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**Nevin Kozcu Cakir**   
Mugla Sitki Kocman University, Turkey

**Gokhan Guven**   
Mugla Sitki Kocman University, Turkey

**Cuneyd Celik**   
Mugla Sitki Kocman University, Turkey

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# Integration of Mobile Augmented Reality (MAR) Applications into the 5E Learning Model in Biology Teaching

Nevin Kozcu Cakir, Gokhan Guven, Cuneyd Celik

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## Abstract

This research aims to determine the effect of MAR's integration into 5E learning in teaching biology. Particularly, its impact on the academic success of the preservice teachers and their attitudes towards digital technology is studied. To this end, the convergent parallel mixed research method is used. The study was conducted with the 31 preservice science teachers in a General Biology Laboratory Course in the 2018-2019 academic year. As the data collection tools, "Achievement Test with Open-Ended Questions", "Attitude Scale towards Digital Technology" and "Semi-Structured Interview Form" were used. The evaluation of the research results indicates that MAR practices in the biology laboratory have increased the academic success and positively affected the attitudes of preservice teachers towards digital technology. Moreover, preservice teachers expressed that applications of MAR facilitated their learning and understanding, making the lessons more attractive. Accordingly, the use of MAR applications are recommended in teaching Biology to examine various anatomical structures.

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## Introduction

The diversity in technological products introduced with the development of technology in the world increases the use of technology by activating individuals' interests and curiosity. Mobile phones are among such products that we consistently carry with us in our daily life. According to the 2019 Global Digital Report, the number of mobile-phone users increased by 100 million (2%) compared to the previous year, reaching 67% (5.1 Billion) of the world's total population. With three million new users in 2019 (3.9%), this number reached 93% in Turkey. 77% of these people use smartphones. In the same report, it is predicted that upward trend will continue over time. Individuals' predisposition and susceptibility to technology will also gradually increase (Global Digital Reports, 2019).

In the current century, smartphones with their various unique functions can perform tasks similar to the ones performed by computers. Sometimes they could even display superior features. Due to the ease of accessibility and use, they are utilized by individuals from every business sector to carry out numerous activities, regardless of age and profession. Generation Z's susceptibility to technology and their use of such technologies in daily life has brought up the use of such technologies in their learning environments in academic environments, and

programs or applications have been developed for use in educational contexts. These applications and programs can support and enrich the learning process with their potential features (Gan & Balakrishnan, 2016; Kaliisa, Palmer, & Miller, 2019).

It is observed that the curriculums are insufficient in terms of fulfilling the diverging expectations of today's youth, which is expressed as generation Z (Somyurek, 2014). Therefore, work is being carried out to reshape the curriculum/environments by enabling the using innovative technologies (Celik, Guven, & Kozcu Cakir, 2020; Kozcu Cakir & Guven, 2019). On the other hand, science education programs, where the use of technological tools is essential, have also been restructured. Here, the aim is not only to raise science-literate individuals but also to provide students with necessary skills required by 21st-century. Effective technology use in education and training environments comes to the fore among such skills. Accordingly, modern devices and innovative technologies have become essential to produce and support rich teaching environments (Kozma & Anderson, 2002; Wang & Hannafin, 2005). Web 2.0 technology tools such as simulations, animations, game-based mobile applications, cartoon-based visuals, image, video, and audio editors are some new technology applications in education (Kazanci & Donmez, 2013). One of these applications also is mobile augmented reality (MAR).

Mobile augmented reality is defined as a platform where simultaneous interaction between virtual and real objects is established by adding virtual objects such as 2D or 3D images, sound, video, GPS location information on real images with the help of a tablet or mobile device (Dunleavy, Dede, & Mitchell, 2008; Rhodes, 2015). This technology is first adopted in the defense industry, especially in the military industry and exercises, with the 3D design of the products. In time, it has become widespread as a decoration simulation tool in architecture, location-based guides, and engineering simulation tools in the field of travel (Lee, 2012; Somyurek, 2014). MAR has also been started to be used effectively in the field of education, as it could integrate real and virtual environments, effortlessly embody abstract concepts, provide multiple environments. It appeals to many senses, and contributes to the development of several unique skills, even in the classroom environment (Hung, Chen, & Huang, 2017; Ozdemir, 2017). When the literature is examined, it is seen that it is used in physics education: especially in the subjects of magnetism, magnetic field lines, astronomy and electricity (Abdusselam & Karal, 2020; Martin Gutierrez, Fabiani, Benesova, Meneses-Fernandez, & Mora, 2015; Zhang, Sung, Hou, & Chang, 2014); in chemistry education: especially in the subjects of periodic table, the properties of the atom (Wojciechowski & Cellary, 2013); in biology education specifically with regard to human anatomy, genetics and ecosystem issues (Hsiao, Chen, & Huang, 2012; Kucuk, Kapakin, & Goktas, 2015). Augmented reality is used not only on the basis of theoretical education but also as an interesting technological application in informal teaching environments.

## **Literature Review**

The literature shows that the use of MAR applications in teaching practices improves students' spatial skills in providing 3D and 2D visualization (Martin Gutierrez et al., 2010; Wojciechowski & Cellary, 2013). It increases persistence in learning due to the inclusion of multiple senses in the learning process (Radu, 2014; Wojciechowski & Cellary, 2013); and as it offers a remarkable learning environment, students' interest in the

lesson increases (Wei, Weng, Liu, & Wang, 2015; Yilmaz & Batdi, 2016). MAR provides a straightforward implementation of the teaching methods that cannot be carried out under all conditions (Abdusselam, 2014; Lee, 2012) and it enables meaningful learning by linking topics with daily life (Cai, Wang, & Chiang, 2014). Some abstract concepts are made concrete and easier to teach (Klopfer & Squire, 2008; Wu, Lee, Chang, & Liang, 2013); and it can carry the learning process out of the classroom as well (Huang, Chen, & Chou, 2016). Moreover, it is emphasized that MAR applications will comprise an indispensable part of the teaching process soon as they provide personalized educational opportunities according to the individual learning speed (Lee, 2012), and flexible learning environments to the individuals regardless of time and place in the learning process (Ozdemir, 2017).

It is especially stated that the MAR applications in science education enable the visualization and concretization of 3-dimensional structures or concepts such as plant-animal cells, the structure of DNA, solar system, systems, sense organs; by offering a remarkable learning environment, they decrease the negative perceptions of students towards learning science and contribute positively to their academic success by enabling the spatial visualization/ consideration of the concepts. Biology, one of the fundamental areas of science education, is an integral part of our daily lives because it examines living organisms and their life processes. However, due to words with Latin origin and abstract concepts used in the lessons, biology is one of the Subjects that students have most difficulties, problems in understanding and highest level of failure (Katircioglu & Kazanci, 2002; Lukin, 2013). It is also observed that students cannot structuralize it in their minds because they have various misconceptions about biology and cannot embody its concepts (Kirilmazkaya & Kirbag Zengin, 2016; Kose, Ayas, & Usak, 2006).

In a biology lesson, “systems” is shown among as one of the most difficult topics to be absorbed by students (Sungur & Tekkaya, 2003). Some studies show that there are learning difficulties in relation to the systems issues, and there are misconceptions accordingly (Pelaez, Boyd, Rojas, & Hoover, 2005; Selvi & Yakisan, 2004). The same studies suggest that, rather than the direct presentations, alternative techniques should be used to eliminate these misconceptions. That is so because, teaching based on teacher-centered narratives can cause students to make wrong connections between the systems that make up our body (Gungor & Ozgur, 2009). Because the elements that make up this system are known as much either as the smaller parts that can be observed (the outward-looking aspect of the eye, the part of the nose outside the body) or as the static image existing in the textbooks (holistic anatomy of the brain).

Moreover, understanding the structure of the kidney or heart with only human senses and limiting this phenomenon to the method of presentation will not make it possible for the learning to be fully realized. Thus, it is thought that the education will be enriched by utilizing the conveniences provided by the technology and transforming the body elements into a mobile kinetic structure. Studies on this subject emphasize that the use of MAR applications is essential in the teaching of various concepts in biology (Celik, Guven, & Kozcu Cakir; Chang, Chung, & Huang, 2016; Chiang, Yang, & Hwang, 2014; Hsiao, Chen, & Huang, 2012; Perez-Lopez & Contero, 2013). Especially the brain, which is one of the nervous system elements, has a complex structure, it is crucial for the learning to be realized to understand the structure better or to examine it in person. Related to

this, Oakley (2012) stated that the dissection technique is a good way to examine anatomical structures and to understand these structures easily by students. However, the small number of the structure to be dissected in the laboratory and the large number of students who examine it may prevent all students from having an effective learning process (Deveci Topal & Ocak, 2014). Because the structure to be dissected in laboratory is limited in number and there are too many students, education is given to a limited number of individuals during the dissection. While the complexity of the regions to be examined on the brain can prevent students from accessing information, it could also lead to deficiencies of training skills. For this reason, recently, technology-supported trends have started to appear in the dissection methods in laboratory (Elizondo Omaña, Guzmán López, & García Rodríguez, 2005; Villiers & Monk, 2005). MAR applications, one of these technological trends, can help students be guided during dissection by revealing the brain in 3-dimensional and clear ways. However, MAR applications should be carried out in learning environments based on the constructivist approach. Because students can ensure that information is structured in mind through active learning with this approach (Acikgoz, 2014). Various learning models have been developed for using this approach in learning environments. One of these learning models is the 5E learning model.

In particular, this model is based on a structuralist approach to create rich learning environments and increase its quality by designing science lessons (Bybee, Taylor, Gardner, Scotter, Powell, Westbrook, & Landes, 2006). Thus, it can be expected that the MAR applications integrated into the 5E learning model will enable students to understand the subjects better, and to configure the concepts easily in their minds, thereby increasing their academic success. Besides, the availability of 3D technology in teaching environments may affect students' attitudes towards digital technology. From this point of view, this research aims to determine the effects of conducting activities related to circulatory, urinary, nervous systems, and sense organs, within the scope of General Biology Laboratory II, with mobile augmented reality (MAR) applications integrated into the 5E learning model. Besides, it is aimed to determine preservice science teachers' views about these practices. Accordingly, the following research questions are examined:

- (1) What is the effect of MAR practices integrated into the 5E learning model carried out in the biology laboratory on the academic success of preservice teachers?
- (2) What is the effect of MAR practices integrated into the 5E learning model carried out in the biology laboratory on the preservice teachers' attitudes towards digital technology?
- (3) How do MAR practices integrated into the 5E learning model carried out in the biology laboratory affect the learning process of preservice teachers?
- (4) How do MAR practices integrated into the 5E learning model performed in the biology laboratory effect the preservice teachers' attitudes towards digital technology?
- (5) What are the general views of preservice teachers towards MAR applications integrated into the 5E learning model carried out in the biology laboratory?

## **Method**

### **Research Model**

In the research, a mixed research method, including both qualitative and quantitative data collection and analysis

processes were used. The pattern classification of the study is a converging parallel pattern (Creswell & Plano Clark, 2011). In this pattern type, the process of quantitative and qualitative data collection and analysis occurs simultaneously or in periods close to each other. The integration of data usually takes place after separate analysis (Fetters, Curry, & Creswell, 2013). In the quantitative dimension of the research, the within-subject experiment design was used. After this process, it is tried to obtain more detailed information on subject by using the semi-structured interview form. The pattern of the study is given in Table 1.

Table 1. Research Pattern

<b>Pretest</b>	<b>Application</b>	<b>Post-test</b>
Achievement Test with Open-Ended Questions	Mobile Augmented Reality Applications	Achievement Test with Open-Ended Questions
Attitude Scale towards Digital Technology		Attitude Scale towards Digital Technology
		Semi-Structured Interview Form

### **Study Group**

The study group consists of 31 preservice teachers (25 females and 6 males) who took the “General Biology Laboratory” course during the spring semester of the 2018-2019 academic year, studying at the department of Science Teaching of the faculty of education of a state university in Turkey. The participants’ ages vary between 19 and 20. The study group was determined with Purposeful Sampling Method.

### **Data Collection Tools**

In the study, the attitude scale towards digital technology and the achievement test consisting of open-ended questions related to circulatory, urinary, nervous systems, and sense organs were used to obtain quantitative data. Qualitative data were collected using a semi-structured interview form.

#### *Attitude Scale towards Digital Technology*

The scale was developed by Cabi (2016) to determine the students’ attitudes towards digital technology through validity and reliability studies. It is a 5-point Likert type scale, consisting of 39 items. It has eight sub-dimensions: competence (10 items), social networks (4 items), and technology use in the course (4 items), interest in technology (5 items), technology for me (4 items), negative aspects (5 items), recreational use (4 items) and conscious use (3 items). For example, the item “*Using digital technology in my lessons increases my interest in the course*” is included in the technology usage sub-dimension of the scale. The overall Cronbach’s Alpha reliability coefficient for the scale was calculated as 0.90.

#### *Achievement Test with Open-Ended Questions*

The achievement test was composed by researchers in such a way that it could cover subjects of circulatory

(heart), urinary (kidney), and nervous systems (brain), as well as sense organs (eyes). The test includes four visual questions about the anatomy of the heart, brain, kidney, and eye, and six open-ended questions regarding the functioning of these structures. For example, the question “How does the blood filter function in the kidney?” is related to the functions of the kidney. Findings obtained from open-ended questions were quantified according to the correct answers given by preservice teachers with the help of a rubric encoded between 0 and 10. Thus, the points that can be obtained from the achievement test are between 0-100. Expert opinions regarding the content validity of open-ended questions were obtained. The experts consist of two science educators, a biology educator, and an assessment and evaluation specialist. Regarding the reliability of the test, the consistency between raters was examined, and it was found to be between 0.91-1.00.

#### *Semi-Structured Interview Form*

The interview form was used to determine the preservice teachers’ opinions on mobile augmented reality applications in the biology laboratory. The interview form contains four open-ended, semi-structured questions. The questions were prepared by the researchers and they aim to reveal the preservice teachers’ thoughts on MAR practices (1 item), learning processes (1 item), and digital technology (2 items) carried out in the biology laboratory. While ensuring the construct validity of the prepared questions, expert opinion (two specialists in science education and one assessment and evaluation specialist) is referred. The final form of the interview form was given by making the necessary corrections in line with the experts’ opinion. In this context, interviews were held with 28 preservice teachers, together with 15-minute semi-structured questions. Interview data were recorded with a voice recorder. The interview form had the following questions:

- (1) Did MAR applications in the biology laboratory have an impact on your learning of scientific knowledge? Please explain.
- (2) Would you like to use technological tools such as MAR applications in your laboratory when you become a teacher? Explain why.
- (3) Has there been any change in your attitude towards technology thanks to the MAR application examples carried out in the biology laboratory? Explain why.
- (4) What do you think about MAR applications performed in the biology laboratory?

#### **Implementation of the Research**

The research was carried out in the biology laboratory for two weeks (50 min + 50 min), two weeks for data collection, one week for the introduction of MAR applications, and four weeks for mobile augmented reality events. The study was carried out within the scope of the 2nd grade “General Biology Laboratory” course of the science teaching program. Within the scope of the course, dissection procedures related to the anatomy and functions of heart, brain, kidney, and eye together and MAR applications integrated into the 5E learning model were carried out together with preservice teachers. The applications were carried out in a laboratory environment suitable for the 5E learning model based on the constructivist approach, where preservice teachers took an active role with the teacher in a guiding position. The content of the application corresponding to each week is given in Table 2.

Table 2. The Application Process of the Research

Weeks	Applications
1. Week Application of data collection tools	Achievement Test with Open-Ended Questions Attitude Scale towards Digital Technology
2. Week MAR introduction	Introducing MAR applications, how they are realized, associating them with the subject and the concept and making sample applications.
3. Week MAR Applications	Application 1: MAR application of the anatomy of the brain and dissection process
4. Week MAR Applications	Application 2: MAR application of the anatomy of the eye and dissection process
5. Week MAR Applications	Application 3: MAR application of the anatomy of the heart and dissection process
6. Week MAR Applications	Application 4: MAR application of the anatomy of the kidney and dissection process
7. Week Application of data collection tools	Achievement Test with Open-Ended Questions Attitude Scale towards Digital Technology Semi-Structured Interview Form

A sample course content is given below regarding the MAR applications integrated into the 5E learning model performed within the scope of the study.

**Engagement:** Various questions are asked to determine the pre-knowledge of preservice teachers on the subject: “Into how many parts is the nervous system divided?” “What are the elements that make up the central nervous system?” and “What are the tasks of the human brain?” At this stage, questions from daily life are used to draw preservice teachers’ attention to the subject: “Do you think there is a functional difference when the dimensions of the human brain and elephant brain are compared? If so, what difference is there?” The preservice teachers were asked, “Do you think the left hemisphere of the brain controls the right side of our body and the right hemisphere to the left side?” to create a discussion environment in the laboratory, thus enabling them to question their ideas and try to establish relationships between concepts.

**Exploration:** Preservice teachers are informed about the usage and operation of *The BrainAR* application. Besides, MAR marker paper (given in Appendix), which used in this application, is distributed, and the teachers are asked to examine the brain anatomy with the help of application (see Figure 1). Preservice teachers are asked various questions about the anatomy of the brain in the application, and they are asked to answer these questions individually. Preservice teachers try to visually explore the anatomy of the brain and configure it in their minds by using the MAR application.

**Explanation:** At this stage, preservice teachers are asked to reflect the information on the anatomy of the brain, which they learned in MAR practice, to the brain dissection and explain the functions of these structures (see Figure 2). For this purpose, class discussion is initiated first in the laboratory, followed by a group discussion.





Figure 1. Marker Paper\* and MAR Application

(\*: The marker paper is pictures or real objects which used to activate visual elements on the mobile device.)

**Elaboration:** At this stage, the anatomy and related functions of the brain are associated with daily life. For example, a video about “Einstein and His Brain” is shown to preservice teachers, and a class discussion is held on this subject.



Figure 2. Brain Dissection

**Evaluation:** Preservice teachers are asked to write a science-diary about the applications. The science diary include the following contents; “the purpose of the activity”, “the learned Biology concept and the scientific information about it”, “affective experiences related to the activity” and “integration of the activity into daily life”. The science diaries are evaluated by the researchers by means of the rubrics prepared.

### **Data Analysis**

In the research, quantitative data obtained from the achievement test consisting of attitude scale towards digital technology and open-ended questions were analyzed with SPSS 26 program. Accordingly, to compare the pretest and posttest average scores for the measurements between dependent groups, paired-samples t-test was used. For paired-samples t-test, the effect size was calculated. The guidelines (proposed by Cohen, 1988) for

interpreting this value are: .10=small effect, .30=moderate effect, .50=large effect. The sound recordings obtained from semi-structured interviews were deciphered into text in computer environment and analyzed using a descriptive analysis method, which is one of the most common qualitative analysis methods. Besides, frequency and percentage values related to these descriptions are given.

Some operations were performed in relation to reliability and validity of the data collected in the current study on the basis of the concepts of transferability, and consistency. The detailed description method was applied to enhance the transferability of the results of the research. Within the context of the description method, direct quotations were made from the statements of the students. Consistency analysis method was used within the concept of “consistency” regarding the reliability of qualitative data. In line with this method, an expert in qualitative research looked at the research as an outsider and conducted an examination of the consistency of the researchers in the process of the construction of data collection tools, data collection, analysis and interpretation. The required arrangements were made for these analyses by the researchers.

## Results

### Quantitative Findings

#### *Findings related to the First Research Question*

Academic achievement scores of preservice teachers for open-ended questions before and after MAR applications were analyzed with paired-samples t-test analysis. The related findings are presented in Table 3.

Table 3. Paired-Samples t-Test Results for Academic Achievement Scores

Variable	Pre test		Post test		t(31)	p	Cohen's d
	M	SD	M	SD			
Academic achievement	10.71	8.25	67.97	17.96	15.34	.000	.89

When Table 3 is examined, it is found that preservice teachers' academic achievement scores showed a statistically significant difference before and after MAR practices integrated into the 5E learning model performed in the biology laboratory [ $t(31) = 15.34, p < 0.05$ ]. It is seen that this difference is in favor of preservice teachers' posttest score results. It has been determined that the effect size of this determined difference is large. Accordingly, it can be said that MAR practices integrated into the 5E learning model carried out in the biology laboratory positively affect the academic success of preservice teachers.

#### *Findings related to the Second Research Question*

The attitude scale towards digital technology consists of the following sub-dimensions: social networks, use of technology in the course, interest in technology, technology for me, negative aspects and conscious use. The preservice teachers' scores on the attitude towards digital technology before and after MAR applications and the whole scale were analyzed by paired-samples t-test, and related findings are given in Table 4.

Table 4. Paired-Samples t-Test Results for Attitude Scores towards Digital Technology

Variables	Pre test		Post test		t(31)	p	Cohen's d
	M	SD	M	SD			
Competence	21.74	4.67	37.48	5.34	-11.569	.000	.82
Social networks	10.03	3.04	13.84	3.20	-3.834	.001	.32
Technology use in the course	8.10	2.67	15.32	3.50	-9.234	.000	.74
Interest in technology	9.42	2.81	19.94	3.91	-10.609	.000	.79
Technology for me	6.58	1.76	15.26	4.38	-9.789	.000	.76
Negative aspects	15.35	3.55	18.13	1.89	-3.793	.001	.32
Recreational use	12.71	2.87	13.58	2.36	-3.046	.005	.23
Conscious use	5.13	1.65	12.55	1.93	-14.266	.000	.87
Digital technology attitude (Total score of the scale)	90.71	11.98	146.90	14.95	-16.300	.000	.90

When Table 4 is analyzed, it is found that there was a statistically significant difference between the scores of each sub-dimension in the attitude scale towards digital technology and the preservice teachers' total score before and after the MAR applications integrated into the 5E learning model realized in the biology laboratory [tcompetence = -11.569, tsocial networks = -3.834, tuse of technology in the course = -9.234, tinterest in technology = -10.609, ttechnology for me = -9.789, tnegative aspects = -3.793, tconscious use = -14.266, tdigital technology attitude = -16.300,  $p < 0.05$ ]. It is seen that this difference is in favor of the pretest score results obtained from the preservice teachers' sub-dimensions and scale. It has been determined that the effect sizes of these determined differences are all large. In this regard, it can be said that the MAR applications integrated into the 5E learning model carried out in the biology laboratory positively affect the preservice teachers' competence, social networks, use of technology in the course, interest in technology, technology for me, negative aspects, entertainment and conscious use sub-dimensions and attitudes towards digital technology.

### Qualitative Findings

#### *Findings related to the Third Research Question*

During the interviews made after MAR applications, preservice teachers were asked the following question: "Did MAR applications performed in the biology laboratory have an impact on your learning of scientific knowledge? Please explain." The frequency and percentage values of the preservice teachers' answers to this question are given in Table 5.

When Table 5 is examined, it is seen that preservice teachers stated that MAR applications have positive effects on scientific knowledge learning processes. Preservice teachers said that MAR applications contribute to their learning because they show the anatomical structures in 3D; they provide visual and auditory examination opportunities, and objectify abstract concepts and enable continuous learning. In this context, it can be said that the effect of MAR applications integrated into the 5E learning model carried out in the biology laboratory on the learning processes of scientific information has a positive effect.

Table 5. Opinions about the Effect of MAR Applications on Learning Processes

<b>Opinions</b>	<b>f</b>	<b>%</b>
It allows us to see structures in three dimensions	16	57
It allows us to examine the structures visually and audibly	16	57
It objectifies abstract concepts	14	50
It eases the learning by contributing	9	32
MAR application allows me to learn permanently	9	32
It configures concepts related to biology in mind easily	6	21

The answers given by preservice teachers in the interviews regarding these situations are given below:

*Preservice teacher-5:* The MAR applications we have made have contributed to my continuous learning by providing us with the opportunity to see various structures in biology subjects in 3 dimensions and by transferring functions and tasks in auditory format.

*Preservice teacher-8:* While some concepts remained abstract in previous applications, they became much more concrete after these applications in the biology laboratory.

*Preservice teacher-19:* Structures that were not presented well in the pictures of the previous applications were better structured in our minds with MAG applications. Thus, it made me learn the subject more clearly and understandably.

#### *Findings related to the Fourth Research Question*

During the interviews made after MAR applications, the following questions were asked to preservice teachers: “Would you like to use technological tools such as MAR applications in laboratory when you become a teacher? Explain why?” and “Have there been any changes in your attitude towards technology thanks to examples of the MAR applications carried out in the biology laboratory? Explain why?” Frequency and percentage values regarding the answers given by preservice teachers towards the first question are shown in Table 6.

Table 6. Opinions about the Use of Technological Tools such as MAR Applications in Laboratory

<b><i>Application request</i></b>	<b><i>f</i></b>	<b><i>%</i></b>
Yes	26	93
No	2	7
<b><i>Reasons</i></b>		
The application is an easy program	20	72
Using technological tools in daily life	18	64
Attracting students' attention	15	54
Enabling learning	14	50
Having high visual supports	14	50
Competence in using technology	12	43
Feeling insufficient in using technology	2	7

When Table 6 is analyzed, it is seen that most of the preservice teachers stated that they want to use technological tools such as MAR applications in laboratory applications when they become teachers. Preservice teachers reported that they could choose to use technology in laboratory applications due to MAR applications being an easy program, attracting students' attention, enabling learning, having high visual supports, and using such technological tools and equipment daily life. Moreover, in the interviews it was determined that while most preservice teachers felt competent in using such technological applications, only two preservice teachers did not consider themselves sufficient.

The answers given by preservice teachers in the interviews regarding these situations are given below:

*Preservice teacher-7:* When I become a teacher, I would like to use technological applications such as MAR in my lessons. Because such applications attract the attention of the students and enable them to learn more efficiently.

*Preservice teacher-13:* ... I would like to use it because different technologies such as mobile phones are frequently used in our daily life. Thus, the students' attitude towards the lesson will be more positive.

*Preservice teacher-26:* ... I don't want to use it because I feel incompetent in using technology.

Frequency and percentage values regarding the preservice teachers' answers for the second question are given in Table 7.

Table 7. Opinions about the Effect of MAR Application Samples on Technology Attitudes

<i>The status of change</i>	<i>f</i>	<i>%</i>
Yes, in a positive way	26	93
No, there is not	2	7
<b><i>Reasons</i></b>		
Technology eases daily routine	16	57
Increasing student performance	15	54
Technological applications make the lesson fun	15	54
Technology being effective in teaching	13	46
Integrating technology used in daily life into the lesson	10	36
MAR applications being transferable to different areas	5	18
Increasing interest in biology	4	14

When Table 7 is analyzed, it is seen that the majority of preservice teachers stated that the samples of MAR application carried out in the biology laboratory caused a positive change in attitudes towards technology. Preservice teachers indicated a positive difference in their attitude towards technology due to fact that MAR applications made daily routine easy. The increased student performance, made the lesson enjoyable. They were effective in teaching, as it was possible to transfer them to different fields. These applications raised the interest in biology. Besides, two preservice teachers stated that MAR practices did not change the attitudes towards technology. As a reason for this situation, they noted that using such technological applications is difficult, and they do not see themselves adequate in terms of using technology. In this context, it can be said

that MAR practices integrated into the 5E learning model carried out in the biology laboratory have a positive effect on the preservice teachers' attitudes towards digital technology.

The answers given by preservice teachers in the interviews regarding these situations are given below:

*Preservice teacher-8:* I was not aware of the existence of such an application. Thanks to the applications made, I learned something nice and discovered that I could learn the lessons better with such applications. So my attitude towards technology has changed.

*Preservice teacher-15:* ... I realized that technology is not only made up of entertainment and social media but also of applications that make learning enjoyable.

*Preservice teacher-28:* ... No, it didn't. Because using technology is challenging me a bit. I am not good at using technological applications.

*Findings related to the Fifth Research Question*

In the interviews made after the MAR applications, the following question was asked to preservice teachers: "What do you think about MAR applications performed in the biology laboratory?" The frequency and percentage values of the preservice teachers' answers to this question are given in Table 8.

Table 8. General Opinions about MAR Applications in Biology Laboratory

<i>Opinions</i>	<i>f</i>	<i>%</i>
Facilitates learning and understanding	25	89
Gives preliminary information before dissection experiment	20	72
Making the lesson fun and attractive	20	72
Provides a productive learning environment	19	68
Provides attention and focus	17	61
Contributes to the development of the teaching profession	6	21
Saves cost and time	5	18

When Table 8 is examined, it is seen that preservice teachers stated that the MAR practices carried out in the biology laboratory facilitate learning and understanding, provide prior knowledge before dissection in the laboratory, make the lesson fun and attractive, and provide a productive learning environment. Furthermore, preservice teachers stated that MAR practices are effective in increasing their focus and attention, contributing to the teaching professions' development and saving time and money. In this context, it can be said that preservice teachers expressed various positive opinions about MAR practices integrated into the 5E learning model realized in the biology laboratory.

The answers given by preservice teachers in the interviews regarding these situations are given below:

*Preservice teacher-2:* Normally, we experiment. However, before the experiment, obtaining preliminary information with the MAR application allows us to dominate the experiment more.

*Preservice teacher-10:* The applications made the lesson more enjoyable and exciting. In this way, I

focused on the lesson and listened to it because it attracted my attention.

*Preservice teacher-22:* It was a useful application. I think that I will use such practices in our future teaching life.

## **Discussion**

As the first result of the research, it was determined, in line with the quantitative data, that MAR practices integrated into the 5E learning model performed in the biology laboratory were effectively increasing the academic success of preservice teachers. Also, qualitative data obtained from the interviews regarding the learning processes showed that preservice teachers structured concepts that could not be fully understood in mind in the laboratory environment and that their learning became more comfortable. There may be many reasons for this development.

The first reason may be that the MAR applications made within the scope of the study have 3D visual and auditory features, and the concepts are structured spatially. Thus, preservice teachers are provided with an opportunity to easily configure the x, y, z coordinates of anatomical structures in their minds. In studies related to this, it has been determined that the students have improved their spatial skills due to the 3D visual presentation feature of MAR applications and thus they can structure concepts better in their minds (Gun & Atasoy, 2017; Martin Gutierrez et al., 2010; Wojciechowski & Cellary, 2013).

The second reason may be that preservice teachers can adjust their learning speeds and manage the individual learning process by using MAR applications in a laboratory environment because preservice teachers have the opportunity to repeat many applications with MAR in learning anatomical structures and can progress according to their learning speed. Besides, learning to perform dissection procedures carried out in a biology laboratory in crowded groups creates a disadvantage for minds that are slower than others. MAR applications, which are carried out in a laboratory environment for this situation, provide preservice teachers with the opportunity to manage their learning processes with numerous repetition opportunities. Regarding this, Williams (2012) stated that today's students, defined as generation Z, prefer an interactive and tactual environment with multiple stimuli. Thus, the students of the generation Z prefer individualized learning environments, instead of teamwork as they control their learning speed (Lee, 2012; Tas, Demirdogmez, & Kucukoglu, 2017).

The third reason could be the fact that with MAR applications it is possible to provide the preservice teachers with prior knowledge visually and audibly before the dissection procedures of anatomical structures start. Thus, MAR applications guide preservice teachers to be more aware and consciously examined in dissection procedures of anatomical structures. In various studies conducted in the literature, it has been determined that there are improvements in cognitive levels as MAR practices guide students and help them teach in this direction (Hung, Chen, & Huang, 2017; Ozdemir, 2017).

In the second result of the study, it was determined, in line with the quantitative data, that MAR practices integrated into the 5E learning model carried out in the biology laboratory were effective in increasing the

attitudes of preservice teachers towards digital technology. Also, in the qualitative data obtained from the interviews regarding attitudes towards digital technology, preservice teachers stated that such applications attract their attention, make the lessons fun, increase in-class performance, and interest in the biology lesson. The integration of a technology product frequently used in daily life with the use of mobile devices in the MAR applications made here may have enabled the attitude to develop positively. Similarly, it has been stated in other studies that MAR practices affected positively the students' attitudes towards learning and lessons (Abdusselam, 2014; Wei, Weng, Liu, & Wang, 2015; Yilmaz & Batdi, 2016). In addition, the difficulty of obtaining the necessary materials for the examination of anatomical structures such as the brain, heart, kidney, and eye in the biology laboratory environment may hinder the learning process. This situation can be eliminated by allowing the organ to be dissected, regardless of time and location, to be easily accessed and examined by MAR applications. Thus, the fact that preservice teachers realize that they can overcome such difficulties thanks to technological applications such as MAR may have caused their attitude towards technology to develop positively. In other studies, it has been determined that MAR applications create learning opportunities for various disciplines in laboratory environments and provide affective developments by facilitating learning (Abdusselam, 2014; Akcayir, Akcayir, Pektaş, & Ocak, 2016; Martin-Gutierrez et al., 2015).

In the final result of the research, it was determined, in line with qualitative data that preservice teachers expressed various positive opinions about MAR practices integrated into the 5E learning model carried out in the biology laboratory. Preservice teachers stated that MAR applications facilitate learning and understanding, provide preliminary information before dissection in the laboratory, make the lesson fun and attractive, and provide a productive learning environment. They also emphasized that MAR practices are effective in providing focus and concentration, contributing to the development of the teaching profession and saving time and money. Similarly, in other studies, the following general features of augmented reality applications are underlined; providing a learning environment that can be applied in interactive and informal environments, being open to cooperation and group-questioning; providing learning concepts related to the regarding lesson easily, and constructing them permanently in mind and developing a positive attitude towards the subject or lesson (Yilmaz & Batdi, 2016).

## **Conclusions**

As a conclusion, in this study, it was determined that MAR practices integrated into the 5E learning model carried out in the biology laboratory were effective in increasing the academic success of the preservice teachers and in affecting positively their attitudes towards digital technology. In this context, the using MAR applications in biology teaching can be used to improve prospective teachers' cognitive and affective domains because preservice teachers can structure the anatomy related to biology spatially according to their learning speed with the possibility of 3D visual and auditory examination provided by such applications. Besides, MAR applications provide preservice teachers with pre-information in dissection procedures of anatomies and guide them in examining their subject in a more aware and conscious way. On the other hand, with MAG applications, mobile devices are involved in the learning environment. A technological product, which is frequently used in daily life, is integrated into the laboratory environment. Also, MAG applications allow easy access to the organ to be



dissected, regardless of time and location.

### Recommendations

In the future, a semi-experimental study with a control group can be carried out by integrating many participants in different fields, such as physics and chemistry. This study can help researchers examine the effects of MAR applications integrated into the 5E learning model on different variables in biology teaching. It is suggested that such MAR applications should be developed and used to embody abstract concepts in biology teaching.

### Limitations

Several limitations were present in the study reported here. The research is limited by (a) the internal validity of the study due to the absence of a control group, (b) the generalizability of the study results due to the small number of participants, (c) subject matter that only covers the biological study of the body organs such as the heart, brain, kidney, and eyes.

### References

- Abdusselam, M.S. & Karal, H. (2020). The effect of using augmented reality and sensing technology to teach magnetism in high school physics. *Technology, Pedagogy and Education*, 29(4), 407-424.
- Acikgoz, K.U. (2014). *Aktif Öğrenme*, [Active Learning]. İzmir: Biliş Yayınçılık.
- Akcayir, M.G., Akcayir, G., Pektas, H.M., & Ocak, M.A. (2016). Augmented reality in science laboratories: The effects of augmented reality on university students' laboratory skills and attitudes toward science laboratories. *Computers in Human Behavior*, 57, 334-342.
- Bybee, R.W., Taylor, J.A., Gardner, A., Scotter, V.P., Powell, J.C., Westbrook, A., & Landes, N. (2006). *The BSCS 5E instructional model: Origins and effectiveness*. Colorado Springs, Co: BSCS, 5, 88-98.
- Cabi, E. (2016). Attitude scale for digital technology. *Kastamonu Education Journal*, 24(3), 1229-1244.
- Cai, S., Wang, X., & Chiang, F.K. (2014). A case study of augmented reality simulation system application in a chemistry course. *Computers in Human Behavior*, 37, 31-40.
- Celik, C., Guven, G., & Kozcu Cakir, N. (2020). Integration of mobile augmented reality (MAR) applications into biology laboratory: Anatomic structure of the heart. *Research in Learning Technology*, 28, 1-11.
- Chang, R.C., Chung, L.Y., & Huang, Y.M. (2016). Developing an interactive augmented reality system as a complement to plant education and comparing its effectiveness with video learning. *Interactive Learning Environments*, 24(6), 1245-1264.
- Chiang, T.H.C., Yang, S.J.H., & Hwang, G.J. (2014). An augmented reality-based mobile learning system to improve students' learning achievements and motivations in natural science inquiry activities. *Educational Technology & Society*, 17(4), 352-365.
- Cohen, J.W. (1988). *Statistical power analysis for the behavioral sciences* (2nd edition). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Cresswell, J.W. & Plano Clark, V.L. (2015). *Mixed method researches, design and execution* (Dede, Y. &

- Demir, S. B. Çev.). Ankara: Anı Yayıncılık.
- Deveci Topal, A., & Ocak, M.A. (2014). The effect of the anatomy course prepared by the blended learning environment on students' academic achievement. *Educational Technology Theory and Practice*, 4(1), 48-62.
- Dunleavy, M., Dede, C., & Mitchell, R. (2008). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. *Journal of Science Education and Technology*, 18(1), 7-22.
- Elizondo-Omaña, R.E., Guzmán-López, S., & García-Rodríguez, M.D.L.A. (2005). Dissection as a teaching tool: Past, present, and future. *The Anatomical Record*, 285B(1), 11-15.
- Fetters, M.D., Curry, L.A., & Creswell, J.W. (2013). Achieving integration in mixed methods designs principles and practices. *Health Services Research*, 48(6), 2125–2133.
- Gan, C.L. & Balakrishnan, V. (2016). An empirical study of factors affecting mobile wireless technology adoption for promoting interactive lectures in higher education. *The International Review of Research in Open and Distributed Learning*, 17, 214-239.
- Global Digital Reports (2019). Digital in 2019. Retrieved <https://wearesocial.com/global-digital-report-2019> in 17 January 2020.
- Gun, E.T. & Atasoy, B. (2017). The effects of augmented reality on elementary school students' spatial ability and academic achievement. *Education and Science*, 42(191), 31-51.
- Gungor, B. & Ozgur, S. (2009). The causes of the fifth grade student's misconceptions originated from didactic about digestive system. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education*, 3(2), 149-177.
- Hsiao, K.F., Chen, N.S. & Huang, S.Y. (2012). Learning while exercising for science education in augmented reality among adolescents. *Interactive Learning Environments*, 20(4), 331-349.
- Huang, T.C., Chen, C.C., & Chou, Y.W. (2016). Animating eco-education: To see, feel, and discover in an augmented reality based experiential learning environment. *Computers & Education*, 96, 72-82.
- Hung, Y.H., Chen, C.H., & Huang, S.W. (2017). Applying augmented reality to enhance learning: a study of different teaching materials. *Journal of Computer Assisted Learning*, 33, 252-266.
- Kaliisa, R., Palmer, E. & Miller, J. (2017). Mobile learning in higher education: A comparative analysis of developed and developing country contexts. *British Journal of Educational Technology*, 50(2), 546-561.
- Katircioglu, H. & Kazanci, M. (2002). The effect of computer use in Biology teaching on student attitudes. *Educational Science and Practise*, 1(2), 225-233.
- Kazanci, A. & Dönmez, F.I. (2013). *Okul 2.0 Eğitimde Sosyal Medya ve Mobil Uygulamalar* [Social Media and Mobile Applications in School 2.0 Education]. Ankara: Anı Yayıncılık.
- Kirilmazkaya, G. & Kirbag-Zengin, F. (2016). Determination of photosynthesis misconceptions' through vee diagrams and preservice teachers' views towards these tools. *Erzincan University Journal of Education Faculty*, 18(2), 1537-1563.
- Klopfer, E. & Squire, K. (2008). Environmental detectives: the development of an augmented reality platform for environmental simulations. *Educational Technology Research and Development*, 56(2), 203-228.
- Kose, S., Ayas, A., & Usak, M. (2006). The effect of conceptual change texts instructions on overcoming prospective science teachers' misconceptions of photosynthesis and respiration in plants. *International*

- Journal of Environmental and Science Education*, 1(1), 78-103.
- Kozcu Cakir, N. & Guven, G. (2019). Arduino-assisted robotic and coding applications in science teaching: Pulsimeter activity in compliance with the 5E learning model. *Science Activities*, 56(2), 42-51.
- Kozma, R. & Anderson, R. (2002). Qualitative case studies of innovative pedagogical practices using ICT. *Journal of Computer Assisted Learning*, 18(4), 387-394.
- Kucuk, S., Kapakin, S., & Goktas, Y. (2015). Medical faculty students' views on anatomy learning via mobile augmented reality technology. *Journal of Higher Education & Science*, 5(3), 316-323.
- Lee, K. (2012). Augmented reality in education and training. *TechTrends*, 56(2), 13-21.
- Lukin, K. (2013). Exciting middle and high school students about immunology: An easy, inquiry-based lesson. *Immunologic Research*, 55 (1-3), 201-209.
- Martin-Gutierrez, J., Saorin, J.L., Contero, M., Alcaniz, M., Perez-Lopez, D.C., & Ortega, M. (2010). Design and validation of an augmented book for spatial abilities development in engineering students. *Computers & Graphics*, 34, 77-91.
- Martin-Gutierrez, J., Fabiani, P., Benesova, W., Meneses-Fernandez, M.D., & Mora, C.E. (2015). Augmented reality to promote collaborative and autonomous learning in higher education. *Computers in Human Behavior*, 51, 752-761.
- Oakley, J. (2012). Science teachers and the dissection debate: Perspectives on animal dissection and alternatives. *International Journal of Environmental & Science Education*, 7(2), 253-267.
- Ozdemir, M. (2017). Experimental studies on learning with augmented reality technology: A systematic review. *Mersin University Journal of the Faculty of Education*, 13(2), 609-632.
- Pelaez, N.J., Boyd, D.D., Rojas, J.B., & Hoover, M.A. (2005). Prevalence of blood circulation misconceptions among prospective elementary teachers. *Advances in Physiology Education*, 29, 172-181.
- Pérez-López, D. & Contero, M. (2013). Delivering educational multimedia contents through an augmented reality application: A case study on its impact on knowledge acquisition and retention. *The Turkish Online Journal of Educational Technology*, 12(4), 19-28.
- Radu, I. (2014). Augmented reality in education: A meta-review and cross-media analysis. *Personal and Ubiquitous Computing*, 18, 1533-1543.
- Rhodes, G.A. (2015). Future museums now-augmented reality musings. *Public Art Dialogue*, 5(1), 59-79.
- Selvi, M. & Yakisan, M. (2004). Misconceptions about enzymes in university students. *Gazi University journal of Gazi Educational Faculty*, 24(2), 173-182.
- Somyurek, S. (2014). Gaining the attention of generation Z in learning process: Augmented reality. *Educational Technology in Theory and Practise*, 4(1), 63-80.
- Sungur, S. & Tekkaya, C. (2003). Student achievement in human circulatory system unit: The effect of reasoning ability and gender. *Journal of Science Education and Technology*, 12(1), 59-64.
- Tas, H.Y., Demirdogmez, M., & Kucukoglu, M. (2017). Possible effects of future architects' Z generation on business life. *International Journal of Society Research*, 7(13), 1031-1048.
- Villiers, R.D. & Monk, M. (2005) The first cut is the deepest: reflections on the state of animal dissection in biology education, *Journal of Curriculum Studies*, 37(5), 583-600.
- Wang, F., & Hannafin, M.J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development*, 53(4), 5-23.


- Wei, X., Weng, D., Liu, Y., & Wang, Y. (2015). Teaching based on augmented reality for a technical creative design course. *Computers & Education*, 81, 221-234.
- Williams, S. (2010). Welcome to generation Z. *B&T Magazine*, 60(273), 1-12.
- Wojciechowski, R. & Cellary, W. (2013). Evaluation of learners' attitude toward learning in ARIES augmented reality environments. *Computers & Education*, 68, 570-585.
- Wu, H.K., Lee, S.W.Y., Chang, H.Y., & Liang, J.C. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & Education*, 62, 41-49.
- Yilmaz, Z.A. & Batdi, V. (2016). A meta-analytic and thematic comparative analysis of the integration of augmented reality applications into education. *Education and Science*, 41(188), 273-289.
- Zhang, J., Sung, Y.T., Hou, H. T. & Chang, K.E. (2014). The development and evaluation of an augmented reality-based armillary sphere for astronomical observation instruction. *Computers & Education*, 73, 178-188.

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### Author Information

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#### **Nevin Kozcu Cakir**

 <https://orcid.org/0000-0002-7538-7882>

Muğla Sitki Kocman University

Kötekli, Muğla

Turkey

#### **Gokhan Guven**

 <https://orcid.org/0000-0001-9204-5502>


Muğla Sitki Kocman University

Kötekli, Muğla

Turkey

Contact e-mail: [gokhanguven@mu.edu.tr](mailto:gokhanguven@mu.edu.tr)

#### **Cuneyd Celik**

 <https://orcid.org/0000-0002-1188-6260>

Muğla Sitki Kocman University,

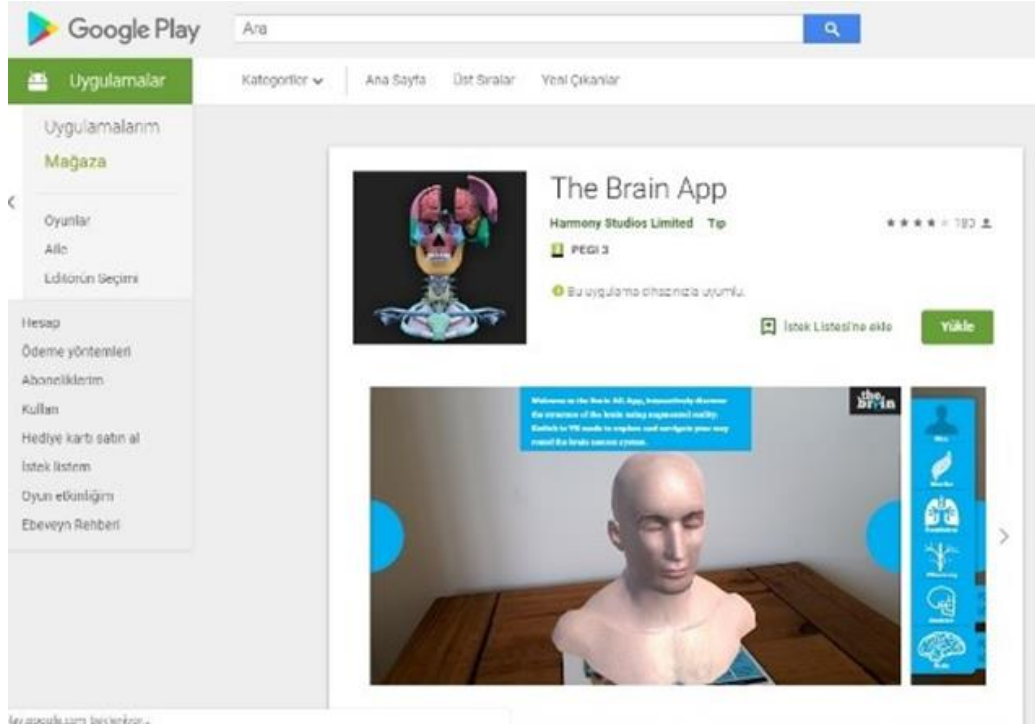
Kötekli, Muğla

Turkey

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## Appendix. Marker Paper

- (1) The name of the MAR application differs according to the operating system of the phone. For this reason, the name of the application for the Google Play Store is "The Brain App".



- (2) The application opens after it is installed on the phone.
- (3) After opening, the program will turn on your phone's camera. The viewfinder of the camera was read by the marker prepared within the context of Biology Laboratory Course and shown at the back.
- (4) The emerging 3D model is examined in depth according to the directions given in the course.