TÜRK FEN EĞİTİMİ DERGİSİ
Yıl 17, Sayı 1, Mart 2020

Journal of
TURKISH SCIENCE EDUCATION
Volume 17, Issue 1, March 2020

http://www.tused.org

The Effect of Using Virtual Reality in 6th Grade Science Course the Cell Topic on Students' Academic Achievements and Attitudes towards the Course

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Received: 05.01.2020 **Revised:** 01.03.2020 **Accepted:** 25.03.2020

The original language of article is English (v.17, n.1, March 2020, pp.109-125, doi: 10.36681/tused.2020.16)

Reference: Sarioglu, S. & Girgin, S. (2020). The Effect of Using Virtual Reality in 6th Grade Science Course the Cell Topic on Students' Academic Achievements and Attitudes Towards the Course. *Journal of Turkish Science Education, 17* (1), 109-125.

ABSTRACT

In this study, it was aimed to investigate the effect of virtual reality usage in science teaching on 100 students attending 6th grade in Orhaneli district of Bursa province in 2017-2018 academic year. The study was designed as an experimental model of quantitative research methods. The Cell Knowledge Test developed by the researcher in the experimental and control groups generated by random assignment was applied separately before and after the cell subject was processed. In the experimental group, before and after the use of virtual reality applications which were adapted by the researcher, the attitude levels towards the course and the differences between these levels were revealed with the help of an Attitude Scale towards Science and Technology Course. As a result of the research, it was concluded that the use of virtual reality technology in the cell subject teaching has a significant effect on students' achievement and attitudes towards the course.

Keywords: Virtual reality, instructional technology, student attitude.

INTRODUCTION

Educational technologies include materials such as computers, interactive whiteboards, projection devices, tablets, holograms, augmented reality, and other tools, support tools such as computer, interactive whiteboard, projection device, tablet, hologram, and augmented reality (Akpinar, 2006; Cepni, Ayas, Ozmen, Ayvaci, Akdeniz & Yigit, 2019). Considering their age and developmental periods, these technologies attract attention especially with the features that increase the interest and achievement of today's primary and secondary school students (Akpinar, Aktamis, & Ergin, 2005; Arici, 2013; Sahin, 2017). One of the most up-to-date educational technologies is virtual reality technology. Especially with the development observed in this field after 2016 (Ornes, 2017), virtual reality and virtual reality technology started to take the stage in the field of education (Fernandez, 2017). One of

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the most important features of this technology is its application individually (Ozkan, 2016). Today, students are in need of training in accordance with their personal speed, especially in individualized education programs (Cepni, 2011) and virtual reality technology can be seen as a tool with the potential to meet this need. In addition, the use of virtual reality applications which can be considered as dangerous such as disease studies, cell and tissue examination training, and various chemistry experiments, has a vital importance (Forbes, Pan, & Hamilton, 2016).

In the developing world, the perspective on education is changing and old methods and techniques are replaced by different methods and techniques to overcome the difficulties in education (Barron & Orwig, 1993; Cavas, Huyuguzel Cavas & Taskin Can, 2004; Gullupinar, Kuzu, Dursun, Kurt, & Gultekin, 2013). It is known that traditional approaches are insufficient in the understanding of abstract concepts (Brooks & Brooks, 1993; Koseoglu & Kavak, 2001; Can & Simsek, 2016), and that students need tools and materials and new technologies that can be used in the classroom to fully learn these concepts (Cepni, 2016; Ari, 2011; Arici, 2013). Considering today's technology and conditions, the constructivist approach in education alone is also insufficient in especially answering the needs of students to learn individually and according to their own paces (Arias & A.Davis, 2017; Tutwiler, 2019). One of the ways to overcome these problems and make progress is to use technology in the field of education (Gullupinar et al., 2013). In this context, students' hands-on learning with technological applications increases the effectiveness of teaching (Arici, 2013). One of the technologies used in education is virtual reality technology (Baratoff & Blanksteen, 1993). Virtual reality technology, as content players created in three-dimensional environment, offers the viewer an experience close to real life, especially with the latest developments (Ozkan, 2016). Virtual reality technology is used in many educational fields such as aviation, military, architecture, mathematics and science and increases the quality of education (Bayraktar & Kaleli, 2007). Inexpensive flight training can be provided with virtual flight systems prepared to train pilots (Can & Simsek, 2016). In medical education, students are provided with numerous experiments through virtual cadavers created for candidates (Cavas et al., 2004). In architectural education, virtual reality technology is used to gain the ability to transfer the design that the person designed in the mind to the other individuals in the most appropriate way (Sekerci, 2017). Virtual reality can also be used in many courses such as history, mathematics, pharmacy, and science and in many teaching levels (Rosen, 1993; Javidi, 1999). Virtual reality technology is widely used in various fields such as manufacturing, urban design, architecture, engineering, museum exhibitions, health, Military, Medical Education, and is becoming more and more widespread (Le, Pedro, & Park, 2015; Forbes et al., 2016). It has started to be used in the field of education with its facilities (Andolsek, 1995; Bayram, 1999; Roussou, 2004; Kayabasi, 2005; Walczak, Wojciechowski, & Cellary, 2006; Bayraktar & Kaleli, 2007; Freina & Ott, 2015; Fernandez, 2017).

By using virtual reality in the field of education, students can do research, communicate with information, increase their interest in the lesson and make meaningful learning (Shin, 2003). Students will be active in this whole process, access information in scientific and realistic ways, and the permanence of the information they learn will be ensured as they structure their own knowledge (Aretz, 1991; Duncan, Miller & Jiang, 2012). In virtual environments created using virtual reality technology, the student actively directs the environment or objects using the visual, auditory and tactile senses related to the subject studied. In this way, the student is not passive and is at the center of the teaching (Martín-Gutiérrez, Mora, Añorbe-Díaz, & González-Marrero, 2017). With this feature, it is possible to evaluate the virtual reality environment as an effective teaching tool (Javidi, 1999). In order for virtual reality programs to be a powerful teaching tool, students must be related to their

previous learning. In this way, the student is provided to interact with the course content in person (Arici, 2013).

There are many advantages to using virtual reality in education. With virtual reality technology, it can be facilitated by examining the hard-to-reach places, showing microscopic cells and organelles, studying experiments and events that are impossible or dangerous in the classroom environment, and presenting abstract concepts in many new ways (Brill, 1994; Liu, Bhagat, Gao, Chang & Huang, 2017, p. 106). It helps not only to the important points of the subject to be taught, but also to learn in a more realistic way (Cavas et al., 2004; Duncan, Miller & Jiang, 2012). It can contribute to the development of students' complex thinking, creative thinking and abilities (Roussou, 2004). Students can participate in the application regardless of time and space and can manage their own learning by staying in practice as much as they want according to their own pace (Tepe, Kaleci & Tuzun, 2016). By traveling over time, students can experience different historical periods and have the opportunity to see three-dimensional places such as the solar system where it is not possible to go physically (Freina & Ott, 2015). Virtual environments engage students, provide rich perceptual clues and multifaceted feedback, entertain while teaching and facilitate concept teaching (Can & Simsek, 2016).

One of the difficulties in science teaching is that the experiments that are desired in the laboratory environment cannot be performed due to the absence or scarcity of materials or because the experiments are dangerous (Freina & Ott, 2015; Duban, Aydogdu, & Yuksel, 2019). Virtual reality applications are relatively inexpensive tools that allow students to participate in experiments by living individually, without the dangers of experiments and chemicals (Fernandez, 2017). From this point of view, virtual reality applications can be considered as an important material for science education with the potential of helping to overcome all of these difficulties. Considering from this point of view, it is a matter of curiosity whether virtual reality experience will provide more effective learning by using the abstract subjects that students have difficulty in embodying. Tackling this problem, "the effect of virtual reality application integrated to the teaching of 6th grade science lesson cell subject on the academic achievement and attitude of the students" is the focus of this research.

Considering the promises and potential of virtual reality technology, it can be considered as an application that can bring a new breath to science education. Although there is a rising interest on the subject of virtual reality and its uses in education (Liu et al., 2017), especially since 2016 with the emerging of VR technologies (Kavanagh et al., 2017), whether this integration of technology is actually effective in science classes and if so, to what extend this effect would be is a question. There are studies that suggest VR applications in science class improve students' academic achievements or their attitudes towards science concepts, but these studies need to be confirmed by further research and experiments (Martín-Gutiérrez et al., 2017). The data obtained within the scope of the studies carried out can provide the necessary information to integrate virtual reality technology into the courses, as well as shed light on future studies (Arici, 2013). In addition to the fact that the studies on virtual reality on science education are limited, it is seen that the researches about the place and importance of virtual reality applications in science education are still in the beginning stage worldwide and in our country, it is expected that this study will be useful in these aspects. Along with this, it will be useful to state that there has been some studies focusing on virtual reality's increasing usage in education in general (Duncan et al, 2012; Kavanagh et al., 2017; Arias & Davis, 2017). In these studies, virtual reality technology and the its underlying concepts such as its types, new videos, three dimentional imaging, and its differences from augmented reality are well-established. Brill (1994), explained the tools and equipment used in virtual reality environments are divided into three parts as "Stage, Desktop and Mirror World". In the stage environment, users feel that they are in a completely virtual environment. The desktop

environment requires a computer system, mouse, data glove, or an equipment system that will enable interaction by providing data entry. Viewers participate in virtual reality in the mirror world by watching the spread of the images by the computer. And this situation keeps the viewer from feeling in an unknown environment. Along with technology, the desktop component of virtual reality has evolved into smaller head-mounted displays. These components allow the viewer to move more freely and are more accessible as they are much cheaper. From this point of view, virtual reality technology is a much better candidate of experimental studies in classrooms and thus the studies are moving in this direction. These limited studies, as pointed out before, suggest that virtual reality integrated in classrooms can help students' academic achievements and attitudes towards science lessons (Arıcı, 2013; Freina & Ott, 2015; Kavanagh et al., 2017; Liu et al., 2017). At this point, the need for understanding whether virtual reality integration in science classes improve academic achievement and attitude towards science course on every subject of the course emerges.

In this context, the main purpose of the research is to determine the effect of the virtual reality application integrated into the teaching of the science course "Building Blocks of Living: Cell" subject of primary school 6th grade students on their achievements and attitudes towards science lesson. In accordance with this main purpose, the differences between the achievement levels of the experimental group and the control group students were examined, and in this way, it was aimed to measure the effect of the use of virtual reality applications on the subject of students in science education on student achievement. In addition, it was aimed to determine whether the attitude levels of the experimental group students towards the course show a change as a result of the application. In this context, "Does the application of virtual reality integrated into the teaching of 6th grade science course cell topic have an effect on students' academic achievement and attitude towards the course?" question constitutes the problem sentence of the research. In order to find an answer to this question, the following sub-problems have been designed and their answers have been sought.

1. Is there a significant difference between the means of pre-test achievement test scores of the experiment and control group students?
2. Is there a significant difference between the means of post-test achievement test scores of the experiment and control group students?
3. Is there a significant difference between the means of pre-test and post-test achievement test scores of the students in the experimental group?
4. Is there a significant difference between the means of pre-test and post-test achievement test scores of the control group students?
5. Do the attitudes towards science course of students using virtual reality technology differ before and after applying the lessons?
6. Is there a significant relationship between students' attitudes towards the course and their achievements using virtual reality technology?

METHODS

The research is in line with the nature of the experimental model, as the effect of virtual reality technology on student achievement and attitude in sixth grade science class will be investigated. The research design of the study is the semi-experimental design with pre-test post-test control group. In this design, there are two groups created with unbiased assignment. One of the groups is determined as the experiment and the other as the control group. Both groups are measured before and after the experiment, but the independent variable is applied only to the experimental group and the effect of the independent variable is examined in the experimental group (Karasar, 2003; Creswell, 2017). In this study, the study group consisted of different classrooms and it was not possible to mix the classrooms and assign from scratch.

Hence, the research design is semi-experimental. In the next step, the pre-test scores from achievement test were compared to ensure that the groups were formed through unbiased assignment, so that the experimental and control groups were not significantly different before the experiment. This way, the equity of study groups is ensured. The subject of "Cell" in the "Cell and Divisions" unit within the "Living and Life" learning area was taught in accordance with the science curriculum (MNE, 2018) based on the constructivist approach. The teachers of the experimental and control groups are the same. Practitioner graduated from Gazi University Science Education Department and has 10 years of professional experience. While teaching the concepts, cell structure and organelles to the students in the experimental group, the teacher made use of virtual reality technology as well as teaching appropriate to the constructivist approach without using virtual reality technology in the control group. While teaching the concepts of the cell, its structure and organelles, to provide accordance with constructivist approach, the lessons were planned with 5E model and interactive whiteboard is used frequently. The cell topic in the curriculum consists of three objectives as "Compares animal and plant cells in terms of their basic parts and functions.", "Discusses the views about the structure of the cell from past to present by associating it with technological developments." and "Explains the cell-tissue-organ-system-organism relationship.". In accordance with the curriculum and considering students' needs, the study took two weeks. During the study in the experimental group, students were given VR headsets and watched a virtual reality video compatible with the objective for 5 to 10 minutes at the end of each objective.

In accordance with the semi-experimental model, the developed achievement test was applied to both groups before and after the study as pre-test and post-test. The attitude scale towards science lesson before and after the study was applied only to the experimental group as pre-test and post-test.

Table 1. *Research design*

Group	Achievement Test		Attitude scale		Method
	Pre-test	Post-test	Pre-test	Post-test	
Control	+	+	-	-	Constructivist
Experimental	+	+	+	+	Constructivist + Virtual Reality

a) The Study Group

The study group of the research consists of 100 students studying in 6th grade in 2017-2018 academic year in public schools in Orhaneli district in Bursa. Some of these students are male and some are female students. Information showing demographic characteristics of the study group is given in Table 2. The characteristics of the students in the study group were reported in Table 1.

Table 2. *Demographic characteristics of the study group*

Gender	Group	Number of Students	Total
Female	Control	28	58
	Experimental	30	
Male	Control	22	42
	Experimental	20	
Total		100	100

b) Teaching and Application Process

Adaptation of Instructional Material

The animations used for the virtual reality technology to be used in the lesson were translated and reproduced in Turkish by the researchers (Sarioglu & Girgin, 2018a). In order to adapt the instructional material into students' native language, with the permit of owner of the original video, the video was downloaded, translated, narrated, reproduced as virtual reality video and published again by the researcher. The videos are now accessible via multiple websites such as youtube, dailymotion and vimeo.

Application in the Control Group

In the research, the control group consists of 50 students studying at the 6th grade level. The cell knowledge achievement test prepared to determine the pre-learning of the students was applied as a pre-test. By applying the achievement test to both groups as a pre-test, the pre-learning levels of the students in the control group were determined. Within the scope of the application, the cell topic was taught using interactive whiteboard presentation and applications, with the participation of students, within the framework of the constructivist approach and using the question-answer method. After this application, the achievement test was re-applied as a post-test to all students in the control group.

Application in Experimental Group

In the research, the experimental group consists of 50 students. Firstly, the achievement test was applied as a pre-test in order to determine the level of the experimental group students. The results of the pre-test application were compared with the results of the pre-test application in the control group, and it was determined that the two groups had equivalent pre-learning. Then, students were informed about application activities. It is aimed to provide the greatest benefit to the students with the most comfortable use of glasses, by giving information such as virtual reality technology, the way of using the virtual reality headset, the buttons and functions on it, and focusing the image. During the application, using the interactive whiteboard presentation, the subject of the cell was processed using the narrative and question-answer method within the scope of the constructivist approach, and then learning was reinforced by watching the virtual reality content named "Journey Inside the Cell" prepared by the researcher through virtual reality technology. This content is an interactive video that lasts about 11 minutes for each student, and the students were able to interactively select the structures they want to learn about by looking around them and listen to the voiceover prepared by the researcher in three dimensions. After these applications, the achievement test was applied as a post-test to all students in the experimental group and the data obtained from the research were analyzed.

c) Data Collection Tools

In this study, a "Cell Knowledge Achievement Test" (Sarioglu & Girgin, 2018b), consisting of 25 multiple choice test questions, and "Attitude Scale Towards Primary Science and Technology Course" was used by obtaining the necessary permissions to measure students' attitudes towards the science course (Nuhoglu, 2008). The achievement test consisting of 25 items were chosen from a 27-item pool of questions by the researchers and according to four experts in the field 5 questions were removed from test for face and content validity. The Cronbach's alpha reliability coefficient of the test was calculated as 0.883. There

are 10 positive and 10 negative 20 items in the attitude scale prepared in 3-point Likert type. Cronbach's Alpha internal consistency coefficient is .87. The application was done in the second semester of the 2017-2018 academic year.

Achievement test

While preparing the achievement test questions, 6th grade curriculum achievements were examined. In addition, it is aimed to collect data suitable for the purpose of the research. Reliability and item analysis were carried out by applying the 27-item cell knowledge achievement test, which was created as a result of the literature review by the researchers, to a pre-trial group of 149 students. The reliability and validity of the tests were provided with a second pre-application before the actual application. In this way, it is aimed to reveal the preliminary and final scores of the students in terms of their achievement in science lesson. The achievement test was reduced to 25 questions by taking the opinions of three science teachers and a science education specialist working in Bursa and the validity coefficient was calculated as .883 according to the formula KR-20 (Sarioglu & Girgin, 2018b). This value means that the validity of the test is high (Creswell, 2017). Descriptive data of the achievement test are given in detail below. Data showing item difficulty and discrimination indices of achievement test are given in Table 3.

Table 3. *Item difficulty and discrimination indices for achievement test*

Question	Item Difficulty (p)	Discrimination (d)
1	.49	.66
2	.34	.37
3	.34	.46
4	.52	.57
5	.56	.38
6	.44	.81
7	.72	.73
8	.33	.46
9	.33	.38
10	.29	.40
11	.44	.48
12	.38	.32
13	.53	.44
14	.71	.38
15	.49	.36
16	.34	.73
17	.47	.30
18	.37	.51
19	.79	.59
20	.43	.47
21	.46	.30
22	.52	.54
23	.56	.34
24	.45	.59
25	.41	.40

When the data in Table 3 were analyzed, it was seen that the item difficulty coefficients ranged between .29 and .79. Item Difficulty range is .50, and the absence of

excessively easy and extremely difficult questions can be considered as a desired condition for the test (Creswell, 2017). The discrimination indices of the items in the test ranged from .30 to .81. According to these values, the test can be said to be sufficiently distinctive (Washington, 2020). Since it was seen that the discrimination of 16 items in the test was very good and the discrimination of 9 items was quite good, it was decided to use the test in practice.

d) Data Analysis

SPSS package program was used to analyze the data of attitude and achievement tests. T-test for dependent samples was used for comparing the achievement test pre-test / post-test mean scores of each of the experimental and control groups, and independent groups t-test were used to compare the experimental and control groups with each other. Table 4 shows the tests used for each group and the test used. In addition, the findings were interpreted by considering the mean, standard deviation and *p* (significance) values. In order to examine whether there is a significant relationship between the attitudes of the students in the experimental group towards the science lesson and the achievement of the lessons on the cell topic, Pearson Correlation test was applied, and the results were interpreted accordingly.

FINDINGS

Findings on Sub-Problems

In this section, normality tests of process group data are performed, and test results to determine whether data on variables show normal distribution are expressed in tables and numerical methods. The results of the Kolmogorov-Smirnov and Shapiro-Wilk tests with statistical descriptors show that the data was normally distributed at the .05 significance level. The normality test results of the data of the process groups are given in Table 4. In accordance with these results, the data of the groups were analyzed by parametric tests.

Table 4. *Kolmogorov-Smirnov and Shapiro-Wilk Normality Test results of groups*

Test	Group	***Kolmogorov-Smirnov***			***Shapiro-Wilk***		
		Statistic	**sd**	**p**	**Statistic**	**sd**	**p**
Pre-test	Control	.11	50	.12	.98	50	.50
	Experimental	.11	50	.17	.97	50	.29
Post-test	Control	.11	50	.12	.97	50	.36
	Experimental	.12	50	.07	.95	50	.04
Attitude	Difference	.15	50	.06	.96	50	.40

As can be seen from the examination of the data shown in Table 4, the results of at least one of the Kolmogorov-Smirnov and Shapiro-Wilk tests suggest that group data was not normally distributed at the level of .05 significance. However, since the group sizes were more than 30 and at least one of the tests showed that the data was normally distributed, the data was considered to be normally distributed (Creswell, 2017). Therefore, the data of the groups were analyzed using parametric tests.

a) Comparison of Pre-test Mean Scores of Experimental and Control Group Students

Pre-tests were applied to students in the experimental and control groups before starting the study. In order to determine whether there is a statistically significant difference between the achievements of these students related to the science course, the independent samples t-test was applied to the pre-test results and the findings related to this are given in Table 5.

Table 5. *Test analysis results of the experimental and control groups' scores from the pre-test application for independent groups*

	Group	N	$\overline{X}$	SS	*t*	*p*
Achievement level	Experimental group	50	38.40	8.28	0.21	.25
	Control group	50	38.80	10.39		

When the data in Table 5 are examined, the difference between the pre-test means ($\bar{x}$ = 38.40, ss = 8.28) of the students in the experimental group and the pre-test averages of the students in the control group ($\bar{x}$ = 38.80, ss = 10.39; p = .25>.05) is not meaningful. According to this result, it can be said that the science course achievements of the students in the experimental group and the control group did not differ statistically and their pre-learnings about the science course was statistically the same.

b) Comparison of Post-test Mean Scores of Experimental and Control Group Students

To determine whether there is a statistically significant difference between the students who learned the "Cell" topic in a learning environment supported by virtual reality technology, and the achievement of the students who learned the "Cell" topic with the course taught only in the science curriculum (MNE, 2018) based on the constructivist approach, t-test for independent groups was applied and the results are given in Table 6.

Table 6. *Test analysis results for independent groups of the scores of the experimental and control groups from the post-test application*

	Group	N	$\overline{X}$	SS	*t*	*p*
Achievement level	Experimental group	50	88.40	7.51	5.60	.00
	Control Group	50	78.00	10.75		

When the data in Table 6 are analyzed, it is found that there is a significant difference between the post-test means of the students in the experimental group ($\bar{x}$ = 88.40, ss = 7.51) and the post-test means of the students in the control group ($\bar{x}$ = 78.00; ss = 10.75; p = .00 <.05). Accordingly, it can be said that students who use virtual reality technology about cell topic, have a higher level of achievement compared to other students.

c) Comparison of Pre-test and Post-test Mean Scores of Experimental Group Students

Dependent groups t-test was applied to statistically determine whether there is a significant difference between the pre-test means of the students in the experimental group and the post-test means as a result of their learning supported by using virtual reality technology. Findings of the results obtained are given in Table 7.

Table 6. *Test analysis results for the dependent groups showing the relationship between the pre-test means and post-test means of the experimental group*

	Group	$\overline{X}$	SS	t	p
Pre-Test Post-Test	Experimental Group	51.52	8.42	43.25	.00

The pre-test and post-test means, as a result of the t-test conducted to determine whether there is a significant difference between the means of the test scores performed before and after the study, in the 50-person experimental group, where the effect of teaching about the subject of "cell" made with virtual reality technology on students' course achievement was investigated, a significant difference was found ($p = .00$; $p < .05$) between pre-test and post-test means. Accordingly, it can be said that education with virtual reality has a significant effect on science course achievement.

d) Comparison of Pre-test and Post-test Mean Scores of Control Group Students

Dependent groups t-test was applied to statistically determine whether there was a significant difference between the pre-test mean scores of the control group and the post-test mean scores that were made as a result of the teaching and learning performed only as instructed by the curriculum. Findings of the results obtained are given in Table 8.

Table 7. *Test analysis results for the dependent groups showing the relationship between the pre-test means and the post-test means of the control group*

	Group	$\overline{X}$	SS	t	p
Pre-Test Post-Test	Control Group	40.08	7.77	36.46	.00

As a result of the t-test conducted to determine whether there is a significant difference between the mean scores of the test scores performed before and after the teaching conducted in accordance with the constructivist approach, there is a significant difference between the pre-test and post-test means ($p = .00$; $p < .05$) . Accordingly, it can be said that teaching performed in accordance with the constructivist approach has a significant effect on students' science achievement. However, as seen in Table 6, the achievement mean of the experimental group is higher than the control group.

e) Comparison of Attitudes of Students Using Virtual Reality Technology to the Course Before and After the Application

To determine whether there is a statistically significant difference between the averages of the attitude scales performed before and after the application of virtual reality to students in the 50-person experimental group, learning using virtual reality technology, dependent groups t-test was applied. The results obtained are given in Table 9.

Table 8. *Test analysis results for dependent groups showing the relationship between mean scores of attitude scales performed before and after virtual reality application to the experimental group*

	Group	$\overline{X}$	SS	t	p
Difference Between Attitude Scales Means	Experimental Group	18.83	8.48	12.17	.00

A statistically significant difference is observed between the mean scores of attitude scales performed before and after virtual reality application to students in the experimental group ($p = .00$; $p < .05$). Accordingly, it can be said that teaching with virtual reality technology has a significant effect on students' attitudes towards science course.

f) The Relationship between Students' Attitudes towards the Class and their Achievements Using Virtual Reality Technology

The Pearson Correlation Coefficients were examined to reveal whether there was a significant relationship between the attitudes towards the lesson they demonstrated after the application of virtual reality to the students in the 50-person experimental group learning using virtual reality technology and their achievements on the cell topic. The data related to these results are given in Table 10.

Table 9. *Pearson correlation test results showing the relationship between their attitudes towards the course they show after the virtual reality application to the experiment group and their achievements on the cell topic*

		Achievement scores	Attitude scores
Achievement scores	r	1	.86
	p		.00
Attitude scores	r	.86	1
	p	.00	

When the results shown in Table 10 are examined, there is a positive relationship between the experimental group students' cell knowledge achievement test scores and attitude test scores after virtual reality applications ($r = .86$; $p = .00$; $p < .05$). In this case, it can be said that the students who have a high attitude towards the course have high academic achievement on the subject of cell.

DISCUSSION and CONCLUSION

The findings obtained in this section are compared with the studies in the literature and the results obtained are presented. In this context, these findings are discussed hierarchically according to the research sub-problems.

When the test data of the transaction groups given in Table 4 are examined, the results of Kolmogorov-Smirnov and Shapiro-Wilk normality tests show that the data of the study groups are normally distributed. When Table 5 is examined, where the pre-test scores of the experimental and control groups are given, it can be concluded that there is no significant difference between the pre-test scores of these two groups, and therefore, the sample selection was made through unbiased assignment. In this context, the experimental design applied has been shown to be valid.

When the post-test achievement scores of the Cell Knowledge Achievement Test questions given in Table 6 are analyzed for independent groups, it is observed that there is a significant difference between the post-test scores of the experimental and control groups.

This difference should be at the level of p = .00 significance with an average of 10.4 points in favor of the students in the experimental group, according to the education in accordance for the science curriculum (MNE, 2018), which is based on the constructivist approach on the students' learning about the Cell subject revealed that it was more effective. These findings are in line with other studies in the literature regarding the contributions of virtual reality technology to science education as Arici concluded that virtual reality applications used in science class astronomy lessons makes learning more effective and Freina and Ott stated that virtual reality applications can alter students' attitudes towards science lessons (Arici, 2013; Freina & Ott, 2015). Thus, combined with the result of this study, it can be concluded that virtual reality applications have positive effects on students in terms of both achievement and attitude towards the course.

Dependent groups t-test results aiming to statistically describe whether there is a significant difference between the achievement test pre-test averages of the experimental group and the post-test applications done at the end of learning supported by the use of virtual reality technology are given in Table 7. According to these results, there was a significant difference between the pre-test and post-test scores of the students in the experimental group. In this case, it can be concluded that education supported by virtual reality technology has a positive effect on students' learning about the topic of Cell. On the other hand, when the dependent groups t-test results given in Table 8 regarding whether the difference between the pre-test and post-test scores of the control group students was significant, it was seen that the teaching performed according to the constructivist approach also had a significant effect on learning the subject of the cell. These findings also coincide with the results of relevant studies in the literature on the constructivism approach as constructivist approach has been shown to be an effective tool in science teaching (Brooks & Brooks, 1993; Koseoglu & Kavak, 2001; Tufekci Aslim, 2011). The study in this regard, also supports that constructivist approach using 5E technique improves students' academic achievement levels. In this case, both science education with constructivist approach and science education supported with virtual reality contribute to students' academic achievement.

When Table 9, which contains the data from the attitude test, which is another step of the research is examined, it is seen that the attitudes of the students in the experimental group towards science lesson increased by an average of 18.83 points. These data, which are statistically significant according to the results of dependent groups t-test, reveal that the use of virtual reality on teaching of the cell topic, positively affects students' attitude towards the course. It is seen that these results are compatible with other studies investigating the effect of educational technologies in the classroom on students' attitudes towards the course (Akpinar et al., 2005; Andolsek, 1995; Winn, 1997; Sahin, 2017). This situation leads to think that use of educational technologies in the classroom contributes to students' attitudes towards course and with the result of Table 9, it can be said that virtual reality is one of these technologies.

When Table 10, which contains data on the relationship between students' attitudes towards class and their achievements is examined, it was concluded that there is a positive relationship between attitude and course achievement when virtual technology is used. As the students' attitudes towards the course increase, achievements of students also increase. The conclusion that virtual reality technology increases attitude towards the course and increases course achievement in parallel with this, is consistent with the results of other studies examining attitude and achievement towards the course in the literature (Sahin, 2017; Akpinar et al., 2005; Freina & Ott, 2015). Thus, it can be said that the parallel increase of achievement and attitude towards the course can be achieved by using virtual reality applications in science lessons as well.

As a result of the study, it was seen that supporting the constructivism approach used in learning environments as much as possible with virtual reality technology, had a positive effect on students' academic achievement. In our age, digital technology and the innovations it brought to our lives cannot be denied. During the course, it is observed that the use of materials that students will have difficulty in understanding, imagining, or teachers will have difficulty in preparing, makes teaching more effective. Keeping education out of these technological developments cannot be considered a rational approach. Although it is stated that there is not enough study about the integration of virtual reality in education in the world (Freina & Ott, 2015), such studies are quite new in our country as well (Arici, 2013; Altinpulluk & Kesim, 2015; Can & Simsek, 2016; Ornes, 2017; Ozkan , 2016). With many more and various studies to be done, it will be possible to use digital technology more effectively in the field of education, in our schools and evaluate how it contributes to education.

According to Cepni (2011), students 11 and older are defined in the abstract process period in Piaget's learning theory during. Abstract process period is the highest level of cognitive level and includes skills such as distinguishing, determining variables, dreaming, and perceiving abstract concepts. It is seen in the literature that 11-12 age group students who have just made a transition to abstract period have difficulty in learning abstract concepts (Akpinar, 2006; Benli Ozdemir, 2019). It is seen that the factors affecting the secondary school age students who have recently transitioned to the abstract period are examined under three main headings as the student himself, the concept of the concept and the learning environment (Lacin Simsek & Tezcan, 2008). Therefore, learning environments are evaluated to be effective in teaching abstract concepts. Benli Ozdemir (2019) concluded that animation-supported science teaching is effective in correcting misconceptions of middle school 6th grade students. In parallel, Akpinar (2006) revealed that computer aided science teaching positively influences student achievement in teaching abstract concepts but observed that it does not affect students' attitudes towards the course. These researches show that educational technologies are used in teaching abstract concepts and the results show positive promises. This study, as it concludes that virtual reality helps students to understand abstract concepts more easily, is in parallel with the literature. Besides its effects on achievement and attitude, virtual reality can contribute to students' features such as abstract processing and high-level thinking (Kavanagh, Luxton-Reilly, Wuensche, & Plimmer, 2017) amongst other 21st century skills.

As the research results clearly show, it can be argued that the benefits of virtual reality technology for science education are valid not only in cell topic but also in other units and other subjects (Arici, 2013; Tepe et al., 2016). In addition, starting from the conclusion that the use of virtual reality applications in science education increases both students' achievement levels and attitudes towards the course, the need to increase and support the use of such materials in education has been revealed. Although the results of this research revealed that virtual reality technology has a positive effect on students' achievement and attitude, the nature and reasons of these effects still need to be revealed through qualitative research. This research lays the foundation for further qualitative research in the literature, investigating the reasons for the effects of the use of virtual reality in science education and student views.

Suggestions

Virtual reality technology needs to be studied on different topics, with different samples, at different grade levels and research results. It is suggested that virtual reality technology should be explored with more studies in education, since such research will

provide a deeper understanding of the subject. It is possible to access a wide variety of materials that can be found in video sharing sites such as YouTube and platforms like AppStore and PlayStore under today's conditions. In addition to this, it has become easier to reach with the increase of the variety of virtual reality glasses and the cheaper prices. In order to integrate such technologies into lessons, it is also necessary to work towards raising awareness technology skills of teachers. In this context, virtual reality content development studied can be done with teachers in service or prospective teachers via government funded projects. This may open the way for contents to be available in many subjects and teachers can access these contents much more easily.

In order to contribute to the development of practices, it may be recommended to make use of open course resources of universities at home and abroad. From this point of view, organizing in-service trainings to be provided within the Ministry of National Education will also increase the usage rates of these technologies in lessons. Moreover, with the support of government and private institutions, teacher trainings and content creation activities should be increased.

In order to provide this technology for use in the classroom, financial resources can be provided for the supply of materials from institutions such as national scientific agencies, district governorship and regional development agencies and international agencies such as UNICEF or EU. During use in the lessons, it may be recommended for students not to use them for more than ten minutes per person on average because longer usage of virtual reality headsets may cause blurred vision or trigger claustrophobia or lead to cognitive overload (Le et al., 2015; Kavanagh et al., 2017; Liu et al., 2017). In cases where the materials are not sufficient for the number of students, classroom management can be provided by making the materials available to the students in order and by employing other students in the process.

Although, there are also some limitations about using virtual learning environments in education. For example, Gutierrez et al. (2017) stated that even if younger people are native digital learners, this does not mean that they are competent in terms of pedagogy and researches in this context are still needed. Also, Kavanagh et al. (2017) listed the limitations of virtual reality from 35 paper in the field and stated the most important ones as software usability, cost, technological infrastructure and time limitations. Virtual reality applications, today, still have a rather confusing software infrastructure and can be difficult to use. Although reduced, it still costs, and funding is another limitation. Liu et al. (2017) also added that along with these limitations, improvement of simulations and interaction experiences limitations. They also pointed out that cognitive overload is a very serious issue and must be taken into consideration.

REFERENCES

Akpinar, E. (2006). *Computer Assisted Instruction in Constructing of Abstract Concepts in Science.* Teaching: “The Unit Electricity in Our Life” [Unpublished doctoral dissertation]. Dokuz Eylul University.

Akpinar, E., Aktamis, H., & Ergin, O. (2005). Students' views on the use of educational technology in science course. *The Turkish Online Journal of Educational Technology, 4*(1), 93-100.

Altinpulluk, H., & Kesim, M. (2015). *Paradigm changes in augmented reality applications from past to present.* [Conference presentation]. Academic Informatics Conference. Eskisehir: Anadolu University.

Andolsek, D. L. (1995). Virtual reality in education and training. *International Journal of Instructional Media, 22*(2), 145-156.

Aretz, A. (1991). The design of electronic map displays. *Human Factors, 33*(1), 85-101. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.841.9984&rep=rep1&type=pdf

Arias, A. M., & Davis, E. (2017). Supporting children to construct evidence-based claims in science: Individual learning trajectories in a practice-based program. *Teaching and Teacher Education, 66*, 204-218.

Arici, V. A. (2013). *A study on virtual reality programs in science education: "solar system and beyond: space riddle" example.* [Unpublished master's thesis]. Adnan Menderes University.

Baratoff, G., & Blanksteen, S. (1993). *Tracking devices.* Retrieved from The Encyclopedia of Virtual Environments: https://www.hitl.washington.edu/projects/knowledge_base/virtual-worlds/EVE/I.D.1.b.TrackingDevices.html

Barron, A., & Orwig, G. (1993). *New technologies for education: a beginner's guide.* USA: Libraries Unlimited Inc.

Bayraktar, E., & Kaleli, F. (2007). *Virtual reality on commercial applications*. [Conference presentation]. Academic Informatics Conference. Kutahya. Retrieved from https://www.researchgate.net/profile/Erkan_Bayraktar/publication/237599951_sanal_gerceklik_ve_uygulama_alanlari/links/54a00a790cf267bdb9014ec1.pdf

Bayram, S. (1999). Virtual reality applications in education. *MU Atatürk Faculty of Education Journal of Educational Sciences* (11), 49-54.

Brill, L. (1994). Metaphors for the travelling cybernaut. *Virtual Reality World, 1*(1), 30-33.

Brooks, J. G., & Brooks, M. (1993). *In search of understanding: the case for constructivist classrooms.* Alexandria: Association for Supervision and Curriculum Development. Retrieved Feb 05, 2019, from http://ocw.metu.edu.tr/pluginfile.php/9173/mod_resource/content/1/In%20Search%20of%20Understanding.pdf

Can, T., & Simsek, İ. (2016). New technologies in education: virtual reality. In A. Isman, H. F. Odabası, & B. Akkoyunlu, *Educational technology readings 2016* (pp. 351-361). Ankara: TOJET.

Creswell, J. W. (2017). *Research design: qualitative, quantitative, and mixed methods approaches.* California: SAGE.

Cavas, B., Huyuguzel Cavas, P., & Taskin Can, B. (2004). Virtual reality in education. *The Turkish Online Journal of Educational Technology, 3*(4), 110-116.

Cepni, S., Ayas, A., Ozmen, H., Ayvaci, H. S., Akdeniz, A. R., & Yigit, N. (2019). *Science and technology teaching from theory to practice.* Ankara: Pegem.

Cepni, S., Ormanci, U., & Ulger, B. B. (2016). Science literacy. In S. Cepni (Ed.), *Understanding the PISA and TIMSS logic and questions* (pp. 217-265). Ankara: PEGEM.

Duban, N., Aydogdu, B., & Yuksel, A. (2019). Classroom teachers' opinions on science laboratory practices. *Universal Journal of Educational Research, 7*(3), 772-780.

Duncan, I., Miller, A., & Jiang S. (2012). A taxonomy of virtual worlds usage in education. *British Journal of Educational Technology, 43*(6), 949-964.

Fernandez, M. (2017). Augmented virtual reality: how to improve education systems. *Higher Learning Research Communications, 7*(1), 1-15. Retrieved from http://dx.doi.org/10.18870/hlrc.v7i1.373

Forbes, P. A., Pan, X., & Hamilton, A. F. (2016). Reduced mimicry to virtual reality avatars in autism spectrum disorder. *Journal of Autism & Developmental Disorders,* (46), 3788–3797.

Freina, L., & Ott, M. (2015). *A literature review on immersive virtual reality in education: state of the art and perspectives.* [Conference presentation]. eLearning and Software for Education (eLSE). Bucharest. Retrieved from Academia: http://www.academia.edu/12273022/a_literature_review_on_immersive_virtual_reality_in_education_state_of_the_art_and_perspectives

Gullupinar, F., Kuzu, A., Dursun, O. O., Kurt, A. A., & Gultekin, M. (2013). The use of technology in national education and its results: evaluation of the pilot implementation of the conqueror project from the parents' perspective. *SDU Faculty of Arts and Sciences Journal of Social Sciences* (30), 195-216.

Gutierrez, J. M., Mora, C. E., Diaz, B. A., & Marrero, A. G. (2017) Virtual technologies trends in education. *EURASIA Journal of Mathematics Science and Technology Education, 13*(2), 469-486.

Javidi, G. (1999). Virtual reality and education. Tampa, South Florida, USA. Retrieved from http://repositorio.minedu.gob.pe/bitstream/handle/123456789/1523/Virtual%20Reality%20and%20Education.pdf?sequence=1&isAllowed=y

Karasar, N. (2003). *Scientific research method.* Ankara: Nobel.

Kavanagh, S., Luxton-Reilly, A., Wuensche, B. & Plimmer, B. (2017). A systematic review of Virtual Reality in education. *Themes in Science and Technology Education, 10*(2), 85- 119. Retrieved April 3, 2020 from HYPERLINK "https://www.learntechlib.org/p/182115/" https://www.learntechlib.org/p/182115/.

Kayabasi, Y. (2005). Virtual reality and its use for educational purposes. *The Turkish Online Journal of Educational Technology, 4*(3).

Koseoglu, F., & Kavak, N. (2001). Constructivist approach in science education. *Journal of Gazi Education Faculty, 21*(1), 139-148.

Lacin Simsek, C., & Tezcan, R. (2008). Factors affecting the development of children's thoughts on science concepts. *Elementary Education Online, 7*(3), 569-577.

Le, Q. T., Pedro, A., & Park, C. S. (2015). A social virtual reality based construction safety education system for experiential learning. *J Intell Robot Syst*, 487-506. doi:10.1007/s10846-014-0112-z

Liu D., Bhagat K.K., Gao Y., Chang TW., Huang R. (2017) *The Potentials and Trends of Virtual Reality in Education.* In: Liu D., Dede C., Huang R., Richards J. (eds) *Virtual, Augmented, and Mixed Realities in Education.* Smart Computing and Intelligence. Springer, Singapore

MNE. (2018). *Science course curriculum.* Ankara: MNE. Retrieved Temmuz 18, 2018, from http://mufredat.meb.gov.tr: http://mufredat.meb.gov.tr/Dosyalar/201812312311937-FEN%20B%C4%B0L%C4%B0MLER%C4%B0%20%C3%96%C4%9ERET%C4%B0M%20PROGRAMI2018.pdf

Nuhoglu, H. (2008). Development of an attitude scale for primary school science and technology course. *Elementary Education Online, 7*(3), 627-639.

Ornes, S. (2017, July/August). Virtual Reality. *Discover Magazine*, 48-49.

Ozdemir Benli, E. (2019). The effect of animation-supported science teaching on the elimination of misconceptions about the concepts of sun, earth and moon of 6th grade students and attitude towards astronomy. *Baskent University Journal of Education, 6*(1), 46-58.

Ozkan, O. (2016). The compatibility of widely used presence questionnaires with current virtual reality technology. Istanbul: Bahcesehir University.

Rosen, J. (1993). The role of telemedicine and telepresence in reducing health care costs: In medicine meets virtual reality interactive technology and healthare. *Visionary Applications For Simulation Visualization Robotics*(20), 187-194.

Roussou, M. (2004). Learning by doing and learning through play: an exploration of interactivity in virtual environments for children. *Computers in Entertainment, 2*(1), 1-23.

Sarioglu, S., & Girgin, S. (2018a). *Turkish translation of vr videos for virtual reality glasses: the body vr: journey inside a cell example.* [Conference presentation]. 2nd International Symposium of Education and Values (ISOEVA). (pp. 190-198). Antalya.

Sarioglu, S., & Girgin, S. (2018b). *Development of achievement test in science education: cell knowledge achievement test.* [Conference presentation]. 2nd International Symposium of Education and Values (ISOEVA). (pp. 199-210). Antalya.

Shin, Y. K. (2003). Virtual experiment environments design for science education. [Conference presentation]. *2003 International Conference on Cyberworlds* (pp. 388-395). Singapore: IEEE. doi:10.1109/CYBER.2003.1253480

Sekerci, C. (2017). Use of virtual reality in interior design. *International Journal of Social Research, 10*(51), 135-1362.

Tepe, T., Kaleci, D., & Tuzun, H. (2016). *New trends in educational technologies: virtual reality applications.* [Conference presentation]. 10th International Computer and Instructional Technologies Symposium (ICITS). Rize

Tutwiler, M. S. (2019). Exploring The relationship between attentional capture and prior knowledge in a science-based multi-user virtual environment: an individual growth model analysis. *Journal of Science Education and Technology, 28*(4), 299-309.

Tufekci Aslim, S. (2011). Constructivist approach. In S. Buyukalan Filiz, *Learning teaching theories and approaches* (pp. 336-351). Ankara: Pegem.

Walczak, K., Wojciechowski, R., & Cellary, W. (2006). *Dynamic interactive VR network services for education*. [Conference presentation]. ACM symposium on virtual reality software and technology, 277-286.

Washington, U. o. (2020, 19 03). *Understanding item analyses*. Retrieved from https://www.washington.edu/: https://www.washington.edu/assessment/scanning-scoring/scoring/reports/item-analysis/

Winn, W. (1997). *The impact of three-dimensional immersive virtual environments on modern pedagogy.* Human Interface Technology Laboratory. Seattle: University of Washington. Retrieved from: http://astro.uchicago.edu/cosmus/Daniela/viz_research/viz%20papers/VIRTUAL_EDUCATION/winn_1997.pdf