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The Effect of 7th Grade "Cell and Divisions" Unit Teaching with Augmented Reality Technology on Students' Academic Achievement[1]

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ABSTRACT

This study was carried out to determine the effect of the 7th grade 'Cell and Divisions' unit of the science course with augmented reality technology on the academic achievement of the students. The study group of this research, which was prepared in the "pretest-posttest control group" quasi-experimental model, consists of 79 students in the 7th grade attending a public school in the Antakya district of Hatay province in the 2017-2018 academic year. There are 40 students in the experimental group and 39 students in the control group. While the "Cell and Divisions" unit was taught to the experimental group students by using active learning, technology-centered and internet interactive learning methods with augmented reality applications, the control group students received regular education in line with the program. The application was completed by the researcher within 16 lesson hours. The "Cell and Divisions Achievement Test" (CDAT), which was used as a data collection tool and for which validity and reliability studies were conducted, was administered to both groups before and after the application. In the analysis of the collected data, dependent and independent t-tests from statistical procedures were tried to be analyzed using SPSS 21 package program. At the end of the evaluation of the data; it was concluded that the academic achievement of the students in the experimental group was significantly higher than the students in the control group and the effect size was calculated intermediate level effect. It is thought that the use of augmented reality applications in science courses may have positive effects on students' achievement.

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INTRODUCTION

In the 21st century, with the development of technology and science, the dimensions of technological tools and applications are getting smaller and smaller, while their impact on people is increasing, which leads to a differentiation in the technological knowledge of students. Technological breakthroughs, which have an important place in the rapid development and changes in the world, inevitably affect the world of education and training. In particular, the rapid changes and inventions in information technologies in recent years have brought significant contributions to the field of education and training as well as the comfort and benefits they bring to all areas of life (Yuen et al., 2013; Pamuk et al., 2013; Somyürek, 2014; Karacaoğlu,2020; Dere & Demirci, 2021). Information and communication technologies have an important role to play in ensuring intercultural and interdisciplinary integration. The importance given to lifelong learning in developed countries is increasing day by day. Although schools have an important place in the achievement of knowledge, they alone are not considered sufficient in today's conditions. For this reason, a new term "learning to learn" is emerging, triggered by developments in education and information technologies (Karacaoğlu, 2018).

When the studies on the nature of technology are examined, it is known that the views on the nature of technology are limited to electronic devices, cell phones and computers, and there are suggestions that studies on this subject should be studied further (Lewis, 1999; Jones & De Vries, 2009; Volk & Dugger, 2005; Topkaya et al., 2015). For this reason, it is thought that each member of the society should be aware of the nature of technology. Williams (2000) states that students should perceive technology in a holistic approach rather than something separated into theory, content, application or process. While society expects citizens to access, use and analyze data, it also requires the use of science and technology. This will be possible through science and technology literacy (Özcan & Yılmaz).

As stated in the science curriculum, it is aimed to raise all individuals as science literate. For this purpose, a holistic perspective was adopted in the Science Curriculum, which was renewed in 2018; in general, the research-questioning-based learning strategy based on the transfer of knowledge, in which the student is responsible for his/her own learning, active participation in the process is ensured by Ministry of National Education (MEB, 2018).

In addition to scienctific literacy, science education also has various purposes for students. Technology has become an indispensable part of our lives thanks to easily accessible and usable applications on tablet computers and smartphones, which are called portable technology. According to TUİK (Turkish Statistical Institute, 2014), the computer usage rate of individuals between the ages of 16-24 is 70.3%, while the internet usage rate is 73.3%. These percentages are increasing every year. When the statistical data are analyzed, it can be said that the use of technology will increase and change according to the needs of society. The effects of the developments in technology have also been in the field of education and science education. Although computer-mediated technologies, or in other words online technologies, have been developed to replace face-to-face interaction, it is a question mark whether they can actually replace the face-to-face interaction seen in the classical classroom environment (Usta & Mahiroğlu, 2008).

Computer-based learning strategies have been used for many years. Recently, many mobile applications have been developed as computers have become portable with mobile devices such as tablets and phones. One of these applications is augmented reality (AR) applications. Mobile augmented reality applications are used in smart glasses, tablet computers and smartphones. Although AR applications used in these devices are basically built on the same logic, they have different features in themselves. Some of the features of AR applications enable their use in educational studies (Specht,et al., 2011).

AR technology first emerged from the work of Ivan Sutherland and his students with computer

graphics at Utah and Harvard Universities in the 1960s and was developed in the 1970s. While AR technology was first officially used in the United States Air Force and NASA, it became widespread and reached more masses after the 1990s (Feiner, 2002). AR technology is an environment where people interact with virtual objects placed in the real world environment through different applications. According to Milgram and Kishino (1994), it is the state of reality obtained with virtual objects placed in the real world environment.

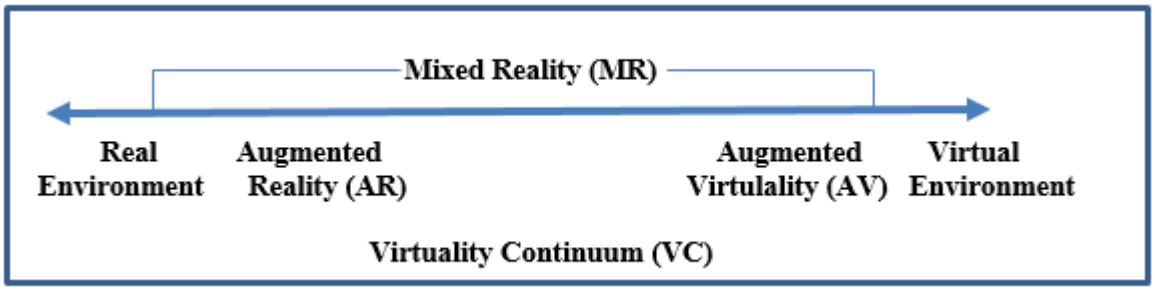


Figure 1. *Augmented reality (AR) Demonstration (Milgram and Kishino, 1994).*

Although research on AR has increased in recent years, most of the research is related to how it is used in learning and teaching (Dunleavy & Dede, 2014). The studies conducted in Turkey are mostly related to physics subjects, but however, there are few studies on the use of AR in biology courses (Arslan, et. al., 2020; Özeren & Top, 2023).

Supporting the teaching environment with visual materials keeps the attention of learners alive, concretizes concepts, and simplifies difficult subjects. It is thought that AR will also have a share in providing this visuality. The recent development of AR technology is remarkable. With AR technology, images combining real and virtual environments have been used in the fields of informatics, education, military, entertainment and health, and simultaneous interaction between environments has been provided (Azuma, 1997).

AR is a multidisciplinary field of computer science that includes computer-human interaction, 3D computer graphics, computer vision, and computer vision, where computer graphics are embedded into real video images in real time, combining virtual reality and the real world (Dias, 2009). Similarly, Cai et al. (2013) defined AR as the transfer of computer-generated two- or three-dimensional virtual information to the real environment with the help of human-computer interaction techniques, computer vision techniques, sensory technologies, 3D graphics technology and multimedia techniques. According to Hsiao et.al, (2012), AR is the projection of virtual objects onto the real world in order to provide interaction between different users.

AR has been used in computer-based applications for many years, but recently it has started to be used in mobile devices with applications developed for mobile devices. Mobile AR applications are mobile applications that enable the creation of augmented reality through a mobile device (smartphone, tablet) and use images, locations or pointer symbols.

When AR applications are analyzed, they are examined as location and image based. Both applications have different and common aspects. Location-based AR applications use the location data of mobile devices with the support of WiFi or GPS systems and transfer the information created on the computer to the mobile screen of the person simultaneously (İbili & Şahin, 2015). The location-based AR application is shown in Figure 2.

Figure 2. *Location based AR example*

When image-based AR systems are examined, the objects defined in the AR environment (photograph, motion, graphic image, sound detection and logo) are used as pointers and graphics, virtual data, or 2D/3D objects are added according to the points determined by analyzing the image of the pointer taken with the camera (Abdusselam & Karal, 2012).

In order to improve the quality of science education, it is considered important to enable students to perceive abstract concepts and to present these concepts to students in a visually enriched way. The use of AR applications in teaching socio scientific issues, astronomy and the structure of matter, which are abstract to students, will create a concrete learning environment by contributing to visuality.

There are various studies on the use of AR in science teaching. In these studies, it is stated that teaching is concretized with AR and students' progress according to their own learning pace. In studies in which not only students but also teachers were included in the study group (Dunleavy et.al, 2009; Clarke, 2013), research was conducted on the beneficial and negative aspects of the use of AR, technological difficulties and feedback from students. Some AR applications for the use of AR in science education are given in Figure 3 (Somyürek, 2014).

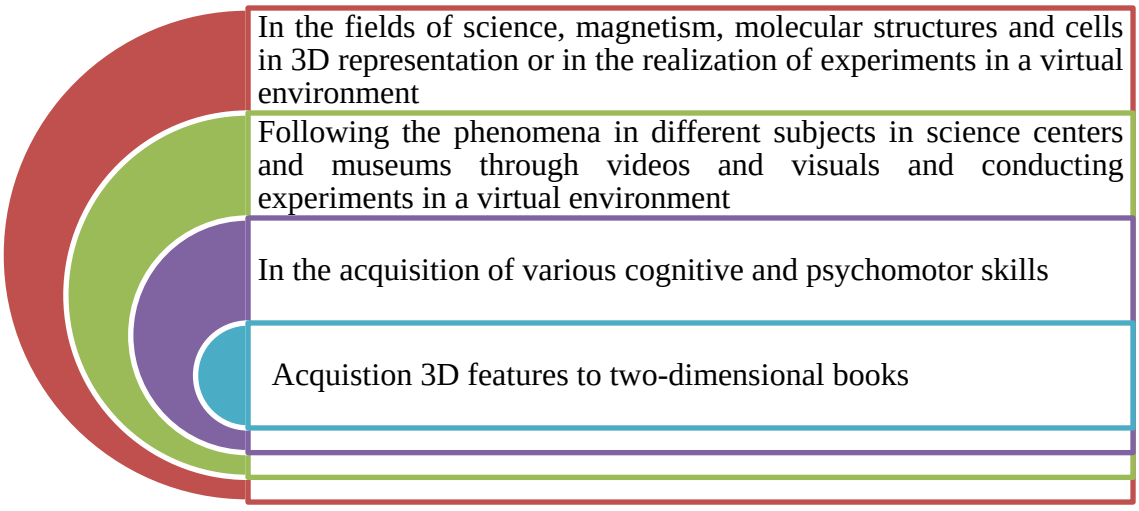


Figure 3. *Uses of AR in Science Education*

Science subjects are made up of events and phenomena that we live and experience in our lives. Precisely, science is intertwined with our daily lives. The fact that science subjects are not selected from students' daily lives prevents the internalization of knowledge and causes students to think that these subjects belong only to laboratories and their concrete environment (Laçin Şimşek, 2011).

Yeşilyurt and Kara (2007) emphasize that the constructivist model approach should be adopted in science teaching. It is not possible to construct knowledge with traditional teaching approaches. For this reason, it was stated that technology-supported teaching would be effective in the structuring process (Kurt, 2006). In order for students to learn science concepts, they should be actively involved in the

teaching process and a teaching environment in which active participation is ensured should be created.

AR-supported learning environments in which information technologies are used can present objects to students as if they were real, thus providing effective learning (Altun & Büyükduman, 2007). In order for students to better understand the subject of cell and divisions, technological content supported by 3D objects should be presented to the learning environment. Students should have the ability to see and comprehend the basic parts of the cell, organelles and their functions, and the characteristics of mitosis and meiosis from different angles. The fact that these topics are interesting increases students' willingness to learn (Yair, 2001). In addition, supporting the teaching process with three-dimensional and interactive images instead of tools in learning environments created with two-dimensional drawings will add a new dimension to the teaching material. With AR technology, which is rapidly being integrated into educational environments, it aims to increase the quality of education, students' achievement, motivation and attention (Korucu et al., 2016).

The main problem of the study was determined as "Do teaching practices supported by AR activities have an effect on students' academic achievement in the teaching of 'Cell and Divisions' unit in Science course?". The sub-problems of the research are as follows;

1. Is there a significant difference between the pretest CDAT scores of the experimental and control group' students before the AR application?
2. Is there a significant difference between the scores of the experimental and control group' students from the CDAT after the AR application?
3. Is there a significant difference between the pretest and posttest CDAT scores of the experimental group (EG) students who participated in the lesson with AR applications?
4. Is there a significant difference between the pretest and posttest CDAT scores of the students in the control group (CG) in which the lessons were planned with the methods suggested by the current curriculum?

METHOD

Quasi-experimental research design, which is one of the quantitative research methods, was used in the study and can be used in cases where control and experimental groups cannot be formed randomly and pre-existing classrooms are used. In this method, experimental and control groups are compared with an intervention without random assignment (Fraenkel & Wallen, 2000; McMillan & Schumacher, 2010). In both groups of the study, the "Cell and Divisions" unit in the science curriculum updated in 2018 was taught. While cell cards developed with AR technology were used in the EG, the CG was taught with the existing textbook and the existing curriculum. "Cell and Divisions Achievement Test" was used to determine the achievement of the students in both the experimental and control groups before and after the application. Since the post-test was carried out by applying different applications to the two groups in the study and the differences and relationships that may occur between the groups were determined, the comparative unequal groups' post-test model was used in the study. The research model of the study is presented in Figure 4.

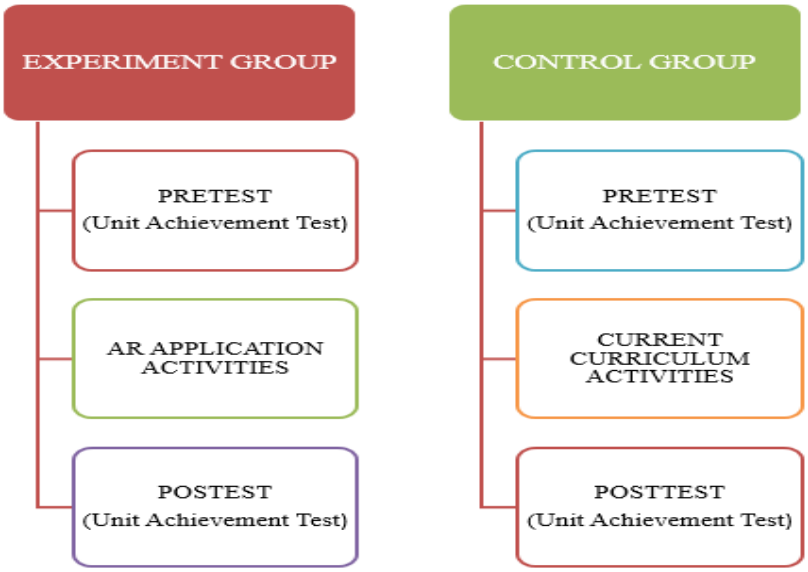


Figure 4. *Research model*

The study group consisted of 79 students attending the 7th grade in a public secondary school in Antakya district of Hatay province in the 2017-2018 academic year. Demographic information about the sample is presented in Table 1.

Table 1. *Data of research group*

Groups	Female	Male	Total
EG	18	22	40
CG	20	19	39
Total	38	41	79

As a data collection tool, the "Cell and Divisions Achievement Test" (CDAT) was used before and after the application to both groups. CDAT consists of 32 questions. After the pilot application of the test, 7 test questions were removed from the test because their discrimination index was below .30, leaving 25 questions remaining. The KR-20 and descriptive statistics results of HBBT are given in Table 2.

Table 2. *CDAT pilot study KR-20 and descriptive statistics results*

Number of questions	N	X	SD	KR-20
25	162	14,75	4,77	0,78

When Table 2 is examined, KR-20= 0.78 was found in the test. This value shows that the test is a reliable test. As a result of the statistical procedures, the test variance was found to be 25.72.

In this study, the achievements stipulated by the curriculum developed by the Ministry of National Education (MEB) in 2018 were applied to the experimental and control groups with different teaching methods. The applied teaching methods are the independent variables of the research. In this study, the achievements stipulated by the curriculum developed by the Ministry of National Education in 2018 were

applied to the experimental and control groups with different teaching methods. The dependent variable used in this study is the academic achievement of the students in the cell and divisions unit of the science course.

Since it may cause bias in the study, the researcher taught both groups. Most of the AR materials used in the EG were created by the researcher. The rest were downloaded as mobile applications from play store and app store. The lessons in the experimental and control groups were completed in a total of 16 hours in 4 weeks, 4 hours each week.

The following steps were followed in order the applying the method prescribed by the current curriculum to the CG.

Achievement 1. "Compares plant and animal cells and cells in terms of their parts and functions": The activity on page 24 of the textbook was carried out in line with the answers received from the students. Then, students were shown the visuals of plant and animal cells and asked about the similarities and differences between the visuals.

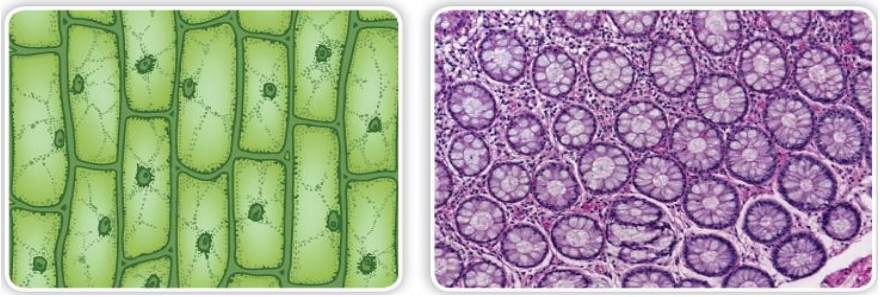


Figure 5. Images of Plant and Animal Cells

Visuals of plant and animal cells were given, the basic parts of the cell and organelles were emphasized and students were asked to make plant and animal cell models.

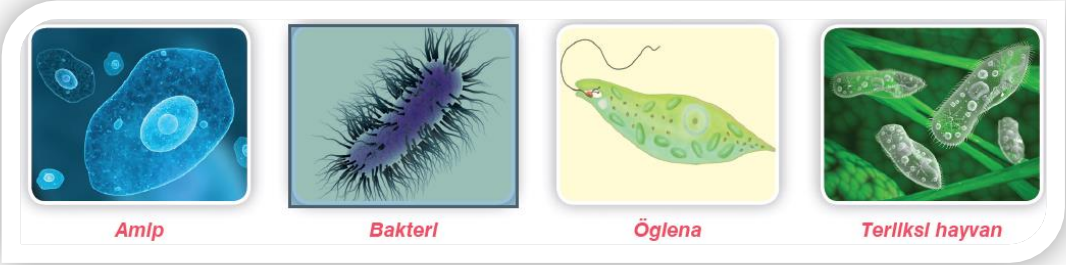
Image 1. *Examples of the activities carried out by the students in the CG during the implementation process*

The cell models made by the students were evaluated and feedback and corrections were given to the students about the organelles and their functions. The students were asked "Which material represents what in the models you made as cell model. What are the similarities and differences between the models you made and the models made by your friends?" and the answers were analyzed and evaluated.

Achievement 2. "Discusses the views on the structure of the cell based on technological developments": It was stated that the human eye can see objects larger than 200-250 micrometers, and that microorganisms cannot be seen with the eye due to their smaller size. It was mentioned that there is a special magnifying device to see these creatures, and opinions about the cell were expressed in chronological order.

Finally, the definition, development and working principle of the microscope were emphasized.

Achievement 3. "Explains the relationship between cell-tissue-organ-system-organism": It was stated that some living things are composed of a single cell and some of them are composed of many cells and the



students were shown the microscope images of single-celled living things in Figure 6.

Figure 6. *Microscope images of some microscopic organisms*

It was stated that some microscopic creatures are disease-causing and some are beneficial, and the benefits and harms of bacteria to humans and the related text on "*www.bilimcocuk.tubitak.gov.tr"* about microscopic creatures were read. Then, examples of multicellular organisms were asked for and the cell-tissue-organ-system-organism relationship was explained. End-of-topic evaluation was made with "Let's apply what we have learned".

Achievement 4. "Explain the importance of mitosis for living things": The learning process started with questions such as how our wounds heal after a while when we fall; how huge trees are formed from tiny saplings; how we grew so big when we were small enough to fit in the mother's womb and the answers from the students were written on the board and discussed. After all feedbacks were provided, the concept of cell division was emphasized and it was stated that there are two types of cell division.

Achievement 5. "Explains that mitosis consists of different successive stages": Visuals of mitosis were shown in the textbook and EBA, and how the stages are realized was expressed. By focusing on the difference seen in plant and animal cells, the stages of mitosis, which are mixed in the curriculum presented interactively in EBA, were made to the students and it was stated that mitosis consists of successive stages. An evaluation was made about the subject with the "Let's apply what we have learned activity".

Achievement 6. "Explains the importance of meiosis for living things": The learning process was initiated with the question of why we are different from our siblings even though we were born from the same parents and the students' answers were discussed. Students' knowledge about the cells undergoing meiosis and the chromosome change in meiosis was tested and the students were helped to reach some inferences with questions. (If the number of chromosomes had not been reduced by half, the number of chromosomes would have doubled in each generation...)

Achievement 7. "Demonstrates on the model how meiosis occurs in reproductive mother cells": With the visuals in the textbook and EBA, the stages of meiosis and the change of chromosomes in each stage were emphasized and students were able to place the mixed stages in the correct order.

Achievement 8. "Compare the differences between meiosis and mitosis": In line with the information they learned, they were made to prepare a table including the characteristics of mitosis and in which organisms it is seen; the characteristics of meiosis and in which organisms it is seen, in which cells of the organism it can be seen, and end-of-unit evaluation questions were made. Then, the learning process was completed by applying post-tests.

In the application of the method supported by Mobile Application and Augmented Reality to the EG, the following steps were followed below.

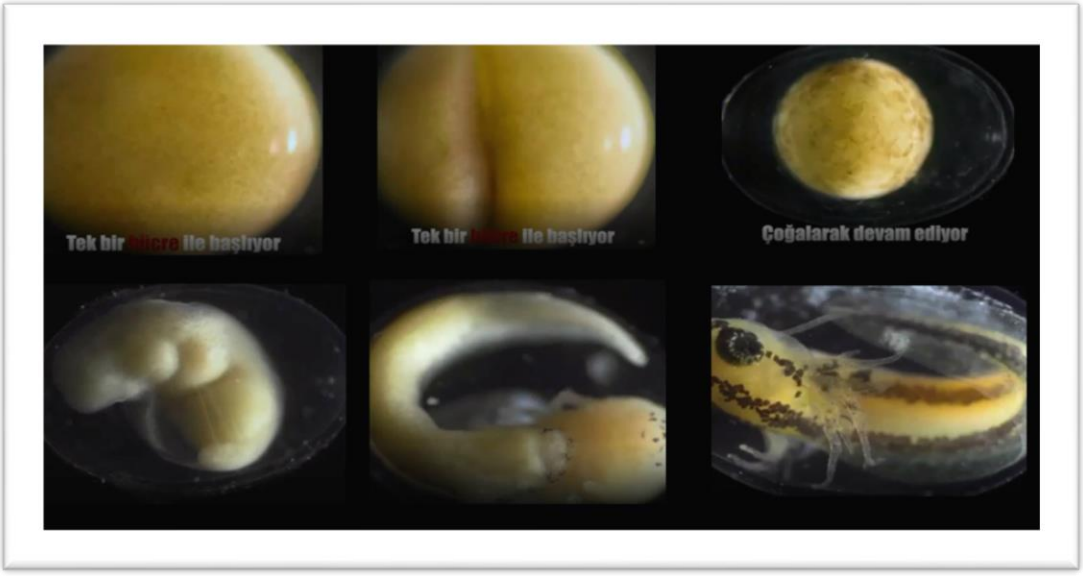
The class was divided into 8 groups of 5 students and tablet computers with AR Science, Hp Reveal and Quiver mobile applications were distributed to each group. First of all, the students were given information about how to use the applications, and then the application was carried out in the EG according to the course program prepared in parallel with the unit achievements.

Achievement 1. "Compares plant and animal cells and cells in terms of their parts and functions": In Grade 5, it was stated that living things are classified as plants, animals, microscopic creatures and fungi and students were asked to give examples of each living group. Based on the characteristics of living things, the cell was defined and then the pictures of plant and animal cells in Figure 3.5 were distributed to the students and they were asked to color the pictures.

Figure 7. *Observation of plant and animal cells with the Quiver app*

Then, the AR science cards in Figure 8, which are about plant and animal cells, were distributed to the students and students' attention was drawn to the subject both visually and aurally.

Figure 8. *Observation of plant and animal cells with AR science cards*



The AR cards on each organelle were presented to the learning environment visually and audibly, and the students in the group were allowed to learn individually at their own pace.

Achievement 2. "Discusses the views on the structure of the cell based on technological developments": Depending on the development of technology, the structure of the cell was examined in more detail and the studies carried out by scientists were given to the students in each group with the video-supported AR cards in Figure 8, and made by the researcher. After the information conveyed on the AR cards, students were asked for their ideas about the structure of the cell and they were asked to make inferences by making connections between their own ideas and scientific information. Students shared their ideas on this subject with their classmates.

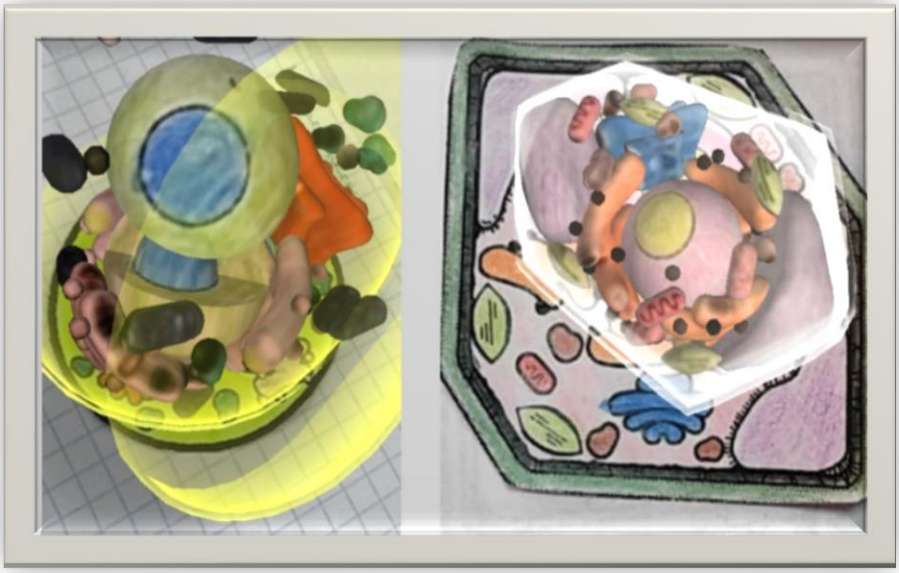


Figure 9. *Image section from the AR cards prepared by the researcher*

Achievement 3. "Explains the relationship between cell-tissue-organ-system-organism": With the video-supported AR card in Figure 9, which was prepared by the researcher, the students were given the card containing the stages of the organism starting from the egg cell to the formation process of the organism and were asked to follow the process carefully. Then, the relationship at each stage was explained to the students by the teacher and finally, end-of-section evaluation questions were asked.

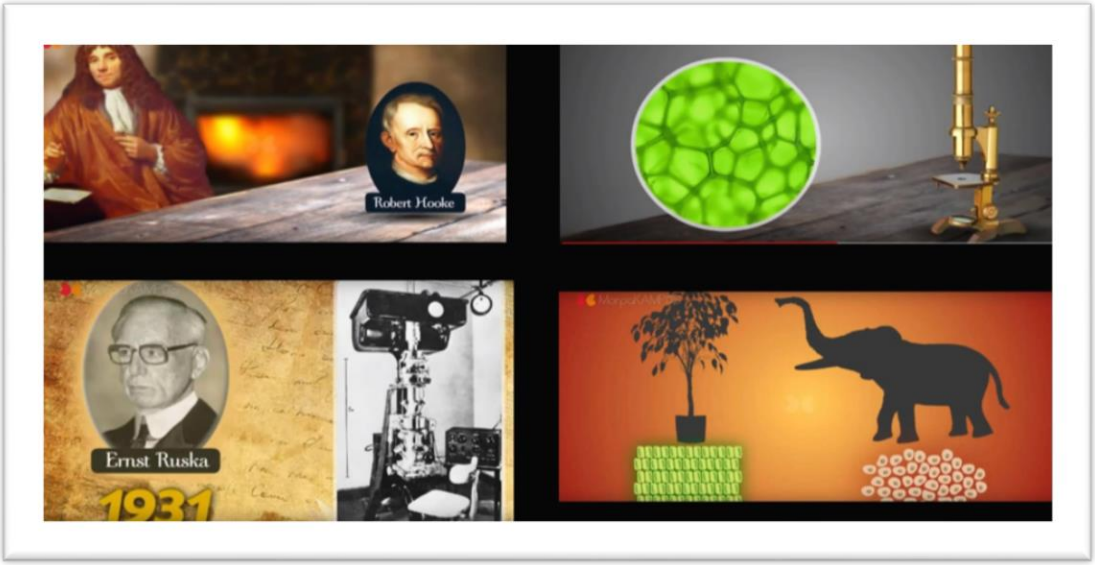


Figure 10. *AR card image showing the cell-tissue-organ-system-organism relationship*

Achievement 4. "Explains the importance of mitosis for living things": The lesson was started with the lesson preparation section in the textbook and it was stated that cell division is divided into two as meiosis and mitosis.

With the AR cards developed by the researcher, learning achievements 5, 6, 7 and 8 were given to the students and posters containing cell divisions in Image 2, were made to apply the information learned. AR applications that address these achievements are given in the appendix.

Image 2. *Posters on cell division made by students*

Students in the EG actively participated in the lesson throughout the teaching process. This application revealed that tablets and phones, one of the technological tools, will contribute to the learning process when used in accordance with the nature of technology. Finally, the application ended with end-of-unit evaluation questions and post-tests.

Data Analysis

SPSS 21.00 package program was used to analyze the data obtained through the research. In order to decide which tests to use in the data analysis step, normality tests were performed, extreme values were determined and it was decided to use dependent and independent t-tests from parametric tests.

FINDINGS / RESULTS

In this section, statistical analyses related to AR supported instruction and the findings obtained from the research questions are presented. In the data analysis process, Kolmogorov-Smirnov test results were used since the sample size was over 29 people in both the experimental and control groups (Kalaycı, 2016). The analysis of the test results is shown in Table 3.

Table 3. *CDAT Kolmogorov-Smirnov test results*

	Statistic	df	p
EG Pretest	,142	40	,040*
CGPretest	,181	39	,002*
EG Posttest	,153	40	,019*
CGPosttest	,246	39	,000*

When Table 3. is examined, it was concluded that the CG pre and post HBBT and the EG pre and post HBBT negatively affected the normal distribution (p<.05), therefore skewness and kurtosis values were examined.

Table 4. *Skewness and kurtosis coefficients pretest-posttest cdat result*

Scale	Group	Skewness	Kurtosis
CDAT Pretest	Experimental	-,102	,205
	Control	-,919	-,467
CDAT Posttest	Experimental	-1,304	-,185
	Control	-2,218	-1,154

According to Kalaycı (2016), if the skewness and kurtosis values are between +3 and -3, the data are considered to be normally distributed. It was observed that the data were within the specified range. Therefore, while analyzing the data in the study, the assumptions of using parametric tests were examined and the research problems were analyzed by using appropriate tests after compliance was ensured.

An independent t-test was conducted to determine whether there was a significant difference between the academic achievement pretest scores of the EG students, in which the lessons were taught with augmented reality and mobile applications, and the CG students, in which the lessons were taught using the methods recommended by the current curriculum. Independent samples t-test results are given in Table 5

Table 5. *Independent samples t-test analysis results of CDAT pretest scores*

Groups	N	$\bar{X}$	SD	t	p
EG	40	10,63	3,176	-1,938	,056
CG	39	11,95	2,883		

When the data in Table 5 are analyzed, the mean score of the EG was 10.63 with a standard deviation of 3.176, while the mean score of the CG was 11.95 with a standard deviation of 2.883. When these scores were analyzed, it was seen that the average of the CG was higher. However, as a result of the statistical analysis between the two groups, there was no statistically significant difference between the CDAT pretests (t= -1,938; p>0,05). According to these findings, it can be said that the achievement levels of the students in the experimental and control groups in the Cell and Divisions unit are similar.

Independent t-test was applied to determine whether there was a statistically significant difference between the CDAT posttest mean scores of the EG students and the CG students. The results of the analysis are given in Table 6.

Table 6. *Independent samples t-test analysis results of CDAT post-test scores*

Groups	N	$\bar{X}$	SD	t	p
EG	40	15,83	4,712	2,957	,004
CG	39	13,31	2,494		

When the data in Table 6 are analyzed, the mean score of the EG was 15.83 with a standard deviation of 4.712, while the mean score of the CG was 13.31 with a standard deviation of 2.494. When these scores were analyzed, it was seen that the average of the EG was higher. When the statistical analysis of the post-tests between the two groups was examined, it was concluded that there was a significant difference in favor of the CDAT EG (t= 2,957; p<0.05). According to these findings, the reason for the increase in the course success of the students in the EG after the application can be shown as the students' continuous active participation in the process and their interest in the applied technology. The effect size was calculated as d=0.665 and $\eta 2$= 0.996. This indicates a intermediate level effect.

Paired sample t-test was conducted to determine whether there was a statistically significant difference between the CDAT pretest-posttest mean scores of the EG students. The results of the analysis are given in Table 7.

Table 7. *Paired samples t-test analysis results of CDAT EG pretest and posttest scores*

Test Type	N	$\bar{X}$	SD	t	p
Pretest	40	10,63	3,176	-7,278	,000
Posttest	40	15,83	4,712		

When the data of the EG in Table 7 are examined, it is understood that the pre-test score was 10.63 with a standard deviation of 3.176, and the post-test score was 15.83 with a standard deviation of 4.712. When these data are analyzed, it is seen that the average post-test score of the EG is high. In line with the statistical analysis, there was a statistically significant difference in favor of the CDAT posttest (t= -7,278; p<0,05). The effect size was determined as (Cohen' d) d= 3,968. This indicates a large level of impact.

It was decided to conduct a paired samples t-test to determine whether there was a statistically significant difference between the CDAT pretest-posttest mean scores of the CG students. The results of the analysis are given in Table 8.

Table 8. *Paired samples t-test analysis results of CDAT CG pretest and posttest scores*

Test Type	N	$\bar{X}$	SD	t	p
Pretest	39	11,95	2,883	-4,025	,000
Posttest	39	13,31	2,494		

When the data of the CG in Table 8 are examined, it is understood that the pre-test score was 11.95 with a standard deviation of 2.883 and the post-test score was 13.31 with a standard deviation of 2.494. When these data are analyzed, it is seen that the mean post-test score of the CG varied according to the pre-test score. In line with the statistical analysis, it was concluded that there was a statistically significant difference between CDAT pretest and posttest (t= -,4,025; p<0,05). According to these findings, the active participation of the students in the learning process in the CG increased their academic achievement. The effect size was determined as (Cohen' d) d= 3,812. This indicates a large level of impact.

DISCUSSION, CONCLUSION, RECOMMENDATIONS

The achievement test for the "Cell and Divisions" unit was applied to the experimental and control groups before the study and it was seen that there was no significant difference between the two groups (p>.05). Post-tests were conducted after the implementation and the findings obtained were analyzed. When the data were examined, it was concluded that the arithmetic averages of the students in the EG supported with augmented reality were higher than the CG where the current curriculum was applied. This difference was significant in favor of the EG (p<.05). The reason for this may be that augmented reality technology enables students to use the lesson actively. A similar study was conducted by Özeren and Top (2023). Similarly, this study revealed that the success of students supported by AR technology in the "Cells and Divisions" unit increased significantly. According to these findings, it was concluded that the achievement of the EG increased after the AR applications. Previous studies (Yenice, 2003; Vilkoniene, 2009; Güven & Sülün, 2012; Özkaya, 2013; Sarıkaya, 2015; Tezel & Aydost, 2016) have shown that teaching supported by visual materials and enriched technology environment increases academic achievement. In addition to concretizing the concepts, the materials can be used for fun learning, creative support thinking, use in measurement and evaluation, curiosity awakening, improving visual memory, learning by doing and motivation other contributions, such as enhancement (Dere, 2019).

In this study, the curriculum applied by the Ministry of National Education to middle school students at the 7th grade level included the "Cell and Divisions" unit (MEB, 2018). It was observed that the students'

learning level and participation in the lesson on the functions of cells and organelles were high. The reason may be that they had previously seen this topic in the 6th grade curriculum. Students could not show the same success in cell divisions. Some problems and incomprehensibility emerged in both the experimental and control groups. For example, students in both groups had difficulty in deciding which cell division was mitosis and meiosis by looking at the stages of division. This situation also affected the number of correct answers given to the questions in the achievement test. Nevertheless, it was concluded that teaching with AR in the EG positively affected academic achievement. Previously, Abdusselam and Karal (2012), Özarslan (2013), Sin and Zaman (2014) and Coşkun and Koç (2018) used AR technology in learning environments and observed positive changes in academic achievement.

In the light of these findings, the following suggestions can be given for the applications;

- In this study, it was seen that teaching with AR in Cell and Divisions unit positively affected academic achievement. Most of the AR studies in the field of science education were conducted on astronomy subjects. There are few studies on Cell and Divisions. New applications can be developed for teaching AR programs with other science units.
- Turkish language support of the programs can be improved and users can access them more easily.
- Since both 3D and video-supported AR cards have audio narration, there was noise in the classroom and some of the students expressed that they were uncomfortable. Therefore, videos can be associated with the pictures in the textbooks and students can be allowed to repeat at home.
- AR applications that do not require internet connections can be preferred.
- The following suggestions can be given for the researchers;
- It is thought that the use of AR technology in education will increase when information and technology experts add Turkish language packages to AR programs.
- Since it is thought that the technology used in the research will attract the interest of primary and secondary school students, the effectiveness of the technology used can be investigated by applying it at other grade levels.
- The effect of the method applied in the study on students' academic achievement was examined. The effect of teaching supported by AR on the retention of learning can be investigated.
- Qualitative studies can be conducted to obtain the opinions of students and teachers about AR.
- Since AR technology is a new technology, the use and development of AR applications can be included in Ministry of National Education (MEB) in-service training activities so that teachers can use this technology in their lessons.
- The light coming from the phone or tablet and the resolution features of the camera used while using AR technology sometimes negatively affected the teaching.

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APPENDIX: AR *cards developed by the researchers*