Cumhuriyet International Journal of Education, 11(1): 75-87, 2022
DOI: https://dx.doi.org/10.30703/cije.915897

Cumhuriyet International Journal of Education

| cije.cumhuriyet.edu.tr | Founded: 2011 Available online, ISSN: 2147-1606 Publisher: Sivas Cumhuriyet Üniversitesi

Investigation of the Effect of Augmented and Virtual Reality Applications in E-Learning on Students' Use of Microscopes

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Research Article

History

Received: 14/04/2021
Accepted: 19/12/2021

ABSTRACT

The purpose of this study is to determine the effects of applications developed with augmented and virtual reality technologies on subjects that require the use of microscopes in the e-learning process in science lessons on students' academic achievement, course engagement and self-efficacy beliefs in microscope use. The research was conducted in a quasi-experimental design with three groups, two experimental and one control. In this process, the teaching practices towards the control group (CG) were conducted with the use of the course presentations prepared by the researchers and the content of the Education Information Network related to the subjects covered in the research. While the students in the augmented reality experimental group (AREG) were taught with the same course presentations and augmented reality microscope application (MikrosAR), the students in the virtual reality experimental group (VREG) were taught with the same course presentations and virtual reality microscope application (MikrosAR2). In the study, data were collected through an academic achievement test, a scale of self-efficacy belief in microscope use, a course engagement scale and an observation form. The relationship between pre-test and post-test scores was performed using Kruskal–Wallis one-way analysis of variance. Observation data obtained from learning environments were calculated as frequency and presented by digitizing. Correlation analysis was applied to determine the relationship levels of the variables discussed in the study. According to the results, it was seen that there was no significant difference between the groups in terms of academic achievement, and all the materials used in the groups related to the subject had an equal effect on the students in the e-learning environment. Furthermore, it was observed that students in VREG had significantly higher self-efficacy beliefs in microscope use than students in AREG, therefore, the use of virtual reality technology in the e-learning environment had a positive effect on students' self-efficacy beliefs in microscope use. In addition, it was concluded that the students had a high level of productive interaction in practices, and no difference was observed between the groups in their participation in class. Moreover, it can be stated that course engagement in the e-learning environment is effective on the academic achievement of the student.

Keywords: Augmented reality, e-learning, microscope, science, virtual reality

E-Öğrenmede Artırılmış ve Sanal Gerçeklik Uygulamalarının Öğrencilerin Mikroskop Kullanımlarındaki Etkisinin İncelenmesi

Süreç
Geliş: 14/04/2021
Kabul: 19/12/2021

ÖZ

Bu çalışmanın amacı e-öğrenme sürecinde fen bilimleri dersinde uygulama gerektiren konulardan olan mikroskopla inceleme yapılabilecek konuların işlenmesinde artırılmış ve sanal gerçeklik teknolojileriyle geliştirilmiş uygulamaların öğrencilerin akademik başarılarına, derse katılımlarına ve mikroskop kullanımında öz yeterlik inançlarına etkisinin belirlenmesidir. Yarı deneysel desen kullanılan bu araştırma ikisi deney ve biri kontrol grubu olmak üzere üç grupla yürütülmüştür. Süreçte kontrol grubuna araştırmacılar tarafından hazırlanan ders sunuları ve araştırma kapsamında ele alınan konularla ilgili EBA içerikleriyle öğretim uygulamaları gerçekleştirilmiştir. Artırılmış gerçeklik deney grubunda aynı ders sunuları ve AG mikroskop uygulaması (MikrosAR) ile öğretim gerçekleştirilirken, sanal gerçeklik deney grubunda yine aynı ders sunuları ve SG mikroskop uygulamasıyla (MikorsAR2) süreç tamamlanmıştır. Uygulamada veriler akademik başarı testi, mikroskop kullanımında öz yeterlik inancı ölçeği, derse katılım ölçeği ve gözlem formu ile toplanmıştır. Öğrenme ortamlarından elde edilen gözlem verileri frekans olarak hesaplanmış ve sayısallaştırarak sunulmuştur. Araştırma kapsamında ele alınan değişkenlerin ilişki düzeylerini tespit etmek amacıyla korelasyon analizi uygulanmıştır. Elde edilen sonuçlara göre; gruplar arasında akademik başarı açısından anlamlı bir farkın olmadığı, gruplarda konuyla ilgili kullanılan bütün materyallerin e-öğrenme ortamında öğrencilere eşit etki ettiği, öğrencilerin mikroskop kullanımda öz yeterlik inançları açısından sanal gerçeklik grubu lehine anlamlı bir fark olduğu, bu durumun e-öğrenme ortamında farklı teknolojilerinden sanal gerçeklik teknolojisinin kullanımının öğrencilerin mikroskop kullanımında öz yeterlik inançlarına yönelik olumlu yönde etki ettiği, öğrencilerin uygulamalarda verimli bir etkileşimde bulunmalarının etkisinin yüksek olduğu, derse katılımları açısından ise gruplar arasında anlamlı bir farkın oluşmadığı sonuçlarına ulaşılmıştır.

Anahtar Kelimeler: Artırılmış gerçeklik, e-öğrenme, fen bilimleri, mikroskop, sanal gerçeklik

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How to Cite: Abdüsselam, Z., and Erten, S. (2022). Investigation of the effect of augmented and virtual reality applications in e-learning on students' use of microscopes, *Cumhuriyet International Journal of Education*, 11(1): 75-87

Introduction

It is one of the main goals of education for individuals to understand the events they encounter in daily life and to prepare them for life. One of the fields that help to achieve these goals is science. Science is one of the means that contribute to students' understanding and interpretation of nature with its theoretical and practical structure (Coştu, Ünal, and Ayas, 2007). In this sense, the use of educational tools such as real models, symbols, two- or three-dimensional materials in science applications eases learning processes (Babur, 2016). Especially learning environments with real objects, where students have the opportunity to practice and learn by experiencing, encourage students to think more by creating exploratory processes (Erten, 1991). Students who are active in this process have an increase in their self-confidence and perform various studies. It could also increase students' self-efficacy beliefs.

Self-efficacy is the awareness individuals have about the things they could do; in other words, their potential and their acceptance of doing what should be done (Koray, 2003). Self-efficacy creates a belief about how much success a person can achieve in overcoming problems (Senemoğlu, 2012). The increase in self-efficacy belief could make it easier for students to reach their learning goals (Çelik, 2009). However, the lack of content or materials in many schools in the learning environments causes the practices not to be done as desired, students to do the applied courses only in crowded groups or simply watch the course instead of practicing and experiencing (Bozkurt and Sarıkoç, 2008). These difficulties may cause the student to remain passive and not have self-efficacy beliefs at the desired level. Examining the self-efficacy of individuals in face-to-face or e-learning environments is significant in terms of revealing the effects of these environments on students' self-efficacy development.

Today, the problems caused by the remote administration of education due to the suddenly developing Covid-19 pandemic that affects the whole world have been added to the difficulties faced in the education process. These issues had a direct impact on training activities and provision of training through e-learning practices using digital technologies in Turkey has been attempted as in other countries (Bakioğlu and Çevik, 2020). Schools were closed on March 16, 2019 in Turkey, gradually opened for a short period and then fully closed again by the course of the Covid-19 pandemic (MEB, 2020). In this process, the ways teachers and students access and deliver information have become more diverse with technology. Educational Informatics Network (EBA) system was used in Covid-19 pandemic period in Turkey and materials such as various animations, presentations, videos were provided to students and teachers in this system (Gömlekçi, 2019). Thus, each student can ensure the continuity of their education and reinforce their learning by accessing the content, visual and audio elements prepared in accordance with the level of their age group in this educational environment, exchanging information with their peers and sharing their comments (EBA, 2021). E-learning is practised by transferring the content using technologies such as information, communication and the internet in learning processes. Determining how these technologies could be used in face-to-face or e-learning process in lessons and their effects on learning situations guides to researchers in their studies. However, it may not be sufficient to use only learning materials such as animations, videos and presentations when using information technologies for learning purposes. In this respect, including current technologies such as Augmented Reality (AR) and Virtual Reality (VR) in learning processes will contribute to the enrichment of digital materials.

Students' motivations, learning needs, expectations of lessons, desires and behaviours in this age differ from the previous generations. The opportunities provided by the developing technology are used to meet the expectations for the variable learning process (Bulun, Gülnar, and Güran, 2004). The fact that science is one of the courses that are convenient for the use of technology and includes many scientific and abstract concepts alleviates the utilization of technology when teaching these concepts with various methods and techniques (Ayas, Karataş, Ünal, and Çalık, 2001). Recent studies indicated that current technologies such as AR and VR have been used in science teaching (Al-Azawi, Albadi, Moghaddas, and Westlake, 2019; Kamińska et al., 2019; Huang et al., 2019). Since current technologies have been given a mission of enhancing students' interest by increasing the interaction in the e-learning process and meeting the expectations for the learning environment (Jee, Lim, Youn, and Lee, 2014), and due to the possibility that current technologies could have different results in learning environments (Cheng and Tsai, 2013), it is significant to examine technologies such as AR and VR.

Learning objectives could be achieved with the inclusion of three-dimensional (3D) teaching materials created with the use of AR and VR, technologies that have had an increasing use in recent years (Abdüsselam, 2014). VR is a technology where the user can interact with the 3D digital objects created via a software in the computer environment. VR is most commonly used in fields such as health, gaming, cinema, architecture and education. With this technology, exemplifications could be made with simulations in education and abstract objects could be taught. For instance, an experiment that may harm children in a science lesson can be implemented in a virtual environment without causing any harm while an event is animated with VR applications in the history lesson (Komşul, 2012). In VR, the individual experiences the feeling of being in a different environment that is completely simulated outside genuine environment (Atalay, 2019). In AR, another technology, real-world objects are enriched with digital objects such as digital sounds, text, photographs, drawings or 3D models to increase the lucidity of the real object (Güngördü, 2018). Azuma (1997) describes AR as a technology where real and virtual objects interact simultaneously, and virtual world objects and real-world objects are combined while Milgram and Kishino (1994) defines AR as reality environments where digital-media outcomes are preferred as an alternative to actual-world items.

It is expected that the use of teaching materials created with AR and VR technologies will appeal to more sensory organs of students and this will increase the learning and permanence (Çoban, 2017). Since 3D computer models reduce the subjects and concepts to a simpler understandable level, they could give the learner the feeling of experiencing the event (Korakakis, Pavlatou, Palyvos, and Spyrellis, 2009). Furthermore, due to the fact that these models give students the opportunity to view the subject from different angles (Çoban, 2009), students observe events more easily. The use of teaching materials supported by AR and VR technologies and the visualization of abstract concepts and events with these technologies can be thought to facilitate students' learning and transform learning environments into interesting, fun and realistic places. A number of mobile applications produced with these technologies have been developed. Students could use these applications with tools such as computers, tablets, and smartphones regardless of a certain place and time for the face-to-face or online class. The subjects and concepts that can be examined with a microscope in the science class of the secondary school of the Ministry of National Education (Turkey) can be given as examples where these applications could be used. Students are faced with the use of microscopes at various stages throughout their education. In this context, to improve the abilities of students about utilizing microscope and to give necessary support to the teachers who train these students are principal (Harman, 2012). Uzel, Diken, Yılmaz, and Gül (2011) found that teachers had the most problems in sharpening the image and taking a cross-section when using a microscope. Therefore, the use of new technologies in these fields will further enrich the learning environments for the subjects to be taught (Yeşilyurt, 2004). For example; Tan, Lewis, Avis, and Withers (2008) developed applications with AR technology, about the utilization of materials in a number of science museums in the UK in order to develop a positive attitude towards science. One of these applications is the development of a web-based microscope by storing microscopic images of several materials in one center. The images obtained are supported by the system up to six times magnification and the person is aimed to be informed about the structure of the object. On the other hand; Paxinou, Georgiou, Kakkos, Kalles, and Galani (2020) created virtual biology laboratories with microscopes using VR technology to examine the effects of the virtual microscope. As a result of the research, they asserted that the environment they developed was supportive for understanding the details and had promising potential. In particular, Paxinou et al. (2020) states that the use of VR microscopes contributed to students' ability to use light microscopy in traditional practices. Additionally; Zhou, Tang, Lin, and Han (2020) designed a microscope that can be used in an education environment with AR and VR technologies and stated that this developed tool contributed to the development of learning outcomes, positive emotions and motivate autonomous learning situations of the students. They also suggested investigating the advantages of both technologies separately. The cited studies were carried out face-to-face and experimentally. This study is similar to previous studies in terms of using the microscope via AR and VR technologies, and enlarging objects with applications. However, applications in the e-learning environment are also needed in new researches. In addition, it is believed that this research will provide the studies by demonstrating the effects of using AR and VR microscopes as separate technologies in e-learning environments. Moreover, according to the literature, it is significant to support students for the examination of subjects and concepts that can be examined with a microscope in science class in secondary school. Accordingly, analysing the effects of using the applications supported by current technologies in e-learning environments on course engagement and academic achievements, and examination of the self-efficacy status, which is an indicator of how successful the person is in overcoming the issues, will meet the need for guidance for educators and managers in the e-learning process. The purpose of this study is to determine the influence of applications in e-learning process developed with augmented and virtual reality technologies in subjects that require microscope examination in the science lesson, on students' academic achievement, course engagement and self-efficacy beliefs about using a microscope. Within the scope of the determined aim, responses to next questions are pursued.

- Does the use of different technologies in e-learning environments cause a significant difference in academic achievement of students?
- Does the use of different technologies in e-learning environments cause a significant difference in the self-efficacy beliefs of students in microscope usage?
- Does the use of different technologies in e-learning environments cause a significant difference in students' course engagement?
- What is the level of the relationship between students' academic achievements, self-efficacy beliefs about using microscope and course engagement?

Method

In this study, which aimed to reveal the effect of the applications developed with AR and VR current technologies on students' academic achievement, their course engagement in the class and self-efficacy beliefs in microscope use, a quasi-experimental design with a pre-test and post-test control group was used in the e-learning process. In this design, paired groups are randomly determined as experimental groups (Büyüköztürk, 2007). Within the scope of the study, three groups, two of which were experimental and one control, were randomly determined. The reason for determining the two experimental groups was the recommendation in the literature that AR and VR technologies should be examined separately. The control group contains the opportunities provided by the Ministry of National Education to teachers and students in the e-learning process. The pre-test experiment of the groups was carried out face-to-face in the classes with decreased number of students in accordance with the social distance rules in consequence of the Covid-19 pandemic. Due to the decision of Ministry of National Education to switch to distance education by closing schools, teaching practice was carried out in the form of e-learning. In the process, teaching practices were carried out to control-group (CG) with the lecture presentations, which were prepared by the researchers with EBA contents related to the topics covered in the research. While teaching was performed with the same lecture presentations and AR microscope application (MikrosAR) in the AR experimental group (AREG), students in the VR experimental group (VREG) were taught with the same lecture presentations and VR microscope application (MikrosAR2). In the end of the study, final test practice was carried out remotely and the results of the groups were compared.

The research process flow is displayed on Figure 1. The pilot study of the academic achievement test created by the researchers after the literature review in the research was conducted after obtaining the necessary ethical permissions. As a result of the necessary analyzes, the final form of the test was created and ethical permission was obtained for the main study again. Then, the academic achievement test, the self-efficacy scale for the use of the microscope and the course engagement scale were applied to 8th grade students as pre-test and post-test. The reason for conducting the study with 8th grades is that the students in these grades have experienced the light microscope within the scope of the science lesson in their learning process in the 5th, 6th and 7th grades, and they have previously practiced various activities using the microscope within the curriculum.

Study Group

In the research, a convenience sampling method was chosen among the non-random sampling methods. With this method, the researcher tries to prevent loss of time and workforce by collecting data from an easily accessible sample (Ekiz, 2009). The researcher conducted the study with 58 students from 8th grade in a secondary school in centre of Giresun province, where he worked as teacher, and determined the study groups on a voluntary basis in line with the permissions given by their parents. Moreover, the number of students coming to the school was less than the regular period due to the Covid-19 pandemic. Most of the students from classes 8D (18 volunteers), 8B (20 volunteers) and few students from classes 8H (11 volunteers) and 8F (9 volunteers) demanded to participate in the study. Therefore, students who demanded to participate from 8H and 8F classes were formed as one group. Moreover, three groups were randomly determined as 8D AREG, 8B VREG and 8H-F CG.

Data-Collection Tool

The data of the experiment were obtained using the test of academic achievement, self-efficacy belief in microscope usage scale, course engagement scale and observation form. Details about the scales are given in order.

Academic achievement test (AAT)

The researchers, using various test books and textbooks published by the Ministry of National Education's general directorate of assessment and examination services for secondary school students to measure the academic success of students in science subjects, prepared the AAT. To determine the comprehensibility of the language of the test and the validity of the items, opinions were taken from three field experts, two from the field of science and one from the field of Turkish teaching. Next, the pilot study of the test, which consisted of 25 multiple-choice questions, was carried out with data collected from 125 8th grade students from two different secondary schools. Then, the data were analysed with SPSS 22 version software, and five items with item discrimination indexes of .30 and below were excluded from the test after the pilot study. The indices of the distinctiveness of the remaining 20 items were between .32-.71 while the average index of the distinctiveness of the test was calculated as .49. Also, the item difficulty index of the items in the test was between .28 and .84, and the average difficulty index of the test was determined as .67. To clarify, item difficulty index is the determination of whether an item is easy or difficult according to the response rate. As the obtained value approaches one, the item becomes easier, and as the value approaches zero, the item becomes more difficult. Additionally, KR-20 formula was applied, to determine the reliability of the test and the KR-20 value of the test was determined as .85. A test score of .70 or higher is considered as an indicator that the reliability of a prepared test is high (Büyüköztürk, 2007). Thus, the value we determined as .85 indicates that the reliability of the test is high. According to these results, it can be said that the AAT is able to make valid and reliable measurements.

Self-efficacy belief scale in using microscope (SBS)

Within the scope of the research, the self-efficacy belief scale in the use of microscope developed by Ünal Baş (2013) was used. The necessary permission was obtained from the researcher for the use of the scale. The scale consists of 30 questions. The total scores obtained from this test were calculated as self-efficacy beliefs about using microscope. While the lowest score that can be obtained from the scale is 30, the highest score is 150. In addition, the Cronbach Alpha reliability coefficient of the scale was reported as .979.

Course engagement scale (CES)

The scale, which was developed by Handelsman, Briggs, Sullivan, and Towler (2005) to determine students' participation in science class and adapted to Turkish by

Gürer (2013), was used in the study after obtaining the necessary permissions from the researcher. The original version of the scale is 23 items, the highest point that could be reached being 105, whereas the lowest score being 21. It was stated that as the score rises, the student's participation in the class also increases. In addition, the Cronbach Alpha reliability of this 21-item scale was calculated as .91.

Observation form (OF)

This form was developed by researchers and was finalized by taking the opinion of an academic expert in the field of informatics. The application process was recorded by the researcher who carried out the teaching, and while the researcher was performing the application, the process was observed by another researcher who is an expert in the field of informatics. Each session was observed and the technical problems in using technology (hardware problems and problems arising from usage) experienced by the students were recorded by the researcher who made observations with this data collection tool. Since the limitations arising from technical problems in the use of current technologies have been frequently mentioned in the literature, the observations in this study were examined in this respect.

Validity and Reliability of the Research

Researchers aim to eliminate or reduce threats to the validity of research in their experimental studies (Creswell and Creswell, 2017). Internal validity in experimental research means that the observed differences on the dependent variable are directly related to the independent variable, not the unintended variables (Creswell, 2012). In quasi-experimental studies, factors such as selection, background, maturation and loss of subjects; time loss, interaction in the measurement process, separate measurement tools and processes and biased grouping can threaten internal validity (Fraenkel, Wallen, and Hyun, 2011). In this study, the negative effects of a number of factors that reduce internal validity were tried to be prevented by including the control group in the research design (Karasar, 2020). In addition, identical data collection tools were applied to all participants in order to increase the internal validity of the study. Thus, the negative impact that may occur due to data collection tools has been tried to be eliminated. In order to keep the voluntary participation of the students at the highest level and minimize the loss of subjects, small gifts such as sweets and chocolate were given to the participants before the study, and this factor, which threatened the internal validity, was tried to be minimized. Also, with random sampling, it was aimed to control the features that were not included in the application, such as student ability, motivation or attention span, which would affect the research result (Creswell, 2012). It was assumed that the effect of the maturation factor on all groups would occur equally thanks to random sampling, and it was thought that this factor could be controlled. On the other hand, external validity in experimental research is related to the generalizability of the findings obtained from the study (Creswell, 2012). Factors threatening external validity were tried to be controlled by randomly determining the sample, clearly describing the application and not informing the participants about the application (Fraenkel et al., 2011). Also, during the application period, the applications were taught to all groups in equal time using the same lesson plan. In the process, dual measurements were taken from all students (Creswell, 2012).

Context of the Study

Within the scope of the study, the determined groups were educated by taking into account the subjects that can be examined with a microscope from the curriculum of the science class in the 5th, 6th, 7th grades of the Ministry of National Education. In this context, grade levels, the subjects and achievements at these grade levels, and the duration of education of these subjects within the scope of the study are given in the table of specifications below.

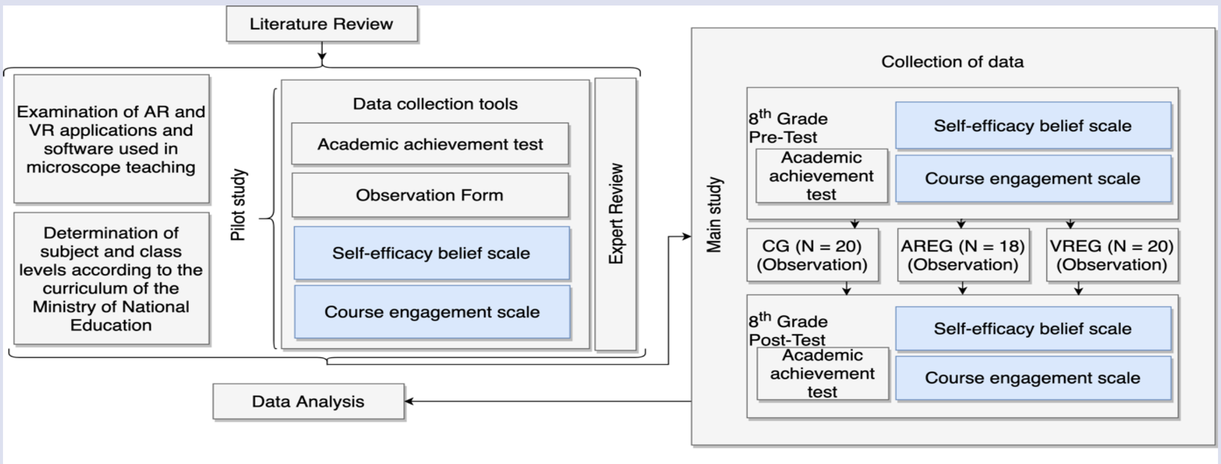


Figure 1. Research process

Table 1. Table of specifications

Grade Level	Subject / Concepts	Achievement	Time of Education
5	Getting to Know Living Things (Similarities and differences in living things, microscopic organisms, fungi, plants, animals, microscope)	Classifies living beings according to their similarities and differences by giving examples.	2 lessons
6	The Circulatory System	Defines the structure and functions of blood.	2 lessons
7	Similarities and differences between cell, plant and animal cell	Compares animal and plant cells in terms of their basic parts and functions.	2 lessons
5, 6, 7	Microscope parts and their use	-	2 lessons

As can be seen in Table 1, the Ministry of National Education does not present the microscope parts, the tasks of these parts and the use of the microscope as a subject and achievement. However, the subjects that can be examined with the microscope are provided in the textbooks.

The study was carried out for two weeks during 8 lessons for the all groups. To ensure continuous communication with students in all groups, the instant messaging application groups were established, and all the communication in the process was made with these applications. First, pre-tests were applied to all groups before the study while same tests were applied as post-test after the studies were completed. However, since the schools were completely closed and the e-learning process started, the teaching processes and post-tests were conducted remotely, except for the introduction of AR and VR microscope applications. Then, the teaching process and applications in all groups were carried out by the researcher. When the applications for microscopes and microscopic examinations in the Google Play Store were examined, it was seen that many of the applications published in the store offer the function of a magnifier (Microscope Magnifier) by making micro shots only with the phone's camera. Moreover, it was observed that some applications need to be applied by connecting an additional camera or a magnifying device to the phone or tablet (MScopes), while in others, images obtained in laboratories are presented as pictures (AnatLab Histology). The applications chosen for this study offer a structure that the student could practically use the parts of the microscope, the tasks of the parts and the images of the objects that are able to be examined under the microscope as part of the science lesson. Since the language of the applications is Turkish, they are easy to use for students and teachers. In addition, they are free and developed with AR and VR technologies. Moreover, the same content is included in both applications and they can be used in many mobile devices (Abdüsselam, Kilis, Şahin Çakır, and Abdüsselam, 2018). Hence, MikrosAR was preferred for AREG while MikrosAR2 was preferred for VREG not to mention the fact that the team that developed the applications was contacted and application permissions were obtained. Furthermore, as Kocasaraç (2003) stated, students need to be able to record and visualize the data they generate, models, activities or observations they develop in the educational applications they use, and need to be able to share their figures and drawings with each other and their teachers. Thus, applications in the study were selected since they have these features.

Next, the control group was contacted via online communication and the lessons were completed in 8 hours for two weeks at appropriate times. The content of the course was prepared within the framework of the lesson plan prepared by the researchers. The presentations prepared by the researchers and used in the experimental groups were covered with textbooks of the Ministry of Education, with direct expression and question-answers. With verbal participation, students were activated to participate in the lesson, and they were asked to give examples by relating the subjects to daily life. In addition, only the animations and videos related to the subject presented in the EBA system displayed in Figure 2 were used in this group.

In the learning process, there is no material that students can use microscope or make microscopic examinations interactively. Exercises in the EBA system, screening test questions, and unit evaluation questions in the textbook were answered remotely to reinforce the lessons. Examples of the relevant images in EBA used in the teaching process in CG are presented in Figure 2.

Before introducing the MikrosAR application for AREG, the link of the application was shared with the students and they were asked to download the application to their phones or tablets. For the students who cannot bring any device to the classroom, the researcher downloaded the application to the tablet and the phone she provided and introduced it by letting the students use the device in the classroom. The old phones brought by some students during the application caused them not to fully use the MikrosAR application. Those students also experienced the application with the devices brought by the researcher. The triggers brought by the researcher had been dealt to students before they started using the application. The introduction of the application and the explanation of how it is used were given in classrooms by taking Covid-19 pandemic measures where the number of students was reduced during two lesson hours. Since each class was divided into two groups in the classroom system with a reduced number of students, each lesson was conducted with 8-10 students. Since the schools started distance education, the learning process of the subjects within the scope of the study was done remotely. Students were contacted through the group set up in the instant messaging application, and a time suitable for them was determined for conducting the study. The sequence of the subjects in the lessons was from 5th grade to 7th grade. Besides, each subject was taught in eight lessons for two weeks, with a presentation prepared by the researchers and the students making practices with MikrosAR application. In addition to MikrosAR application during the teaching process, lecture presentations were taught with direct instruction, questions and answers. The students were enabled to participate in the lesson with their verbal expressions and to become active in the process with examples from daily life on the subject they learned. Exercises in the EBA system, screening test questions, and unit evaluation questions in the textbook were answered remotely on the system to reinforce lessons. Images from the teaching process with AREG are presented in Figure 3.

The introduction of the MikrosAR2 application was made to VREG face-to-face in a classroom environment where the number of students was reduced. Before the introduction, the students installed the MikrosAR2 application on their phones, and the students without any mobile device used the application with the devices brought by the researcher. Moreover, the smartboard in the classroom was also used in the promotion of MikrosAR2. The introduction of the application and the explanation of how it is used were carried out by taking Covid-19 pandemic measures in classrooms with a reduced number of students during two lessons. Also, the teaching process of the study was performed remotely. The students were contacted through the communication group, and a suitable hour was determined for them to do the experiment. The teaching of the subjects was followed in the same order as AREG, however, the applications were carried out with MikrosAR2 for two weeks in 8 lessons. In the teaching process, in addition to MikrosAR2 application, lecture presentations were provided with direct lectures, questions and answers. Students were enabled to participate in the lesson with their verbal expressions, and they were activated in the process with examples from daily life on the subject they learned. Exercises in the EBA system, screening test questions, unit evaluation questions in the textbook were solved on the remote system to reinforce the lessons. Images from the teaching process with VREG are shown in Figure 4.

Figure 2. a. Microscope and its parts

b. Images of microscopic organisms

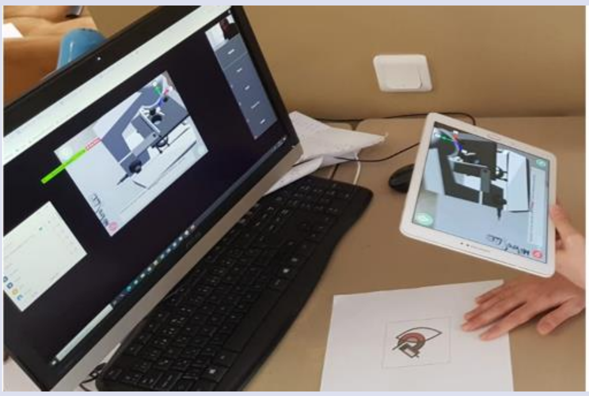
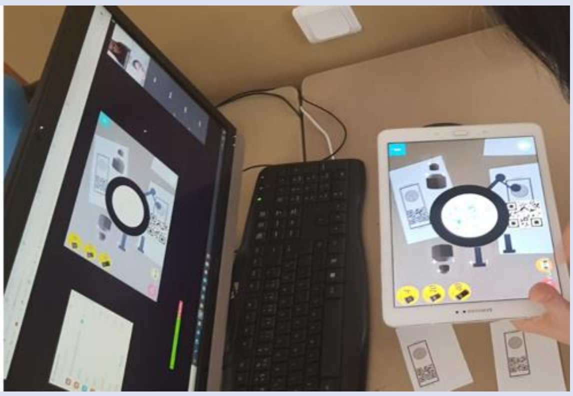
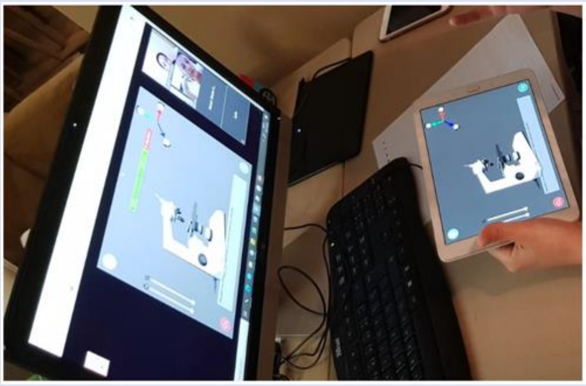


Figure 3. a. Microscope and its parts



b. Images of microscopic organisms



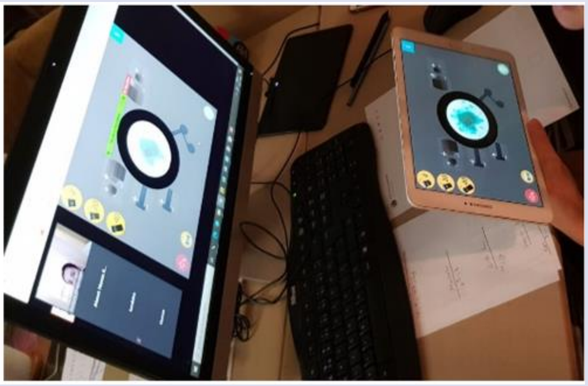


Figure 4.a. Microscope and its parts b. Images of microscopic organisms

Data Analysis

Document analysis technique is administered in the research. Document analysis is the collection and examination of written and visual materials (Sönmez and Alacapınar, 2013). Before conducting the research, researcher may form basic categories or themes to be used in document analysis based on the theories in the field (Yıldırım, 2010). Accordingly, the categories to be used in document analysis are gathered from the literature before conducting the research. First, normality values should be calculated to analyze the data obtained within the scope of the research. As a result of the Kolmogorov-Smirnov normality test performed with SPSS, academic achievement, course engagement and self-efficacy beliefs in microscope usage (p < ,05) did not have a normal distribution. Hence, it is decided to perform non-parametric statistics in the comparative analysis of the data. The relationship between the AAT, SBS and CES pre and post-test scores of the groups was analyzed with Kruskal–Wallis one-way analysis of variance. Observation data obtained from learning environments were calculated as frequency and presented by digitizing. Also, correlation analysis was performed to determine the relationship levels of the variables considered within the scope of the study. If the correlation coefficient obtained is 1.00, it is interpreted as a perfect positive relationship, if it is -1.00, a perfect negative relationship, and if it is zero, there is no relationship. The ranges with the correlation coefficient provide information about the level of relationship. If the coefficient value is between 1.00 and .70, it is defined that there is a relationship with high level, if it is around .70-.30, a moderate-relationship and between .30 and .00, a low level of relationship is defined (Büyüköztürk, 2007).

Ethics

In this study, all rules stated to be followed within the scope of "Higher Education Institutions Scientific Research and Publication Ethics Directive" were followed. None of the actions stated under the title "Actions Against Scientific Research and Publication Ethics", which is the second part of the directive, have not been carried out.

Ethics committee permission information

Ethical review board name = Hacettepe University
Date of ethics review decision = 11 Feb 2020
Ethics assessment document issue number=35853172-300

Findings

The data obtained from examinations within the scope of this study on the effects of the use of different technologies in the e-learning environments of secondary school students on students' academic achievement (AA), self-efficacy beliefs (SB) in microscope use and course engagement (CE) are presented below.

In order to identify the influence of the use of different technologies the students' academic achievement in e-learning environment, the pre-test and post-test scores were tested with Kruskal–Wallis one-way analysis of variance and the results are given in Table 2.

When Table 2 is examined, it can be said that the groups are equivalent to each other since there is no difference in academic achievement pre-test scores of students [X^2 = 3.629, p> .05]. In post-test scores, there was no significant difference between groups [X^2 = 2.943, p> .05] in terms of academic achievement. In this case, we can say that the use of different technologies in e-learning atmosphere had no effect on students' academic success.

To identify the effect of utilization of different technologies in the e-learning environment on the self-efficacy confidence of students for microscopy utilization, pre-test and final test scores were tested with Kruskal–Wallis one-way analysis of variance and the results are given in Table 3.

When Table 3 is examined, it can be said that the groups are equivalent to each other [X^2 = 3.321, p> .05] since no difference is observed between pretest scores of students' self-efficacy beliefs about using microscope. Moreover, students in the VREG group had higher scores [X^2 = 8.480, p<.05] in the post-test in terms of self-efficacy beliefs about using the microscope. In this case, it can be said that utilization of virtual reality technology in e-learning environment positively affected students' self-efficacy beliefs positively in microscope use.

To determine the influence of utilization of different technologies on course engagement of students in e-learning environment, pre-test-post-test scores were tested with Kruskal–Wallis one-way analysis of variance, and the results are given in Table 4.

When Table 4 is examined, it can be said that the groups are equivalent to each other since no difference is found in pretest scores of students for course engagement [X^2 = 5.472, p> .05]. In terms of post-test scores, there was no significant difference between groups [X^2 = 4.588, p> .05] in terms of course engagement. In this case, it can be said that utilization of different technologies in e-learning environment had no effect on students' course engagement in the class.

Within the scope of the research, relation between academic achievement (AA) of students, self-efficacy beliefs in using microscope (SB) and course engagement (CE) in the e-learning environment was investigated. The level of relationship between variables is given in Table 5.

When the students participating in the study were evaluated in groups, a moderately-positive significant relation between course engagement and their academic achievement is determined in terms of the examined variables in the control group [r = .447, p <.05]. In terms of the variables in AREG, there was a moderately positive significant relationship between students' course engagement and their self-efficacy beliefs about using the microscope [r = .490, p<.05]. Furthermore, a moderately positive and significant relationship [r = .561, p<.05] was found between academic achievements and self-efficacy beliefs about using microscope in this group.

Table 2. Kruskal–Wallis one-way analysis of variance results of the academic achievement pre-test and post-test scores of the groups

	Group	N	Mean	Sd.	X2	p	Significant difference
Pre-Test	AREG	18	25.56	2	3.629	.163	No
	VREG	20	35.18				
	CG	20	27.38				
Post-test	AREG	18	28.81	2	2.943	.230	No
	VREG	20	34.30				
	CG	20	25.33				

Note: *p<.05

Table 3. Kruskal–Wallis one-way analysis of variance results of self-efficacy beliefs of students about the use of microscopy pre-test and post-test scores of the groups

	Group	N	Mean	Sd.	X2	p	Significant difference
Pre-Test	AREG	18	28.14	2	3.321	.190	No
	VREG	20	34.85				
	CG	20	25.38				
Post-test	AREG	18	28.44	2	8.480	.014*	CG<VREG
	VREG	20	37.70				
	CG	20	22.225				

Note: *p<.05

Table 4. Kruskal–Wallis one-way analysis of variance results of course engagement pre-test and post-test scores of the groups

	Group	N	Mean	Sd.	X2	p	Significant difference
Pre-Test	AREG	18	22.08	2	5.472	.065	No
	VREG	20	31.10				
	CG	20	34.58				
Post-test	AREG	18	22.61	2	4.588	.101	No
	VREG	20	33.90				
	CG	20	31.30				

Note: *p<.05

Table 5. Relationship level of students between the variables examined

		AA	CE	SB
CG	AA	1.000	.447*	.146
	CE	.447*	1.000	.430
	SB	.146	.430	1.000
AREG	AA	1.000	.168	.561*
	CE	.168	1.000	.490*
	SB	.561*	.490*	1.000
VREG	AA	1.000	.246	.381
	CE	.246	1.000	.737**
	SB	.381	.737**	1.000

Note: *p<.05 **p<.01

In terms of variables in the virtual reality group, a high level of positive, strong and important relationship between students' course engagement in the class and their self-efficacy beliefs about the use of microscope is observed [$r = .737, p<.01$]. Besides, it is observed that there was a moderately positive relation between academic achievement and self-efficacy beliefs about the use of the microscope in this group, but this relationship is not significant [$r = .381, p>.05$]. It can be stated that course engagement in the class in the e-learning environment affected

academic-achievement of students. However, the use of applications such as augmented and virtual reality technologies that allow students to interact in the same environment had an effect on students' self-efficacy beliefs about using microscopes.

Table 6 shows how many students experience hardware problems (interruptions in sound or video streaming when students have slow internet or complete interruption of the internet) or usage problems (The phones or tablets used by many students had low image speed and processing even though they run the application used in the research, the camera on their phone or tablet had a low resolution, the user responded late to commands, the transition between user interfaces was slow, students had problems in adjusting the light when using the triggers) in each lesson during the teaching process of the research. At the end of all lessons, CG students experienced hardware-related problems 14-times while usage problems 2-times. AREG students experienced hardware problems 24-times and usage problems 50-times. Moreover, students experienced hardware problems 13-times and usage problems 8 times at the end of all lessons. It is identified that CG students experienced the least usage problems while the students in VREG experienced the least hardware problems.

Discussion and Results

In this study, the multiple effects of using applications developed with current AR and VR technologies on students when teaching subjects that are able to be examined with a microscope in science class in the e-learning process were examined. In parallel with the research sub-problems; academic achievements, self-efficacy beliefs about using microscope and course engagement in the class were investigated, and the relationship between these variables was examined.

Based on the findings, the use of AR and VR applications contributed to the success of the students, but this contribution was not statistically significant. They are different structures for students to learn and teach subjects. Jee et al. (2014) stated that AR applications in the e-learning process positively affected academic achievement. Also, Yıldırım (2020) stated that AR applications increase academic achievement and affect permanence. Besides, Aldalalah, Ababneh, Bawaneh, and Alzubi (2019) indicated that AR was at forefront of academic success compared to VR. The research showed parallelism with the positive effect of AR and VR technologies in the literature on supporting students' academic achievement. However, the fact that the materials used in all groups have a strong role in supporting learning in the process may be sufficient to support all groups academically. The richness of EBA content used in the control group may be an important factor in the increase of academic success in this group.

When the sub-problem of the study related to self-efficacy beliefs in using a microscope was evaluated, it was seen that VR applications positively affected students' self-efficacy beliefs in using microscopes in e-learning environments. Since no specific study has been found regarding the effects of using AR and VR technologies in the e-learning environment on students' self-efficacy beliefs in microscope use, students' self-efficacy beliefs and the use of current technologies are examined in general terms. Lehikko (2020) mentioned that VR contributed to students' self-efficacy while Alsowat (2017) indicated otherwise. According to the outcomes obtained in this study, the fact that the high-level of interaction VR offered to students had an effect on students' confidence of self-efficacy in utilization of microscope is parallel to literature. However, it can be said that there was no increase in students' self-efficacy beliefs in AREG unlike VREG due to the students' hardware or user-related problems in the use of AR technologies. In CG, it may be stated that the decrease experienced in students' self-efficacy confidence stemmed from the lack of an application in the learning environment where students could interact with microscope use and microscopic examinations.

Regarding the third sub-problem examined in the research process, it is seen that despite the use of current technologies in the learning processes in the e-learning environment, no significant difference is observed in students' course engagement. In the literature, due to the interaction of current technologies in the learning environment (Kamińska et al., 2019), and the contribution of virtual and augmented reality technologies to course engagement, these technologies have been identified in the activity processes in e-learning environments (Hamada, Mohamed, Mohamed, and Youssef, 2016).

Formanek, Buxner, Impey, and Wenger (2019) stated that students' participation in the e-learning environment is related to their motivation. Also; Bai, Hew, Sailer, and Jia (2021) stated that students' motivation in e-learning is affected by their self-efficacy beliefs. Therefore, it can be said that course engagement is related to self-efficacy beliefs. In the research, doing the experiment in the e-learning environment in all groups, teaching all the lessons through e-learning for the first time due to the Covid-19 pandemic, and studying a specific subject such as a microscope in the research narrowed the scope of the research. The lack of a significant difference between students' course engagement in the study may be due to the effect of these situations on their self-efficacy beliefs and motivations.

Table 6. Observation results

	Number of Students Experienced Problems					
	CG		AREG		VREG	
	Hardware Problems	Usage Related Problems	Hardware Problems	Usage Related Problems	Hardware Problems	Usage Related Problems
Lesson 1	3	0	4	7	3	1
Lesson 2	2	1	3	6	2	0
Lesson 3	2	0	4	8	3	2
Lesson 4	1	0	2	8	2	1
Lesson 5	3	0	2	7	1	0
Lesson 6	0	1	4	5	0	2
Lesson 7	2	0	3	4	2	1
Lesson 8	1	0	2	5	0	1
Total	14	2	24	50	13	8

Within the scope of the research, students were activated in the learning process in all groups for their participation as they tried to establish relationships with daily life during the lecture process, and were given the opportunity to express these relationships in the learning environment. For this reason, it can be said that the students' course engagement and academic achievement positively affected each other directly or indirectly. Also, the use of AR microscope applications in the teaching of contents that can be examined with a microscope in the e-learning environment supported student’s course engagement. Thus, the course engagement and self-efficacy beliefs of the students in microscope usage positively affected each other. In addition, the academic achievements and self-efficacy beliefs of these students in microscope usage also affected each other positively. On the other hand, presenting VR microscope applications to students in the e-learning environment positively affected the relationship between students' course engagement and their self-efficacy beliefs in microscope usage. It can be stated that as the problems experienced by students in the use of AR and VR technologies decrease, their self-efficacy confidence about utilization of microscope increases. For instance, it can be said that course engagement and self-efficacy beliefs about using microscope were higher in VREG group since they did have fewer problems during the experiment. The fact that students at AREG had problems in practice may have caused this relationship level to occur less. During the learning process that was carried out for 8 lesson hours in the e-learning environment, the number of the students that had hardware and usage problems is recorded via the observation form. When the internet was slow or completely shut down, hardware problems (f = 14) experienced in CG caused interruptions in audio and video. It is thought that the problems arising from usage were at a minimum level due to the fact that the teachers had used the EBA system before. In the Covid-19 pandemic process, up-to-date technologies are assigned important roles in supporting education (Ray and Srivastav, 2020) and the learning process could continue with these technologies. However, there are some technical problems in the process, thus, the process may be negatively affected (Pınar and Dönel Akgül, 2020). Although the AR application within the scope of the study was introduced to the students through face-to-face training, the students had trouble adjusting the light while using the triggers in the home environment. Furthermore, the low resolution of the camera on their phone or tablet disrupted the triggering process in the application (f = 50). These situations are thought to negatively affect the efficiency of the application. Although the VR application was the same as the AR application in terms of content, it was observed that students had fewer problems due to the lack of responsibilities such as adjusting any image or light or activating the triggers. In this sense, Jee et al. (2014) have assigned a number of tasks to AR technology in e-learning environments and mentioned some difficulties encountered in applications regarding the matters such as functionality and hardware. The fact that the expectations from the AR learning environment could not be fully met due to the technical problems experienced, even though the students were attracted in experiment, explains why the participation of students in AREG was not as much when compared to VREG. Moreover, Huang et al. (2019) compare the AR and VR technologies in their research and state that VR was immersive and engaging by spatial-presence mechanism, whereas AR was a more functional medium for carrying auditory-information by spatial-presence pathway. However, in addition to students having excitement for both technologies in the learning environment, there may be situations where they may have difficulties in a number of ways (Al-Azawi et al., 2019). Within the scope of the study;

- Analyzing the hardware situations of the target audience in advance, as the occurrence of technical problems in augmented-reality apps utilization in research affects application success,
- Prioritizing virtual reality in applications to be made with current technologies due to the fact that students experience fewer problems in virtual reality applications during the experiment,
- Making applications developed with current technologies in e-learning environments with broader topics that could be studied in a longer time,
- Developing VR applications in a structure that allows students' interactions to be at the highest level as technology allows

- could be suggested as issues to be noted by researchers who consider studying in this field.

Limitation

The research is limited to 58 secondary school students studying in the 8th grade in the 2020-2021 academic year. Due to the small sample size, the findings could not be generalized to larger groups. This study was conducted with limited data collection tools and could not be examined qualitatively. It is recommended that a qualitative study be carried out for future studies, since determining the opinions of students in terms of the use of AR and VR technologies in e-learning, especially in line with the interviews with the students, can be useful in explaining the quantitative results obtained in the research. By applying these teaching materials to larger groups, quasi-experimental studies can be planned and this process can be followed with richer data.

Acknowledgements

This article is based on an unpublished doctorate thesis.

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