 15 students selected from the experimental group. Achievement test was applied as permanence test five weeks after at the end of the application. Photographs of the execution of the application are shown in Figure 4.

Preparing AR teaching material

While preparing AR based teaching materials, the picture based system was used as the system and video based imaging was used as the way of viewing. In image-based systems, virtual data is transferred by image recognition techniques on real-world image (Karal and Abdüsselam, 2015). Video-based imaging, used as a form of viewing, is presented to the user on the screen by adding virtual data to real-world images taken from cameras (Azuma, 1997).

In the first stage of preparing AR material, the document containing the first four weeks of the basics of programming lesson was created and icons were placed on it. Then, video animations related to the course topics in the document were developed. At the last stage, the icons designed on the course document were paired with video animations via the AR program and students were provided with access to these course videos with the help of mobile devices (mobile phone, tablet etc.). The preparation stages of the material are shown in Figure 5.

It is aimed to enrich and efficiently use the course document created while preparing AR material, thanks to video animations. In this context, "Computer history", "Algorithms", "Flow diagrams and Loop statements" are explained through the document every week. After the lecture, video animations with explanations and various examples related to the subject were shown to the students via mobile devices (mobile phones, tablets etc). The students easily reached the solution of the examples in the document, the visual representation of complex algorithms and flow diagrams by reading the icons on the document and had the opportunity to use it again and again whenever they want. In this way, students were provided with the opportunity to obtain more than the information contained in the course document and to see abstract concepts in a concrete way.

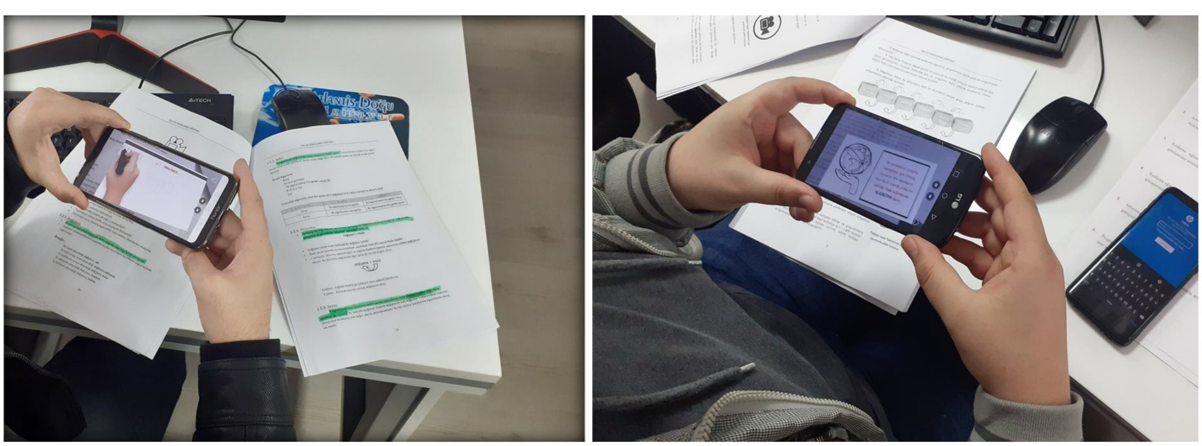

Figure 4. Photos of the execution of the application.

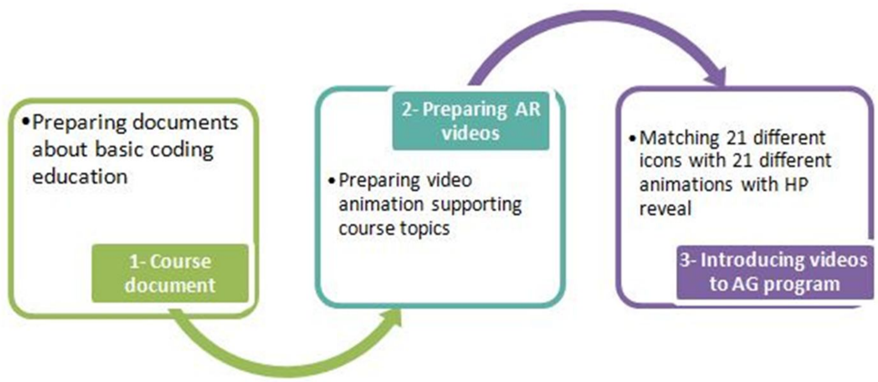

Figure 5. Development stages of AR material.

RESULTS

This section includes quantitative and qualitative results of the study.

Results related to quantitative dimension

Hypothesis 1: There is a significant difference between the pre-test and post-test scores of the students from the achievement test in the experimental and control groups.

According to Table 1, it is seen that the pre-test ($\bar{X}$ = 9.61) and post-test ($\bar{X}$ = 21.2) scores of the experimental group students differ statistically in favor of the post-test t (33) = - 24.53; $p < 0.05$]. Similarly, the pre-test ($\bar{X}$ = 10.1) and post-test ($\bar{X}$ = 17.26) scores of the control group differ statistically in favor of the post-test [t (29) = - 23.04; $p < 0.05$]. This situation shows that academic success increased in both groups.

Hypothesis 2: There is a significant difference between the post-test scores of students from the achievement test in the experimental and control groups.

When Table 2 is examined, it is seen that the post-test ($\bar{X}$ = 21.2) score of the experimental group students differ significantly from the post-test ($\bar{X}$ = 17.26) score of the control group students [t (62) = 5.454; $p < 0.05$]. Accordingly, it can be said that the applications performed using AR technology are more effective than the traditional method in teaching the subjects related to coding education.

Hypothesis 3: There is a significant difference between the scores of students from the retention test in the experimental and control groups.

Table 3 shows the independent groups t test results regarding the permanence test scores of the groups. Considering these results, it is observed that the permanence test scores of the experimental group students ($\bar{X}$ = 20.26) differ significantly from the permanence test scores of the control group students ($\bar{X}$ = 15.8) [t (62) = 8.995; $p < 0.05$]. In this context, it can be said that the applications performed using AR technology are more effective at the point of permanence than the traditional method.

Results related to qualitative dimension

In this section, the analysis of the qualitative data resulting from the semi-structured interview and the results that came with it are included.

When students' views on AR course material are examined, it is seen that these opinions are divided into two categories as **positive** and **negative** (Table 4). Students' positive views are examined in four different categories: **contribution to learning, addressing different sensory organs, reflecting the content of the lesson and enabling the repeated use**. Negative opinions are listed as **keeping the phone steady, technical inadequacy and loudness of the background sound**. After the implementation, the students mentioned that the AR course material facilitates mostly learning in terms of contributing to the lesson and then said that it increases the efficiency, supports permanent learning and individual learning. A student (MS3) who thinks the material makes the lesson easier, said, "*It makes the lesson easier and helps me to understand it easier*." The students also expressed their opinions about the application increases the efficiency, and (FS8) stated the efficiency of AR applications by saying "*The application we use via the phone that we all have helps us learn more efficiently through video".* In addition, a student (MS3) who stated negative opinions

Table 1. Dependent group's t test results regarding the pre-test and post-test scores from the achievement test of the experimental and control groups.

Groups	n	$\bar{X}$	Sd	df	t	p
Experimental group						
Pre-test	34	9.61	1.51	33	-24.53	0.000*
Post-test	34	21.2	3.12			
Control Group						
Pre-test	30	10.1	1.9	29	-23.04	0.000*
Post-test	30	17.26	2.58			

Table 2. Independent group's t test results regarding the post-test scores from the achievement test of the experimental and control groups.

Groups	n	$\bar{X}$	Sd	df	Levene		t	p
					f	p		
Experimental	34	21.2	3.12	62	2.524	0.117	5.454	0.000*
Control	30	17.26	2.58					

Table 3. Independent group's t test results regarding the permanence scores from the achievement test of the experimental and control groups.

Groups	n	$\bar{X}$	Sd	df	Levene		t	p
					f	p		
Experimental	34	20.26	2.24	62	3.90	0.53	8.995	0.000*
Control	30	15.8	1.62					

Table 4. Views on augmented reality course material.

Themes			Codes	f
Views about the material	Positive	Contribution to learning	Facility	15
			Efficiency	8
			Permanence	7
			Individuality	2
		Addressing different sensory organs	Visual Richness	13
			Interesting	4
		Reflecting the content of the lesson	A richness of information	5
		Enabling the repeated use		2
	Negative	Keeping the phone steady		2
		Technical inadequacy		2
		Loudness of the background sound		1

about the material said "… *We have to keep the phone in the same position. It is difficult to hold the phone steady until the video ends*. " Another student (MS2) who thinks that the augmented reality material is technically insufficient emphasized the deficiencies of this technology by saying "… *There is a new technology and it has deficiencies*".

As shown in Table 5, when students' views about the

Table 5. Contribution of AR course material to learning subjects related to coding education.

Themes		Codes	f
Contributions to learning	Facilitation	Facility	7
		Permanence	3
		Practicality	1
	Enrichment	Visual richness	7
		Diversity of information	2
		Addressing different sensory organs	1
		Diversity of examples	1
	Individualization	Speed	2
		Effective participation	1
		Individuality	1

contribution of AR course material to learning coding subjects are examined, it is seen that it is divided under the main theme of contributions to learning into three categories as **facilitation**, **enrichment** and **individualization.** Also, facilitation from these categories is divided into codes in terms of **convenience**, **permanence** and **practicality**; enrichment is divided into codes such as **visual richness**, **diversity of information**, **addressing different sensory organs**, **diversity of examples**; and individualization respectively, **speed**, **effective participation** and **individuality**. A student (MS6) who thought that the material facilitates the learning of the subjects related to coding education said "*It is easier for me to learn through video because it is visual*". Another student (MS15) stated that "*I learned more easily and learned more because learning is more effective*." One of the students who expressed the view that the material provides permanent learning on coding education (MS14) said "*I learned the subjects more permanently because it increased my interest in the lesson*". A student who gave an opinion on the speed and individuality code under the individualization category (MS9) said that "*It has accelerated my learning. Thanks to this application, I was able to answer the questions that I was afraid to ask the teacher, and this made it easier for me to learn coding*." he emphasized fast and individual learning.

The opinions of the students about the **difficulties** they experienced while using AR technology are examined under three main categories as the main theme of difficulties; **usage-related difficulties**, **sound-induced difficulties** and **technological defects**. Also, usage-related difficulties from these categories are divided into codes in terms of **ergonomic insufficiency (phone)**, **limitation of the matching area**, **device and program requirement**; sound-induced difficulties are divided into codes such as **background sound level (loudness)**, **no audio commentary**; and technological difficulties respectively **not detected video code** and **video opening speed**. When Table 6 is examined, it is seen that the ergonomic inadequacy code is in the code position with the highest frequency. A student who gave an opinion about the ergonomic inadequacy code within the difficulties arising from use (MS1) said, "*Keeping the phone or tablet stationary constantly is one of the biggest problems*". A student (FS7), who gave an opinion on the code of the limited pairing area in use-related difficulties (FS7), emphasized the limitation of the pairing area by saying "*Sometimes the video moves on the screen as you move the phone*". A student who gave an opinion about the fund level code (MS11) said that *"… the background music sound in the videos can be distracting*." One of the opinions about the technological defects (MS2) is "*Sometimes the image is not available when the phone is holding the icon*".

The opinions of students about the facilities provided by AR technology were examined under two main categories, namely **content-related** and **application-oriented** facilities, under the main theme of facilities. Content-related facilities include **visuality**, **accessibility**, **comprehensibility**, **rapid learning**, **richness in content**, **permanence**, and **practicality**; Application-oriented facilities are divided into codes, such as **portability**, **competence** and **individuality**, respectively. When Table 7 is examined, the visual code frequency is seen as the highest code in the content related category. One of the students who emphasized visuality (MS3) said "*It is useful to explain the subjects that cannot be understood with visuals*". The accessibility feature (MS4), which is provided by the facilities provided by this technology, is stated as "*We can reach the information immediately without losing time*". A student who expressed his opinion about the portability code in the application-oriented convenience category (MS1) used the words "*It is very nice to be able to carry the information with us at any time*".

As shown in Table 8, the suggestions of students about the different uses of AR technology for educational

Table 6. Difficulties while using AR technology.

Themes		Codes	f
Difficulties	Usage related	Ergonomic insufficiency (phone)	8
		Limitation of the matching area	3
		Device and program requirement	2
	Sound induced difficulties	Background sound level (loudness)	4
		No audio commentary	2
	Technological defects	Not detected video code	2
		Video opening speed	1

Table 7. Conveniences provided by the use of AR technology.

Themes		Codes	f
Facilities	Content-related facilities	Visuality	7
		Accessibility	5
		Comprehensibility	4
		Rapid learning	3
		Richness in content	3
		Permanence	2
		Practicality	2
	Application-oriented facilities	Portability	2
		Competence	1
		Individuality	1

Table 8. Different usage suggestions of AR technology for educational purposes.

Themes	Codes		f
Different uses and suggestions	Usage areas	In all courses	3
		Learning foreign language	3
		In courses requiring memorization	2
	Usage suggestion	With visual diversity	8
		With audio narration support	5
		With different stages	1
		With appropriate sound level	1
		With real-life sections	1
		With smart board	1

purposes are examined under two main categories: **usage areas** and **usage suggestions** under different themes. In usage areas divided into in all courses, courses requiring memorization, learning foreign languages; Usage suggestions are divided into sub-themes with visual diversity, audio narration, different stages, appropriate sound level, real-life sections, and smart board, respectively. One of the students who emphasized that AR should be used in all courses (MS9) said "*... it should be used in all stages of the whole class*." A student who defends that it can be used effectively in courses requiring memorization (FS7) emphasized that visualizing foreign language lessons by visualizing them by saying "*It can be an application on learning English words by using more images*". Another student (MS11) suggested "*Visual elements can be used more and audio narrations can be added to the visuals*".

It is tried to be showed that students' opinions on the usage areas of AR technology other than education, nine different coding, in the fields of engineering, health, information sharing platforms, astronomy, marketing, advertising, tourism and science in all sectors under the main theme of usage except the education sector. A student (MS9) who advocates that AR should be used in all sectors expressed his opinion as "*It enables us to think of things that we cannot think of in concrete terms that can be easily used in every field*". A student who thinks that AR technology should be used in the field of engineering (MS6) said "*It can be used in the engineering field because it is practical*". Another student (MS10) who suggested that it should be used in the field of health and engineering said "*It can be used in many areas where visuality is needed, for example, doctors and engineers can benefit from these applications*" (Table 9).

Table 9. Suggested usage of augmented reality technology in different fields other than education.

Themes	Codes	f
Usage areas except the education sector	In all sectors	5
	In the field of engineering	2
	In the field of health	2
	On information sharing platforms	1
	In the field of astronomy	1
	In the field of marketing	1
	In the field of advertising	1
	In the field of tourism	1
	In science	1

DISCUSSION

In this research, the effects of the usage of course material based on AR on learning and students' opinions on the process were determined. As a result of the applications, the teaching of coding subjects using AR course material and traditional teaching method had positive effects on student success, but it was determined that using AR material was more effective than traditional teaching method on coding instruction. Accordingly, it is possible to say that the usage of AR course material is effective in increasing student success. Likewise, AR-supported teaching material increased the permanence in learning. A similar situation was observed in the studies of Atalay (2019), Eren (2019) Altıok (2020) and Peder-Alagöz (2020). In a similar study conducted by Ersoy et al. (2016), it was revealed that the teaching activity designed with AR had a positive effect on students' achievements. In the study carried out by Sırakaya (2015) within the scope of Science and Technology course, it was determined that software created by AR contributed positively to students' achievements. Yıldırım (2018) conducted an experimental study using the mobile AR software he developed and revealed that AR technology has more positive effects on academic achievement compared to printed books. In a study conducted by Küçük and his friends (2014), it was determined that AR technology increased academic success. Buluş Kırıkkaya and Şentük (2018), Ibáñez and the others (2020), stated that applications using AR technology positively affect students' success and environments supported by AR applications increase academic success. Altun and Yüksel (2021), in their study examining the effect of AR technology on students' foreign language writing skills, concluded that this technology positively affects academic achievement. Similarly, Boboc et al. (2021) examined the impact of AR technology on mechanism science learning and concluded that AR technology increases academic success in mechanism. Yıldırım (2020) explained the solar systems subject of the science course using AR technology in his experimental study and concluded that this technology increases academic success. In addition, there are various studies that show that AR technology increases academic success in science courses (Demirel, 2019; Karakaş, 2020; Sarıyıldız, 2020; Cai et al., 2021). In Sarıyıldız's (2020) study within the scope of the science lesson, it was concluded that A.R-based materials positively affected both the success of the students and their motivation for the lesson. This result supports the results of the current studies. On the other hand, there are studies that have been concluded that AR technology does not have a positive effect on success (İbilli and Şahin, 2013; Gün, 2014; Baysan and Uluyol, 2016; Erbaş, 2016; Yılmaz and Batdı, 2016;). In a study conducted in the field of physics education (Karakaş, 2020), the effect of AR application was examined; but no difference was found on student achievement and motivation for the lesson when compared to traditional teaching. Similarly, in a study conducted in the field of social studies teaching (Azı, 2020), it was determined that AR did not affect student achievement, but it had a positive effect on the attitude towards the lesson. This can be attributed to the conduct of the studies in different grade levels, environments and learning areas. At the same time, teachers'/lecturers' methodological differences and their competencies in the preparation and use of AR materials may also be determinant in these differences in success.

The results obtained in the qualitative dimension of the research largely support the quantitative dimension. Within the scope of the research, positive features such as AR based teaching materials contribute to learning, address different sensory organs, reflect the course content and allow for repeated usage. In a similar study conducted in the field of science education, the reasons for the effectiveness of AR applications were listed as enabling repetition, having an audio-visual feature, entertaining and 3D feature (Yıldırım, 2020). It has been demonstrated that the material prepared in accordance with AR technology provides convenience, efficiency and permanence in learning, while also emphasizing individuality. Baysan and Uluyol (2016), Sivri and Arı (2020), stated that AR technology offers students the opportunity to self-learn. This result supports the results of the current studies. Moreover, in the research, the fact that AR technology offers visual richness to the learner and attracts attention as well as the wealth of information is listed among the positive features of the material. Shelton and Hedley (2002), Altıok (2020), state that AR technology makes difficult to understand subjects more understandable with the help of visuals. Similar situations were highlighted in the studies of Atalay (2019) and Eren (2019). In the study conducted by Sarıyıldız (2020) in science lesson, students emphasized that learning with AR material became easier and more fun and positively affected their interest in the lesson. On the other hand, the opinions of the students within the scope of the research, the negativities regarding the AR material were also determined. For example, keeping the phone steady on pairing AR-supported materials and mobile devices during application, some technical deficiencies that may arise and the loudness of the background sound in the videos are some sources of negativity. In a similar study by Karakaş (2020), it was revealed that the students had some software and hardware problems related to AR applications/materials. In the researches, it has been clearly stated that if the design is not taken into consideration, the learning process can be negatively affected by this situation (Kruijff et al., 2010; Altıok, 2020).

It has been demonstrated that AR based teaching material facilitates learning the subjects related to coding education, enriches the process while providing learning and is especially important in terms of providing individual speed and effective participation. In this context, it draws attention that AR technology is effective in providing visual richness, diversity of information and examples. Delello (2014), Zhang et al. (2014) and Taşkıran et al. (2015) and Kurtoğlu (2019) stated that AR technology enables students to participate actively in the lesson. Somyürek (2014), Sivri and Arı (2020) stated that AR technology will address the Z generation and in this way the interest in the lesson will increase. Erdem (2015) similarly states that enriched learning environments have positive effects on students' success. Wojciechowski and Cellary (2013) stated that the use of materials created by AR technology embodies abstract concepts and facilitates learning. While Şentürk (2018), Sáez-López et al. (2020), Lampropoulos et al. (2020), reveals that AR technology facilitates learning, makes it fun and attractive and embodies the subject, Kurtoğlu (2019), Sivri and Arı (2020), stated that AR technology increases motivation towards learning and makes the lesson more understandable and easy. In a different study, it was determined that AR supports positive situations such as easy learning, concretization, focus, curiosity and fun (Peder-Alagöz, 2020).

Another important point concerns the process of using the material. The difficulties experienced by the learners in the usage of materials were also considered during the study process and these difficulties are included in the results of the study. In this context, the learners have experienced some difficulties due to usage, sound and technological defects. The troubles are especially in the ergonomic dimension, the pairing of the stage and the mobile device. Munoz (2018) stated that computers and tablets work well in using technologies such as AR and VR; however head-mounted displays and stereoscopic glasses are more practical and more comfortable as they allow free use of hands. As a matter of fact, while Özkale and Koç (2014) emphasized ergonomics and health in their studies, they stated that applications based on tablet use may cause neck and spine pain in the user. At the same time, Akçayır and Akçayır (2017), in their study on the challenges of AR use in education, emphasized that AR is difficult to use for students, it is difficult to use in large groups, and its design is difficult, as well as there are some ergonomic problems. Moreover, it is another troublesome situation that the videos used in the study contain background music but not audio narration. When similar studies on the subject of AR (İbili and Şahin, 2013; Ke and Hsu, 2015) were examined, it was seen that some problems may arise due to the lack of perception of the video code. Related studies have revealed that AR applications are not suitable for education in all aspects and contain some limitations (Pérez-Sanagustín, Hernández-Leo, Santos, Kloos and Blat, 2014; Durak et al., 2020).

As a result of the research, it has been revealed that the usage of AR technology provides facilities to the learners both the content of the course and practical applications. In this context, facilities such as accessibility, understandability, practicality, portability, competence, and individuality are emphasized. The use of mobile devices has enabled AR technology to be easily accessible, portable and practical (Zurita and Nussbaum, 2004).

Another subject that is emphasized in the scope of the research is that the learners bring suggestions about the process after their experiences. In this regard, it has been revealed that students within the scope of the research find AR applications to be used in different fields of education. In a similar studies conducted by Demirel (2019) and Sarıyıldız (2020), it was concluded that AR materials can be used for teaching purposes in different fields. It is thought that AR material will be helpful especially in the course contents that require memorization and based on foreign language learning. This result shows that the studies of Taşkıran et al. (2015) and Redondo et al. (2020) are in parallel with their studies using AR technology to study English. Çakır et al. (2015) also revealed that AR technology positively affects academic success in teaching foreign languages. On the other hand, in a study on the use of AR in teaching Turkish to foreigners, it was determined that the effect of AR is not different from the traditional method (Kanal, 2020).

Furthermore, in the current study, it was suggested that these materials should offer more visual diversity, provide real-life sections, support with a more appropriate sound level, voice narration and smart board when preparing AR-supported material. Indeed, according to Patirupanusara (2012), İbili et al. (2020), Kerr and Lawson (2020) three-dimensional learning materials prepared by using AR technology is more effective than traditional methods and provides more efficient learning. Accordingly, it is believed that materials with AR support will be used in enriching the visual aspect and will have more impact on learning. In addition, the proposal regarding the fact that AR based teaching material contains real-life sections. With this suggestion, it is thought that AR material can be an alternative in situations where it will be difficult to apply in real life. This is because, with AR technology, subjects that cannot be observed or implemented in real life and that are difficult to reach can be easily moved to educational environments (Shelton and Stevens, 2004; Wojciechowski and Cellary, 2013; Redondo, Cózar-Gutiérrez, González-Calero and Ruiz, 2020).

Another issue that is emphasized is the availability of AR technology except from education. In this context, while the learners state that such applications can be used in all sectors; they emphasized that it can be used especially in the field of engineering and health. Similar studies in the field support the current results (Aslan and Erdoğan, 2017; İçten and Bal, 2017).

The quantitative dimension and the qualitative dimension of the study gave consistent results. While AR based material developed within the scope of the research positively affected learning, it was seen that the learners gave a positive opinion about this material. Considering all results, the following recommendations are presented:

1. AR applications should be widespread in different lessons suitable for students' levels and the learning outcomes of the lessons.
2. In order to increase the effect of AR application, three dimensional objects and animations with high visual diversity should be used more.
3. Audio lesson support should be added to AR based materials to be prepared to increase comprehensibility and efficiency. If different voices are used except for audio lectures, the volume should be adjusted so as not to distract.
4. In order to overcome the ergonomic difficulties arising from the fact that mobile devices used in AR technology are kept on the code in order to match the code with the visual, the usage periods of the visuals to be used in teaching should be adjusted correctly.
5. While preparing course material with AR technology; Parameters such as age, level, classroom environment and technological infrastructure of the group that will use the material should be taken into consideration.
6. AR technology should be used in the fields of science, health, foreign language teaching and engineering in order to obtain practical knowledge and experience of situations, events, experiments or objects that are difficult to access, observe, and experience.
7. The quantitative dimension of the research should be strengthened by supporting the attitude / motivation scales and the qualitative dimension with the opinions of the practitioner (teacher) and observations.

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